5. Water Resources

This section provides an overview of regional climatic conditions (Section 5.1), water supply, including both surface and groundwater supply (Sections 5.2 and 5.3), and water quality (Section 5.4). Summary information on the regional water supply relative to demand is provided in Section 7.

5.1 Climate

Four climate data collection stations have historically been and/or are currently located in the Taos planning region. Additionally, a fifth station is located just outside the region and is also representative of climate conditions in the area. These five stations were used to characterize climatic conditions in the region. Table 5-1 lists the periods of record for the five identified climate stations in the Taos planning region, and Figure 5-1 shows the locations of the stations. Table 5-1 also lists two snowpack telemetry (SNOTEL) stations that were used to document snowfall in the higher elevations (Figure 5-1).

Table 5-1. Climate Stations in or Near the Taos Planning Region

Station Name	Period of Record [a]		Latitude	Longitude	Elevation (ft msl)
	Data Start	Data End [b]			
Taos County [c]					
Tres Piedras, New Mexico	01/01/1914	07/28/2006	3640	10559	8,140
Cerro, New Mexico	02/01/1932	07/28/2006	3644	10536	7,650
Red River, New Mexico	01/01/1915	07/28/2006	3642	10524	8,680
El Rito, New Mexico	01/01/1933	07/28/2006	3620	10611	6,870
Taos, New Mexico	01/01/1914	07/28/2006	3625	10534	6,970
Snotel Stations					
North Costilla [d]	10/01/1979	09/30/2005	36° 99’	105° 26’	10,600
Gallegos Peak [e]	10/01/1980	09/30/2005	36° 19’	105° 56’	9,800

[a] Period of record not necessarily continuous between start and end dates.

[b] Reflects date data was downloaded for this water plan; more recent data may be available

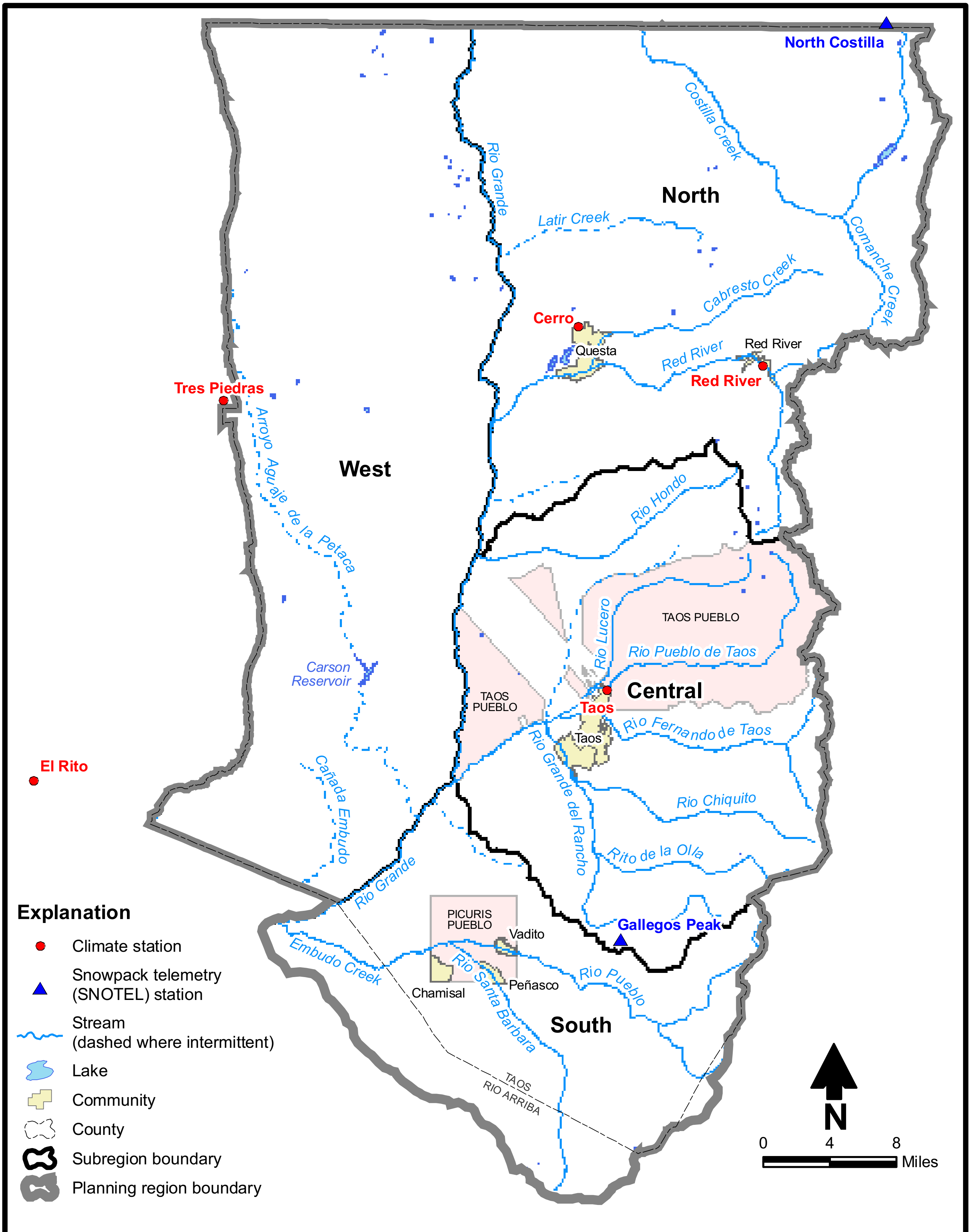
Information sources:

[c] http://www.wrcc.dri.edu/summary/mapnm.html

[d] http://www.wcc.nrcs.usda.gov/snotel/snotel.pl?sitenum=665&state=nm

[e] http://www.wcc.nrcs.usda.gov/snotel/snotel.pl?sitenum=491&state=nm

ft msl = Feet above mean sea level



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TAOS REGIONAL WATER PLAN
Climate Stations

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Figure 5-1

5.1.1 Temperature

As shown in Table 5-2, the average temperature at the five climate stations ranged between 39 and 49 degrees Fahrenheit (°F) for the available time period of record. Appendix E1 contains figures showing the annual average temperatures and the long-term monthly average, minimum, and maximum temperatures at these stations. Figure 5-2 shows the annual temperature range at Taos, one of the stations with the longest period of record (1914 to 2004) in the region.

5.1.2 Precipitation

Precipitation varies considerably across the region and is influenced by both location and elevation. Weather systems may enter the planning region from the west (Pacific), northeast (Arctic air masses from the plains), and southwest (Gulf of California). As indicated in Table 5-2 and Appendix E1, average precipitation, including both snowmelt and rainfall, ranges from about 12 to 21 inches. Contoured precipitation throughout the planning region is illustrated in Figure 5-3, and Figure 5-4 shows the total annual precipitation at Taos. The large annual variability shown in Figure 5-4 is common in the region.

The two SNOTEL stations (Table 5-1) provide both rainfall and snow water equivalent (SWE, an indication of the amount of moisture available in the snowpack) data. Appendix E1 contains figures showing daily SWE values and monthly average, minimum, and maximum snowpack at each of the stations for the available period of record. As indicated by these figures, snowpack is also highly variable over the period of record.

5.1.3 Evaporation and Evapotranspiration

No evaporation data are available from NOAA stations within the Taos Region; however, Johnson (1999) provided estimates of mean annual evaporation at reservoirs in the surrounding area (Table 5-3). The compilation of these data showed the highest daily evaporation occurring in June (average values 0.27 to 0.38 inch per day).

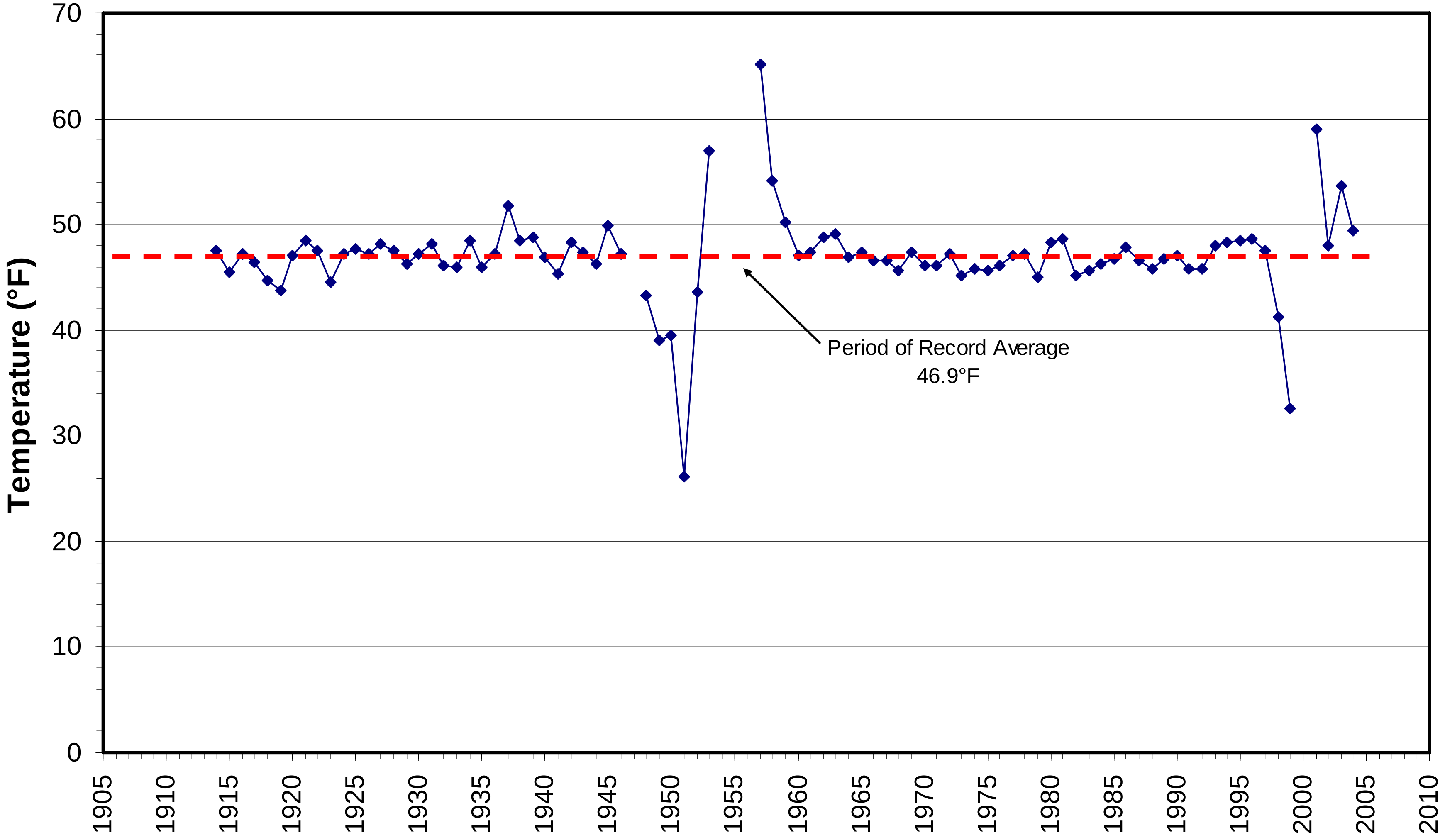
Table 5-2. Precipitation and Temperature at Representative Climate Stations in the Taos Water Planning Region

Station Name	Temperature [a] (°F)				Precipitation [a] (inches)			
	Annual Average	Annual Average Minimum	Annual Average Maximum	% of Possible Observations [b]	Annual Average	Annual Minimum	Annual Maximum	% of Possible Observations [b]
Tres Piedras, New Mexico	42.0	25.9	58.1	67	13.86	5.92	24.83	94
Cerro, New Mexico	44.5	28.7	60.3	72	12.68	7.26	19.29	96
Red River, New Mexico	39.3	22.8	55.7	71	20.60	11.61	29.01	77
El Rito, New Mexico	49.0	34.2	63.8	56	12.23	4.95	21.90	97
Taos, New Mexico	47.1	30.8	63.4	93	12.30	6.39	22.73	98

Source: Western Regional Climate Center web site (http://www.wrcc.dri.edu/summary/mapnm.html)

[a] For period of record through July 28, 2006.

[b] Percentage of observations that were available for period of record through December 31, 2005; for example, 90% indicates that data were missing for 10% of the months.



TAOS REGIONAL WATER PLAN

Average Annual Temperatures
Taos Climate Station

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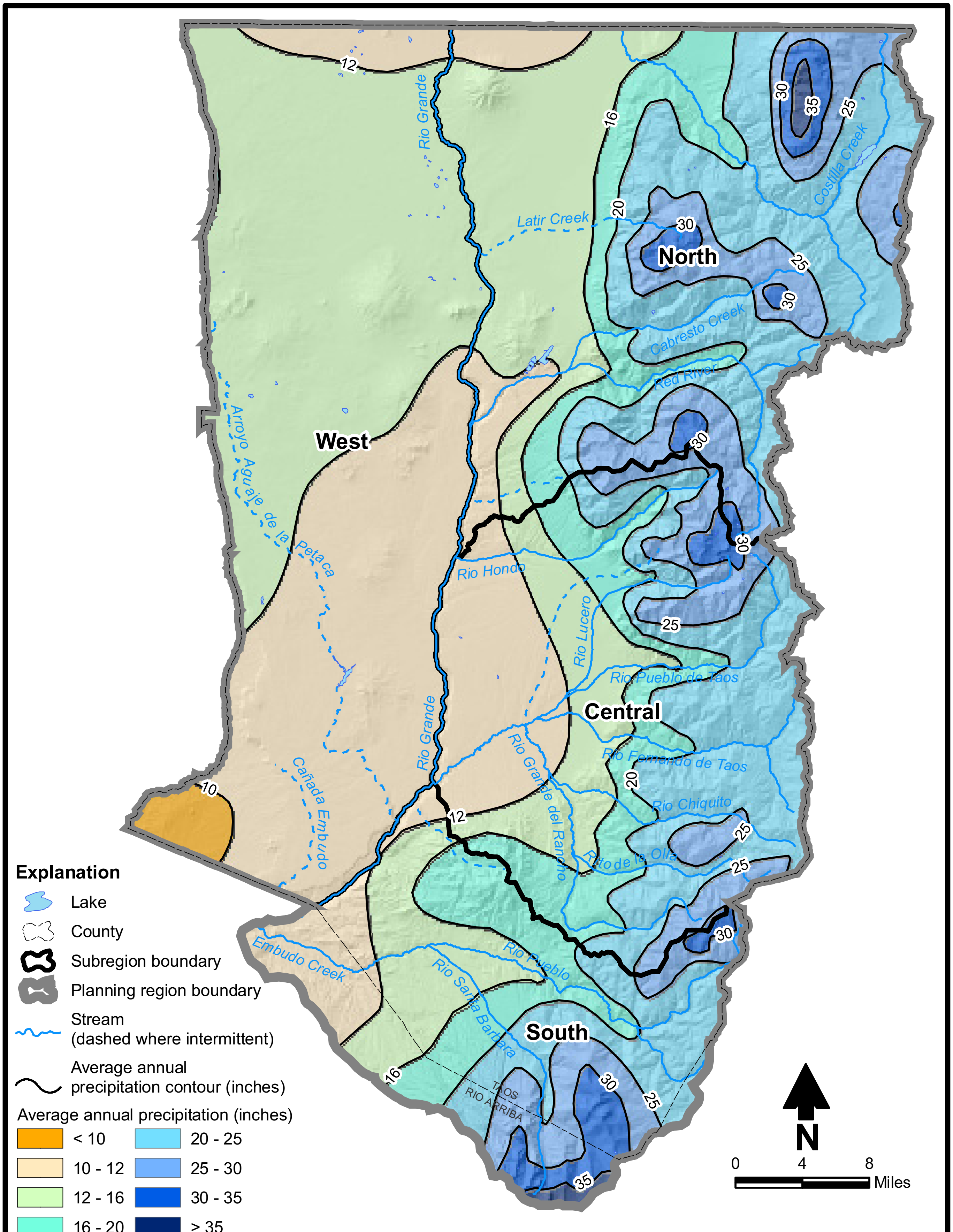
Figure 5-2



Source: New Mexico Water Resources
Research Institute

TAOS REGIONAL WATER PLAN
Average Annual Precipitation

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Figure 5-3

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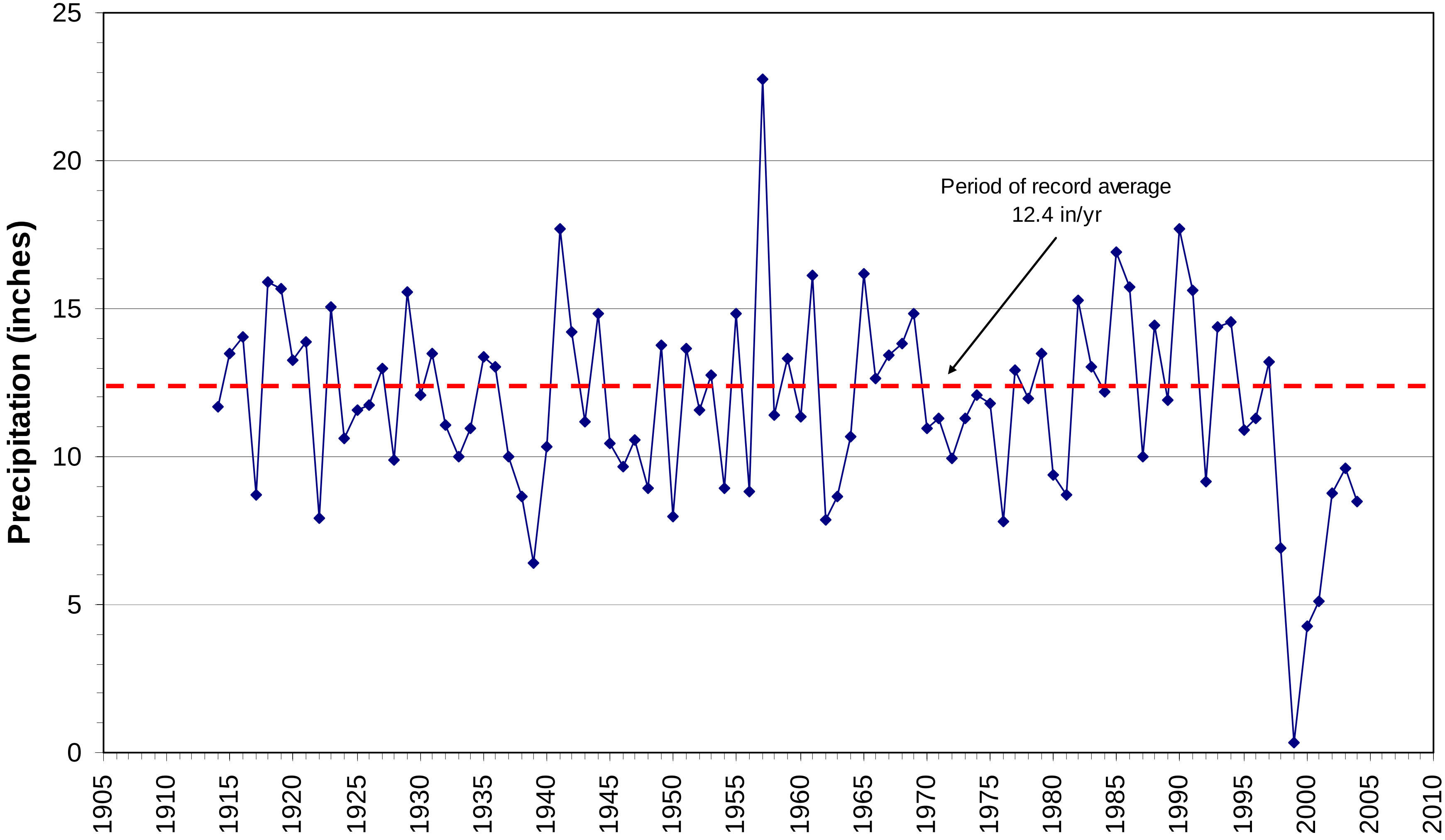

Note: The 1999 value includes 8 months in which data were missing for more than 26 days. Data were also missing for a portion of 2000 and 2001.

TAOS REGIONAL WATER PLAN

Total Annual Precipitation

Taos Climate Station

Figure 5-4

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Table 5-3. Mean Annual Lake Evaporation Rates for NOAA and USBR Evaporation Stations in the Taos Vicinity

County	Station name	Elevation (feet)	Mean Annual Evaporation (in/yr)
Rio Arriba	Abiquiu Reservoir	6,380	48.9
	El Vado Dam	6,740	38.0
	Heron Reservoir	7,240	34.1
Conejos (Colorado)	Conejos 3NNW	7,900	40.3
	Platoro	9,840	29.0
Colfax	Eagle Nest	8,260	36.0

Source: Adapted from Johnson, 1999

Evaporation rates for reservoirs in the Taos area were also reported by the OSE (Table 5-4). The net evaporation rate is the gross evaporation rate, which varies depending on temperature, minus annual precipitation. The total annual depletion from evaporation varies depending on the total surface area, which is greater when the reservoir is full than in dry years. Total evaporation depletions from reservoirs in the region are discussed in Section 6.

Table 5-4. Reservoir Evaporation Rates in the Taos Region

Gage	Year	Gross Evaporation Rate (ft/yr)	Rainfall (ft/yr)	Net Evaporation Rate (ft/yr)
North subregion				
Costilla Creek Reservoir	1990	2.50	2.08	0.42
Costilla Creek Reservoir	2000	2.90	1.35	1.55
Cabresto Lake	1990	2.92	2.08	2.25
Cerro Dam	1990	3.58	1.33	1.59
Central subregion				
Talpa Lake	1990	3.75	1.00	2.75

Source: Wilson, 1992; supporting database for OSE 2000 water use report (Wilson et al., 2003)

5.1.4 The Palmer Drought Severity Index

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, and can be used as an aid in planning and decision making. The Palmer Drought Severity Index (PDSI), created in 1965 by W.C. Palmer to measure the variations in moisture supply, is calculated using precipitation and temperature data and the available water content of the soil. These data are then used to calculate evapotranspiration, soil recharge, runoff, and moisture loss from the surface layer, and moisture conditions are standardized so that comparisons among regions and differing time frames can be made (Hayes, 1999). Based on a score determined through these analyses, the drought status at any given time is described according to the classifications listed in Table 5-5.

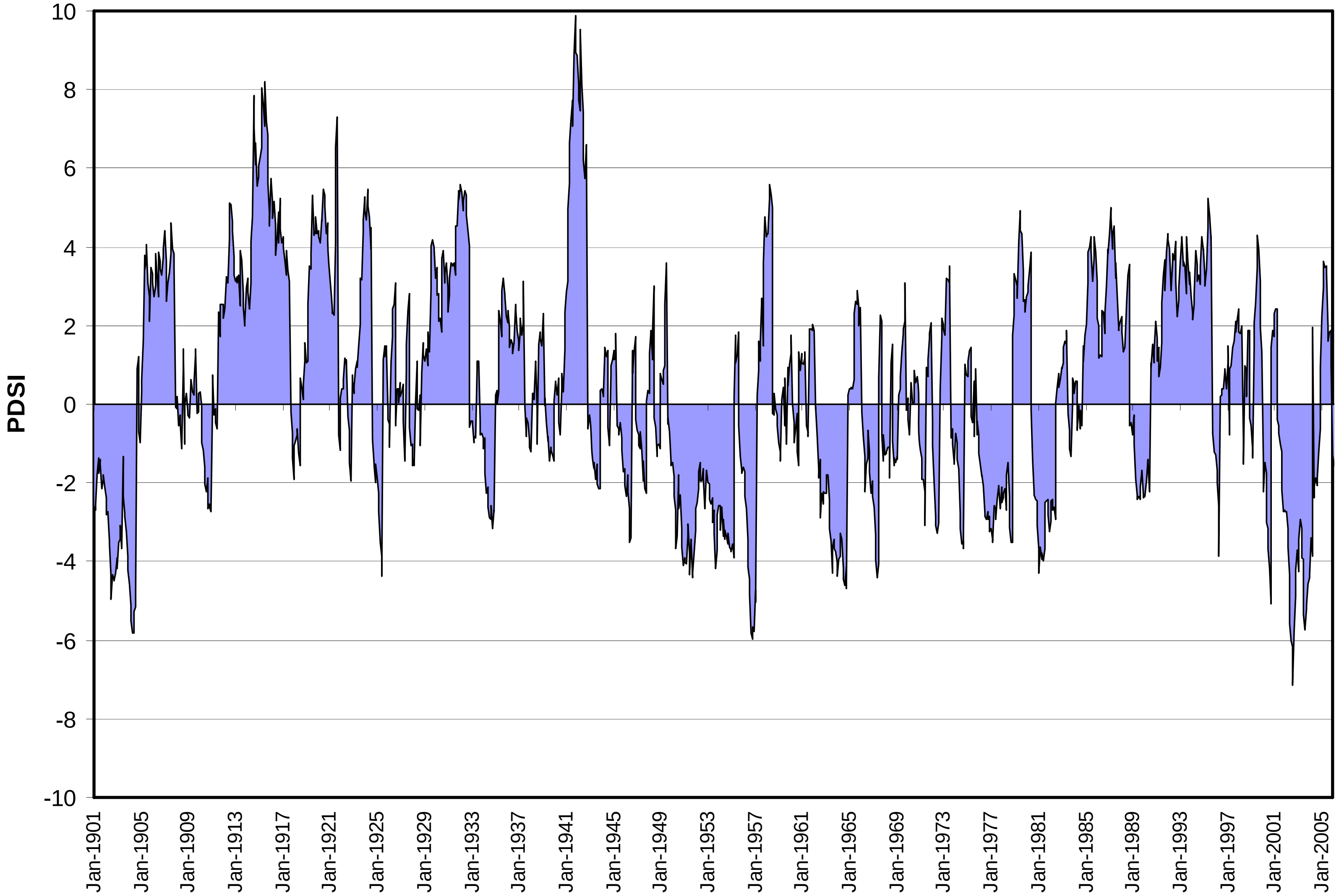
Table 5-5. Palmer Drought Severity Index Classifications

PDSI Classification	Description
+ 4.00 or more	Extremely wet
+3.00 to +3.99	Very wet
+2.00 to +2.99	Moderately wet
+1.00 to +1.99	Slightly wet
+0.50 to +0.99	Incipient wet spell
+0.49 to –0.49	Near normal
–0.50 to –0.99	Incipient dry spell
–1.00 to –1.99	Mild drought
–2.00 to –2.99	Moderate drought
–3.00 to –3.99	Severe drought
–4.00 or less	Extreme drought

The PDSI is calculated for climate divisions throughout the United States. The Taos planning region is entirely within the Northern Mountains climate division (New Mexico Climate Division 2). Figure 5-5 shows the long-term PDSI for Division 2. Of interest are the large variations from year to year and the significant number of drought years that have occurred since 2000.

5.1.5 Pacific Decadal Oscillation

The Pacific Decadal Oscillation (PDO), a long-lived El Niño-like pattern of Pacific climate variability, serves as an indicator of climatic trends that can help predict long-term precipitation. In the southern United States the warm (positive) PDO phase is correlated with anomalously



TAOS REGIONAL WATER PLAN

Palmer Drought Severity Index
Climate Division 2

Figure 5-5

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wet climatic conditions and the cool (negative) PDO phase is correlated with anomalously dry climatic conditions (Mantua, 2002). A warm (positive) PDO phase began in 1977, and 20th century PDO events have generally lasted for approximately 20 to 30 years (Mantua, 2002); however, it is difficult to detect real-time shifts in the PDO, and scientists are not clear if a shift back into the cool (negative) phase has yet occurred (Gutzler et al., 2002; Gutzler, 2006).

5.1.6 Climate Change and Impacts to Water Supply

As noted in a recently completed report on the effects of global climate change on New Mexico’s water supply and ability to manage water resources (NM OSE, 2006b), global temperatures are rising, as evidenced by decreased icepack and snowfields and retreat of glaciers. This global warming is thought to be due to the presence of greenhouse gases, concentrations of which are continuing to increase. In New Mexico, wintertime average temperatures have increased statewide by about 1.5 degrees since the 1950s (NM OSE, 2006b). Increased temperatures lead to high evapotranspiration, lower soil moisture, and a greater potential for drought. More intense but probably less frequent storms could lead to more extreme flooding events.

According to the OSE report, the following effects of global climate change are likely to occur in New Mexico:

- Temperature is expected to continue to rise.
- A greater percentage of precipitation is expected to fall as rain rather snow.
- The amounts of snowpack and snow water equivalency are expected to decrease.
- Smaller spring snowmelts and/or earlier runoff are expected to diminish supplies of water for irrigation and ecological health.
- Reservoir and other open water evaporation are expected to increase.

- Evapotranspiration is expected to increase due to water temperatures and longer growing seasons.

- The severity of droughts and floods is expected to be more extreme.

