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of Water Resources
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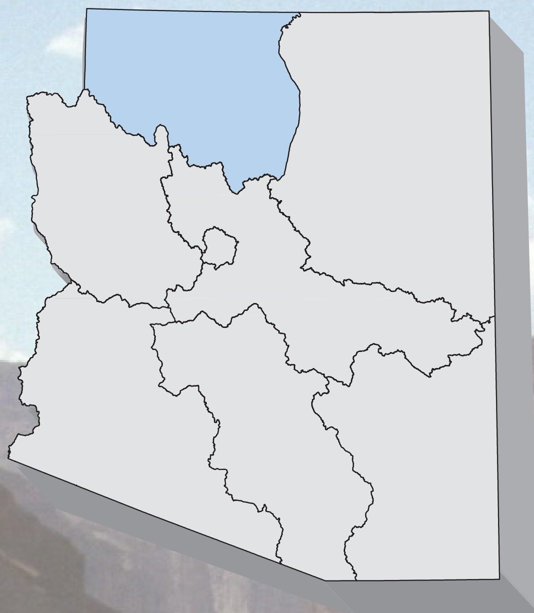
ARIZONA WATER ATLAS

VOLUME 6

WESTERN PLATEAU PLANNING AREA



ACKNOWLEDGEMENTS

Herbert Guenther
Director, Arizona Department of Water Resources

Karen Smith
Deputy Director, Arizona Department of Water Resources

Tom Carr
Assistant Director, Statewide Water Conservation and Strategic Planning

Sandra Fabritz-Whitney
Assistant Director, Water Management

Atlas Team
Linda Stitzer, Rich Burtell – Project Managers
Phyllis Andrews
Carol Birks
Kelly Mott Lacroix
Joe Stuart

Major Contributors
John Fortune
Leslie Graser
William H. Remick
Saeid Tadayon-USGS

Other Contributors
Matt Beversdorf
Roberto Chavez
Laura Grignano (Volume 8)
Mark Preszler
Jeff Tannler (Volume 8)
Dianne Yunker
Patrick Brand
Jenna Gillis
Pam Nagel (Volume 8)
Kenneth Seasholes (Volume 8)
Larri Tearman

Climate
Gregg Garfin - CLIMAS, University of Arizona
Ben Crawford - CLIMAS, University of Arizona
Casey Thornbrugh - CLIMAS, University of Arizona
Michael Crimmins – Department of Soil, Water and Environmental Science, University of Arizona

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Special note about the Atlas Team
Completion of the Atlas would not have been possible without the dedicated professionals that compose the Atlas Team. Most have been involved with the project from its inception in 2003 and their contributions to the success of the project cannot be overstated.

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ARIZONA WATER ATLAS
VOLUME 6 – WESTERN PLATEAU PLANNING AREA

Preface

Volume 6, the Western Plateau Planning Area, is the sixth in a series of nine volumes that comprise the Arizona Water Atlas. The primary objectives in assembling the Atlas are to present an overview of water supply and demand conditions in Arizona, to provide water resource information for planning and resource development purposes and help to identify the needs of communities. The Atlas also indicates where data are lacking and further investigation may be needed.

The Atlas divides Arizona into seven planning areas (Figure 6.0-1). There is a separate Atlas volume for each planning area, an executive summary volume composed of background information, and a resource sustainability volume. "Planning areas" are an organizational concept that provide for a regional perspective on supply, demand and water resource issues. A complete discussion of Atlas organization, purpose and scope is found in Volume 1. Also included in Volume 1 is general background information for the state, a description of data sources and methods of analysis for the tables and maps presented in the Atlas, and appendices that provide information on water law, management and programs, and Indian water rights claims and settlements.

There are additional, more detailed data available to those presented in this volume. They may be obtained by contacting the Arizona Department of Water Resources (Department).

6.0 Overview of the Western Plateau Planning Area

The Western Plateau Planning Area is composed of six groundwater basins located in northwestern Arizona. About half of the planning area lies in the part of Arizona north of the Colorado River referred to as the "Arizona Strip". The planning area contains large tracts of federally protected lands including almost all of Grand Canyon National Park. Elevations range from over 12,000 feet on the San Francisco Peaks to about 1,200 feet at Lake Mead. Nearly half (46%) of Coconino County and 38% of Mohave County are contained within the planning area as well as all or portions of four Indian reservations including the Havasupai, Hualapai, Kaibab-Paiute and Navajo.