While there is no quantitative model for climate change impacts specifically in the Taos Region, climate changes in the planning region are likely to have the following effects:

- More extremes could occur in the surface water flow regime, including larger floods and prolonged droughts resulting in lower surface flows. Thus the supply of water for acéquias along the Rio Grande tributaries may be inadequate a greater percentage of the time.

- More extreme flood events could increase erosion and impact housing and structures close to surface water resources.

- Prolonged drought could diminish watershed health and ecological functions of riparian areas and could increase the risk of catastrophic fires in the large forested areas present in the planning region.

5.2 Surface Water Supply

Surface water is extremely important in the Taos Region; in 2000, approximately 90 percent of water withdrawals in Taos County were from surface water sources (Wilson et al., 2003). In particular, surface water is diverted for agricultural use from approximately 300 acéquias and ditches in Taos County (Section 6.1.2).

The primary surface waterbody in the Taos Region is the Rio Grande, which originates in Colorado and flows through Taos County from north to south. In northern New Mexico, the Rio Grande is fed by perennial rivers and streams, which are in turn fed primarily by precipitation to the Sangre de Cristo Mountains located in eastern Taos County (Johnson, 1999). In addition to these perennial rivers and streams, many ephemeral streams and arroyos provide water to the Rio Grande during storm events. The Taos Region has numerous springs, and alpine lakes occur at high elevations in the eastern region of Taos County (Johnson, 1999).

Section 5.2.1 describes regional surface water drainages, and Section 5.2.2 discusses regional streamflow data. Lakes and reservoirs in the region are discussed in Section 5.2.3.

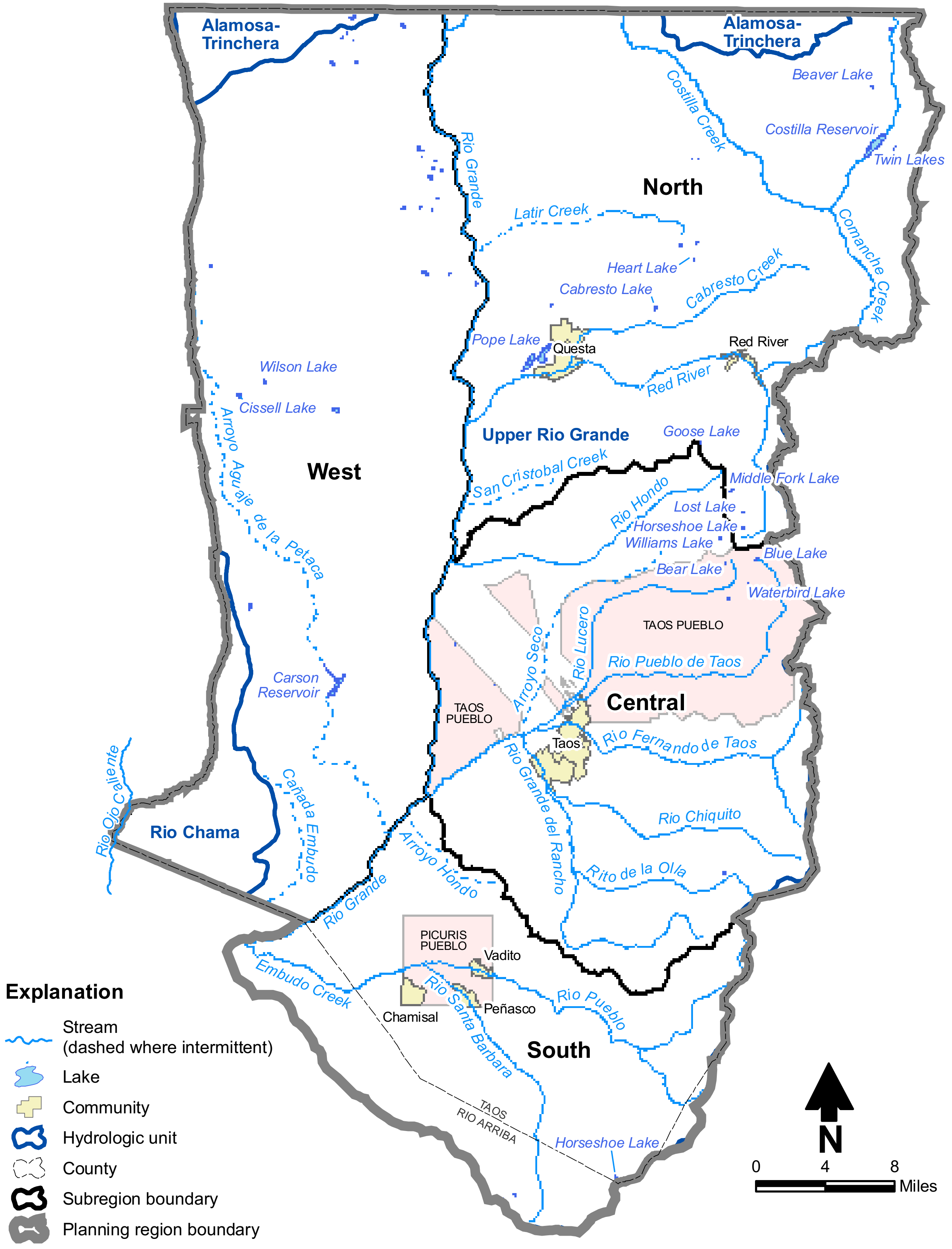
5.2.1 General Hydrologic Setting

Surface water features in the Taos Region include the Rio Grande and its tributaries, including Costilla Creek, Cabresto Creek, Red River, Rio Hondo, Rio Lucero, Rio Pueblo de Taos, Rio Fernando de Taos, Rio Grande del Rancho, Rio Pueblo, Rio Santa Barbara, and Embudo Creek (Figures 5-6 and 5-7). In addition to these perennial rivers and streams, many ephemeral streams (e.g., Latir Creek) and arroyos (e.g., Arroyo Aguaje de la Petaca) flow following storm events. Numerous springs and alpine lakes occur at high elevations in the eastern region of Taos County.

To provide a standard geographic framework for water and land-use planning, the USGS has divided the United States into hydrologic units (USGS, 1976), two of which occur in the Taos Region: the Upper Rio Grande and the Alamosa-Trinchera. The Alamos-Trinchera hydrologic unit (labeled as Rio Grande headwaters on Figure 5-6) is located in the extreme northern part of the planning region. Almost the entire planning region falls within the Upper Rio Grande hydrologic unit.

For this water plan, the Taos Region has been divided into four subregions (Figure 5-6) based on watershed boundaries:

- The *North subregion* covers a 673-mi^2 drainage area in northeast Taos County, from the Colorado-New Mexico state line south to the drainage divide between the Red River and Rio Hondo watersheds. It includes the Rio Grande north of the Rio Hondo and five watersheds:
  - Costilla Creek
  - Sunshine Valley
  - Latir Creek and the Cerro/Guadalupe
  - Red River
  - San Cristobal



TAOS REGIONAL WATER PLAN

Surface Water Features

Figure 5-6

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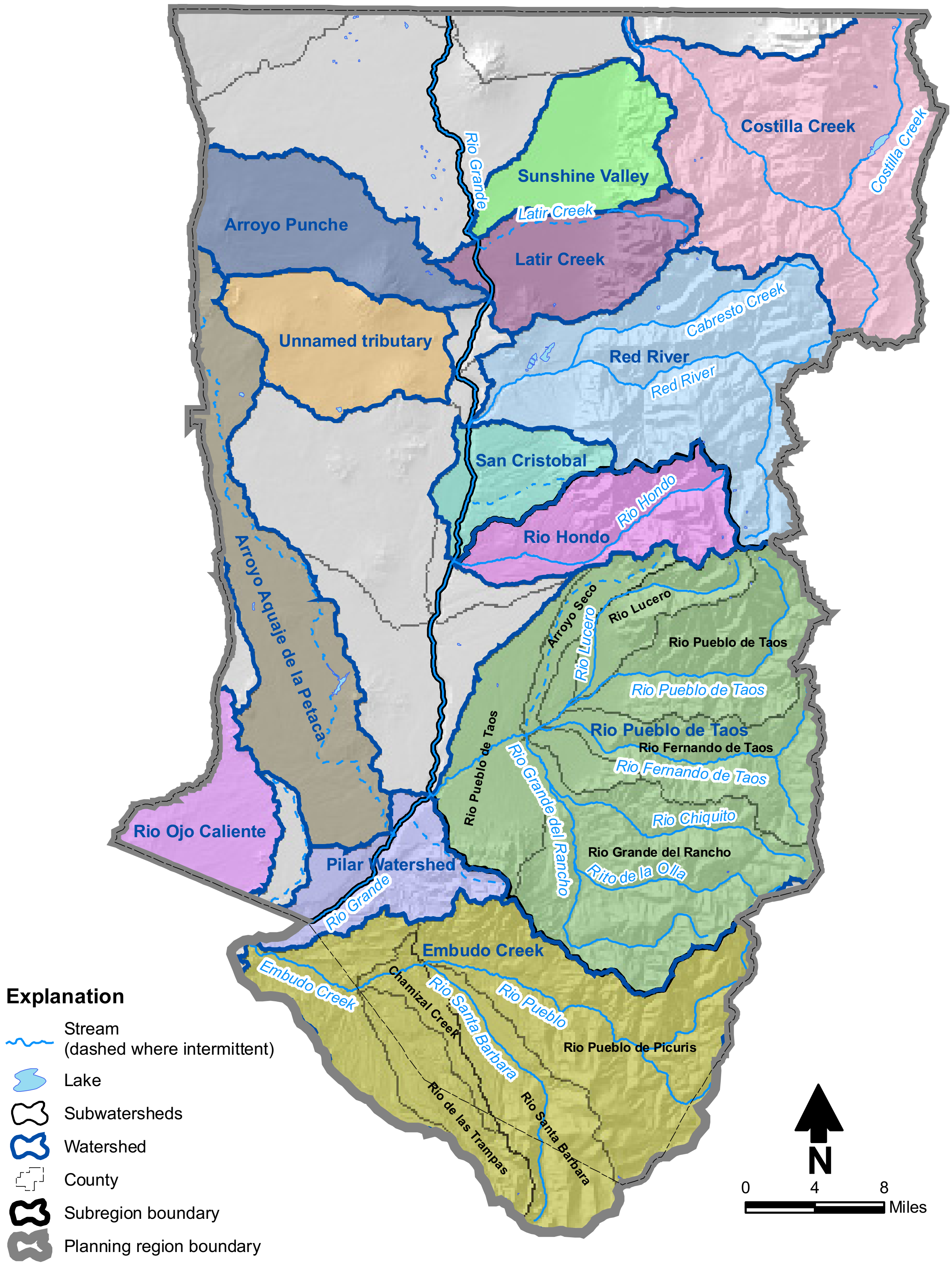

TAOS REGIONAL WATER PLAN

Watersheds

Figure 5-7

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- The *Central subregion* lies south of the North subregion and extends east from the Rio Grande to the Taos-Colfax County line, covering a drainage area of 524 mi^2. It includes the Rio Grande from the Rio Hondo south to Taos Junction and two watersheds:
  - Rio Hondo
  - Rio Pueblo de Taos

- The *South subregion* covers 364 mi^2, including southeast Taos County and the Embudo watershed within northeastern Rio Arriba County, extending south from the Rio Pueblo de Taos and Embudo watershed divide to the planning region boundary. It includes the Rio Grande in the southern part of the region and two watersheds:
  - Pilar
  - Embudo Creek

- The *West subregion* covers a drainage area of 742 mi^2 that flows intermittently to the Rio Grande during storm events (Johnson, 1999). This subregion includes the area of Taos County west of the Rio Grande from the Colorado-New Mexico state line south to the Taos-Rio Arriba County line. The area includes four significant drainage basins:
  - Arroyo Punche
  - Unnamed tributary
  - Arroyo Aguaje de la Petaca
  - Rio Ojo Caliente (part of the Rio Chama hydrologic unit)

Information regarding the watersheds in the Taos Region is summarized in Table 5-6.

5.2.2 Summary of Streamflow Data

Streamflow data are collected by the USGS from many gages in the Taos Region (Figure 5-8). Table 5-7 lists the locations, periods of record, and types of data collected at these stream gages, as well as the estimated acreage irrigated by surface water diversions upstream of the station, as reported in USGS publications. Table 5-8 summarizes the minimum, median, average, maximum, and standard deviation of annual water yields based on data available from the USGS for the entire period of record for each station. Because the periods of record vary for each gage, minimum, median, average, maximum, and standard deviation are also presented for a common period of record (Table 5-8). Percentile flows are summarized in Table 5-9.

Table 5-6. Summary of Watersheds in the Taos Water Planning Region
Page 1 of 2

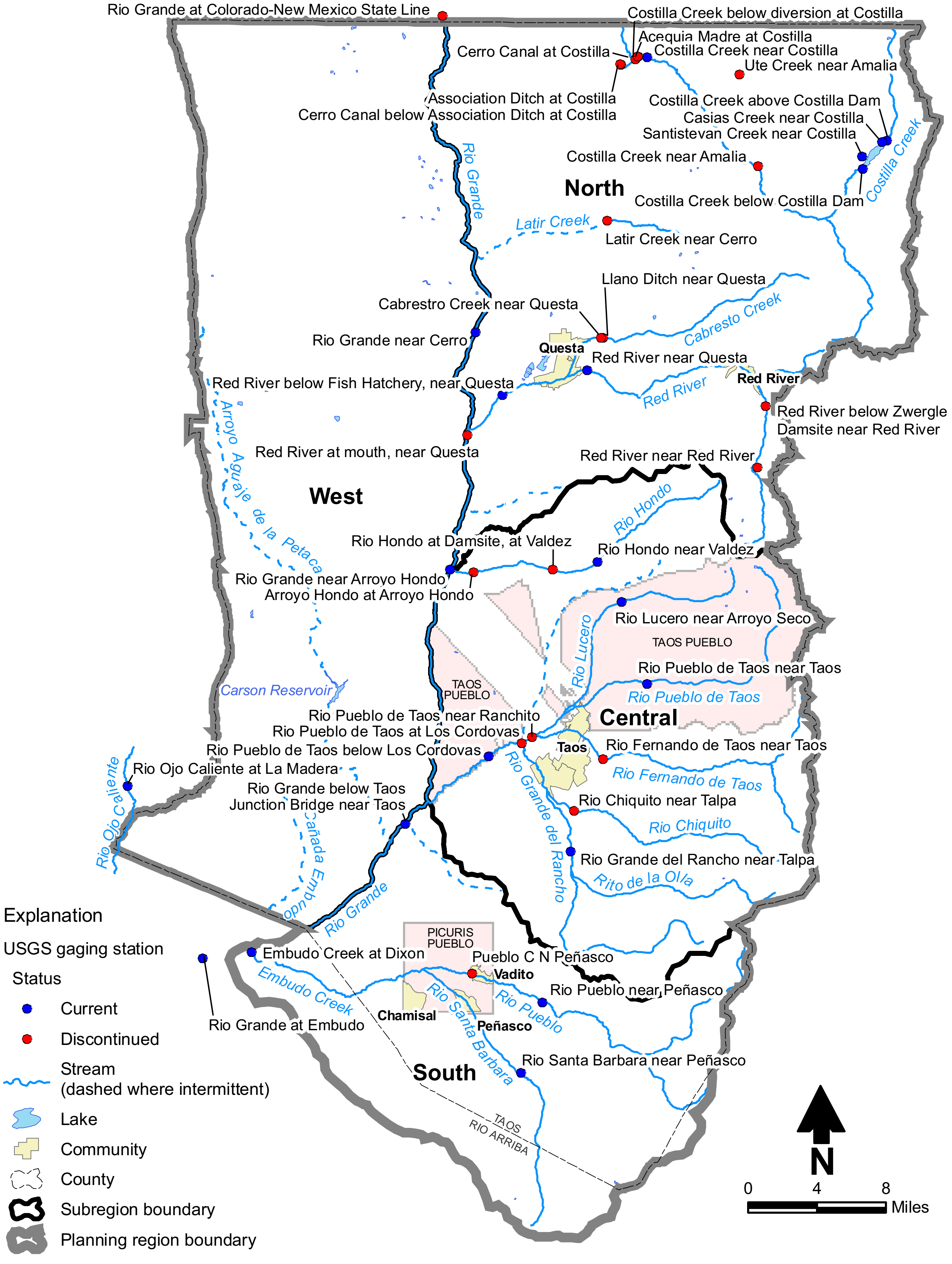
Watershed / Tributary	Elevation Range (ft msl)		Drainage Area (acres)	Comments [a]
	Low	High		
North subregion				
Costilla Creek	7,746	12,940	137,327	
Comanche Creek			27,254	
Latir Creek			45,448	
Ute Creek			10,128	
Sunshine Valley	7,257	11,240	43,619	
Latir Creek	7,129	12,720	45,448	
Red River	6,588	13,161	120,632	Multiple springs occur on the lower reach of Red River, causing an increase in flow between the Red River State Fish Hatchery and the Red River confluence with the Rio Grande.
San Cristobal	6,450	12,073	28,647	
Central subregion				
Rio Hondo	6,470	13,150	45,748	Rio Hondo drains into the Rio Grande at river mile 1677.5; springs discharge along both rivers near this point.
Rio Pueblo de Taos	6,079	13,104	268,600	
Rio Pueblo de Taos west			40,121	
Rio Pueblo de Taos east			74,243	
Rio Lucero			20,596	
Rio Fernando de Taos			43,960	
Rio Grande del Rancho			89,273	Numerous springs are known to discharge on Carson National Forest land along the Rio Fernando and in the Picuris Mountains.
Arroyo Seco			13,501	
South subregion				
Pilar	5,830	10,584	38,344	Warm Springs, Rio Grande (Klaver) Spring, and other springs discharge along the east and west sides of the Rio Grande Gorge near Pilar.
Arroyo Hondo			4,806	
Agua Caliente			3,436	
Embudo Creek	5,830	12,999	204,653	
Embudo Creek			33,488	
Rio Pueblo de Picuris			91,686	
Rio Santa Barbara			42,038	
Chamizal Creek			11,546	
Rio de las Trampas			25,895	

[a] Johnson, 1988

Table 5-6. Summary of Watersheds in the Taos Water Planning Region
Page 2 of 2

Watershed / Tributary	Elevation Range (ft msl) Low	Elevation Range (ft msl) High	Drainage Area (acres)	Comments [a]
West subregion				
Arroyo Punche	7,129	9,446	61,204	The arroyo does not contribute appreciable flow to the Rio Grande.
Unnamed tributary	6,939	9,472	50,678	
Arroyo Aguaje de la Petaca	6,047	9,144	156,762	The arroyo captures a significant amount of runoff; however it is usually dry where it meets the Rio Grande, approximately 3 miles upstream of Pilar. The arroyo is deeply incised, indicating that significant flow can occur during storm events.
Rio Ojo Caliente	6,194	7,926	137,332	

[a] Johnson, 1988



TAOS REGIONAL WATER PLAN

USGS Stream Gaging Stations

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Figure 5-8

Table 5-7. USGS Stream Gaging Stations in the Taos Water Planning Region
Page 1 of 3

USGS Site Number [a]	USGS Site Name	Latitude	Longitude	Elevation (ft msl)	Drainage Area (acres)	Contributing Drainage Area (acres)	Period of Record [b]	
Taos County								
08252000	Rio Grande at Colorado-New Mexico State Line	37°00’03”	105°43’19”	7,390	NA	NA	10/1/1953	9/30/1982
08252500	Costilla Creek above Costilla Dam, NM	36°53’54”	105°15’16”	9,454	16,064	NA	5/1/1937	8/6/2006
08253000	Casias Creek near Costilla, NM	36°53’49”	105°15’37”	9,400	10,624	NA	5/1/1937	8/6/2006
08253500	Santistevan Creek near Costilla, NM	36°53’03”	105°16’52”	9,487	1,376	NA	5/1/1937	8/6/2006
08254000	Costilla Creek below Costilla Dam, NM	36°52’26”	105°16’47”	9,290	34,944	NA	4/9/1937	8/6/2006
08254500	Costilla Creek near Amalia, NM	36°52’33”	105°23’22”	8,521	97,280	NA	5/13/1949	10/6/1981
08255000	Ute Creek near Amalia, NM	36°57’10”	105°24’35”	8,900	7,680	NA	5/1/1949	9/30/1959
08255500	Costilla Creek near Costilla, NM	36°58’01”	105°30’23”	7,900	124,800	NA	3/7/1936	8/6/2006
08256000	Acequia Madre at Costilla, NM	36°58’03”	105°30’57”	NA	NA	NA	10/1/1965	6/30/1992
08258000	Cerro Canal at Costilla, NM	36°57’56”	105°31’07”	NA	NA	NA	10/1/1964	6/30/1992
08258500	Association Ditch at Costilla, NM	36°57’38”	105°32’03”	NA	NA	NA	5/1/1969	9/30/1971
08258600	Cerro Canal below Association Ditch at Costilla, NM	36°57’41”	105°32’05”	NA	NA	NA	4/18/1972	6/30/1992
08260500	Costilla Creek below diversion at Costilla, NM	36°58’03”	105°31’00”	7,861	126,080	NA	10/1/1964	10/14/1986
08263000	Latir Creek near Cerro, NM	36°49’45”	105°32’50”	8,280	6,720	NA	10/1/1945	9/30/1970
08263500	Rio Grande near Cerro, NM	36°44’05”	105°41’05”	7,110	5,401,600	3,520,000	10/1/1948	8/6/2006
08264000	Red River near Red River, NM	36°37’20”	105°23’20”	9,394.20	12,224	NA	10/1/1943	9/30/1964

[a] Bold site numbers indicate active stations

[b] Period of record is not necessarily continuous, and data include some USGS estimated values. Refer to USGS raw data for data specifics.

USGS = U.S. Geological Survey
ft msl = Feet above mean sea level
NA = Data not available

Sources: USGS, 2006
Personal communication from Robert Gold, USGS, July 2005 (for information September 30, 2002 through June 30, 2005)

Table 5-7. USGS Stream Gaging Stations in theTaos Water Planning Region
Page 2 of 3

USGS Site Number [a]	USGS Site Name	Latitude	Longitude	Elevation (ft msl)	Drainage Area (acres)	Contributing Drainage Area (acres)	Period of Record [b]	
08264500	Red River below Zwergle Damsite near Red River, NM	36°40’25”	105°22’50”	8,871.88	16,448	NA	5/1/1963	12/31/1973
08265000	Red River near Questa, NM	36°42’12”	105°34’04”	7,451.92	72,320	NA	10/1/1924	8/6/2006
08265500	Llano Ditch near Questa, NM	36°43’51”	105°33’05”	7,877	NA	NA	10/1/1943	9/30/1996
08266000	Cabrestro Creek near Questa, NM	36°43’50”	105°33’12”	7,845	23,488	NA	10/1/1943	9/30/1996
08266820	Red River below Fish Hatchery, near Questa, NM	36°40’54”	105°39’21”	NA	118,400	NA	8/9/1978	8/6/2006
08267000	Red River at mouth, near Questa, NM	36°38’53”	105°41’34”	6,600	121,600	NA	12/1/1950	9/30/1978
08267500	Rio Hondo near Valdez, NM	36°32’30”	105°33’21”	7,650	23,168	NA	10/1/1934	6/14/2006
08268200	Rio Hondo at Damsite, at Valdez, NM	36°32’07”	105°36’07”	7,254	25,792	NA	4/1/1963	9/30/1966
08268500	Arroyo Hondo at Arroyo Hondo, NM	36°31’56”	105°41’06”	6,670	41,984	NA	10/1/1912	9/30/1985
08268700	Rio Grande near Arroyo Hondo, NM	36°32’04”	105°42’34”	6,470	5,606,400	3,724,800	3/1/1963	6/13/2005
08269000	Rio Pueblo de Taos near Taos, NM	36°26’22”	105°30’11”	7,380	42,240	NA	1/1/1913	8/6/2006
08271000	Rio Lucero near Arroyo Seco, NM	36°30’30”	105°31’49”	8,051.44	10,624	NA	1/1/1913	8/6/2006
08275000	Rio Fernando de Taos near Taos, NM	36°22’32”	105°32’55”	7,140	45,888	NA	1/1/1963	10/17/1980
08275300	Rio Pueblo de Taos near Ranchito, NM	36°23’38”	105°37’23”	6,747	127,360	NA	3/1/1957	10/15/1980

[a] Bold site numbers indicate active stations

[b] Period of record is not necessarily continuous, and data include some USGS estimated values. Refer to USGS raw data for data specifics.

USGS = U.S. Geological Survey
ft msl = Feet above mean sea level
NA = Data not available

Sources: USGS, 2006
Personal communication from Robert Gold, USGS, July 2005 (for information September 30, 2002 through June 30, 2005)

Table 5-7. USGS Stream Gaging Stations in theTaos Water Planning Region
Page 3 of 3

USGS Site Number [a]	USGS Site Name	Latitude	Longitude	Elevation (ft msl)	Drainage Area (acres)	Contributing Drainage Area (acres)	Period of Record [b]	
08275500	Rio Grande del Rancho near Talpa, NM	36°17’52”	105°34’55”	7,238	53,120	NA	10/1/1952	6/20/2006
08275600	Rio Chiquito near Talpa, NM	36°19’55”	105°34’42”	7,223	23,680	NA	3/1/1957	10/17/1980
08276000	Rio Pueblo de Taos at Los Cordovas, NM	36°23’20”	105°38’00”	6,709.59	229,760	NA	4/1/1910	9/30/1965
08276300	Rio Pueblo de Taos below Los Cordovas, NM	36°22’39”	105°40’05”	6,652	243,200	243,200	4/1/1957	7/23/2006
08276500	Rio Grande below Taos Junction Bridge near Taos, NM	36°19’12”	105°45’14”	6,050.30	6,227,200	4,345,600	10/1/1925	8/6/2006
08277470	Rio Pueblo near Peñasco, NM	36°10’14”	105°36’36”	NA	NA	NA	12/1/1991	8/6/2006
08278000	Pueblo C N Peñasco, NM	36°11’40”	105°41’00”	7,500	NA	NA	4/1/1936	9/30/1941
08278500	Rio Santa Barbara near Peñasco, NM	36°06’40”	105°37’55”	8,300	24,320	NA	10/1/1952	5/01/2005
Rio Arriba County								
08279000	Embudo Creek at Dixon, NM	36°12’39”	105°54’47”	5,858.60	195,200	NA	10/1/1923	8/6/2006
08279500	Rio Grande at Embudo, NM	36°12’20”	105°57’49”	5,789.14	6,656,000	4,774,400	1/1/1889	8/6/2006

[a] Bold site numbers indicate active stations
[b] Period of record is not necessarily continuous, and data include some USGS estimated values. Refer to USGS raw data for data specifics.

USGS = U.S. Geological Survey
ft msl = Feet above mean sea level
NA = Data not available

Sources: USGS, 2006
Personal communication from Robert Gold, USGS, July 2005 (for information September 30, 2002 through June 30, 2005)

Table 5-8. Annual Water Yield Statistics for Active Stream Gaging Stations

USGS Site Name[a]	Water Yield for Period of Record[b] (acre-feet)					Water Yield for Standard Period of 1996-2004[a] (acre-feet)				
	Minimum	Median	Average	Maximum	Standard Deviation	Minimum	Median	Average	Maximum	Standard Deviation
Costilla Creek above Costilla Dam[c]	1,651	7,061	8,107	21,813	4,683	1,651	7,116	7,005	15,100	3,816
Casias Creek near Costilla, NM[c]	1,756	11,026	11,651	28,333	6,398	2,558	11,026	10,545	17,463	4,753
Santistevan Creek near Costilla, NM[c]	436	1,872	1,943	4,331	915	436	1,565	1,537	2,309	663
Costilla Creek below Costilla Dam, NM	6,312	11,890	13,502	28,968	5,527	Incomplete standard period data				
Costilla Creek near Costilla, NM	11,243	28,930	31,759	62,960	13,675	11,243	28,738	26,984	39,365	7,917
Rio Grande near Cerro, NM	87,691	271,875	323,054	896,151	204,832	95,870	231,163	269,963	612,002	179,128
Red River near Questa	6,853	31,215	33,735	85,280	16,251	6,853	19,263	22,968	39,338	11,169
Red River below Fish Hatchery near Questa, NM	23,327	56,365	56,422	96,145	19,740	23,327	36,201	40,627	56,594	11,699
Rio Hondo near Valdez, NM	6,620	22,708	25,072	51,917	10,552	6,620	16,796	17,484	28,581	7,530
Rio Grande near Arroyo Hondo, NM	168,081	455,139	488,230	1,067,237	237,345	Incomplete standard period data				
Rio Pueblo de Taos near Taos, NM	3,523	16,925	20,442	52,880	12,039	3,523	11,685	12,539	23,443	6,346
Rio Lucero near Arroyo Seco, NM	3,622	14,848	15,511	35,818	6,187	3,622	11,607	10,893	15,835	4,610
Rio Grande del Rancho near Talpa, NM	2,116	12,938	14,572	32,298	8,085	2,116	6,599	9,621	22,166	6,434
Rio Pueblo de Taos below Los Cordovas, NM	6,643	31,486	44,917	140,793	32,809	6,643	17,717	24,309	50,265	14,780
Rio Grande below Taos Junction Bridge near Taos, NM	194,404	474,564	540,668	1,366,732	272,298	200,934	357,569	413,923	803,304	210,140
Rio Pueblo near Peñasco, NM	4,957	38,020	37,044	90,394	25,888	4,957	19,471	24,870	47,376	14,883
Rio Santa Barbara near Peñasco, NM	7,401	21,757	22,114	35,114	8,774	7,401	19,467	19,708	30,345	7,564
Embudo Creek at Dixon, NM	8,274	51,620	60,496	179,695	35,759	9,081	37,130	45,960	86,717	28,036
Rio Grande at Embudo, NM	201,162	643,838	661,641	1,542,300	319,513	201,162	393,372	454,031	894,506	234,643

[a] Years with complete data unless marked otherwise

[b] Data presented in this table are based on the calendar year streamflow data for each station available on the USGS website (http://waterdata.usgs.gov/nm/nwis/), supplemented by data received directly from Robert Gold and Phil Bowman at the USGS, except as otherwise noted.

[c] Statistics calculated using incomplete annual data; this station has incomplete data for every year in its period of record, because the gage is not operated in the winter

Table 5-9. Summary of Water Yield and Flow Distribution Statistics for Active Stream Gaging Stations

	Average Daily Streamflow (cfs)		Percentile Flows (ac-ft)									
			Standard Period of 1996-2004					Period of Record				
USGS Site Name[a]	Period of Record	Standard Period	Q_{10}[b]	Q_{25}[c]	Q_{50}[d]	Q_{75}[e]	Q_{90}[f]	Q_{10}[b]	Q_{25}[c]	Q_{50}[d]	Q_{75}[e]	Q_{90}[f]
Costilla Creek above Costilla Dam[g]	11.19	9.67	3,619	4,672	7,116	8,010	10,556	2,768	4,672	7,061	10,661	15,238
Casias Creek near Costilla, NM[g]	16.09	14.56	5,144	6,738	11,026	13,863	15,436	3,960	6,208	11,026	16,475	20,196
Santistevan Creek near Costilla, NM[g]	2.68	2.12	637	1,202	1,565	2,177	2,214	844	1,202	1,872	2,410	3,275
Costilla Creek below Costilla Dam, NM	18.64	Incomplete standard period data						7,847	9,276	11,890	16,416	22,167
Costilla Creek near Costilla, NM	43.86	37.26	18,915	23,546	28,738	30,718	33,831	14,674	20,702	28,930	39,869	55,540
Rio Grande near Cerro, NM	446.11	372.79	97,838	144,852	231,163	310,708	518,121	97,140	160,677	271,875	467,052	586,398
Red River near Questa	46.58	31.72	10,970	16,165	19,263	28,388	38,126	14,600	20,472	31,215	45,439	53,320
Red River below Fish Hatchery near Questa, NM	77.91	56.10	28,760	34,030	36,201	48,695	56,229	32,074	43,333	56,365	67,786	84,085
Rio Hondo near Valdez, NM	34.62	24.14	8,905	12,000	16,796	21,953	26,516	12,392	19,072	22,708	30,060	40,504
Rio Grande near Arroyo Hondo, NM	674.20	Incomplete standard period data						233,986	316,730	455,139	597,827	824,190
Rio Pueblo de Taos near Taos, NM	28.23	17.31	5,410	8,255	11,685	16,701	18,229	7,267	11,685	16,925	25,954	38,589
Rio Lucero near Arroyo Seco, NM	21.42	15.04	5,406	7,245	11,607	14,857	15,329	8,048	11,923	14,848	18,627	22,982
Rio Grande del Rancho near Talpa, NM	20.12	13.29	4,753	5,714	6,599	12,938	17,780	5,306	8,125	12,938	21,661	25,374
Rio Pueblo de Taos below Los Cordovas, NM	62.03	33.57	12,095	14,400	17,717	32,950	44,771	13,247	17,726	31,486	69,056	93,881
Rio Grande below Taos Junction Bridge near Taos, NM	746.61	571.59	219,557	258,842	357,569	475,172	705,789	236,068	306,022	474,564	716,240	886,845
Rio Pueblo near Peñasco, NM	51.15	34.34	9,733	16,520	19,471	38,020	44,584	12,045	18,491	38,020	47,376	74,727
Rio Santa Barbara near Peñasco, NM	30.54	27.22	11,661	14,886	19,467	26,246	28,828	10,708	15,788	21,757	30,223	32,993
Embudo Creek at Dixon, NM	83.54	63.47	18,388	25,835	37,130	76,695	80,527	19,737	35,999	51,620	86,294	103,678
Rio Grande at Embudo, NM	913.67	626.98	246,257	280,758	393,372	515,505	772,114	275,089	393,250	643,838	886,061	1,093,977

[a] SeeTable 5-5 for USGS site number and period of record by gage; statistics calculated only for years with complete data (period of record may include some years with data for only part of the year).

[b] Water yields were below this value in 10 percent of the years for the applicable period.

[c] Water yields were below this value in 25 percent of the years for the applicable period.

[d] Water yields were below this value in 50 percent of the years from for the applicable period (same as median).

[e] Water yields were below this value in 75 percent of the years from for the applicable period.

[f] Water yields were below this value in 90 percent of the years from for the applicable period.

[g] Station is not operated during winter; all daily streamflow and percentile flow calculated using data for incomplete years.

cfs = Cubic feet per second
ac-ft = Acre-feet

The 1996 through 2004 period was chosen because, although relatively short, it was the longest common period for the largest number of stations. Figure 5-9 shows summary statistics for annual water yield at these stations for the period of record. As indicated in Table 5-7 and Figure 5-8, use of 21 of the 40 stream gages in the region has been discontinued.

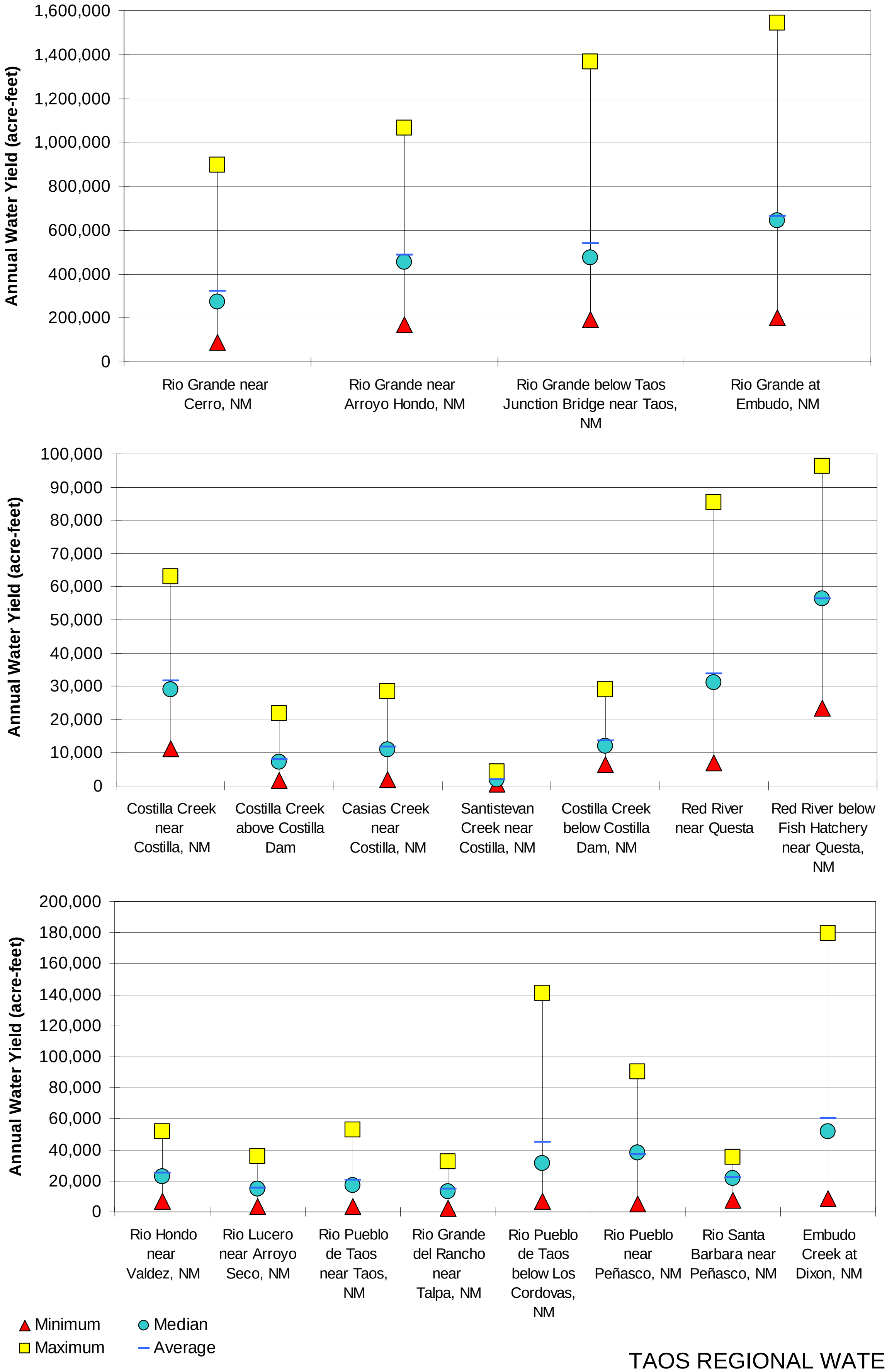
When comparisons are made among watersheds, it is useful to normalize the data. The most common normalization technique is to divide the parameter value by the area of the watershed upstream of the gaging station. Figure 5-10 shows normalized annual yield statistics for the active stream gage stations, for a standard period of 1996 through 2004.

Graphs illustrating annual streamflow for the stream gage stations, including the monthly distribution of streamflow over a water year, are presented in Appendix E2. Tables 5-8 and 5-9, Figures 5-9 and 5-10, and Appendix E2 illustrate the wide variability of annual streamflow, with streamflow being up to an order of magnitude less in low years than in higher years, frequently resulting in shortages during low-flow periods. Additional analysis of the ability of streamflow to fill demands is presented in Section 7.1.

5.2.3 Lakes and Reservoirs

Table 5-10 summarizes the six reservoirs that are located in the Taos Water Planning Region. All of these reservoirs fall in Taos County; none are within the Rio Arriba County portion of the planning region. The largest reservoirs in the planning region, Costilla and Cabresto Reservoirs, fall in the northern section of the planning region. These two reservoirs are described below.

The Costilla Reservoir is located about 15 miles east of the town of Costilla on Costilla Creek and is owned and operated by the Rio Costilla Cooperative Livestock Association for irrigation storage. It is a homogeneous earthfill dam and was built between 1916 and 1920. The reservoir was drained in August 1999 so that the USBR could repair seepage problems (Johnson, 1999). Modifications have resulted in a current structural height of 138 feet, with a 780-foot crest length.



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TAOS REGIONAL WATER PLAN

Annual Water Yield for Period of Record

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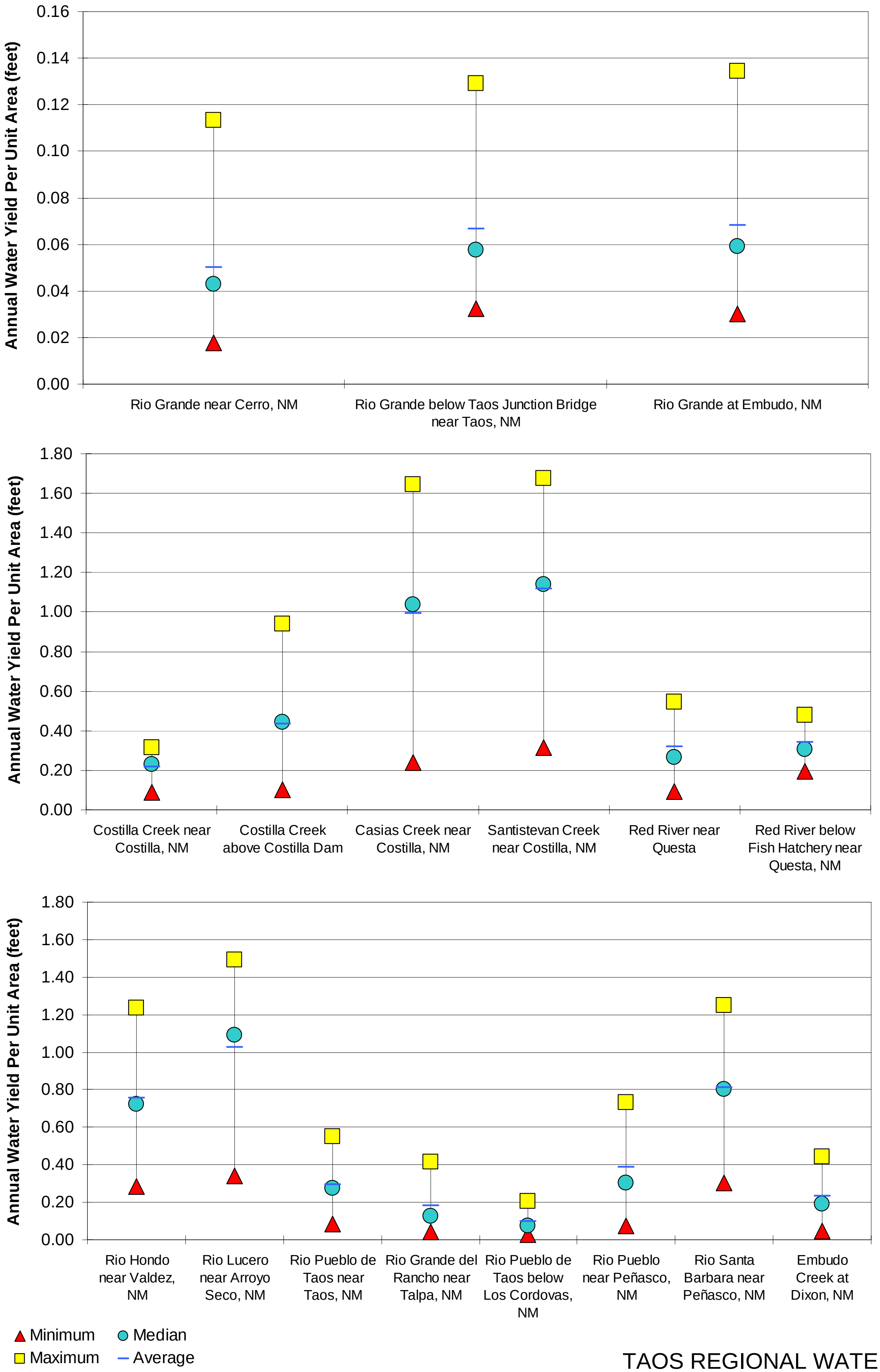
Figure 5-9



TAOS REGIONAL WATER PLAN

Normalized Annual Water Yield
Standard Period of 1996-2004

Figure 5-10

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Table 5-10. Reservoir Summary
Taos Water Planning Region

Reservoir/Dam	River	Region	Purpose [a]	Owner	Maximum Storage Capacity (ac-ft)	Normal Storage (ac-ft)	Average Surface Area (acres)
Taos County							
Costilla Dam	Rio Costilla	North	I	Rio Costilla Cooperative Livestock Association	15,788	15,739	571
Cabrestro Dam	Cabrestro Creek tributary	North	I	Llano Irrigation Company & Cabrestro Lake Irrigation Company	1,235	1,100	32
RC&D Project Measure 83 Dam	Las Cruces Arroyo	Central	FODCTR	Town of Taos	378	241	23
Carson Dam	Aguaje de la Petaca	West	FODCTR	Geraldine Bradley	7,622	0	0
Beaver Park Dam No. 2	Bitter Creek	North	R	Two Lakes Association	15	11	1.6
Cerro Dam	Off channel reservoir (Latir)	North	I	Acequia Madre de Cerro de Guadalupe	68	41	12.3

Source: USACE, 2005

ac-ft = Acre-feet
in/yr = Inches per year
--- = Information not available

[a] I = Irrigation
C = Flood control and storm water management
S = Water supply
R = Recreation
F = Fish and wildlife pond
D = Debris control
T = Tailings
O = Other

The Army Corps of Engineers National Inventory of Dams shows a maximum storage capacity of 15,788 acre-feet for Costilla Reservoir (USACE, 2006). Daily reservoir content records have been reported by the Costilla Creek watermaster for each irrigation season; these records are compiled by the U.S. Geological Survey and published for every water year (Johnson, 1999).

The Costilla Creek Compact (Section 4.5.2) divides each year into the irrigation season, from May 16 to September 30, and the storage season, from October 1 to May 15. Further, it apportions 62.8 percent of Costilla Reservoir storage to New Mexico and 37.2 percent to Colorado. Colorado's portion is delivered through the Eastdale Canal to the Eastdale Reservoir in early spring, and the New Mexico-Colorado apportionment is based on the May 15 volume of water in Costilla Reservoir. Reallocation may occur later in the irrigation season if substantial storage gains occur during the irrigation season.

The Cabresto Reservoir is located on Lake Fork Creek, a tributary to Cabresto Creek, and was constructed between 1922 and 1933 of earthfill with a concrete core. The Cabresto Lake Irrigation Company and the Llano Irrigation Company use the reservoir to store water for irrigation. The dam was modified following failure during a 1957 flood, and its current capacity is 1,110 acre-feet (Johnson, 1999).

Two other reservoirs are located in the northern section of the Taos Region, as well as one each in the West and South subregions (Table 5-10). Storage is minimal at these reservoirs.

Section 6.1.5 provides estimates of open water evaporation for surface water bodies in each subregion.

5.3 Groundwater Supply

Groundwater, which within the planning region is used primarily for municipal and domestic household use, mining, and irrigated agriculture, accounted for approximately 8 percent of all water depletions in the year 2000 (Wilson et al., 2003). Though this is a small percentage of the total use in the planning region, groundwater provides the sole source of drinking water for most communities. With the exception of Red River and San Cristobal (which depend on some supplemental surface water in addition to groundwater), almost all of the region's drinking water comes from groundwater. This section summarizes the groundwater supplies in the planning region.

As discussed in Section 4.5.5.2, groundwater resources in New Mexico are administered by the OSE through declared groundwater basins; the Taos Region resides in the Rio Grande Basin (Figure 4-1). While Section 4 discussed the legal availability of water, which is defined in terms of OSE-declared basins, this section discusses the physical availability of groundwater, as defined by physical hydrogeologic boundaries.

The following subsections include an overview of the regional hydrology by physiographic province, with descriptions of the geologic formations in the planning region (Section 5.3.1), quantitative hydraulic parameters for each of the major aquifers (5.3.2), estimates of recharge (5.3.3), and descriptions of key well fields located within the planning region (5.3.4). Sections 5.3.5 and 5.3.6 discuss water level trends and sustainable yields in the areas of highest water consumption, respectively. Additional information on local geology and aquifer characteristics was provided by a hydrologic consultant to the town of Taos (Glorieta Geoscience, Inc.) and is included as Appendix E3.

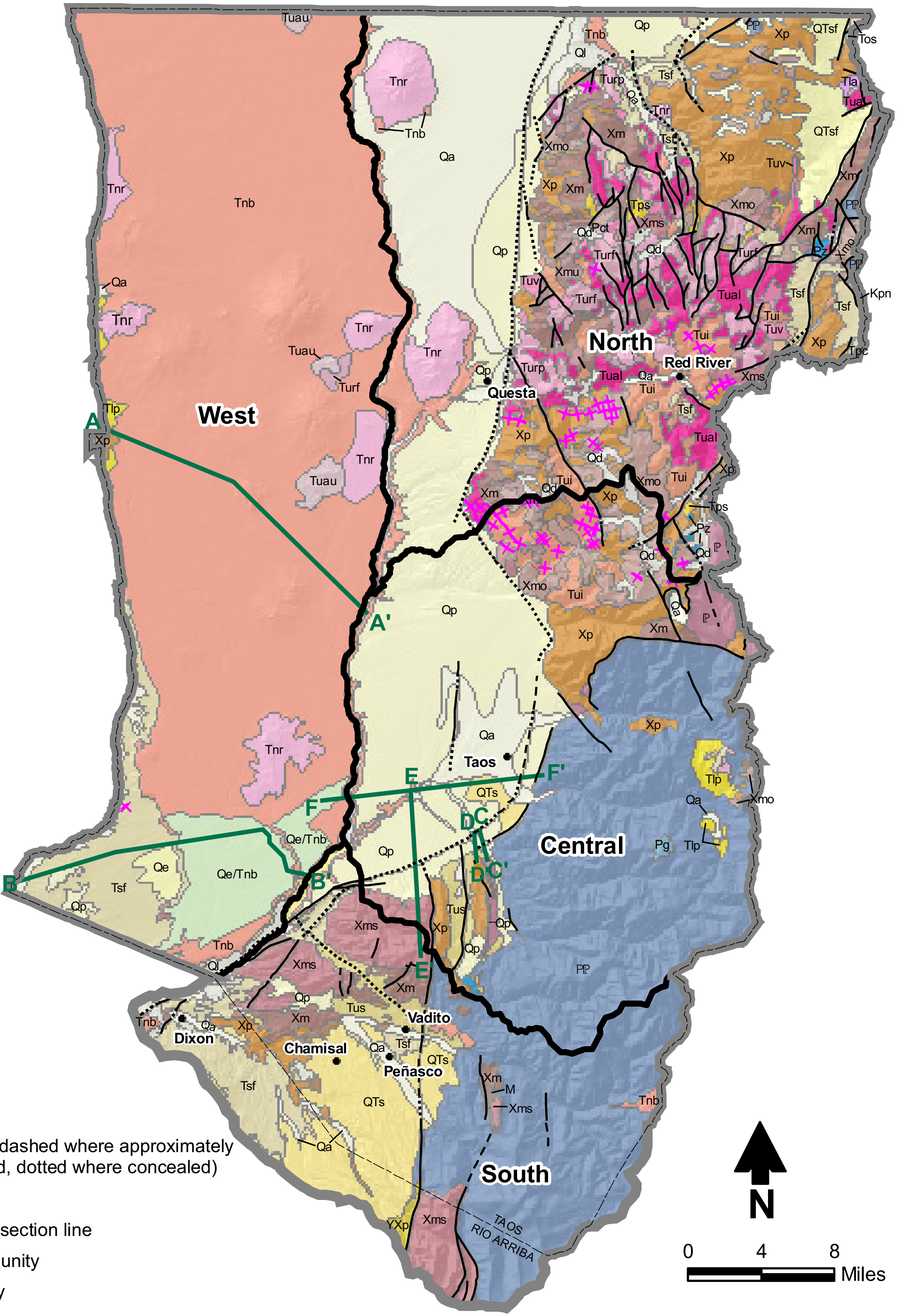
5.3.1 Regional Geology

This section presents a general overview of the geology that controls groundwater occurrence and movement within the planning region. A map illustrating the surface geology of the entire planning region is included as Figure 5-11.

Many hydrogeologic studies have been conducted over the past 40 years in and around the Taos Region:

- J.E. Upson (1939) described the physiographic subdivisions of the San Luis Valley in southern Colorado and northern New Mexico.

- I.J. Winograd (1959) described the hydrogeology of Sunshine Valley and western Taos County.



Explanation

— Fault (dashed where approximately located, dotted where concealed)

+++ Dike

A—A' Cross section line

● Community

County

Subregion boundary

Planning region boundary

Source: Green and Jones, 1997

TAOS REGIONAL WATER PLAN

Surficial Geology

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Figure 5-11 (Page 1 of 2)

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Geologic Units

ds	Disturbed ground
Qa	Alluvium; upper and middle Quaternary
Ql	Landslide deposits and colluvium
Qe	Eolian deposits
Qd	Glacial deposits; till and outwash: upper and middle Pleistocene
Qp	Piedmont alluvial deposits: upper and middle Quaternary
QTb	Basaltic and andesitic volcanics interbedded with Pleistocene and Pliocene sedimentary units
QTsf	Santa Fe Group, undivided. Basin fill of Rio Grande rift region
QTs	Upper Santa Fe Group
Tus	Upper Tertiary sedimentary units
Tsf	Lower and Middle Santa Fe Group
Tlp	Los Pinos Formation of Lower Santa Fe Group (Miocene and upper Oligocene)
Tos	Mostly Oligocene and upper Eocene sedimentary and volcaniclastic sedimentary rocks with local volcanic units
Tnb	Basalt and andesite flows; Neogene. Includes flows interbedded with Santa Fe and Gila Groups
Tnr	Silicic to intermediate volcanic rocks; mainly quartz latite and rhyolite Neogene
Tif	Middle Tertiary felsic shallow-intrusive rocks; phonolites and trachytes of northeastern New Mexico
Tuv	Volcanic and some volcaniclastic rocks, undifferentiated; lower Miocene and Upper Oligocene (younger than 29 Ma)
Tuau	Lower Miocene and uppermost Oligocene basaltic andesites (22-26 Ma)
Tual	Upper Oligocene andesites and basaltic andesites (26-29 Ma)
Turp	Upper Oligocene rhyolitic pyroclastic rocks (ash-flow tuffs) (24-29 Ma)
Tlrp	Lower Oligocene silicic pyroclastic rocks (ash-flow tuffs) (31-36.5 Ma)
Turf	Upper Oligocene silicic (or felsic) flows and masses and associated pyroclastic rocks
Tui	Miocene to Oligocene silicic to intermediate intrusive rocks; dikes, stocks, plugs, and diatremes
Tuim	Upper and Middle Tertiary mafic intrusive rocks
Tla	Lower Tertiary, (Lower Oligocene and Eocene) andesite and basaltic andesite flows, and associated volcaniclastics
Tps	Paleogene sedimentary units; includes Baca, Galisteo, El Rito, Blanco Basin
Tpc	Poison Canyon Formation; Paleocene, Raton Basin
Kvt	Vermejo Formation and Trinidad Sandstone; Maastrichtian
Kpn	Pierre Shale and Niobrara Formation
Kgc	Greenhorn Formation and Carlile Shale, undivided; locally includes Graneros Shale
Kdg	Dakota Group of east-central and northeast New Mexico
J	Jurassic rocks, Middle and Upper, undivided
TRc	Chinle Group; Upper Triassic; includes Moenkopi Formation (Middle Triassic) at base in many areas
Pz	Paleozoic rocks, undivided
Pg	Glorieta Sandstone; texturally and mineralogically mature, high-silica quartz sandstone
Pct	Cutler Formation; used in northern areas and Chama embayment only
Pℙ	Permian and Pennsylvanian rocks
ℙ	Pennsylvanian rocks, undivided
ℙs	Sandia Formation; predominantly clastic unit (commonly arkosic) with minor black shales
M	Mississippian rocks, undivided; Arroyo Peñasco Group in Sangre de Cristo
Yp	Middle Proterozoic plutonic rocks (younger than 1600 Ma)
YXp	Middle and Lower Proterozoic plutonic rocks, undivided
Xms	Lower Proterozoic metasedimentary rocks (1650-1700 Ma); essentially equivalent to Hondo Group
Xm	Lower Proterozoic metamorphic rocks, dominantly felsic volcanic, volcaniclastic
Xp	Lower Proterozoic plutonic rocks (older than 1600 Ma)
Xmo	Lower Proterozoic metamorphic rocks, dominantly mafic (1720-1760 Ma)
Xmu	Lower Proterozoic metamorphic rocks, undivided

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TAOS REGIONAL WATER PLAN
Surficial Geology
Figure 5-11 (Page 2 of 2)

- L.M. Coons and T.E. Kelly (1984) described the effect of structural control on groundwater flow in the Rio Grande trough.

- Lynn A. Garrabrant (1993) described the water resources of Taos County.

- Bauer et al. (1999) described the geology and hydrogeology of the southern Taos Valley in Taos County.

- Anthony L. Benson (2004) described the groundwater geology of Taos County.

- Drakos et al. described basin fill aquifer hydrological characteristics (2004a) and the stratigraphy in the southern San Luis Basin (2004b).