The planning area is relatively sparsely populated. The 2000 Census planning area population was approximately 17,500 with basin population ranging from just 12 in the Shivwits Plateau Basin to over 9,100 in the Coconino Plateau Basin. Colorado City is the largest community with about 4,150 residents in 2006. Other population centers include Williams, Fredonia, Grand Canyon Village, the Beaver Dam/Littlefield area, and Cameron on the Navajo Reservation.

Between 2001 and 2005, an average of over 9,600 acre-feet of water was used annually in

Agriculture in the Kanab Plateau Basin. Agriculture is the largest water user in the Planning Area

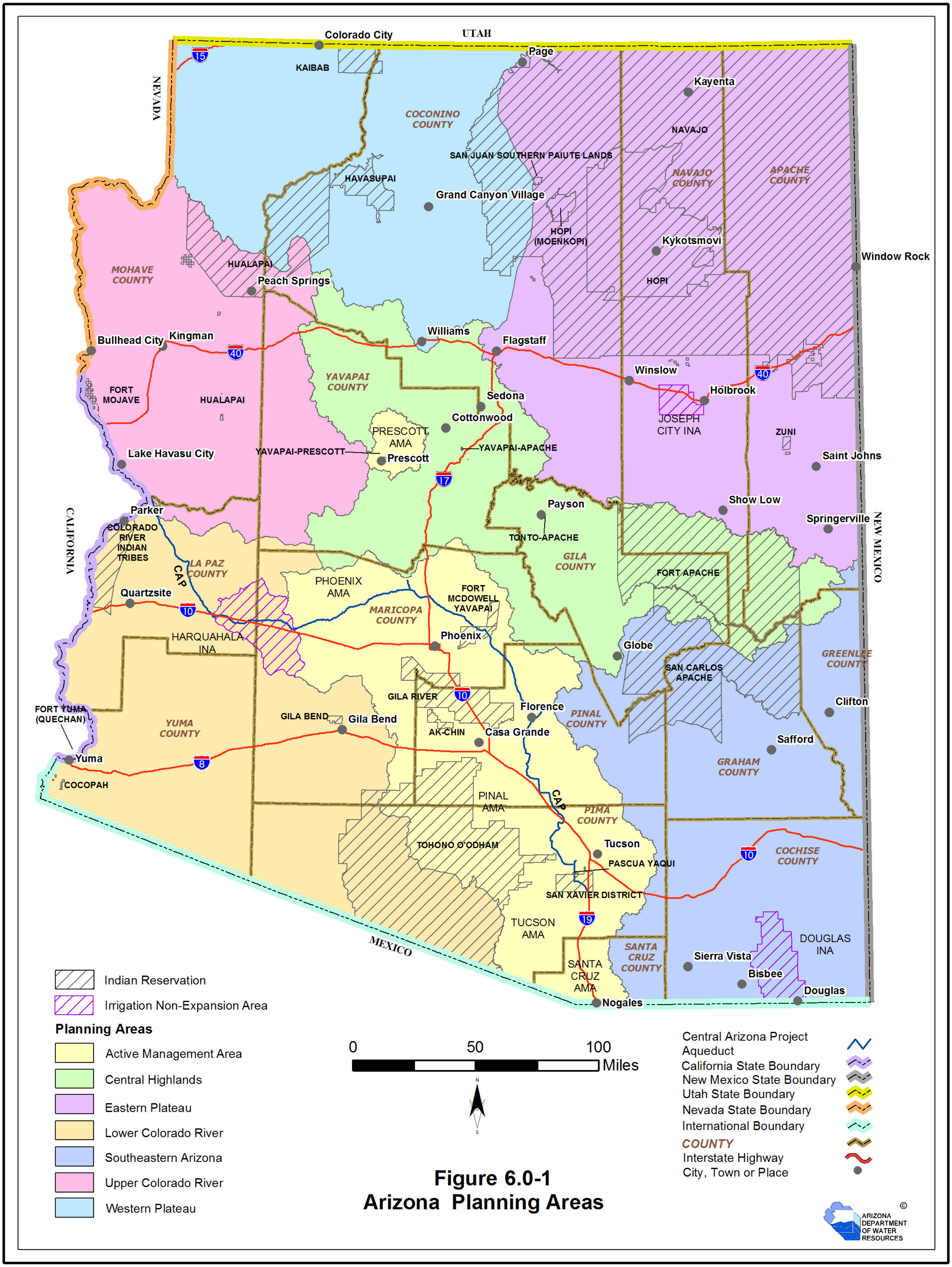


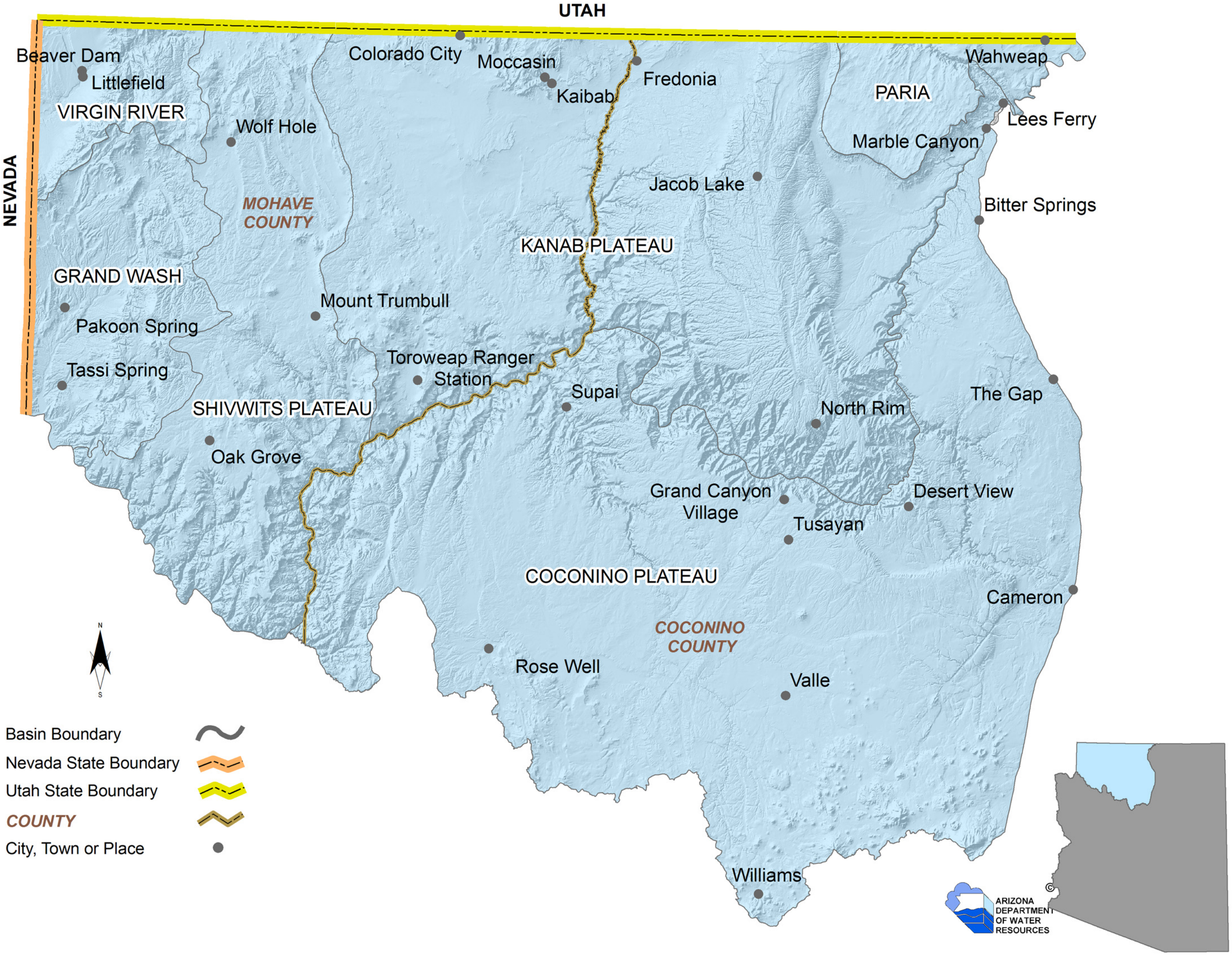
Figure 6.0-1
Arizona Planning Areas

the planning area for agricultural, municipal and industrial uses (cultural water demand). Of this total demand, approximately 6,000 acre-feet was from well pumpage, 3,300 acre-feet was from surface water diversions and almost 300 acre-feet was effluent reuse. Agriculture was the largest demand sector with approximately 4,600 acre-feet of demand a year or 52% of the total demand. The municipal sector demand averaged about 4,000 acre-feet a year (AFA) and industrial demand averaged almost 1,000 AFA.