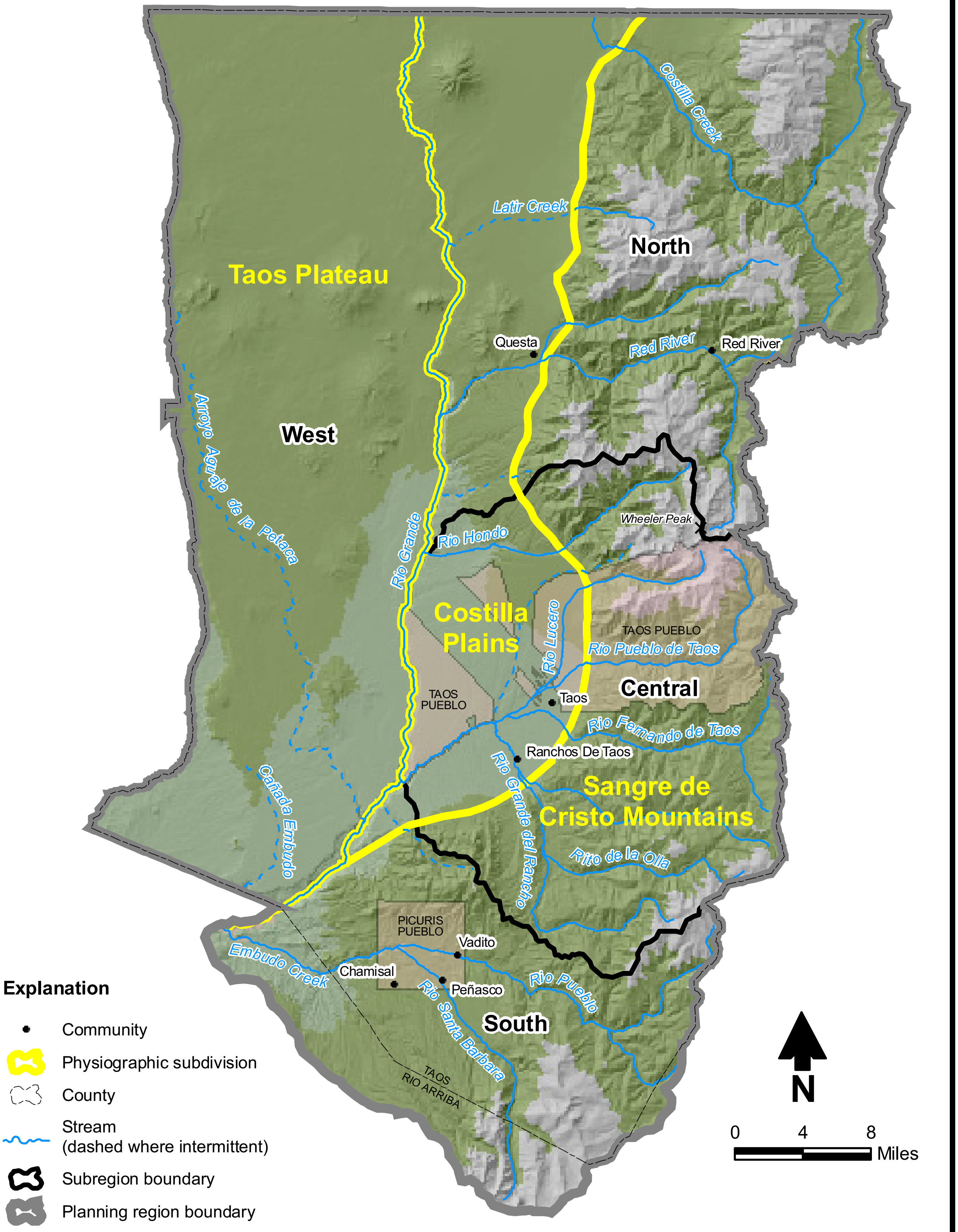
- The New Mexico Bureau of Geology and Mineral Resources (NMBGMR) is conducting aquifer mapping in Taos County and has published a report on the Arroyo Seco area (Rawling, 2005).

These and other existing sources of information, such as USGS monitor well data and plans and reports from municipalities and others in the region (a complete bibliography is provided in Appendix A), were used to help characterize the groundwater supply in the planning region.

5.3.1.1 Physiographic Regions

The Taos Region lies within three physiographic regions: the Taos Plateau, the Costilla Plains, and the Sangre de Cristo Mountains (Figure 5-12; Garrabrant, 1993; Upson, 1971). Descriptions of the physiographic provinces are adapted primarily from Garrabrant (1993), except where noted.

- The Taos Plateau, which is present in the West subregion (Figure 5-12), consists of locally erupted Pliocene basaltic rocks (Bauer et al., 1999) intermixed with Santa Fe Group sediments. This region contains numerous extinct volcanoes, which were associated with the onset of rifting (Dungan et al., 1984).



TAOS REGIONAL WATER PLAN

General Physiographic Subdivisions

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Figure 5-12

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- The Costilla Plains province is present in the North, Central, and a small portion of the South subregions (Figure 5-12). It consists of alluvial-fan and valley-fill sediments that slope gently down and were derived from the Sangre de Cristo Mountains located to the east. The soils are deeper than those on the Taos Plateau, and they are often calcareous below 15 inches. This region also contains a few extinct volcanoes.

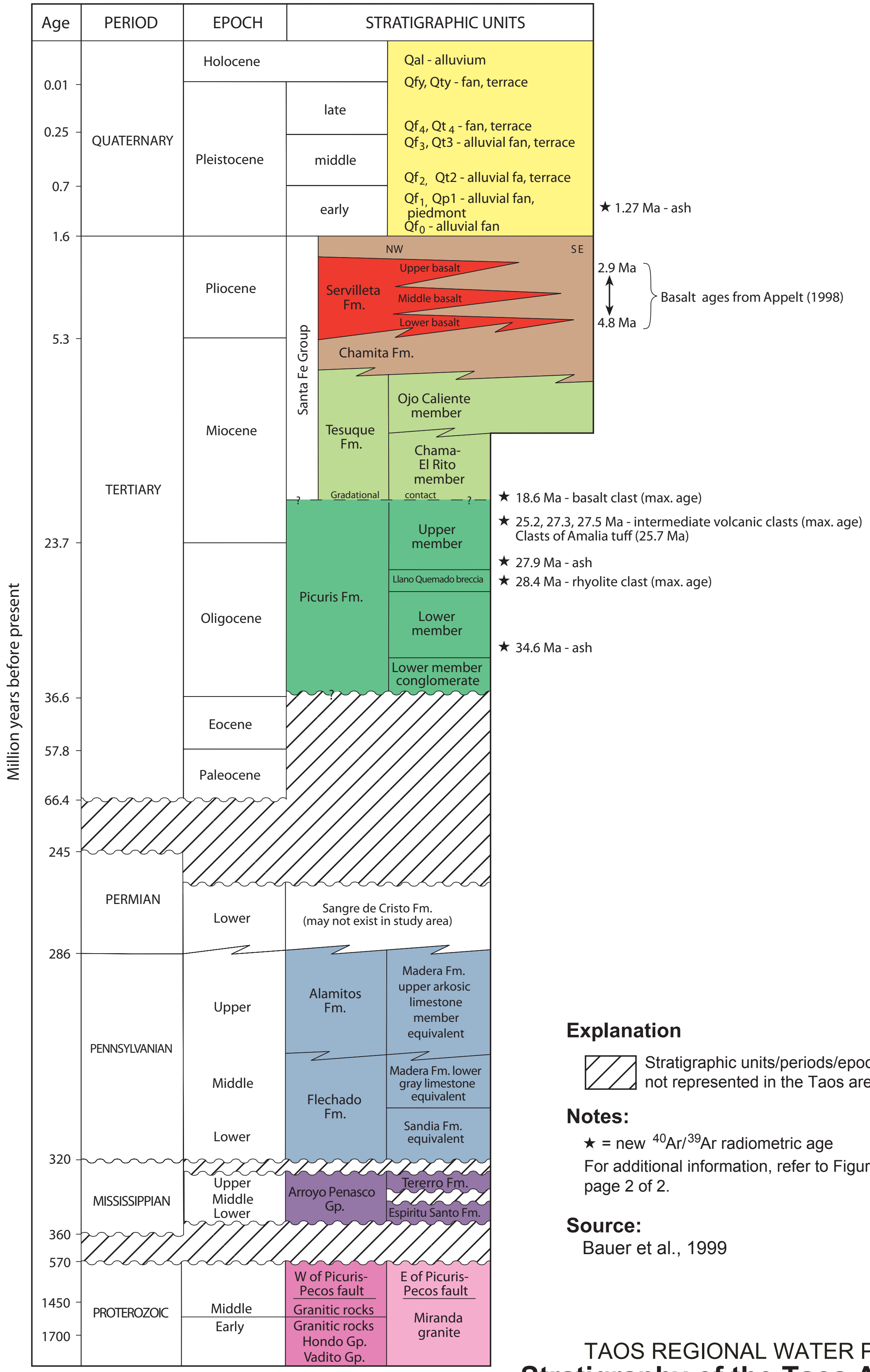
- The Sangre de Cristo Mountains province spans the eastern side of the planning region and is thus present in the North, Central, and South subregions (Figure 5-12). This province is an upthrown fault block composed of Precambrian granite, gneiss, schist, quartzite and pegmatites, with Paleozoic-age sedimentary rocks in the south, including arkose, conglomerate, dolomite, limestone, sandstone, red and gray shale, and siltstone.

The Taos Plateau and the Costilla Plains are within the southern part of the larger San Luis Basin. The San Luis Basin forms the northern segment of the Rio Grande Rift that trends from the middle of Colorado south to Mexico. The Rio Grande Rift contains a series of asymmetric grabens, formed by a roughly east-west extension of the earth's crust during the last approximately 30 million years (Kelley and Duncan, 1984; Dungan et al., 1984). The San Luis Basin dips eastward into a major boundary fault against the Sangre de Cristo Mountains, and it contains numerous intra-basin faults. The basin extends north into Colorado and south to where the Embudo constriction separates the San Luis Basin from the west-dipping Española Basin within the Rio Grande Rift (Coons and Kelly, 1984).

5.3.1.2 Descriptions of Geologic Formations

The following subsections describe, in descending order from ground surface, the primary water-bearing formations present in the Taos Region. A stratigraphic column is provided in Figure 5-13 for reference.

5.3.1.2.1 Recent Quaternary Deposits. Recent Quaternary age deposits are unconsolidated and include pediment gravels, fluvial terrace sands and gravels, and alluvial fan sands, silts, and gravels (Pazzaglia and Wells, 1990). These deposits host the shallow aquifers and provide areas for groundwater recharge (Bauer et al., 1999). The deposits may have a greater water-producing capacity than the underlying Santa Fe Group, but are generally less than 35 feet thick (Coons and Kelly, 1984). Recent Quaternary deposits are present mostly in the Costilla Plains physiographic region.



Explanation

▨ Stratigraphic units/periods/epochs not represented in the Taos area

Notes:

★ = new $^{40}Ar/^{39}Ar$ radiometric age

For additional information, refer to Figure 5-11, page 2 of 2.

Source:

Bauer et al., 1999

TAOS REGIONAL WATER PLAN

Stratigraphy of the Taos Area New Mexico

Figure 5-13

5.3.1.2.2 Pleistocene-Pliocene Deposits. Pleistocene-Pliocene-age deposits underlying the younger surficial deposits comprise an exclusively alluvial facies consisting of poorly sorted unconsolidated clay, silt, sand, and gravel. North of Taos, the informal name Lama Formation has been used to describe the clastic sediments that lie above the basalt flows of the Servilleta Formation (Bauer et al., 1999). The more current designation for this rift fill sequence underlying the younger alluvium is the Blueberry Hill Formation (Bauer et al., 2001).

5.3.1.2.3 Servilleta Formation. A mixed facies consisting of Pliocene-age alluvial sediments and lake deposits interbedded with basalts flows underlying the Blueberry Hill Formation comprises the Servilleta Formation. Various interpretations regarding these deposits have been put forth. Whereas Bauer et al. (1999) have interpreted the sediments interbedded with and overlying the Servilleta basalts as part of the Santa Fe Group Chamita Formation, Lambert (1966) grouped the interbedded basalts and sediments together as the Servilleta Formation. The interpretation used in this discussion assumes that the Servilleta Formation is inclusive of both the basalts and the interbedded sediments.

The Servilleta Formation is near the surface under most of the Taos Plateau and is overlain by Quaternary deposits that are thickest on the Costilla Plains. This east-dipping formation is composed of basalt flows, some of which are fractured, with thin interbedded sediments (Figure 5-13). Generally, the Servilleta contains three basalt units, each consisting of one or more basalt flows with thicknesses as great as 40 feet. The basalt units are interlayered with clastic beds, typically of eolian silt and clays ranging in thickness from 1 to 15 feet (Drakos et al., 2004a), and are underlain by a baked zone, usually consisting of red clay. A permeable conglomeratic facies (possibly ancestral axial Rio Grande), termed the Agua Azul aquifer (Drakos et al., 2004b), is interbedded with the Servilleta basalt east of the Rio Grande Gorge.

5.3.1.2.4 Santa Fe Group. The following description of the Tertiary-age Santa Fe Group was adapted from Coons and Kelly (1984) and Garrabrant (1993), except where noted.

The Santa Fe Group underlies the recent Quaternary deposits in the Costilla Plains and basalt flows of the Servilleta Formation in the Taos Plateau. In the Taos region, it consists of three units:

- The Miocene-age Chamita Formation
- The Ojo Caliente member of the Tesuque Formation
- The Chama-El Rito member of the Tesuque Formation

The volcanoclastic Los Pinos Formation is present in western Taos County, but it is not well described in much of the Taos Region because most wells are completed in shallower units.

The total thickness of basin-fill sediments may be as much as 10,000 feet, but variability in deposition and periodic erosion resulted in beds that are not traceable over long distances (Bauer et al., 1999). The individual formations in each unit are described in the following discussion.

The Chamita Formation consists of poorly sorted sandstone beds with clasts of volcanic and metamorphic rocks that generally coarsen upward in the sedimentary sequence. Thickness of the formation is variable and unknown for many localities; it has been estimated at 150 feet to more than 1,600 feet near the town of Taos.

The Tesuque Formation is divided into the upper Ojo Caliente and the lower Chama-El Rito members (Figure 5-13):

- The Ojo Caliente member, which conformably overlies and interfingers with the Chama-El Rito member, is an eolian sandstone comprised primarily of fine sand (Bauer et al., 1999). It varies in thickness from very thin or not apparent to more than 1,000 feet thick (Drakos et al., 2004a).

- The Chama-El Rito member is composed of pinkish-gray to buff sandstones with conglomerate and minor mudrock interbeds (Bauer et al., 1999). The sandstone and conglomerates are predominantly made up of volcanic clasts with some Precambrian granitic and quartzite clasts (Drakos et al., 2004a). The Chama-El Rito member has a thickness of up to 1,570 feet (Bauer et al., 1999).

5.3.1.2.5 Picuris Formation. The Tertiary-age Picuris Formation is present in the southern Taos Valley, near the north and south borders of the Picuris Mountains. It primarily consists of volcaniclastic sedimentary rocks that represent pre-rift and early-rift activity (Bauer et al., 1999). The Picuris Formation has been divided into three members (Figure 5-13):

- The upper member is a fine-grained, low-permeability, ash-rich sandstone and mudstone.

- The middle Llano Quemado breccia member is a volcanic breccia of angular and poorly sorted rhyolite clasts and may include some reworked volcanic sediments (Bauer et al., 1999).

- The lower member is more coarse-grained than the upper member and includes a basal conglomerate with cobble and boulder-sized material (Bauer et al., 1999; Drakos et al., 2004a).

5.3.1.2.6 Igneous Rocks. The Latir volcanic field, a volcanic complex of andesite, rhyolite tuffs and flows, basalt, granite, and interbedded sedimentary rocks, deposited during the middle to late Tertiary age, forms the part of the Sangre de Cristo Mountains north of Red River, now part of the Questa caldera complex (Lipman and Reed, 1989). The Latir volcanics probably underlie the Sunshine Valley and extend northward to the San Luis Hills, but have not yet been penetrated by wells. The uppermost member of the volcanic series includes porphyritic flows, tuffs, plugs, and dikes and ranges in thickness between 1,360 and 1,500 feet (Clark, 1966). This uppermost member is underlain by a quartz latite porphyry. The lower member of the volcanic rocks includes andesite, tuff, and breccia and ranges in thickness between 1,500 and 1,700 feet (Clark, 1966).

5.3.1.2.7 Paleozoic Rocks. The Sangre de Cristo Formation (Permian) generally crops out high in the Sangre de Cristo Mountains (Winograd, 1959). The formation consists of dark pink and maroon-colored feldspathic sandstone. It ranges in thickness from 600 to 1,000 feet.

It is likely that much of the southern Taos Valley is underlain by Paleozoic rocks that are highly indurated but with local fracture porosity. One well (Taos Town Yard) has been drilled into these rocks (Bauer et al., 1999; Drakos et al., 2004a). The Alamitos Formation was encountered at a depth of approximately 720 feet below ground surface (bgs) and consisted of gray limestone interbedded with fine-grained sandstone and shale beds (Drakos et al., 2004a). The depth at which this unit was encountered at the Taos Town Yard is considered shallow and is attributed to the offset of the Town Yard Fault (Bauer et al., 1999; Drakos et al., 2004a).

5.3.1.2.8 Precambrian System. The oldest rocks found in the planning region are the Precambrian igneous and metamorphic rocks, consisting of gneiss, schist, quartzite, and granite, that form the core of the Sangre de Cristo Mountains north of Taos Pueblo. Much of the valley-fill sediments in the Rio Grande trough in Taos County is composed of materials derived from these rocks (Winograd, 1959). These rocks are generally highly fractured but tightly sealed at depth.

5.3.2 Aquifer Characteristics and Groundwater in Storage

This section discusses the groundwater supply in each of the main water-bearing geologic formations. Definitions of hydrologic terms discussed in this section are provided in the Glossary at the beginning of this report.

Quantitative information regarding aquifer properties is shown in Table 5-11. This table indicates that wells in the deep Tertiary basin aquifer produce up to 500 gallons per minute (gpm), and the Draft Abeyta Settlement Agreement recommended additional development of this resource (U.S. District Court, 2006b).

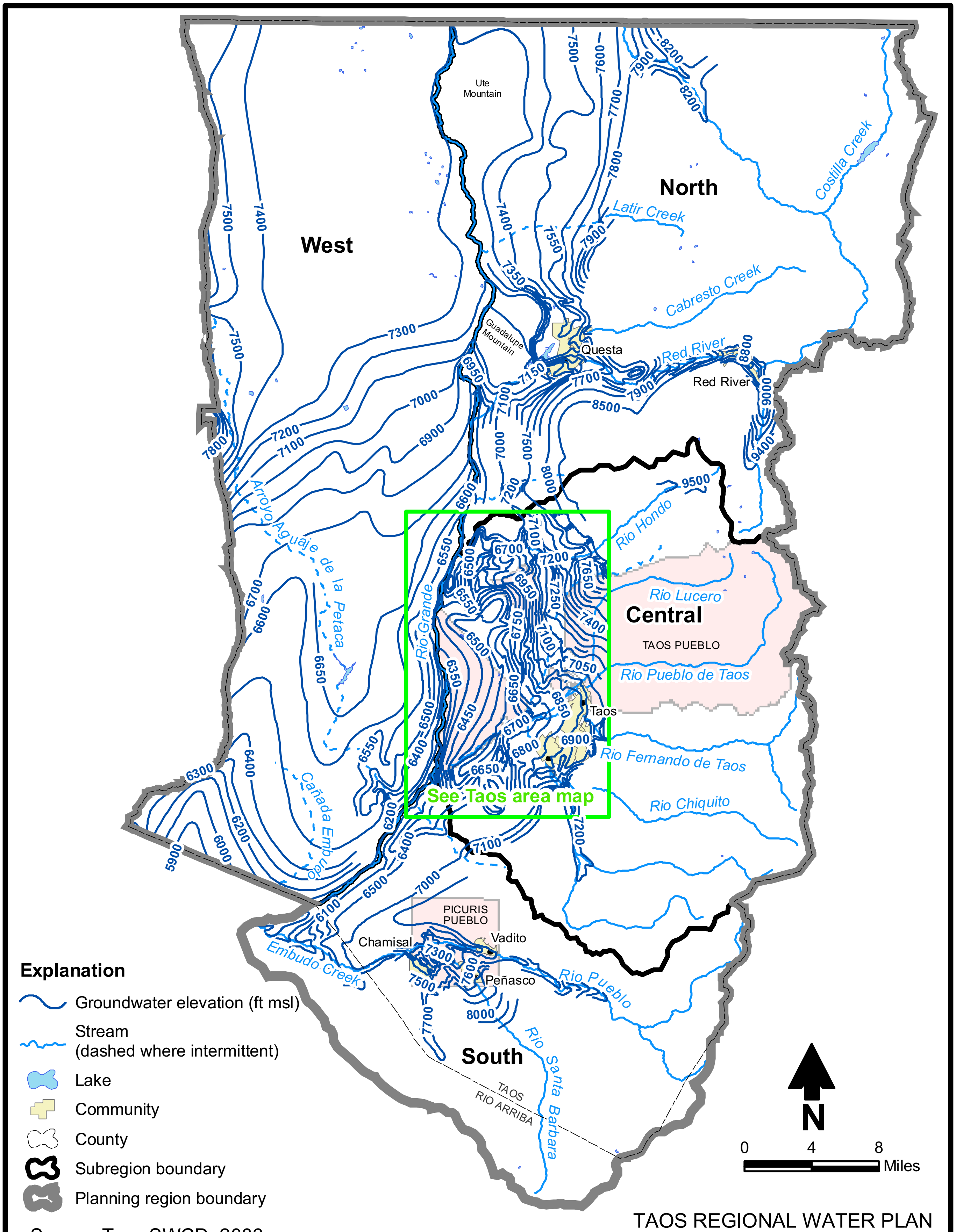
Groundwater is found in the valley alluvium and beneath perennial streams throughout the Taos Region (Garrabrant, 1993). Groundwater elevations in western Taos County (Figure 5-14) indicate southeasterly flow and gradient toward the Rio Grande, while groundwater elevations in the Town of Taos area (Figure 5-15) indicate westerly deepening and flow toward the Rio Grande with offsets occurring along faults (Benson, 2004). Depth to groundwater (Figure 5-16) is shallowest along the Costilla Plains and near the Town of Taos and deepest in western Taos County. Hydrogeology is presented in cross section in Figures 5-17 through 5-21. Additional cross sections representing detailed local conditions have been prepared by and may be available for review from the Taos SWCD.

Table 5-11. Aquifer Properties, Taos Water Planning Region

Physiographic Region	Aquifer Name	Aquifer Thickness (feet)	Well Depths (feet)	Static Depth to Water (feet)	Hydraulic Conductivity (ft/d)	Transmissivity (ft^2/d)	Storage Coefficient	Length of Pumping Test (minutes)	Pumping Rate (gpm)	Recharge	Water Quality Issues
Costilla Plains	Shallow basin fill (unconfined alluvium)	70 to 290 (b, p. 395)	127 to 800 (b, p. 395)	14 to 659 (b, p. 395)	1.6 to 22 (b, p. 395)	150 to 3700 (b, p. 395)	3.0×10^{-4} to 2.5×10^{-2} (b, p. 395)	250 to 5760 (b, p. 395)	18 to 370 (b, p. 395)	Precipitation and infiltrating runoff from Sangre de Cristo Mountains (a, p. 11); discharges from Basin Margin Aquifer (b, p. 402)	---
	Alluvium (leaky-confined or confined), Chamita Fm	---	---	---	---	---	---	---	---	Precipitation and infiltrating runoff of rain and snow from Sangre de Cristo Mountains (a, p. 11)	High fluoride (c)
	Northern wells	100 to 600 (b, p. 395)	470 to 1763 (b, p. 395)	86 to 339 (b, p. 395)	0.1 to 0.9 (b, p. 395)	32 to 310 (b, p. 395)	1×10^{-3} (b, p. 395)	944 to 5760 (b, p. 395)	19 to 70 (b, p. 395)		
	Southern wells	220 to 440 (b, p. 395)	500 to 700 (b, p. 395)	-1 to 18 (b, p. 395)	3.7 to 17.4 (b, p. 395)	810 to 5700 (b, p. 395)	6×10^{-3} to 6.3×10^{-3} (b, p. 395)	1440 to 12960 (b, p. 395)	70 to 440 (b, p. 395)		
	Agua Azul (Servilleta Fm and fractured basalt sediments)	50 to 60 (b, p. 396)	180 to 262 (b, p. 396)	29 to 233 (b, p. 396)	4.7 to 26.7 (b, p. 399)	280 to 1600 (b, p. 396)	8.5×10^{-5} to 5.3×10^{-4} (b, p. 396)	2880 to 5760 (b, p. 396)	8 to 120 (b, p. 396)	Precipitation and infiltrating runoff of rain and snow from Sangre de Cristo Mountains (a, p. 11)	---
	Deep Tertiary basin fill (Tesuque Fm, Ojo Caliente member)	480 to 1200 (b, p. 399)	1720 to 2991 (b, p. 399)	152 to 732 (b, p. 399)	0.2 to 0.8 (b, p. 399)	60 to 640 (b, p. 399)	1×10^{-3} to 2×10^{-2} (b, p. 399)	1361 to 11965 (b, p. 399)	57 to 400 (b, p. 399)	---	High fluoride and iron in approximately 50% of samples (c)
	Deep Tertiary basin fill (Tesuque Fm, Chama-El Rito member)	200 to 530 (b, p. 401)	1200 to 2109 (b, p. 401)	83 to 310 (b, p. 401)	0.6 to 3.4 (b, p. 401)	280 to 1400 (b, p. 401)	5×10^{-4} (b, p. 401)	2737 to 15840 (b, p. 401)	60 to 500 (b, p. 401)	---	---
	Chama-El Rito + Picuris Fm	400 to 530 (c, Table 4)	2020 to 2109 (c, Table 4)	271 to 274 (c, Table 4)	0.8 to 1.5 (c, p. 17)	420 to 800 (c, p. 17)	3×10^{-4} to 6.8×10^{-4} (c, p. 17)	5760 to 15840 (c, Table 4)	210 to 500 (c, Table 4)	---	High pH, fluoride, lead and arsenic (c, p. 18-19)
	Basin Margin Aquifer (fractured Paleozoic sedimentary, metasedimentary, and crystalline rocks)	110 to 300 (b, p. 402)	400 to 1020 (b, p. 402)	93 to 391 (b, p. 402)	5.9×10^{-4} to 2.5×10^{-2} (b, p. 402)	0.1 to 2.8 (b, p. 402)	---	435 to 2880 (b, p. 402)	8 to 48 (b, p. 402)	---	High fluoride and iron (c)
Sangre de Cristo Mountains	Shallow basin fill (alluvium) (unconfined)	70 to 290 (b, p. 395)	127 to 800 (b, p. 395)	14 to 659 (b, p. 395)	1.6 to 22 (b, p. 395)	150 to 3700 (b, p. 395)	10^{-4} to 10^{-2} (b, p. 395)	250 to 5760 (b, p. 395)	18 to 370 (b, p. 395)	From Sangre de Cristo Mountains/snow runoff (a, p. 11)	---
	Basin Margin Aquifer (fractured Paleozoic sedimentary)	110 to 300 (b, p. 402)	400 to 1020 (b, p. 402)	93 to 391 (b, p. 402)	5.9×10^{-4} to 2.5×10^{-2} (b, p. 402)	0.1 to 2.8 (b, p. 402)	---	435 to 2880 (b, p. 402)	8 to 48 (b, p. 402)	---	High fluoride and iron (c)
Taos Plateau	Servilleta Fm, fractured basalt, and Santa Fe Group sediments	---	---	---	---	---	---	---	---	Precipitation and runoff from arroyos (a, p. 11)	High arsenic in some wells (a, p. 67-75)

Sources:
- a: Garrabrant (1993)
- b: Drakos et al. (2004b)
- c: Drakos et al. (2002)

ft/d = Feet per day
ft^2/d = Square feet per day
gpm = Gallons per minute
--- = Information not available



Explanation

- Groundwater elevation (ft msl)
- Stream (dashed where intermittent)
- Lake
- Community
- County
- Subregion boundary
- Planning region boundary

Source: Taos SWCD, 2006

TAOS REGIONAL WATER PLAN

Groundwater Elevations in Taos County

Figure 5-14

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11/13/2007

JN WR05.0235

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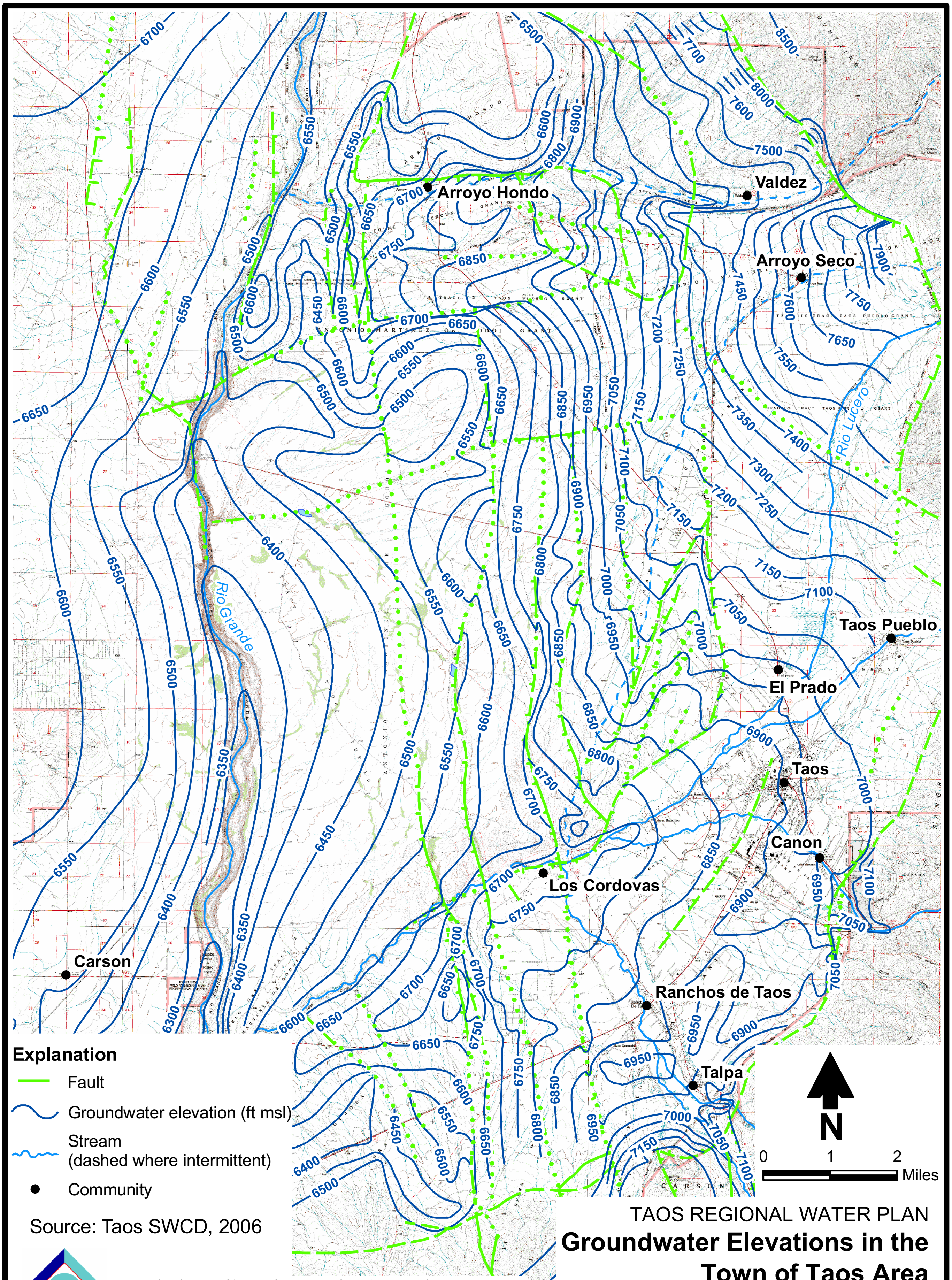

Explanation

- Fault
- Groundwater elevation (ft msl)
- Stream (dashed where intermittent)
- ● Community

Source: Taos SWCD, 2006

TAOS REGIONAL WATER PLAN

Groundwater Elevations in the Town of Taos Area

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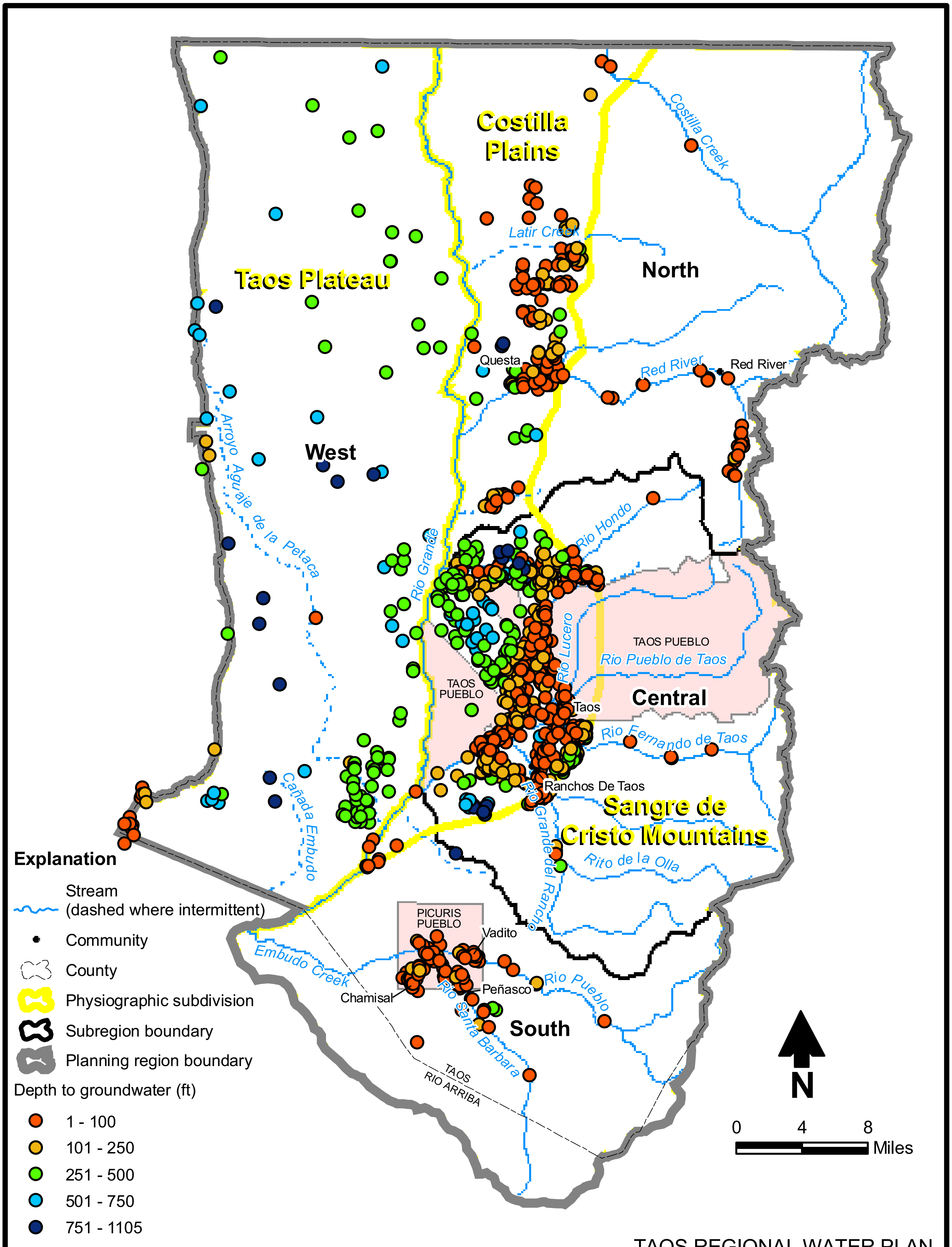
Figure 5-15



Source: Taos SWCD, 2006

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TAOS REGIONAL WATER PLAN

Depth to Groundwater

Figure 5-16

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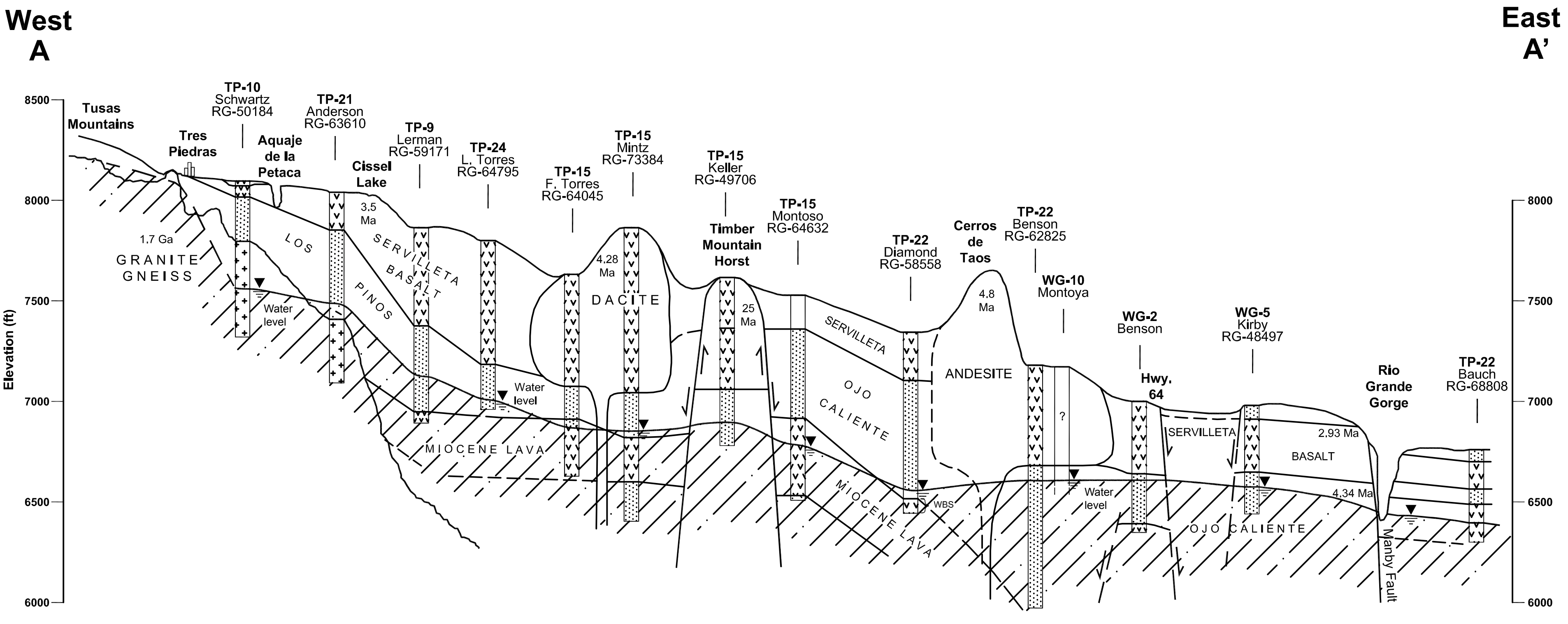

0 7500 ft

Explanation

- ▨ Basalt
- ▨ Clastic
- ▨ Granite
- ▨ Groundwater

Source:
Benson, 2004

Notes:
15x vertical exaggeration

TAOS REGIONAL WATER PLAN

Geologic Cross Section Through Western Taos County, Highway 64

Figure 5-17

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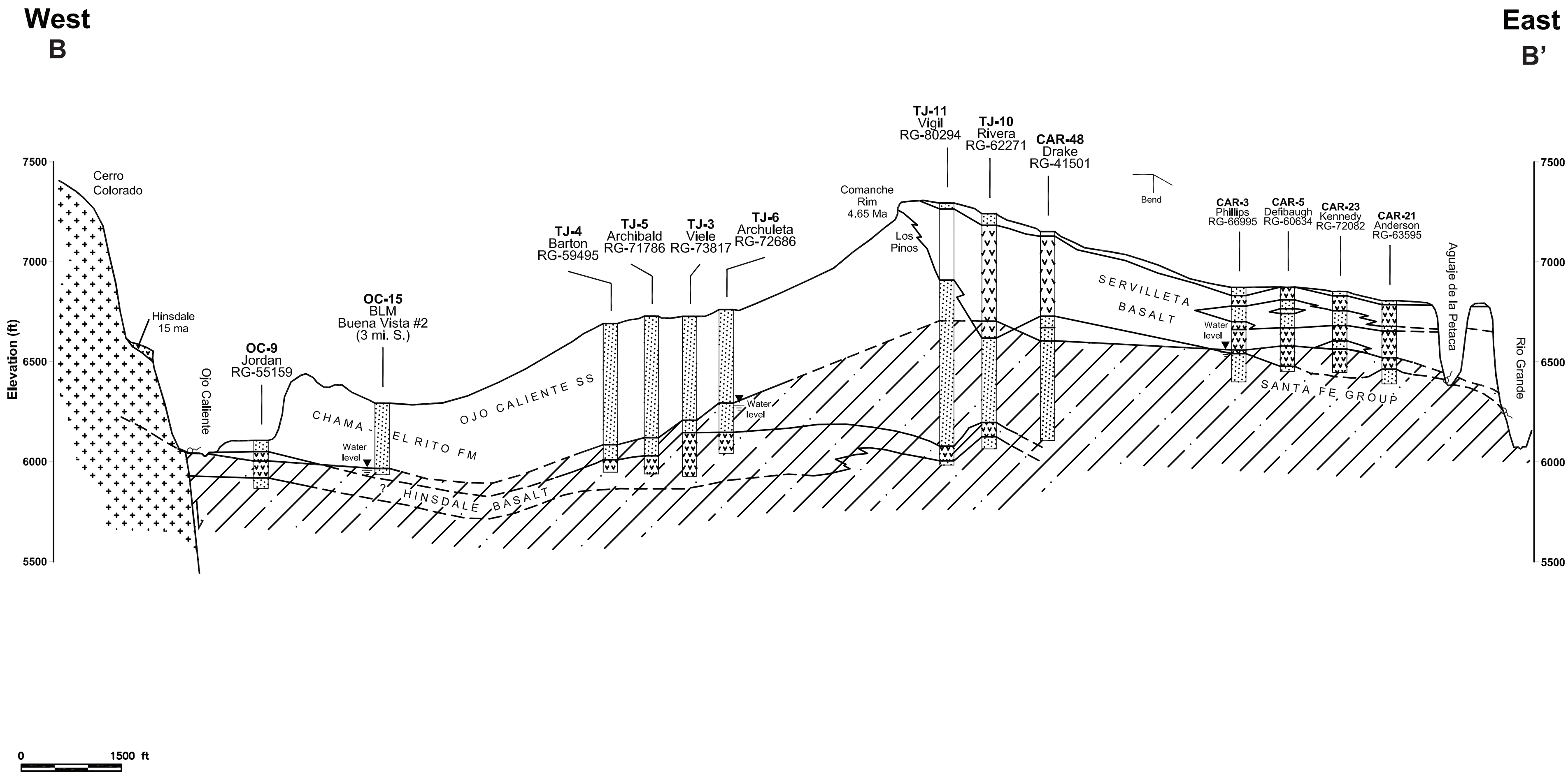
10-30-07
JN WR05.0235



Explanation

- ▨ Basalt
- ▨ Clastic
- ▨ Granite
- ▨ Groundwater

Source:
Benson, 2004

Note:
15x vertical exaggeration

Figure 5-18

TAOS REGIONAL WATER PLAN

Geologic Cross Section Through Western Taos County, Ojo Caliente to Carson

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JN WR05.0235

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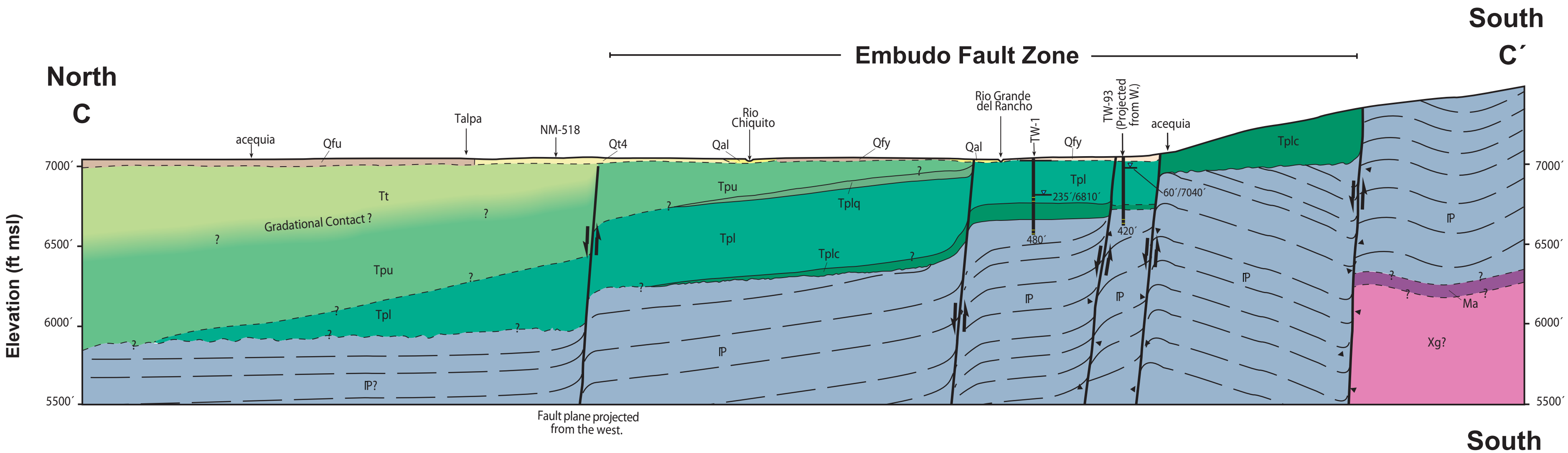

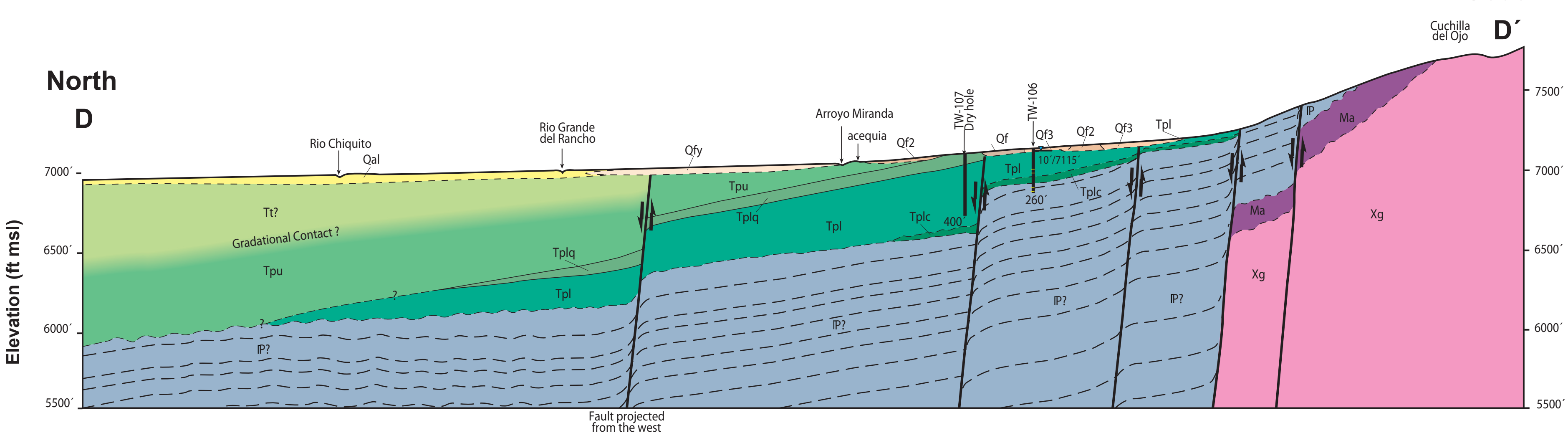

0 500 1000 ft

No vertical exaggeration

Explanation

TW-99	Taos well reference no.
115´/6805	Depth to water/ Elev. of groundwater
847-952´	Well with screened interval
▼	Potentiometric surface elevation
1020´	Total depth

Source:
Bauer et al., 1999

Notes:
Fault geometries are highly generalized in cross section.
Thin Quaternary deposits are not shown.
Explanation of geologic symbols provided on Figure 5-11, page 2 of 2.

TAOS REGIONAL WATER PLAN

Geologic Cross Sections Through the Talpa Area
Taos County, New Mexico

Daniel B. Stephens & Associates, Inc.
10-30-07

JN WR05.0235

Figure 5-19

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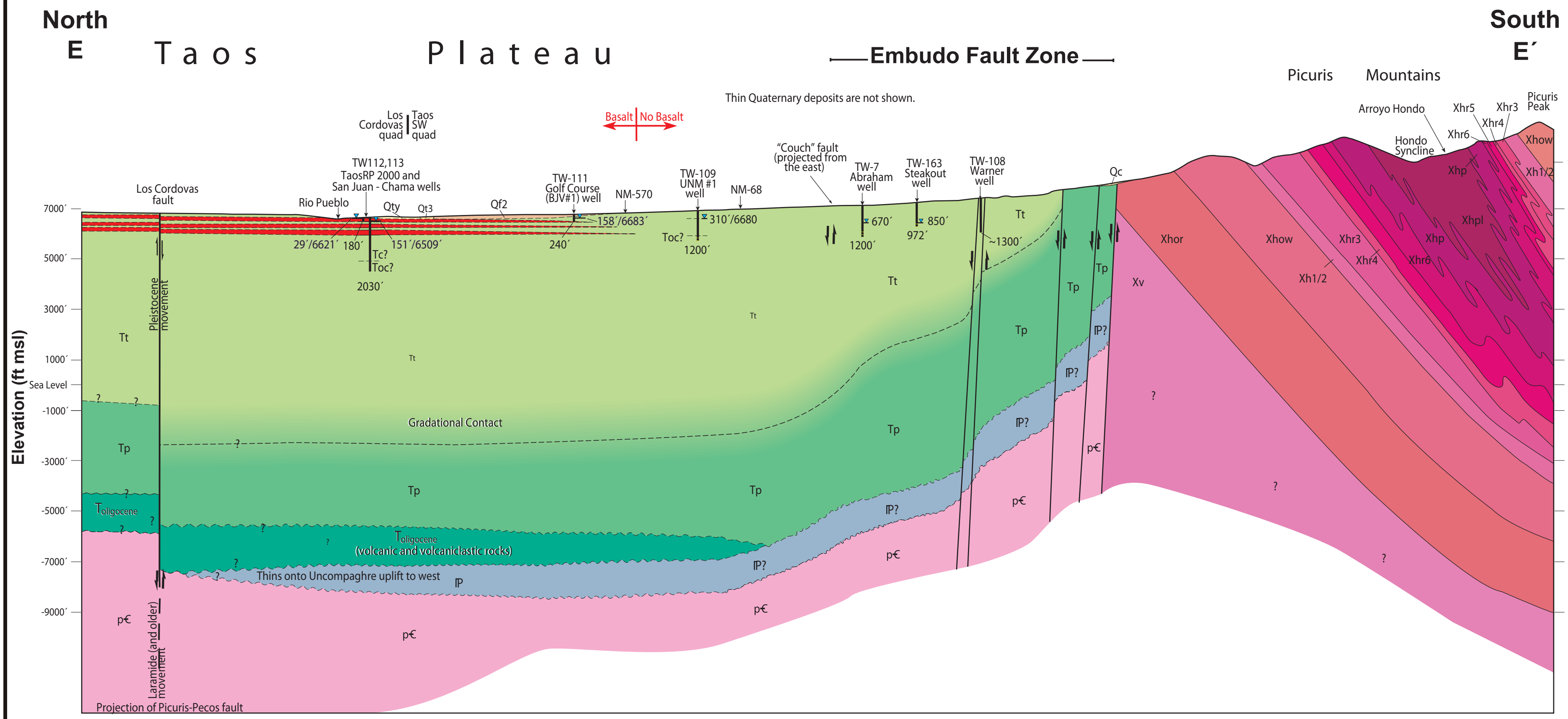

0 4000 8000 ft
No vertical exaggeration

Explanation

TW-99	Taos well reference no.
115′/ 6805	Depth to water/ Elev. of groundwater
847-952′	Well with screened interval
▼	Potentiometric surface elevation
1020′	Total depth

Source:
Bauer et al., 1999

Notes:
Fault geometries are highly generalized in cross section.
Thin Quaternary deposits are not shown.
Explanation of geologic symbols provided on Figure 5-11, page 2 of 2.

TAOS REGIONAL WATER PLAN

North-South Cross Section from the Taos Plateau to the Picuris Mountains, Taos SW and Los Cordovas Quadrangles Taos County, New Mexico

Figure 5-20

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10-29-07
JN WR05.0235

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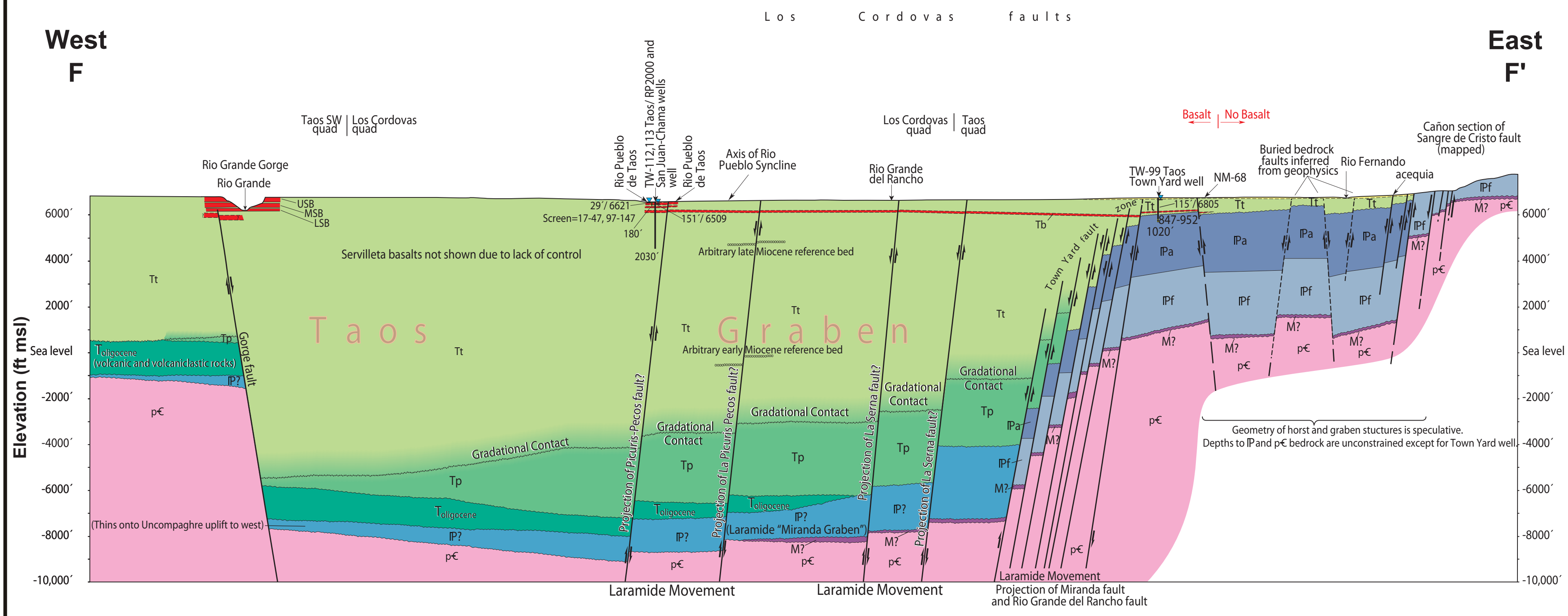

0 4000 8000 ft

No vertical exaggeration

Explanation

TW-99	Taos well reference no.
115´/ 6805	Depth to water/ Elev. of groundwater
847-952´	Well with screened interval
▼	Potentiometric surface elevation
1020´	Total depth
Tt	Tesuque Formation
Tp	Picuris Formation
T oligocene	Oligocene rocks, undivided
IPa	Alamitos Formation
IP	Pennsylvanian rocks, undivided
M?	Arroyo Penasco Group
p€	Miranda granite
IPf	Flechado Formation

Source:

Bauer et al., 1999

Notes:

Fault geometries are highly generalized in cross section.
Thin Quaternary deposits are not shown.
Explanation of geologic symbols provided on Figure 5-11, page 2 of 2.

TAOS REGIONAL WATER PLAN

Geologic Cross Section Through the Taos, Los Cordovas, and Taos SW 7.5' Quadrangles, Taos County, New Mexico

Figure 5-21

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10-29-07 JN WR05.0235

Most of the wells in the Taos Region are in the Costilla Plains, where groundwater can be found primarily in the Quaternary alluvial sediments above the Servilleta Formation, but also in deeper wells within the Servilleta Formation and the underlying Santa Fe Group. In the Sunshine Valley (Northern Costilla Plains), shallow clay deposits (possibly representing an ancestral Sunshine Lake) and basalt beds of unknown extent are present in the western and northern portions of the valley (Benson, 2007). Most of the groundwater is produced from alluvial sediments interbedded with volcanic rocks and clay deposits (Winograd, 1959). Depths to groundwater range from less than 1 foot to 275 feet bgs, and wells yield from 8 up to 440 gpm.

A significant study conducted by Peter Winograd in 1959 reported on the geology and hydrogeology of the Sunshine Valley area (north of Taos) and presented a conceptual model that is generally applicable to the region's aquifer systems today (Bauer et al., 1999). Conclusions of this study included (Winograd, 1959):

- Groundwater in the Sunshine area originates primarily from surface water (Costilla Creek) losses.
- Pumping of groundwater in this area would cause a loss in gains to the Rio Grande.
- Wells could yield sufficient water from the alluvial sediments for irrigation.
- Semi-perched conditions exist for groundwater within the alluvial sediments.
- Groundwater quality in the alluvial sediments and the andesite basalt is very good.

The semi-perched conditions noted by Winograd (1959) have been theorized by Summers and Hargis (1984) to be explained by the downward vertical water gradient seen in deeper wells. This downward gradient is seen in most of the deep wells in the Town of Taos area (Drakos et al., 2004b) except near faults where warmer water may be rising (Benson, 2007).