6.0.1 Geography

The Western Plateau Planning Area covers about 13,700 square miles and includes the Coconino Plateau, Grand Wash, Kanab Plateau, Paria, Shivwits Plateau and Virgin River basins. Basin boundaries, counties and prominent cities, towns and places are shown in Figure 6.0-2. The planning area is bounded on the north by the State of Utah, on the east by the Eastern Plateau Planning Area, on the south by the Central Highlands and Upper Colorado River planning

Figure 6.0-2 Western Plateau Planning Area



areas and on the west by the State of Nevada (Figure 6.0-1). The planning area includes parts of three watersheds, which are discussed in Section 6.0.2. The Kaibab-Paiute Indian Reservation (188 square miles) and the Havasupai Indian Reservation (294 square miles) are located entirely within the planning area. In addition, the planning area includes the western portion of the Navajo Indian Reservation (1,177 square miles) and the northeastern portion of the Hualapai Indian Reservation (741 square miles) (Figure 6.0-1).

Almost all of the planning area is within the Colorado Plateau physiographic province characterized by generally horizontally stratified sedimentary rocks that have eroded into numerous incised canyons and high desert plateaus (Figure 6.0-3). The extreme western part of the planning area, encompassing the western portions of the Virgin River and Grand Wash basins, extends into the Basin and Range physiographic province, which is characterized by northwest-southeast trending mountain ranges separated by broad alluvial valleys. The Coconino Plateau Basin contains the largest elevational range in the planning area with elevations ranging from 1,400 feet where the Colorado River exits the basin in the Grand Canyon to over 12,000 feet in the San Francisco Peaks at the southeastern edge of the basin.

Figure 6.0-3 Physiographic Regions of Arizona

Data source: Fenneman and Johnson, 1946

A unique geographic feature of the planning area is the Grand Canyon, incised by the Colorado River and its tributaries over a 5-6 million year period. The average depth of the canyon is 4,000 feet over its 277 mile length, and 6,000 feet at its deepest point. Its average width is 10 miles. The geologic record at the Grand Canyon is unique in the variety of rocks and their exposure in the canyon walls, with nearly half of the earth's 4.6-billion-year history displayed (NPS, 2005).

Most rocks in the Grand Canyon date from the Paleozoic Era (550-250 million years ago) but there are scattered remnants of Precambrian Vishnu Schist as old as 2 billion years in age in the inner gorge. Western Plateau Plateau Planning Area geology including the location of Precambrian rocks in the Grand Canyon is shown in Figure 6.0-4. With the exception of Kaibab Limestone, younger Mesozoic and Cenozoic rocks (250 million years old to the present) are largely missing at Grand Canyon, having been either never deposited or worn away. The different rock layers in the canyon respond differently to erosion leading to the canyon's distinctive shape (NPS, 2005). Lava flows ranging in age from 1,000 to 1 million years old are found in the western part of the canyon.

The Grand Canyon and the Colorado River form a significant physical barrier between the Arizona Strip and the rest of the planning area and the state. Highway 89A at Navajo

Bridge and Highway 89 at Glen Canyon Dam are the only highways that span the Colorado River linking the Arizona Strip to the rest of the state. By contrast, there are a number of road links between the Arizona Strip and Utah. As a result, the Arizona Strip has strong historic, cultural and economic ties to Utah.

South and east of the Colorado River, the Coconino Plateau marks the southern edge of the Colorado Plateau which covers 130,000 square miles across southeastern Utah, northern Arizona, northwestern New Mexico, and western Colorado. The Coconino Plateau stretches east toward the Colorado River surface water divide and south to the Mogollon Rim, which is less well defined to the northwest, and defines the southern boundary of the Coconino Plateau Basin. Most of the Coconino Plateau is above 5,000 feet in elevation and consists of low hills, mesas, broad valleys and lava flows in the southern portion. The plateau is defined by large elevational changes along its margins, notably the south rim of the Grand Canyon (Bills and others, 2007).

In the northwest corner of the planning area, the Virgin River cuts through the Beaver Dam Mountains creating the Virgin River Gorge. West of the gorge, the topography abruptly changes to a broad alluvial valley with numerous washes that drain the upland and mountain areas. The Virgin Mountains, south of the river, form the southwest edge of the Colorado Plateau.

Vermilion Cliffs, Kanab Plateau Basin. The planning area includes numerous high plateaus, steep cliffs and deeply incised canyons.

Other significant geographic features are numerous high plateaus, steep cliffs, deeply incised canyons and few surface water features.