Scattered deeper wells completed in the Taos Plateau generally yield lower flow rates (Garrabrant, 1993). A limited volume of water is found in the fractured Servilleta basalt (Garrabrant, 1993), and low flow rates (1 to 5 gpm) are found in the underlying very fine-grained Ojo Caliente dune sand (Benson, 2004). The basalt and underlying Santa Fe Group sediments are probably recharged from the Tusas and San Juan Mountains (Benson, 2004). Wells in the northern third of the Taos Plateau are about 200 to 300 feet deep and produce from the

Miocene Los Pinos Formation (Benson, 2004). A recently drilled (spring 2006) community well in the central Taos Plateau produces good quality water from a depth of about 650 feet.

In the Sangre de Cristo Mountains groundwater is withdrawn from shallow wells in the alluvium of stream valley deposits. Runoff from precipitation recharges the alluvium. In general, the Precambrian and Tertiary formations do not store or yield much water (Garrabrant, 1993).

5.3.2.1 Quaternary-Tertiary Aquifers

The shallow Quaternary alluvial clastics are typically unconfined, but semiconfined conditions occur locally where low-permeability clay and silt layers provide flow barriers (Spiegel and Couse, 1969; Winograd, 1959). The sedimentary units within the Servilleta Formation, along with the fractured basalt, has been termed the Agua Azul aquifer (Drakos et al., 2004a) and comprise a moderately productive aquifer west of the Town of Taos. The lower Servilleta basalt and underlying Chamita Formation may act as a transition zone and/or boundary between the shallow and deep aquifers (Drakos et al., 2004b, p. 393), although the currently available data are insufficient to support or refute this hypothesis.

Yields from wells completed in the Santa Fe Group vary throughout the planning region (Table 5-12):

- Wells in the Taos Plateau are typically deeper and have lower yields
- Wells in the Costilla Plains region typically have higher but variable yields
- Yields in the Sangre de Cristo Mountains region are relatively low although high yields are possible where alluvial sediments are hydraulically connected to perennial streams (Garrabrant, 1993).

Fractured basalts, Los Pinos Conglomerate, Ojo Caliente sand, and Miocene lavas provide water in the Taos Plateau (Benson, 2004). The basalt is interbedded with the Santa Fe Group sediments and thickens westward, with individual beds typically less than 50 feet thick and a total thickness of as much as 670 feet. The Servilleta basalt has interbedded clastics that thicken eastward (Benson, 2004).

Table 5-12. Well Data by Physiographic Province and Community

Physiographic Province / Community	Range			Geologic Units
	Depths to Water (ft bgs)	Well Depths (ft bgs)	Well Yields (gpm)	
Taos Plateau				
Ojo Caliente	12-107	54-300	10-20	Alluvium, lower/mid-Santa Fe
Tres Piedras	5-247	25-390	10-12	Flows, plutonic rocks, lower Santa Fe
Other	8-1,080	240-1,200	2-50	Alluvium, eolian deposits, upper, middle, and lower Santa Fe, basalt flows
Costilla Plains				
Pilar	6-60	32-116	--	Alluvium
Ranchos de Taos, Talpa, Llano Quemado	4-213	8-300	5-42	Alluvium, piedmont alluvial
Taos and nearby towns	<1-120 20-868	25-229 262-2,500	8-30 5-760	Alluvium, piedmont alluvial, upper Santa Fe Santa Fe Group
Valdez, Arroyo Seco, Des Montes	3-180	50-375	8-110	Piedmont alluvial
Arroyo Hondo (town)	4-175	18-260	3-40	Piedmont alluvial
San Cristobal	5-125	7-170	15-20	Piedmont alluvial
Questa	5-223	20-500	10-35	Alluvium, piedmont alluvial
Cerro	35-195	60-245	5-15	Alluvium
Sunshine Valley area	4-275	50-535	10-3,000	Alluvium, piedmont alluvial
Costilla	35-140	53-222	5-10	Alluvium, landslide deposits and colluvium
Sangre de Cristo Mountains				
Peñasco and nearby towns	3-119	14-300	3-50	Alluvium, upper, middle, and lower Santa Fe
Rio Pueblo Valley	4-29	58-200	--	Alluvium, undivided Pennsylvanian
Rio Fernando de Taos Valley	10-145	50-503	1-22	Alluvium, lower Santa Fe, undivided Pennsylvanian
Red River (town)	2-135	30-240	10-525	Alluvium
Amalia	4-40	25-160	1-20	Alluvium, piedmont alluvial

Source: Garrabrant, 1993, p. 55, updated with Town of Taos data in consultant reports on file with OSE:
Glorieta Geoscience, Inc., 1995, 2001
Jenkins, 1982

ft bgs = Feet below ground surface
gpm = Gallons per minute

In the Costilla Plains, both the Ojo Caliente and the Chama-El Rito formations of the Santa Fe Group are water-bearing. Where penetrated in deep wells these aquifers have been described as “leaky confined” (Drakos et al., 2004b), but a downward pressure gradient shows lower static water levels than shallow completions that used to be thought of as semi-perched (Benson, 2007). In these cases, the water level in a well actually deepens during drilling once the basalt is penetrated, reflecting a strong downward gradient within the aquifer system and perhaps semi-perched conditions in the overlying alluvial aquifer.

Wells completed in the basalt and underlying sediments in the Taos Plateau generally yield little water (Table 5-12). Depths to water in wells completed in the Taos Plateau are the greatest in the planning region, ranging from 5 to 1,080 feet bgs, and wells yield 2 to 50 gpm.

The deeper aquifer is known to be more than 2,000 feet thick (Drakos et al., 2004b). Deeper test wells (approximately 2,000 feet) drilled more recently have indicated that additional water sources are present in the Tesuque Formation, but groundwater quality may be problematic (due to increased levels of several ions and trace elements, including arsenic) at these depths (Drakos and Lazarus, 1998). Given that most of these deep wells were drilled near faults, these deep waters may be locally mineral bearing along ascending warm waters documented by Reiter and Sandoval (2004). The Town of Taos recently received a grant from the U.S. EPA for innovative arsenic removal from its deep wells (Town of Taos, 2007).

5.3.2.2 Mountain Bedrock Aquifers

Most of the wells in the Sangre de Cristo Mountains produce water from shallow Quaternary-age alluvial sediments in stream valleys (Garrabrant, 1993), but older rocks also produce limited quantities of water in the southern part of the Taos Valley in and south of Talpa. The following discussion is adapted from the hydrogeologic description of the mountain bedrock aquifer by Bauer et al. (1999).

The Tertiary-age volcaniclastic Picuris Formation and Pennsylvanian-age shale, sandstone, and limestone produce water from the Sangre de Cristo Mountain foothills in the southern part of the planning region. Confined and semiconfined conditions are common, and water generally flows to the northwest with moderate to high gradients of 0.1 to 0.7. Faulting near the mountain front may have a strong influence on the groundwater flow direction due to increased hydraulic conductivity along predominant fracture sets.

The Precambrian rocks are generally considered aquicludes (non-water bearing). However, small quantities of water are derived from wells completed in the granite at Tres Piedras (Winograd, 1959). Fractured granite produces water in wells west of Ponce de Leon Hot Springs, but that water contains high fluoride levels (Benson, 2007). Fractured portions of the upper Precambrian system in the Sangre de Cristo Mountains may also yield small quantities of water.

Depths to water in wells completed in the valleys of the Sangre de Cristo Mountains range from 2 to 145 feet bgs, and wells generally yield 1 to 50 gpm of water. In the Town of Red River, the public supply wells yield as much as 525 gpm but this is most likely due to a hydraulic connection to the Red River (Garrabrant, 1993).

5.3.3 Recharge

Recharge is simply the addition of water to an aquifer. Natural recharge to groundwater systems commonly occurs as areal recharge, localized recharge, and recharge from mountain fronts (DBS&A, 1996):

- Areal recharge is natural recharge derived from precipitation that falls on large portions of the landscape and percolates downward through the vadose zone to the aquifer.

- Localized recharge occurs where there is prolonged ponding on the surface, such as in a losing stream (i.e., a stream from which water is flowing to groundwater), a reservoir, or flood irrigation.

- Mountain front recharge typically involves complex processes of saturated and unsaturated flow in bedrock and downslope migration into aquifers at the base of the mountains.

Recharge in the Sangre de Cristo Mountains occurs through direct precipitation and the runoff infiltration from snow and rain in the Sangre de Cristo Mountains (Garrabrant, 1993). Recharge also occurs as a result of acéquia return flow, as discussed in Sections 7.1.1.1 and 7.2.1.1.

5.3.3.1 Documented Recharge Estimates

Recharge data for the planning region are generally sparse. In the Central subregion, the Rio Grande del Rancho, the Rio Chiquito, and the Rio Fernando contribute significant amounts of mountain front recharge to the shallow alluvial aquifer. Additionally, a hydraulic connection between the shallow alluvium and the deeper Santa Fe Formation indicate that local inflow is another significant source of recharge for the Taos Valley (Bauer et al., 1999).

A few researchers have estimated recharge in the planning region:

- Winograd (1959) estimated recharge to the Sunshine Valley (in the North subregion) to be on the order of 20,000 ac-ft/yr. Recharge from surface waters was estimated to exceed 10,000 ac-ft/yr, while annual recharge from precipitation was estimated to be no less than 10,000 acre-feet. These estimates were derived inferentially with order of magnitude accuracy only.

- Barroll and Burck (2006) used an areal recharge rate of 0.5 in/yr for the calibrated groundwater model of the Taos Valley developed by the OSE. Areal recharge was estimated as 4 percent of the average annual precipitation (12.55 in/yr), resulting in a total recharge rate of 1,820 ac-ft/yr for the modeled area.

- Barroll and Burck (2006) estimated 5,310 ac-ft/yr of mountain front recharge from a water budget calculation modified during model calibration.

- Barroll and Burck (2006) also estimated 11,910 ac-ft/yr of recharge due to irrigation return flows from about 12,000 acres of irrigated land.

- Spiegel and Couse (1969) estimated that diversion of surplus seasonal surface water during 30 days of May and June from all the principal streams for deliberate recharge could provide 12,000 acre-feet of additional recharge to the aquifer system annually.

This figure was based on an average 250 cfs of surplus supply with an infiltration rate of 80 percent over a spreading area of 500 to 5,000 acres.

- Lee Wilson & Associates (1978) estimated recharge to the shallow alluvial aquifer as 1 in/yr, a value said to apply to parts of Taos County where irrigation is widely practiced.

- Lee Wilson & Associates (1980) prepared a water budget for six drainage basins that estimated total recharge for Taos County of 29,887 ac-ft/yr.

5.3.3.2 Modeled Recharge Estimates

In order to obtain approximations of recharge in basins where previous work is not available, DBS&A estimated recharge using the method proposed by Maxey and Eakin (1949). The Maxey-Eakin approach to recharge estimation has been independently evaluated by Watson et al. (1976) and Avon and Durbin (1994). Watson et al. (1976) found the Maxey-Eakin approach to yield reliable “first approximation” estimates of basin recharge. Avon and Durbin (1994) compared Maxey-Eakin recharge estimates to independently estimated recharge values for 146 basins and found the Maxey-Eakin estimate to generally lie within 50 percent of the independent estimates.

Maxey and Eakin hypothesized that a direct relationship exists between annual precipitation and annual recharge: the higher the annual precipitation, the higher the annual recharge. This hypothesis was supported by basin water balance studies indicating that higher-elevation, wetter groundwater basins in Nevada exhibited higher annual discharge rates (in the absence of significant groundwater pumping, discharge from a basin should be roughly equal to recharge) than lower-elevation, drier basins. Based on this premise, and using a contoured precipitation map of the State of Nevada prepared by Hardman (1936), they defined average annual recharge to a groundwater basin in Nevada as:

$$\text{Volume recharge per annum} = A_1R_1 + A_2R_2 + A_3R_3 + A_4R_4 + A_5R_5 \qquad (1)$$

where: A_i = the land surface area (L_2) in a groundwater basin encompassed between two iso-precipitation contours

$R_i = r_i P_i$

where: i = precipitation contour

R_i = recharge rate (length/time [L/T]) computed within precipitation zone i

r_i = the percentage of precipitation that becomes recharge within precipitation zone i

P_i = the average annual precipitation rate (L/T) in zone i

Given the pre-existence of the contoured precipitation map of the state (Hardman, 1936), from which areas could be determined, the only set of unknowns in this recharge model are the percentage recharge values (r_i). To estimate r_i, Maxey and Eakin (1949) used independent water balance results from 21 groundwater basins in the State of Nevada. These studies provided volume recharge for those 21 basins, and the contoured precipitation map (Hardman, 1936) provided the required A_i. Using these two known quantities, Maxey and Eakin (1949) solved for the r_i values using multiple regressions. Table 5-13 summarizes the results of their analysis.

Table 5-13. Maxey-Eakin Recharge Percentages for Precipitation Ranges

Precipitation Range (inches)	Percentage of Precipitation That Becomes Recharge
0–8	0
8–12	3
12–15	7
15–20	15
>20	25

Many hydrogeologic and climatic similarities can be found between the planning region and most of the basins studied by Maxey and Eakin in Nevada, which share semiarid climatic regimes. Given the similarities, the Maxey-Eakin recharge model was used in conjunction with a contoured precipitation map of the planning region (Figure 5-3) to estimate recharge within selected groundwater basins in the planning region (Table 5-14). Precipitation ranges were adjusted to correspond to the contours of the precipitation map available.

Table 5-14. Precipitation Ranges and Recharge Percentages Used

Precipitation Range (inches)	Percentage of Precipitation That Becomes Recharge	
	Maxey-Eakin Calculation	Alternate Calculation [a]
<11	3	0
11 to 15	7	1
15 to 19	15	3
>19	25	8

[a] Based on OSE-modeled recharge (Barroll and Burck, 2006)

Using these precipitation ranges results in some slightly higher estimates of recharge than those for the original Maxey-Eakin ranges.

Using the same precipitation ranges and the same areas used for the Maxey-Eakin approach, DBS&A also developed an alternative estimate of recharge to the subregions in the planning region based on OSE-modeled recharge (Barroll and Burck, 2006), which indicated that the percentage of precipitation that becomes recharge in the region is lower than the Maxey-Eakin estimates. The percentages used to develop the alternate estimate are shown in Table 5-14, and the calculated recharge is shown in Table 5-15. The alternative estimate is a more conservative recharge estimate and is therefore more appropriate for planning purposes.

Table 5-15. Calculated Recharge to Groundwater by Subregion

Subregion	Annual Recharge [a]	
	ac-ft	% ppt
North	35,400	6
Central	25,900	5.4
South	18,300	6
West	3,400	1
Total	83,000	

ac-ft = Acre-feet
% ppt = Percentage of precipitation

[a] Calibrated to OSE-modeled recharge (Barroll and Burck, 2006) in the Central subregion and same percentage applied to other subregions using alternate calculation from Table 5-14.

The total groundwater withdrawals in the planning region during 2000 were 8,450 acre-feet (Section 6.1), well below the recharge estimates shown in Table 5-15. Even if it is assumed that the recharge rate in the planning region is only 1 percent of total precipitation, recharge would be more than 18,000 ac-ft/yr, which still exceeds the groundwater withdrawals in the area. Further discussion of the balance of groundwater supplies is provided in Section 7.2.

The region-wide recharge estimate does not necessarily indicate that recharge water will be available to all localized pumping centers; for example, in locations where pumping is concentrated, water levels may decline. Furthermore, legal restrictions on surface-connected groundwater (Section 4) restrict the ability of the planning region to use available groundwater supplies.

5.3.4 Major Well Fields

Although the majority of the Taos Region is dependent on groundwater supply for their water needs, no major well fields are present in the region. The largest well field in the area is the one operated by the Town of Taos in the Central subregion; these wells are at various locations over an approximately 10-square-mile area. The Town of Taos has developed a small well field for diversion of San Juan-Chama Project water (through exchange) on the Rio Pueblo de Taos, below Cordovas. Mutual domestic systems also operate wells throughout the region (Section 6). Approximately 150 wells are located on the Taos Plateau, and an estimated 50 to 100 shallow wells are in the Rio Ojo Caliente valley (Benson, 2007). Most wells are for domestic use and range in depth from shallow, hand-dug wells to public supply wells that are 200 to 300 feet deep (Garrabrant, 1993). The majority of wells are located in the Costilla Plains and several wells exist in the valleys of the Sangre de Cristo Mountains.

5.3.5 Water Level Trends

Groundwater in the Taos Region generally flows toward the Rio Grande (Figure 5-14). Depths to water in the region are summarized on Figure 5-16. Historical changes (or lack thereof) in water levels can provide an indication of the long-term sustainability of groundwater supplies. The following subsections summarize available water level information for the four subregions. These data are primarily from USGS-monitored wells; municipal well water level data are not available for any of the communities in the planning region. Graphs depicting water elevation changes recorded by the USGS throughout the planning region are included in Appendix E4.

5.3.5.1 Effects of Faulting on Groundwater Flow

Many faults in the Taos Valley area vertically offset the water table and act as impermeable or semipermeable barriers to lateral groundwater flow (Benson, 2004). Drakos et al. (2004b) used pumping test results and equipotential head contours to analyze the effects of faulting on groundwater flow in the region. Their results indicate that while most faults do not appear to affect groundwater flow in the shallow aquifer system, the Los Cordovas Faults may impede flow and the Town Yard Fault may enhance flow in the shallow aquifer (Figures 5-20 and 5-21). Drakos et al. (2004b) also indicate that while the Seco Fault and Los Cordovas Faults may be impermeable boundaries for the deeper aquifer, the Town Yard Fault may provide a recharge zone in the deeper aquifer. Under the Hondo Mesa, near the confluence of the Rio Hondo and Rio Grande, a series of faults offsets water levels (Benson, 2004).

5.3.5.2 North Subregion

While most water supply wells in the North subregion are completed in the Quaternary alluvial aquifer, the USGS-monitored wells within this subregion are completed in the alluvial aquifer. As indicated in Table 5-16, water levels in the USGS-monitored wells within the North subregion have increased in seven wells, at an average rate of 0.3 ft/yr, and decreased in two wells, at an average rate of 0.4 ft/yr. Almost all the USGS-monitored wells graphed by Garrabrant (1993) exhibited water level rises since irrigation was discontinued in the 1960s.

5.3.5.3 Central Subregion

As in the North subregion, while Town of Taos water supply wells are completed in the Santa Fe Group aquifer, the only USGS-monitored well located within the Central subregion is completed in the alluvial aquifer (Table 5-17). As shown in Appendix E4, the water level in this well showed an initial decline of 25 feet after the well was drilled, but has remained relatively stable since 1988.

Rawling (2005) has shown a lowering of the water table in the Des Montes area, over a fractured dacite lava field, where groundwater discharge is faster than recharge from the adjacent Rio Hondo during a long-term drought. Rawling also identified areas around Arroyo Seco where the water table has risen somewhat following two years of acéquia irrigation.

Table 5-16. Change in Water Levels in USGS-Monitored Wells Within the North Subregion

		Change in Water Level		
		Amount [b] (ft)	Period of Record	
Aquifer	Well ID [a]		Dates	No. of Years
Alluvium	364404105354301	–3.30	1955-2005	50
	364645105362501	+11.83	1955-1998	43
	364757105372801	+24.77	1955-1971	16
		–0.27	1955-2005	50
	364918105361301	+5.74	1955-1998	43
	365035105360501	+4.72	1974-2005	31
	365129105381701	+19.15	1955-2003	48
	365339105373801	–49.63	1955-1960	5
		–3.62	1960-1998	38
	365644105363501	+6.96	1955-2005	50
	365708105352801	+26.99	1955-1998	43

Source: USGS, 2005b.
[a] Map of well locations is provided in Appendix E4.
[b] Positive numbers signify a rise in water levels; negative numbers signify a drop in water levels.

Table 5-17. Change in Water Levels in USGS-Monitored Well in the Central Subregion

		Change in Water Level		
		Amount [a] (ft)	Period of Record	
Aquifer	Well ID		Dates	No. of Years
Alluvium	362246105395801	–22.30 [b]	1983-2004	21

Source: USGS, 2005b.
[a] Positive numbers signify a rise in water levels; negative numbers signify a drop in water levels.
[b] Water level declined 25 feet between the first and second measurements, but has been relative stable since 1988.

Since 1989, water levels in a series of NMED monitoring wells in El Prado has exhibited a drop of about 20 feet over the 15-year drought, punctuated by annual rises during spring irrigation of about 5 feet (Benson, 2007).

5.3.5.4 South Subregion

No USGS-monitored wells exist in the South subregion, and water levels are not measured on a regular basis in any of the wells in this subregion.

5.3.5.5 West Subregion

Both water supply wells and the lone USGS-monitored well in the West subregion are completed in the Santa Fe Group aquifer. Between 1957 and 2003, water levels in the USGS well decreased an average 0.002 ft/yr (Table 5-18).

Table 5-18. Change in Water Levels in USGS-Monitored Well in the West Subregion

		Change in Water Level		
		Amount [a] (feet)	Period of Record	
Aquifer	Well ID		Dates	No. of Years
Santa Fe Group	361755106025501	–0.10	1957-2003	46

Source: USGS, 2005b.

[a] Positive numbers signify a rise in water levels; negative numbers signify a drop in water levels.

5.3.5.6 Summary of Water Level Trends

The only known areas of lowered water tables, as reported by drillers and pump setters, are in the lower Des Montes area. Other rumored water level declines have been attributable to sediment filling the well bore or routine pump failures (Benson, 2007). A water level monitoring program should be implemented across the Taos Region to identify possible areas of groundwater level decline. The Draft Abeyta Settlement Agreement and relocation and remediation well proposals require that water levels be monitored around these wells.

5.3.6 Sustainable Yields

The concept of sustainable yield generally refers to limiting development to an amount that can be maintained over a long time period or that will not be detrimental to other resources. Commonly accepted requirements for maintaining a “sustainable water supply” (Shomaker, 2001) include:

- For surface water, limiting water use to the net surface supply in any given year

- For groundwater, limiting the amount of water that can be withdrawn to an amount that has no unacceptable effects on groundwater levels or streamflows

Another useful definition of groundwater sustainability is "yield that would not significantly affect the availability of the groundwater system to sustain riparian habitat and perennial springs" (Springer et al., 2002). Aquifer sustainability can also be evaluated by comparing depletions to recharge, as depletions that consistently exceed recharge will ultimately be unsustainable. Recent research by the Sustainable Water Resources Roundtable (Smith and Zhang, 2006) has focused on defining sustainability indicators such as gross water availability, environmental resources and conditions, and infrastructure and drinking water conditions.

Sustainable development has been defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Sophocleous, 1998). The amount of groundwater that can be sustainably developed is impacted by the location and magnitude of pumping within a groundwater basin. Whereas a sustainable yield estimate could be developed from a basin-wide perspective, it may be meaningless if most of the pumping is occurring in a few localities or close to a sensitive wetland or stream. Therefore, sustainable yield is best addressed at a local level, where a more accurate accounting of water budget terms and impacts can be developed.

No quantitative estimates of sustainable yields have been developed specifically for the groundwater basins in the Taos Region, and currently available data are insufficient to evaluate sustainable yields. Additional field studies and modeling efforts would be required to develop quantitative estimates of sustainable yields for all the basins in the planning region. However, as discussed in Section 7, recharge in the Taos Region is typically higher than withdrawals and water levels do not appear to be declining overall. Thus, sustainable yield is not a significant problem in the region at the present time.

5.4 Water Quality Assessment

The ability to meet future water demands requires not only sufficient quantity of water, but also water that is of sufficient quality for the intended use. In order to meet quality standards for drinking water (Section 4.4), most water supplies require at least a minimal amount of treatment. Should the water quality of the drinking water supply become significantly degraded, additional and costly treatment must be provided or additional water supplies located. Where drinking water supply options are limited, water quality impairment can be a significant and expensive problem. Although water quality standards are generally not as high for other uses as for drinking water, water quality must still meet the minimum quality standards for those uses or expensive treatment will be required.

Water quality in the Taos Region was assessed through existing documents and databases. Surface water studies that were especially helpful were two documents prepared pursuant to Section 305(b) of the Federal Clean Water Act (CWA): (1) *2004-2006 State of New Mexico Integrated Clean Water Act §303(d)/§305(b) Report* (NMED, 2004c), and (2) *Record of Decision for the 2004-2006 State of New Mexico Integrated Clean Water Act §303(d)/§305(b) Report* (NMED, 2004a). Information regarding groundwater quality was obtained primarily from the first document, and information on specific sites and facilities that may potentially impact water quality was obtained from various NMED and EPA databases, as cited in the discussions of surface water quality, groundwater quality, and water quality by subregion in Sections 5.4.1 through 5.4.3.

5.4.1 Surface Water

Existing water quality is discussed in Section 5.4.1.1. Potential sources of contamination and measured impacts to surface water bodies are described in Section 5.4.1.2.

5.4.1.1 Existing Surface Water Quality

The Taos Region lies primarily within the Rio Grande Basin. The Rio Grande originates in Colorado and flows through the planning region from north to south, gaining flow from perennial rivers and streams that are fed primarily by precipitation to the Sangre de Cristo Mountains in eastern Taos County. Surface water diverted for various uses must meet the *State of New Mexico Standards for Interstate and Intrastate Surface Waters* (NMAC 20.6.4) for that use and/or tribal water quality standards, for waters that cross Taos or Picuris Pueblo lands (Section 4.4). Surface water quality concerns in the Rio Grande Basin are largely the result of nonpoint source pollution, although point source issues such as those arising from mining discharges and municipal wastewater spills are also a concern.

Several stream reaches within the planning region have been included on the New Mexico 303(d) list of impaired waters (NMED, 2004c). This list is prepared by NMED to comply with Section 303(d) of the federal CWA, which requires each state to identify surface waters within its boundaries that do not currently meet or are not expected to meet water quality standards. Appendix E5 lists each of the reaches in the planning region that are on the 303(d) list; the locations of these reaches are shown on Figure 5-22.

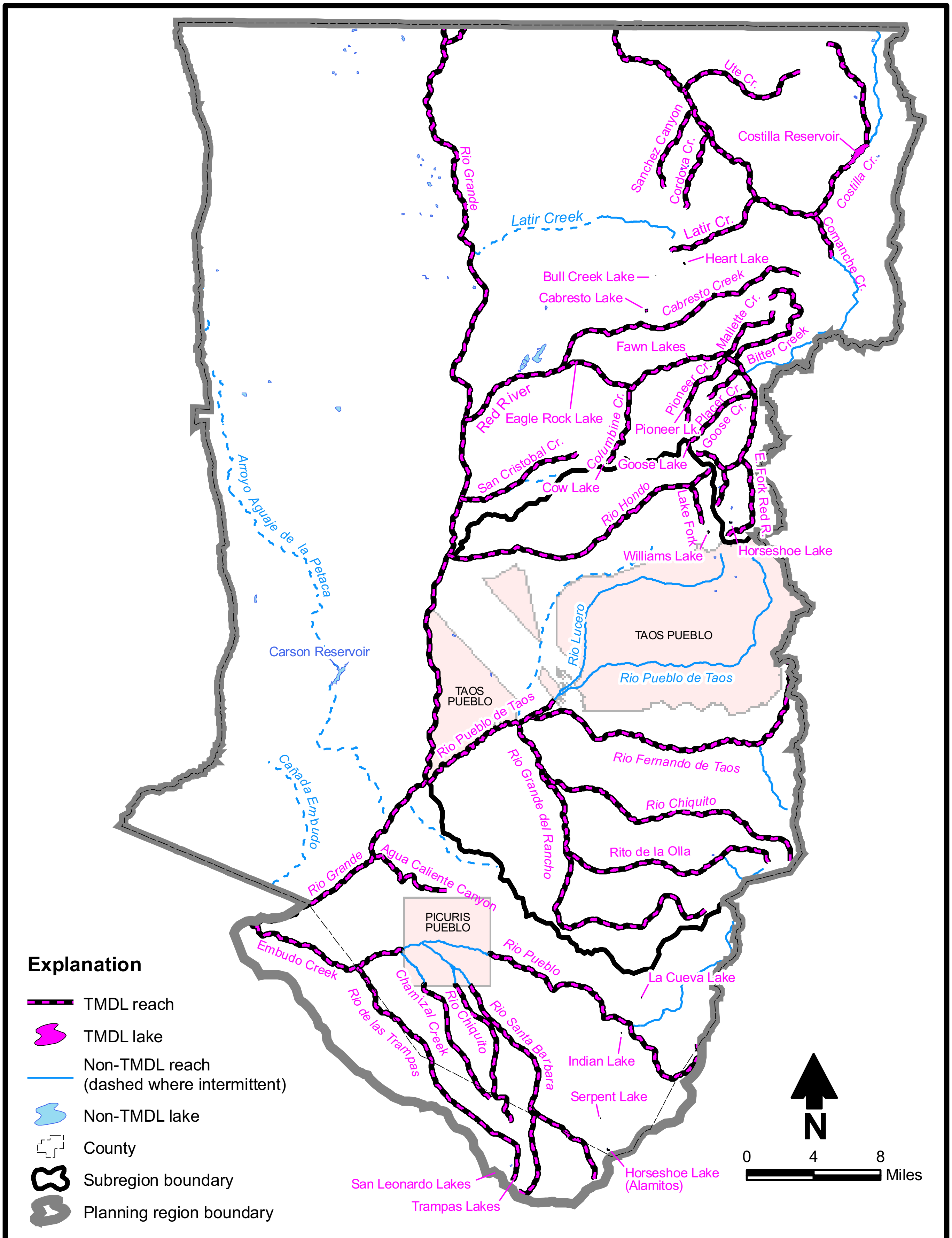
Section 303(d) further requires the states to prioritize their listed waters for development of total maximum daily load (TMDL) management plans. A TMDL documents the amount of a pollutant that a water body can assimilate without violating a state water quality standard. It also allocates that load capacity to known point sources and nonpoint sources at a given flow. Multiple TMDL management plans have already been developed for several streams in the Taos Region (Appendix E5).

River reaches in the planning region that do not fully support their designated uses fail to do so because of turbidity, stream bottom deposits, metals, pH, total ammonia, temperature, pathogens, plant nutrients, and conductivity. The sources for these pollutants include agriculture, recreation, hydromodification, road and highway maintenance, mining, silviculture, resource extraction, municipal and domestic point sources, land disposal, road runoff, and natural and unknown sources (NMED, 2004c). The most common contaminant detected at acute concentrations in the Rio Grande Basin is aluminum; the most common contaminants detected at chronic concentrations in the Rio Grande Basin are aluminum and selenium (NMED, 2004c).

In evaluating the impacts of the 303(d) list on the regional water planning process, it is important to consider the nature of 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). Conversely, the presence of metals can have a significant impact on fish, drinking water, irrigation, and other uses. The presence of the impaired reaches illustrates the degradation that can ultimately affect the water supply.

5.4.1.2 Potential Sources of Contamination

Sources of contamination are considered point sources if they originate from a single location, or nonpoint sources if they originate over a more widespread or unspecified location. Potential point source discharges must comply with the CWA and the New Mexico Water Quality



TAOS REGIONAL WATER PLAN

Water Quality-Impaired Reaches

Figure 5-22

Daniel B. Stephens & Associates, Inc.
06/06/2007
JN WR05.0235

M:/PROJECTS/WR05.0077_TAOS_REGIONAL_WATER_PLAN/GIS/MXDS/REPORT/FIG5-22_TMDL_REACHES.MXD 706060

Standards by obtaining a permit to discharge, referred to as National Pollutant Discharge Elimination System (NPDES) permits. Table 5-19 summarizes NPDES-permitted discharges in the Taos Region (NMED, 2006b).

Table 5-19. Municipal and Industrial NPDES Permittees in the Taos Water Planning Region

Permit No.	Municipality/Industry
Municipalities	
NM0024066	Taos
NM0024899	Red River
Industries	
NM0022101	Taos Ski Valley
NM0022306	Molycorp
NM0030147	NMDG&F Red River Fish Hatchery

Source: NMED, 2006b

Nonpoint sources of pollutants are also a concern for surface water in the Taos Region. The probable sources of nonpoint source pollution in the Rio Grande Basin are agriculture, recreation, hydromodification, road and highway maintenance, silviculture, resource extraction, land disposal, road runoff, and natural and unknown sources (NMED, 2004c). Specific pollutants or threats to surface water quality resulting from these sources are turbidity, stream bottom deposits, metals, pH, total ammonia, temperature, pathogens, plant nutrients, and conductivity (NMED, 2004c).

5.4.2 Groundwater

Although about 90 percent of all water used in Taos County is surface water, groundwater is used for most drinking water, and its quality is thus an important issue. Groundwater contamination has occurred in the Rio Grande Basin (NMED, 2004c), and prevention of future groundwater contamination will be a very important means of protecting groundwater resources.

Groundwater quality concerns in the Rio Grande Basin are largely due to private septic systems (NMED, 2004c), and nitrate contamination, an indication of septic impacts, has been reported in Taos (NMED, 2004c). Potential sources of groundwater contamination are discussed in Sections 5.4.2.1 through 5.4.2.6.

5.4.2.1 Underground Storage Tanks

Leaking USTs are one of the most significant point source contaminant threats. As of April 2005, NMED had reported 45 leaking USTs in the Taos Region, 21 of which are active (NMED, 2005a). Active cases include those in the pre-investigation, investigation, cleanup, and monitoring phases. Information on the status of all UST sites in the planning region is summarized in Table 5-20. Details regarding whether specific UST leaks have impacted groundwater and the status of site investigation and cleanup efforts can be obtained from the NMED database, at www.nmenv.state.nm.us/ust/leakcity.html.

5.4.2.2 Groundwater Discharge Plan Sites

The NMED Ground Water Quality Bureau regulates facilities with wastewater discharges that have a potential to impact groundwater quality. These facilities must comply with the New Mexico Water Quality Control Commission (NMWQCC) Regulations and obtain approval of a discharge plan, which provides for measures needed to prevent and detect groundwater contamination. In particular, NMWQCC Regulations require cleanup of groundwater contamination detected under discharge plan monitoring requirements, as any contamination discharged by these facilities affects the quantity and availability of the water supply.

A variety of facilities fall under the discharge plan requirements, including mines, sewage dischargers, dairies, food processors, sludge and septage disposal, and other industries. As of April 2005, 52 facilities with discharge plans were present in the Taos Region (Table 5-21).

5.4.2.3 CERCLA Superfund Sites

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), commonly known as Superfund, was enacted by the U.S. Congress on December 11, 1980. This law created the Superfund program to respond directly to releases or threatened releases of hazardous substances that may endanger public health or the environment. The Molycorp, Inc. mine near Questa (EPA ID NMD002899094)was added to the National Priorities List in May 2000 due to the threat of uncontrolled acidic, metal-laden runoff from the mine and tailing pond areas to the Red River fishery and nearby endangered species habitat (U.S. EPA, 2007). The contaminants of concern are listed as arsenic, cadmium, cobalt, lead, manganese, and zinc (U.S. EPA, 2000).

Table 5-20. Leaking Underground Storage Tanks in the Taos Water Planning Region
Page 1 of 2

City/Location	Name	Facility ID	Physical Address	Status [a]
Amalia	Lym Inc	29204	746 St Rd 196	NFA
Arroyo Seco	Former El Salta Lodge	54555	494 Highway 150	PI-C
Carson National Forest	Shuree Ponds	30594	Valle Vidal Unit	GWQB
	Susie's Cantina	30845	Hwy 285 N Of, Cutoff To Carson	NFA
Cerro	Gomez Food Mkt	28357	Near Post Office	NFA
El Prado	Montoya Well (Mountain View Grocery-Fina gas station)	29490	1629 Hwy 522, Junction with 64 West	ACC-CAF
	Shell	30579	Hwy 3	NFA
Ojo Caliente	El Taquito Cafe	29286	35317 Highway 285	NFA
	Shell Station	29724	Rt Hwy 285	PI-C
Penasco	A1 Auto Repair	26305	14122 Nm 75, Po Box 445	I-R
	Nmshtd Penasco	26242	NM 75 MP 15 5	NFA
	Rio Lucio	30249	Nm Hwy 75	NFA
	Travelers Service Station	31185	Hwy 75	I-R
Questa	Moly Corp	29444	Three Miles E Of Questa	NFA
	Molycorp Ast Tank Farm	29444	Three Miles E Of Questa	GWQB [b]
	Mountain View Cafe	29493	State Rd 38	C-R
	Ortega Texaco	29809	2460 N 522	NFA
	Questa Mine, Questa	29444	Three Miles E Of Questa	NFA
	V&E Inc	31415	Hwy 522 4 Miles N Of Questa, Box 31	NFA
	Western Bank	1701	P.O. Box 304, Hwy 3	I-R
Red River	Chevron Red Rvr	30177	Main St	C-CAF
	Red River Ski Area	30178	Pioneer Rd	NFA
	Shamrock Rd Rvr	1047	Hwy 38	I-R
	Angelina's Restaurant	53766	Unknown	PI-S
Taos	Allsups #319	26523	S Santa Fe Rd, 1005 Santa Fe Rd	C-R
	At&T Radio Relay	1702	20 Miles N Of Taos	NFA
	Atex #299/Allsps #319	26523	S Santa Fe Rd, 1005 Santa Fe Rd	NFA
	Canon 66 Service Station	27209	526 Kit Carson Rd	PI-C
	Dept Of Pub Svc #13	26241	Sr 64 W	NFA

Source: NMED, 2006a

[a] ACC-CAF = Aggr cleanup completed, State lead with CAF
C-CAF = Cleanup, State lead with CAF
C-R = Cleanup, responsible party
C-S = Cleanup, State lead with LUST TF
GWQB = Referred to the Groundwater Quality Bureau
I-R = Investigation, responsible party
M = Monitoring, responsible party
NFA = No further action required
NFA-S = NFA, suspected release
PI-C = Pre-investigation, confirmed release
PI-S = Pre-investigation, suspected release

[b] Corrective action completed

Table 5-20. Leaking Underground Storage Tanks in the Taos Water Planning Region
Page 2 of 2

City/Location	Name	Facility ID	Physical Address	Status [a]
Taos (cont.)	Exxon Taos	30153	Armory And Pueblo	GWQB
	Former Phillips 66 Station	28123	328 Paseo Del Pueblo Sur	I-R
	Mr Gas 309	29499	Hwy N 68, 816 Paseo Del Norte	M
	Paseo Del Pueblo Sur	29863	826 Paseo Del Pueblo Sur	I-R
	Paseo Pueblo Sr	1856	Hwy 64	C-R
	Placita Emergency	53766	Unknown	NFA-S
	R And R Shamrock - No62, Taos	30115	1332 Paseo Del Pueblo Sur	PI-C
	Robinson Texaco	30278	1201 Paseo Pueblo Sur	ACC-CAF
	Southside Texaco	30690	S Santa Fe Rd, PO Box 2618	NFA
	Southside Texaco	30690	S Santa Fe Rd, PO Box 2618	I-R
	Taos Allsups	1855	Hwy 64	PI-C
	Taos County Rd Dept	30999	120 Herdner Rd	C-R
	Taos County Sheriff	30998	P.O. Box 1914	I-R
	Taos Rv Park	31008	Paseo Del Pueblo Sur	C-S
	Taos Ski Valley	31009	101 Ocean Blvd, Taos Ski	NFA

Source: NMED, 2006a

[a] ACC-CAF = Aggr cleanup completed, State lead with CAF
C-CAF = Cleanup, State lead with CAF
C-R = Cleanup, responsible party
C-S = Cleanup, State lead with LUST TF
GWQB = Referred to the Groundwater Quality Bureau
I-R = Investigation, responsible party
M = Monitoring, responsible party
NFA = No further action required
NFA-S = NFA, suspected release
PI-C = Pre-investigation, confirmed release
PI-S = Pre-investigation, suspected release

Table 5-21. Groundwater Discharge Permits in the Taos Water Planning Region
Page 1 of 2

County	City	Facility Name	Waste Type
Taos	Arroyo Seco	Hacienda De Valdez Condominiums	Domestic
		Abominable Snowmansion	Domestic
	Costilla	Ski Rio	Domestic
	El Prado	Sanchez Mobile Home Park	Domestic
		Ernesto Montoya Property	Domestic
		Mountain View Groceries & Gas	Domestic
		Alice Sanchez Mobile Home Park	Domestic
		Las Colonias Mobile Home Park	Domestic
	Ojo Caliente	Ojo Caliente Housing Subdivision	Domestic
		Ojo Caliente Mineral Springs	Domestic
		Ojo Caliente High School	Domestic
	Peñasco	Taos (County of) - Housing Authority	Domestic
		Penasco Schools	Domestic
	Questa	Questa Mine	Mining
		R & M Septic Service	Domestic
		Questa Mine	Domestic
		Questa (Village of) - Wastewater Treatment Plant	Domestic
		Molycorp - Questa Mine	Mining
	Ranchos de Taos	SMU in Taos - Fort Burgwin	Domestic
		Taos Country Club	Domestic
		Champion Motor Car Wash	Industrial
	Red River	Red River (Town of) - Wastewater Treatment Plant	Domestic
	Taos	Taos Ski Basin Bavarian Restaurant	Domestic
		Taos Ridge Townhouses	Domestic
		Faustin Gonzales Mobile Home	Domestic
		Arroyos Del Norte Elementary School	Domestic
		Taos National Guard Armory	Domestic
		El Monte Lodge	Domestic
		Christian Fellowship Church	Domestic
		Llano Quemado Headstart	Domestic
		Vista del Canon Condominiums	Domestic
		Allsups 319	Industrial
		Alta Vista Subdivision	Domestic
		Cohnsville Trailer Court	Domestic
		Double Rd Dairy	Agricultural
		Quail Ridge Inn	Domestic

Source: NMED, 2005g

Table 5-21. Groundwater Discharge Permits in the Taos Water Planning Region
Page 2 of 2

County	City	Facility Name	Waste Type
Taos (cont.)	Taos (cont.)	RAS - 67214	Industrial
		S and R Septic Service	Domestic
		Taos (Town of) – Wastewater Treatment Plant	Domestic
		Taos Photo Lab	Industrial
		Villas Encantadas	Domestic
		Taos/triple A Septic Service	Domestic
		Silva's Excavation Inc	Domestic
		Bernadine Garcia Mobile Home Park	Domestic
		The Wine Find Restaurant	Domestic
		Taos Trails Brewery Inc	Agricultural
		Long John Silvers-Taos	Domestic
		Fechin Inn Taos	Domestic
	Taos Ski Valley	Austing Haus Hotel	Domestic
		Inn at Taos Ski Valley	Domestic
	Vadito	Sipapu Ski Area	Domestic
Rio Arriba	Embudo	Siete del Norte Embudo Facility	Domestic

Source: NMED, 2005g

5.4.2.4 Landfills

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 closed before the 1989 deadline in order to avoid more stringent final closure requirements. Only one landfill (the Town of Taos Landfill) is located within the planning region, and it is still operating (NMED, 2000).

5.4.2.5 Septic Systems

Collectively, septic tanks and other on-site domestic wastewater disposal systems constitute the single largest known source of groundwater contamination in New Mexico (McQuillan, 2006). Because septic systems are generally spread out in rural areas, they are considered a nonpoint source. In areas with a shallow water table, as is the case in much of the planning region east of the Rio Grande, septic system discharges can percolate rapidly to the underlying aquifer and increase concentrations of several contaminants, including total dissolved solids (TDS), iron, manganese and sulfides (anoxic contamination), nitrate, potentially toxic organic chemicals, and bacteria, viruses, and parasites (microbiological contamination) (NMED, 2002). Septic tanks are of greatest concern in areas with shallow depth to groundwater. As shown in Figure 5-16, the depth to water is less than 100 feet in most wells in the central portion of the Central subregion (in the vicinity of Taos) and in most wells around Questa and Peñasco.

The number of septic systems used to treat wastewater in the region has been estimated at more than 10,000 (Section 8.3). Approximately 45 of the water systems in the planning region do not have central wastewater treatment facilities, and in areas served by those systems, wastewater is treated by septic tanks. In addition, wastewater for the more than 13,000 people in the region who are supplied by domestic wells is treated using septic systems.

Water quality impacts due to septic tanks are most severe in areas where population density is high, depth to water is shallow, and septic systems are used to treat large volumes of wastewater. The areas of greatest concern include:

- The area surrounding Taos in the Central subregion, where an estimated 1,868 septic tanks treat approximately 134,000 gallons of wastewater per day (not including Taos Pueblo)

- Questa in the North subregion, where 41 percent of the population is served by septic tanks treating almost 40,000 gallons of wastewater per day

- The Peñasco area in the South subregion, where 100 percent of the population is served by septic systems treating approximately 40,000 gallons of wastewater per day.

5.4.2.6 Potential Sources and Treatment of Groundwater Contaminants

Based upon data presented by the New Mexico Drinking Water Bureau (NMDWB) for water systems in Taos County, several constituents have been detected above the U.S. EPA's maximum contaminant levels (MCLs), including coliform bacteria, turbidity, total dissolved solids (TDS), gross alpha, and gross beta (NMED, 2006c). These constituents can be derived from either anthropogenic activities or natural conditions.

The coliform bacteria and turbidity are most likely related to anthropogenic activities and well completion issues. Coliform bacteria are derived from several sources including the soil, vegetation, and the gastrointestinal systems of warm-blooded animals. Most coliform bacteria are not pathogens, and they are evaluated as a screening tool to determine if other harmful bacteria may be present in the water system. When coliforms are detected, the water sample is analyzed for pathogens, including fecal coliforms and *Escherichia coli* (E. coli). These pathogens are usually related to septic contamination reaching the well.

Turbidity is a measure of the clarity of water. Cloudy water will have a higher turbidity than clear water, usually due to small particles (e.g., clay or silt) suspended in the water. The U.S. EPA has set an MCL for turbidity as a screening tool to help indicate if potential harmful bacteria may be in the groundwater, as potential pathogens (bacteria, viruses, or parasites) may be transported with the clay or silt into a well. Elevated turbidity is usually related to poor well completion techniques, but it may also indicate that surface water is interacting with the groundwater near the well.

TDS is usually related to background conditions in the aquifer and interaction of groundwater with naturally occurring minerals. TDS has a secondary or non-health-based MCL, which is an aesthetic standard related to taste and color of the water.

Gross alpha and gross beta are derived from the radioactive decay of minerals and are also usually related to background conditions in the aquifer rather than to anthropogenic activities. Alpha particles are from the radioactive decay of uranium, radium, and thorium minerals. Beta particles are from the radioactive decay of tritium, lead, cesium, strontium, and potassium. These types of minerals are common in igneous rocks such as the granites of the Sangre de Cristo Mountains.

Treatment for coliform and other bacteria usually consists of disinfecting the water at the wellhead. Chlorine is the most common form of disinfection for water systems. Filtration systems that use micro- or nano-filtration technology such as reverse-osmosis will also remove bacteria, TDS, turbidity, gross alpha, and gross beta. An alternative to treatment is securing a new water source that has better water quality.

5.4.3 Summary of Water Quality by Subregion

As discussed above, Section 303(d) of the Federal Clean Water Act requires states to develop total maximum daily load (TMDL) management plans for water bodies where water quality is impaired. TMDLs prepared for the region so far (Appendix E5) include those reaches addressed by the Upper Rio Grande TMDLs Part 1 (NMED, 2004b) and Part 2 (NMED, 2005b) and the Rio Hondo Watershed TMDLs (NMED, 2005c). Reaches included in these TMDLs, along with their associated water quality concern, are:

- *North subregion* (Upper Rio Grande TMDLs Part 1)*:*
  - Comanche Creek (temperature)
  - Costilla Creek (temperature)
  - Red River watershed (chronic aluminum TMDLs not prepared due to a potential change in the state standard (0.087 mg/L) for the Red River watershed.)
  - Red River (acute aluminum)

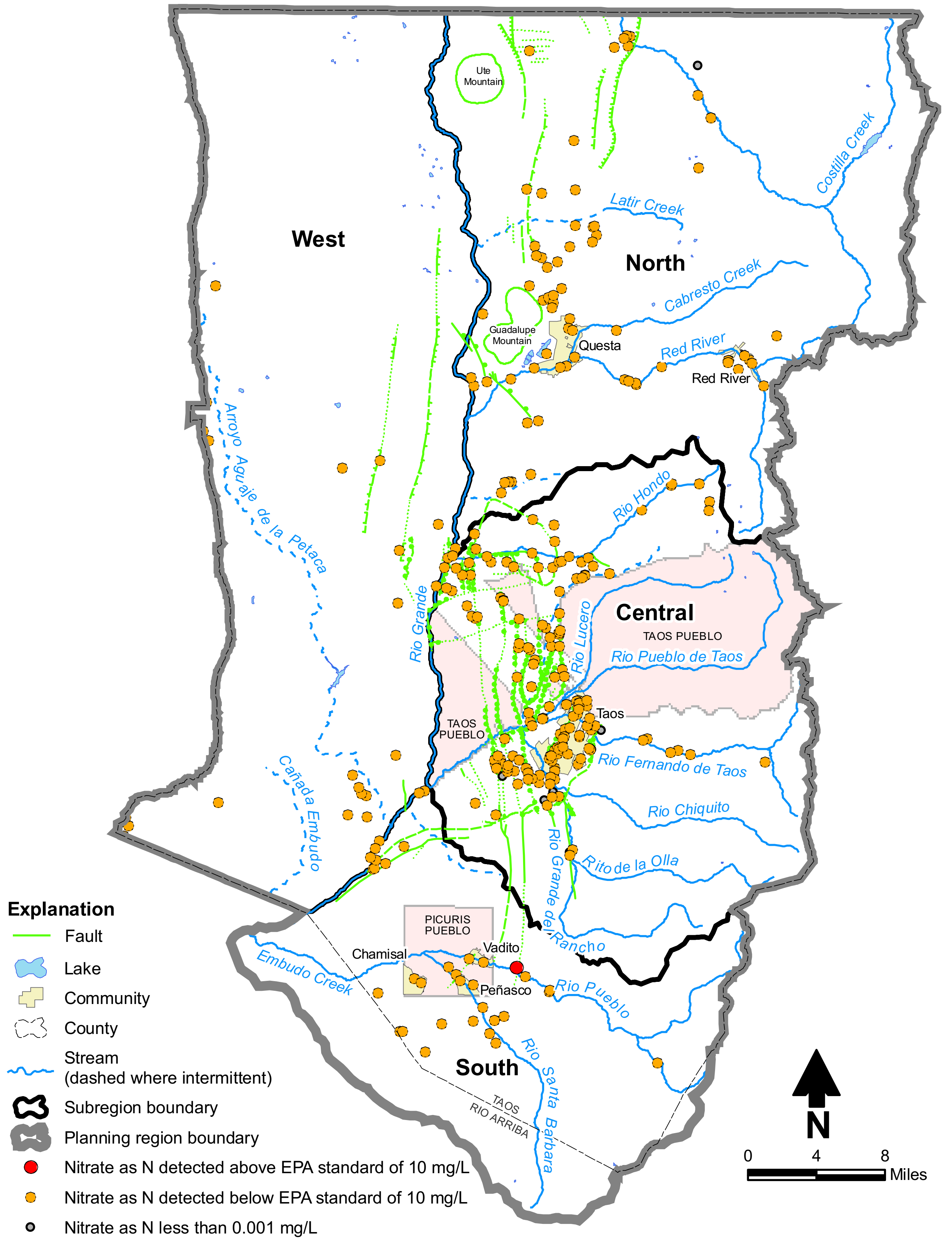
  - Bitter Creek (acute aluminum and sedimentation/siltation [previously listed as stream bottom deposits])
  - Pioneer Creek (turbidity)
  - Placer Creek (acute aluminum)
  - Rio Grande (temperature)

- *Central subregion* (Upper Rio Grande TMDLs Part 1)*:*
  - Rio Fernando de Taos (specific conductance and temperature)
  - Rio Grande del Rancho (specific conductance)
  - Rio Hondo (temperature)
  - Rio Pueblo de Taos (temperature at three separate locations and stream bottom deposits)

- *Central subregion* (Rio Hondo Watershed TMDLs):
  - South fork of Rio Hondo to Lake Fork Creek (total phosphorus and total nitrogen) (This TMDL was written as a precautionary measure to help mitigate the possibility of any future nutrient impairment caused by expansion of the Village of Taos Ski Valley's wastewater treatment plant.)

- *South subregion* (Upper Rio Grande TMDLs Part 2)*:*
  - Embudo Creek (turbidity and stream bottom deposits)
  - Rio Santa Barbara (turbidity)

The following subsections summarize the overall water quality by subregion for the Taos Region. Figures 5-23 through 5-26 illustrate the distribution of selected contaminants of concern in the planning region. Figure 5-23 illustrates that nitrate at low levels is prevalent throughout the region, but in most cases has not exceeded drinking water standards. Similarly, while arsenic is prevalent throughout the region, it has only been detected above drinking water standards in a handful of samples (Figure 5-24). Uranium and fluoride concentrations exceeding drinking water standards have been detected in some samples collected within the region (Figures 5-25 and 5-26). Many of the higher levels of arsenic, uranium, and fluoride are concentrated near fault zones (Figures 5-24 through 5-26).



Source: Taos SWCD, 2006

TAOS REGIONAL WATER PLAN

Nitrate in Groundwater

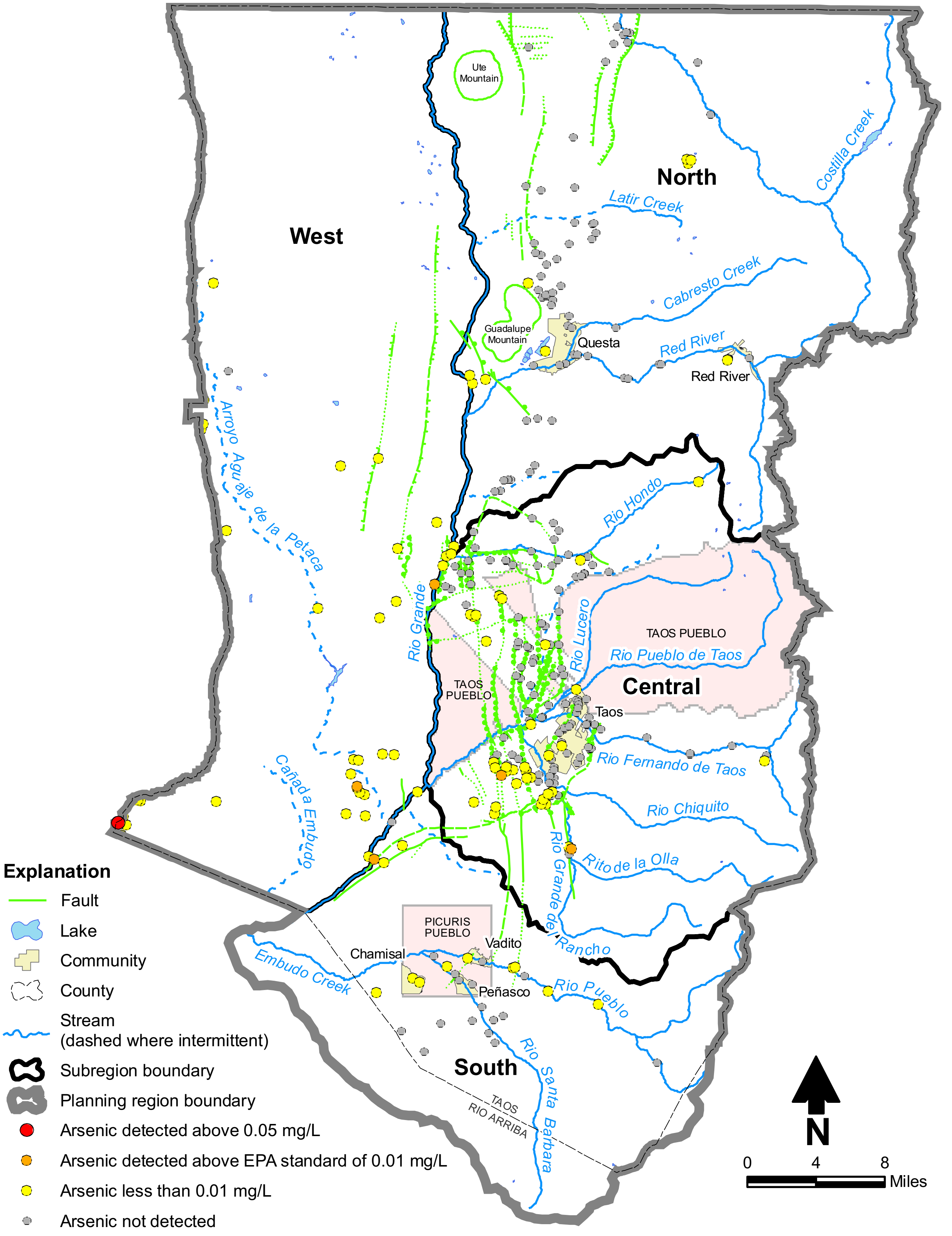
Figure 5-23

Daniel B. Stephens & Associates, Inc.

06/06/2007

JN WR05.0077

M:/PROJECTS/WR05.0077_TAOS_REGIONAL_WATER_PLAN/GIS/MXDS/REPORT/FIG5-23_NITRATE.MXD 706060



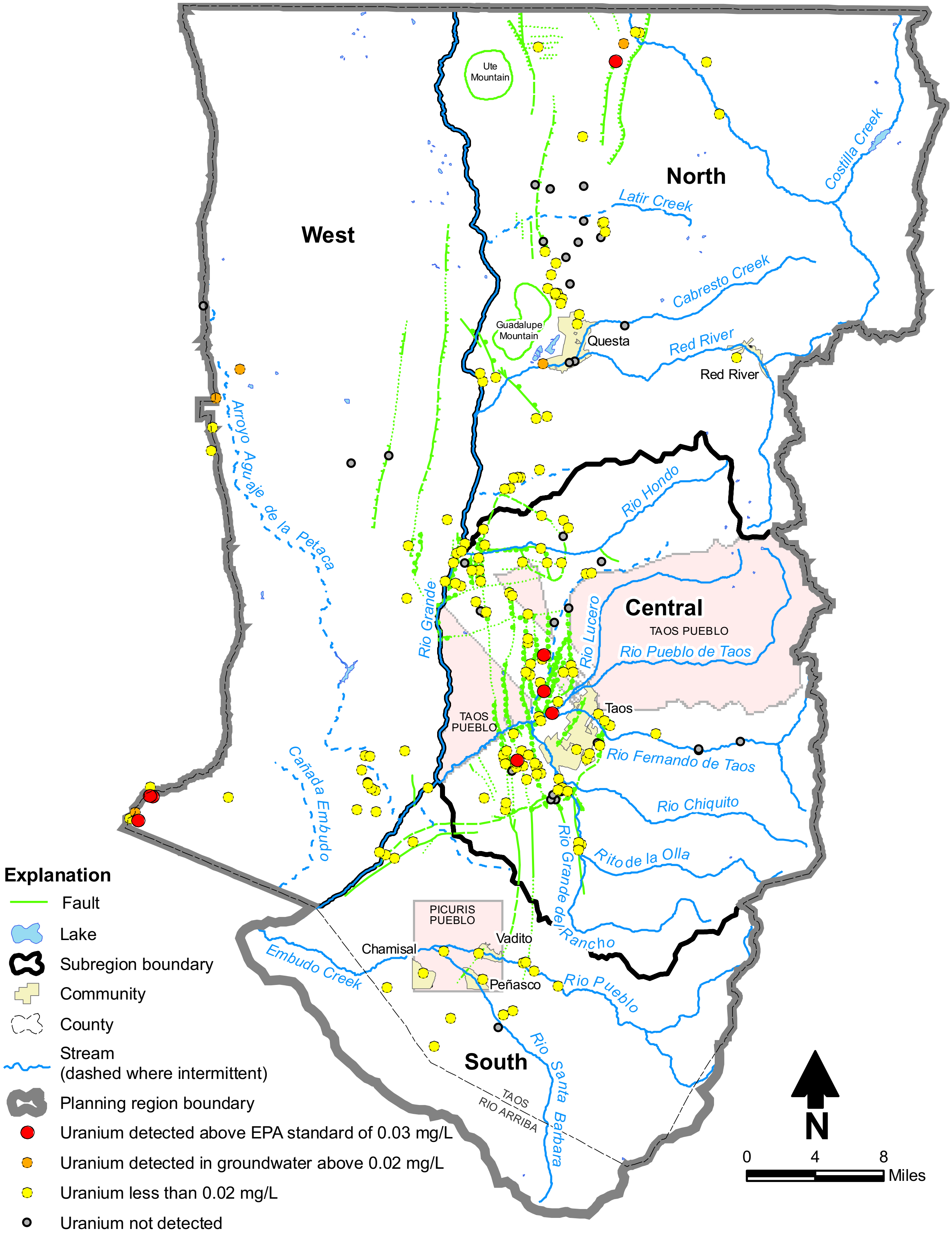
Source: Taos SWCD, 2006

M:/PROJECTS/WR05.0077_TAOS_REGIONAL_WATER_PLAN/GIS/MXDS/FINAL_REPORT/FIG5-24_ARSENIC.MXD 706060

Daniel B. Stephens & Associates, Inc.
11/14/2007
JN WR05.0077

TAOS REGIONAL WATER PLAN
Arsenic in Groundwater

Figure 5-24



Source: Taos SWCD, 2006

TAOS REGIONAL WATER PLAN
Uranium in Groundwater

Figure 5-25

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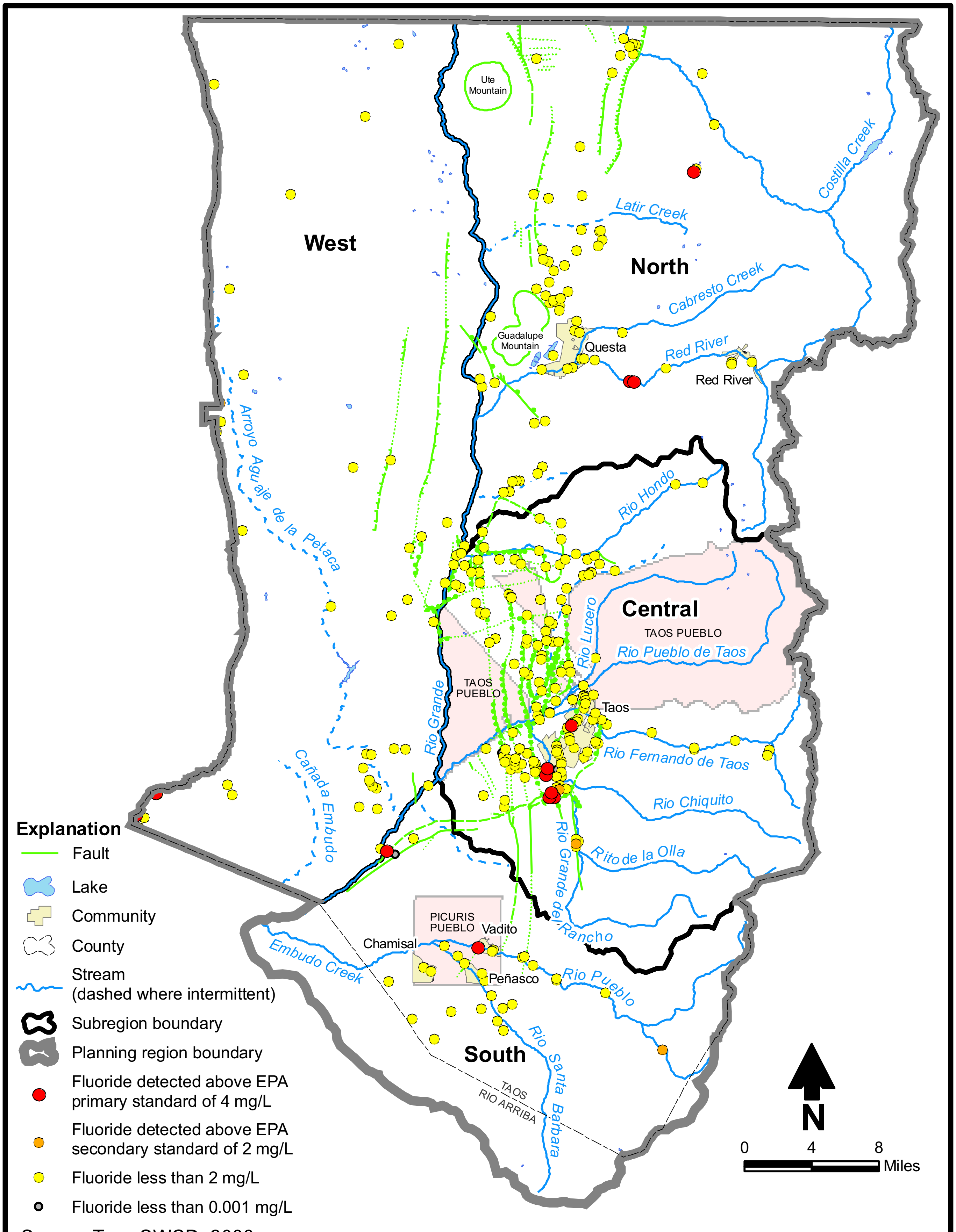
11/14/2007
JN WR05.0077

M:/PROJECTS/WR05.0077_TAOS_REGIONAL_WATER_PLAN/GIS/MXDS/FINAL_REPORT/FIG5-25_URANIUM.MXD 706060



Source: Taos SWCD, 2006

TAOS REGIONAL WATER PLAN

Fluoride in Groundwater

Figure 5-26

Daniel B. Stephens & Associates, Inc.

06/06/2007

JN WR05.0077

M:/PROJECTS/WR05.0077_TAOS_REGIONAL_WATER_PLAN/GIS/MXDS/FINAL_REPORT/FIG5-26_FLUORIDE.MXD 706060

5.4.3.1 North Subregion

Molycorp, Inc., located north of the Red River near Questa, has an active molybdenum mine and tailings pond, including 9 miles of pipeline between the two facilities. The principal pollutants from this site are heavy metals, including arsenic, cadmium, chromium, cobalt, fluoride, lead, manganese, molybdenum, and zinc. The Molycorp site was proposed for addition to the Superfund National Priorities List on May 11, 2000, and a remedial investigation and feasibility study is currently being conducted. Numerous breaks in the pipeline that runs between the mine and tailings pond have resulted in tailings being spilled into Red River and along its floodplain, threatening the fishery and introducing contamination to Red River, a tributary of the Rio Grande. In addition, contaminated groundwater is present at the mine site and under the tailings ponds and is known to flow into the Red River alluvial aquifer and then into Red River through seeps and springs (U.S. EPA, 2007). Molycorp has installed water collection systems to capture seepage-impacted water below the toes of their stockpiles prior to it reaching the Red River; in addition seepage-impacted water collected below the tailings ponds is released through a permitted outfall to the Red River (U.S. EPA, 2007).

In 2001, the USGS and NMED began a five-year cooperative study to differentiate pre-mining or natural background concentrations for the area near the Molycorp mine (Verplanck et al., 2006). This study found seasonal variations in water quality and dramatic changes after monsoonal storms. For example, the pH of surface water in the Red River decreased from 7.8 to 4.8 during a rainstorm in 2002, while metal and sulfate concentrations increased (Verplanck et al., 2006). This low-pH water occurs primarily from runoff at alteration scar locations (areas characterized by natural mineralization and steep slopes that lead to exposed altered rock that is unable to sustain vegetation) within the watershed. The lowest metal and sulfate concentrations are usually seen during snowmelt conditions when surface water in the Red River is diluted.

Intensive surface water sampling was conducted by the NMED in 1999 to develop the Red River watershed TMDL documents that were approved by the EPA in March 2006 (NMED, 2006a). NMED will collect additional water quality data in the Red River watershed as a part of their standard 8-year sampling rotation, with the next monitoring period scheduled for 2008. Water quality data are also collected at the long-term USGS water quality monitoring stations and by the Molycorp mine in Questa.

A petition filed by the New Mexico Department of Game and Fish for use of piscicides to restore the native fish community in the Costilla Creek watershed, from Comanche Creek down Costilla Creek to Latir Creek, was approved by the New Mexico Water Quality Control Commission on August 8, 2006. The piscicides will be used to kill rainbow and brown trout, reducing their competition with native Rio Grande cutthroat trout for habitat and food, in an effort to keep the cutthroat trout from being listed as endangered (Matlock, 2006). The New Mexico Department of Game and Fish plans to begin using piscicides in the summer of 2007 and will conduct one 2- to 3-week-long project per year. Each project will address non-native fish populations in small segments of the watershed, beginning in the headwaters and moving downstream. Cutthroat trout restocking will also occur as part of these projects (Patten, 2006). Downstream water quality monitoring will be required following treatment (DeRose Bamman, 2006).

Review of unpublished data on water wells in the North subregion compiled by the Taos SWCD (Figures 5-23 through 5-26) indicates that:

- Nitrate was detected in most samples below the drinking water standard, although concentrations close to the EPA drinking water standard were detected in wells in Cerro.

- Arsenic was detected at levels below 0.01 mg/L in some of the samples collected, but none of the concentrations exceeded the drinking water standard.

- Uranium was detected at concentrations above 0.02 mg/L in most of the samples collected, and the concentration in one sample exceeded the drinking water standard of 0.03 mg/L.

- Fluoride was detected at levels below the secondary drinking water standard of 2.0 mg/L in almost all samples collected, with three samples exceeding the primary drinking water standard of 4.0 mg/L. Higher fluoride levels in the upper Rio Grande valley may be associated with molybdenum mineralization and/or the presence of fluoride-bearing silicate minerals.

Multiple watershed restoration action strategy (WRAS) documents have been prepared for watersheds in the North subregion, including the Comanche Creek, Red River, and San Cristobal watersheds. Key surface water quality issues identified for these watersheds include:

- *Comanche Creek* (Quivira Coalition, 2005)*:*
  - High surface water temperature
  - High sediment load due to erosion caused by runoff from unconsolidated hillslopes, headcuts, and road cuts, culverts/bridges/roads that alter flow, and cattle and elk grazing

- *Red River* (Red River Watershed Group, 2003)*:*
  - Acid rock drainage from natural hydrothermal scars and abandoned historical mines
  - Sediment and nutrient contamination from excessive livestock and wildlife grazing
  - Nutrient contamination from poorly designed and poorly regulated septic systems
  - Erosion from excessive ATV use and poorly designed and maintained recreational roads, State Highway 38, and other paved roads
  - Erosion from dense forest (lack of ground cover/grass)
  - Water quality impacts from acidic groundwater seeps along the Red River
  - Severe erosion from the Hondo fire scar

- *San Cristobal* (Atencio et al., 2006)*:*
  - Sediment and nutrient contamination from excessive livestock and wildlife grazing
  - Nutrient contamination from poorly designed and poorly regulated septic systems
  - Wetlands, riparian, and stream impacts from dense and poorly regulated development in the upper valley
  - Sediment erosion from excessive ATV use and poorly designed and maintained recreational roads
  - Sediment erosion from road cuts along FS Rd 7 and other paved roads
  - Erosion from the Hondo Fire scar

Data posted on the NMED Drinking Water Bureau web site (http://eidea.state.nm.us/SDWIS) indicate that the Town of Red River has no water quality concerns, while gross beta radioactivity is a concern for the Costilla and Cerro MDWCAs (Table 5-22).

Table 5-22. Water Quality in the North Subregion

Water Quality Parameter	Concentration (mg/L [a])				
	MCL	Costilla [b]	Cerro [c]	Red River [d]	Questa [e]
Turbidity (NTU)	1	0.03	0.36	0.26	0.06
Calcium	NS	33.3	48.4	44.7	41.2
Chloride	250 [f]	10	6.3	10	3.2
Magnesium	NS	5.36	12.3	6.58	7.8
Potassium	NS	5	2.8	5	1.7
Sulfate	250 [f]	---	21	70.3	43
Hardness, calcium/magnesium	NS	105	171	139	135
Odor (TON)	3 [f]	1	1	0	1
pH	6.5-8.5 [f]	7.58	7.25	7.74	7.47
Alkalinity, total	NS	96.4	201.9	65	163.5
Solids, total dissolved (TDS)	500 [f]	150	266	188	233
MBAS -Surfactants	0.5 [f]	0.01	0.025	0.01	0.025
Nitrate+nitrite (as N)	10	0.59	2.8	0.25	0.35
Gross beta (pCi/L)	4 mrem/yr	5.9	4.4	1.87	2.1

[a] Unless otherwise noted

[b] Sample collected from Well #1 on 9/2/1997, except nitrate+nitrite and gross beta, which were collected from Well #2 on 11/14/2005 and 11/18/2003, respectively.

[c] Sample collected from Well #1 on 4/1/1997, except nitrate+nitrite and gross beta, which were collected from Well #1 on 11/14/2005 and 12/15/1999, respectively.

[d] Sample collected from Well #2 on 8/21/1997, except nitrate+nitrite and gross beta, which were collected from Well #5 on 5/17/2005 and 12/21/2005, respectively.

[e] Sample collected from Well #1 on 4/15/1997, except nitrate+nitrite and gross beta, which were collected from Well #1 on 5/17/2005 and 12/21/2005, respectively.

[f] National Secondary Drinking Water Regulations

Source: NMED, 2005f

mg/L = Milligrams per liter
MCL = Maximum contaminant level
NTU = Nephelometric turbidity units
NS = No standard established
--- = Information not available
TON = Threshold odor numbers
pCi/L = PicoCuries per liter
mrem/yr = Millirems per year

5.4.3.2 Central Subregion

Review of unpublished data on water wells in the North subregion compiled by the Taos SWCD (Figures 5-23 through 5-26) indicates that:

- Nitrate was detected in most samples below the drinking water standard.

- Arsenic was detected at levels below 0.01 mg/L in many of the samples collected and at concentrations exceeding the 0.01-mg/L drinking water standard in three samples located along fault zones.

- Uranium was detected at concentrations above 0.02 mg/L in almost all of the samples collected, and the concentration in four of the samples (all of which were located along fault zones) exceeded the drinking water standard of 0.03 mg/L.

- Fluoride was detected at levels below the secondary drinking water standard in almost all samples collected, with one sample exceeding only the secondary standard of 2.0 mg/L and six samples located along fault zones exceeding the primary drinking water standard of 4.0 mg/L. A large area of higher fluoride levels occurs in Talpa and Llano Quemado from groundwater recharged from the Ponce de Leon Hot Springs.

Completed WRAS documents that specifically address areas within the Central subregion include the Rio Hondo, Rio Don Fernando, and Ranchos de Taos sections of the Upper Rio Grande WRAS (Atencio et al., 2006), as well as the stand-alone Rio Pueblo de Taos WRAS document. Key surface water quality issues identified for these watersheds include:

- *Rio Hondo* (Atencio et al., 2006):
  - Fuel loading and risk of fire
  - Acid rock drainage from natural hydrothermal scars and abandoned historical mines
  - Sediment and nutrient contamination from excessive livestock and wildlife grazing
  - Nutrient contamination from septic systems
  - Erosion from recreation (ATVs, dense forest with little to no ground cover, and the Hondo fire scar)
  - Acidic groundwater seeps

- *Rio Don Fernando* (Atencio et al., 2006):
  - Erosion due to recreation, grazing, natural sources, land development, and roads
  - Trash dumping in river
  - Highway maintenance and runoff

  - Habitat modification
  - Septic tanks
  - Fuel loading
  - Risk of fire

- *Ranchos de Taos* (Atencio et al., 2006):
  - Sediment and nutrient contamination from excessive livestock and wildlife grazing
  - Nutrient contamination from septic systems and increased growth
  - Sediment erosion from ATV use and road cuts along State Highway 518, FS Rd 437, and other paved roads
  - Wetlands, stream, and riparian impacts

- *Rio Pueblo de Taos* (Rio Pueblo de Taos Watershed Group, 2005):
  - Runoff from roads and gas stations
  - Stormwater runoff from new and existing development
  - Salt from roads
  - Pesticide runoff
  - Lead contamination from unregulated shooting ranges
  - Erosion due to over-grazing
  - Disturbance and sedimentation from power line installation
  - Septic tanks
  - Old dump sites, illegal dump sites, and new trash
  - Already polluted groundwater and wastewater treatment activities
  - High surface water temperature

Public drinking water system data posted on the NMED Drinking Water Bureau web site indicate that the communities of Arroyo Seco, El Prado, Ranchos de Taos, Taos, Canchito, and Valdez have no water quality concerns, while turbidity and gross beta contamination are of concern in Cañon (Table 5-23). In January 2005, Arroyo Hondo was sent a violation notice for an exceedance of the total coliform maximum contaminant level (MCL).

Table 5-23. Water Quality in the Central Subregion

Water Quality Parameter	Concentration (mg/L [a])								
	MCL	Arroyo Seco [a]	Cañon [b]	El Prado[c]	Arroyo Hondo [d]	Ranchos de Taos[e]	Taos[f]	Ranchito [g]	Valdez[h]
Turbidity (NTU)	1	0.42	11.3	0.84	0.07	0.05	3.5	0.47	0.15
Calcium	NS	29.8	55.8	21.3	49	81.9	25.7	74.4	47.2
Chloride	250 [i]	2.8	14		10		10.5	3.6	8.3
Magnesium	NS	8.1	22.2	3.53	10.8	12.6	7	15.6	6.3
Potassium	NS	0.2		2.12	5	2.14	2.8	0.8	2.1
Sulfate	250 [i]	2	54		28.9	56.5	20	27	16
Hardness, calcium/ magnesium	NS	108	230	67.6	167	256	93	250	144
Odor (TON)	3[i]	1	1	0.05	0	0.05	1	1	1
pH	6.5-8.5 [i]	7.15	7.56	8.26	7.9	8.32	7.32	6.86	7.3
Alkalinity, total	NS	127.5	245.4	72.8	172	281	185.9	261.4	120.4
Solids, total dissolved (TDS)	500 [i]	146	364	96	270	396	234	293	176
MBAS surfactants	0.5 [i]	0.025	0.025	0.01	0.01	0.01	0.025	0.025	0.025
Nitrate+Nitrite (as N)	10	0.79	2.5	0.92	0.98	3	1.3	0.48	1.2

[a] Unless otherwise noted

[b] Sample collected from Well #1 on 6/3/1997, except nitrate + nitrite, which was collected from Well #2 on 12/16/2005

[c] Sample collected from Well #1 on 4/29/1997, except nitrate + nitrite, which was collected from Well #1 on 8/30/2005

[d] Sample collected from Well #1 on 7/9/1997, except nitrate + nitrite, which was collected from Well #2 on 8/17/2005

[e] Sample collected from Well #1 on 8/27/1997, except nitrate + nitrite, which was collected from Well #1 on 11/2/2004

[f] Sample collected from Well #1 on 7/1/1997, except nitrate + nitrite, which was collected from Well #1 on 5/5/2005

[g] Sample collected from Entry Point on 9/12/2002, except nitrate + nitrite, which was collected from Well #4 on 8/30/2005

[h] Sample collected from Well #1 on 6/18/1997, except nitrate + nitrite, which was collected from Well #1 on 12/16/2005

[i] Sample collected from Well #1 on 8/28/2000, except nitrate + nitrite, which was collected from Well #1 on 10/25/2005

[j] National Secondary Drinking Water Regulations

Source: NMED, 2005f

mg/L = Milligrams per liter
MCL = Maximum contaminant level
NTU = Nephelometric turbidity units
NS = No standard established
--- = Information not available
TON = Threshold odor numbers
MBAS = Surfactants via measurement of the methylene blue index

5.4.3.3 South Subregion

Review of unpublished water well data compiled by the Taos SWCD indicates that:

- Nitrate was detected in most samples, but was above the drinking water standard of 10 mg/L in only one sample at an abandoned MDWCA well.

- Arsenic was detected in some of the samples collected; only one well at Pilar (along a fault) exceeded the recently enacted EPA drinking water standard of 0.01 mg/L.

- Uranium was detected at concentrations below 0.02 mg/L in almost all of the samples collected, but none of the concentrations exceeded the drinking water standard.

- Fluoride was detected at levels below the secondary drinking water standard in almost all samples collected, with one sample exceeding only the secondary standard of 2.0 mg/L and two samples, both on faults, exceeding the primary drinking water standard of 4.0 mg/L.

The completed WRAS document that specifically addresses areas within the South subregion is the Pilar section of the Upper Rio Grande WRAS. Key surface water quality issues identified by this document include (Atencio et al., 2006):

- Sediment and nutrient contamination from excessive livestock and wildlife grazing
- Nutrient contamination from septic systems
- Sediment erosion from road cuts along State Highway 68 and other paved roads
- Wetlands, riparian, and stream impacts from dense and poorly regulated development

A WRAS document is also being prepared for the Embudo Creek watershed, but this document is not yet available.

Data posted on the NMED Drinking Water Bureau web site (summarized in (Table 5-24) indicate that the communities of Dixon, Llano, Ojo Sarco, Rio Lucio, Rodarte, Trampas, and Cañoncito have no water quality concerns, while gross beta contamination is a concern in Peñasco, and gross alpha, gross beta, and uranium contamination are of concern in Chamisal.

Table 5-24. Water Quality in the South Subregion

Water Quality Parameter	Concentration (mg/L[a])									
	MCL	Chamisal[b]	Dixon[c]	Llano[d]	Ojo Sarco[e]	Peñasco[f]	Rio Lucio[g]	Rodarte[h]	Trampas[i]	Cañoncito[j]
Turbidity (NTU)	1	0.03	0.08	0.14	0.11	1.91	---	0.06	2.5	0.23
Calcium	NS	44.2	81.6	75.5	50	73.1	75	53.7	62.8	50.8
Chloride	250[k]	10	6.5	23.3	4.7	4	---	3.5	10.5	---
Magnesium	NS	11.2	5.7	9.73	8.2	5.5	9.05	8.7	9	5.02
Potassium	NS	6.65	---	5	1.8	2.8	---	4.4	2.5	1.9
Sulfate	250[k]	21.5	24.6	24.1	12	16	---	21	10	14
Hardness, calcium/ magnesium	NS	156	227	229	158	205	---	170	194	147
Odor (TON)	3[k]	0	1	0	1	1	---	1	1	0.05
pH	6.5-8.5[k]	8.11	7.33	8.1	7.66	7.3	---	7.23	7.19	7.94
Alkalinity, total	NS	240	229.4	198	173.5	214	---	178	189	144
Solids, total dissolved (TDS)	500[k]	350	283	314	199	307	---	275	252	190
MBAS surfactants	0.5[k]	0.01	0.025	0.01	0.025	0.025	---	0.025	0.025	0.01
Nitrate+Nitrite (as N)	10	1.1	0.36	0.86	0.3	0.65	1.7	0.83	1.4	0.64

[a] Unless otherwise noted

[b] Sample collected from Well #1 on 10/8/1997, except nitrate+nitrite, which was collected from Well #1 on 10/19/2005

[c] Sample collected from Well #1 on 2/4/1997, except nitrate+nitrite, which was collected from Well #1 on 12/20/2005

[d] Sample collected from Well #1 on 8/6/1997, except nitrate+nitrite, which was collected from Well #1 on 5/16/2005

[e] Sample collected from Well #1 on 11/8/2000, except nitrate+nitrite, which was collected from Well #2 on 10/19/2005

[f] Sample collected from Well #1 on 2/25/1997, except nitrate+nitrite, which was collected from Well #1 on 5/16/2005

[g] Sample collected from Well #1 on 4/22/1998, except nitrate+nitrite, which was collected from Well #1 on 5/16/2005

[h] Sample collected from Well #1 on 5/15/1997, except nitrate+nitrite, which was collected from Well #1 on 5/16/2005

[j] National Secondary Drinking Water Regulations

Source: NMED, 2005f

mg/L = Milligrams per liter
MCL = Maximum contaminant level
NTU = Nephelometric turbidity units
--- = Information not available
NS = No standard established
TON = Threshold odor numbers
MBAS = Surfactants via measurement of the methylene blue index

5.4.3.4 West Subregion

Review of unpublished water well data compiled by the Taos SWCD indicates that:

- Nitrate was detected in most samples, but none of the concentrations exceeded the drinking water standard.

- Arsenic was detected at levels below 0.01 mg/L in most of the samples collected, with a few samples exceeding the drinking water standard; one sample from near Ojo Caliente Hot Springs exceeded the drinking water standard by over five times. Arsenic and other major ion and trace mineral contamination has been detected at other water wells southward down the Rio Ojo Caliente Valley from the hot springs (Benson, 2007).

- Uranium was detected at concentrations above 0.02 mg/L in almost all of the samples collected, and the concentration in three of the samples exceeded the drinking water standard of 0.03 mg/L.

- Fluoride was detected at levels below the secondary drinking water standard of 2.0 mg/L in almost all samples collected, and two samples along the Rio Ojo Caliente fault zone exceeded the primary drinking water standard of 4.0 mg/L.

The Greater World Community section of the Upper Rio Grande WRAS identified turbidity and erosion from runoff as the key surface water quality issues for the watershed (Atencio et al., 2006).

Data posted on the NMED Drinking Water Bureau web site indicate that turbidity is a concern in Tres Piedras and TDS is a concern in the Rio Ojo Caliente valley (Table 5-25).

Table 5-25. Water Quality in the West Subregion

Water Quality Parameter	MCL	Ojo Caliente [b]	Durane y Gavilan (Ojo Caliente) [c,d]	Tres Piedras [e]
Turbidity (NTU)	1	---	0.34	15.5
Calcium	NS	---	35.4	50.1
Chloride	250 [f]	83.4	68.3	11.5
Magnesium	NS	29.8	19.5	9.87
Potassium	NS	---	6	5
Sulfate	250 [f]	149	131	16.2
Harness, calcium/magnesium	NS	---	169	166
Odor (TON)	3 [f]	---	1	0
pH	6.5-8.5 [f]	---	7.38	8.09
Alkalinity, total	NS	---	309.4	173
Solids, total dissolved (TDS)	500 [f]	---	671	270
MBAS surfactants	0.5 [f]	---	---	0.01
Nitrate+nitrite (as N)	10	0.54	1.2	0.88

[a] Unless otherwise noted

[b] Sample collected from Well #1 on 3/4/1998, except nitrate+nitrite, which was collected from Well #1 on 11/2/2005

[c] Sample collected from Well #2 on 7/11/2001, except nitrate+nitrite, which was collected from Well #1 on 10/26/2005

[d] Located several miles south of Ojo Caliente, just outside the subregion.

[e] Sample collected from Well #2 on 8/26/1997, except nitrate+nitrite, which was collected from Well #2 on 12/6/2005

[f] National Secondary Drinking Water Regulations

Source: NMED, 2005f

mg/L = Milligrams per liter
MCL = Maximum contaminant level
NTU = Nephelometric turbidity units
NS = No standard established
--- = Information not available
TON = Threshold odor numbers
MBAS = Surfactants via measurement of the methylene blue index