6.0.2 Hydrology[1]

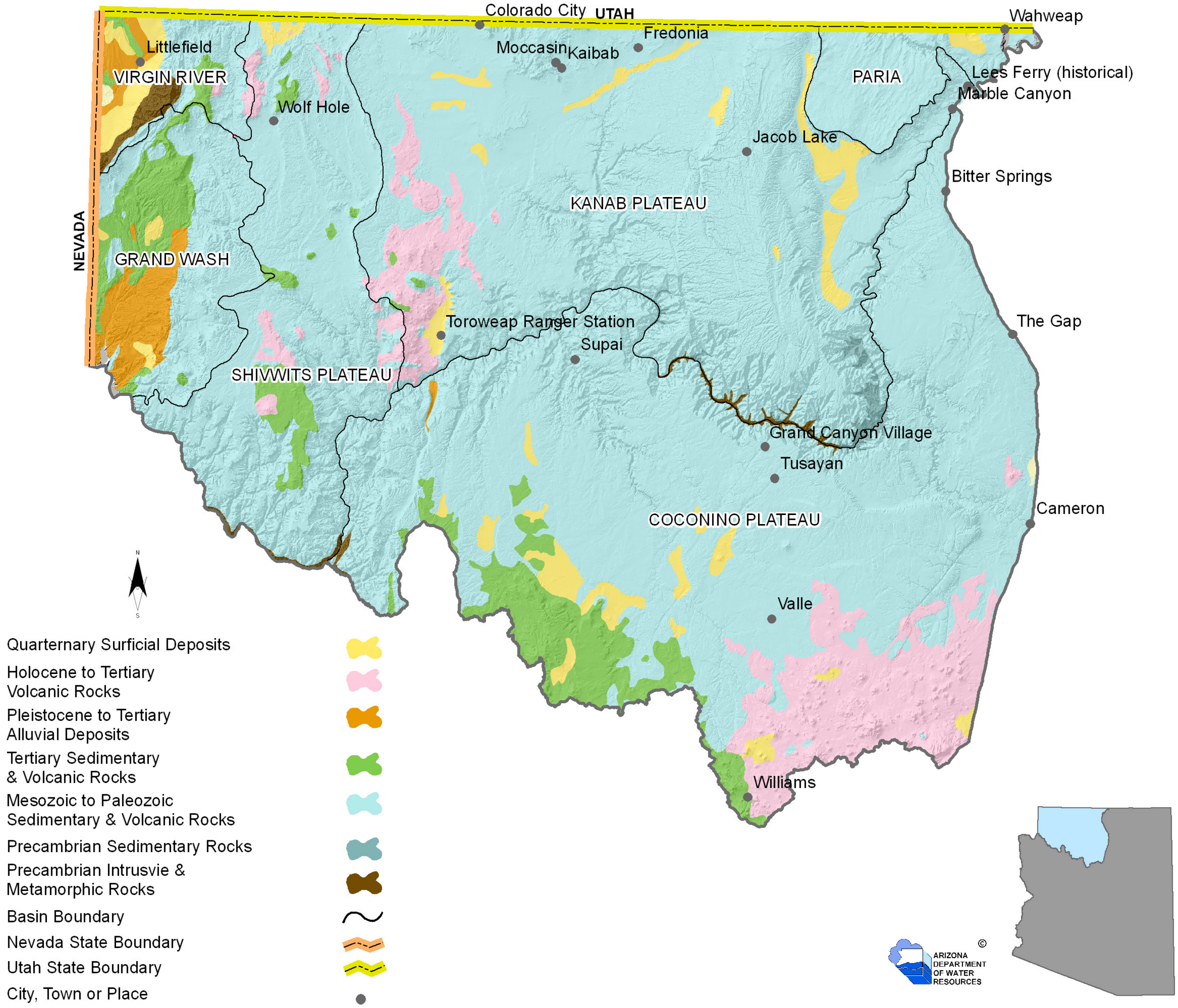
Groundwater Hydrology

The Western Plateau Planning Area is characterized by relatively flat-lying, alternating sequences of sandstones, limestones and shales. As shown in Figure 6.0-4, Mesozoic to Paleozoic sedimentary and volcanic rocks cover most of the planning area. Faults and folds in these rocks affect groundwater movement along the regional gradient. The westernmost basins contain basin-fill sediments that consist of silt, sand and gravel. The characteristics of regional and local aquifers in the planning area are described below.

<u>Coconino Plateau Basin</u>
The Redwall-Muav (R or limestone) aquifer is the primary water-bearing unit of the Coconino Plateau Basin. The Kaibab, Coconino and Supai formations comprise the regional Coconino Aquifer (C-aquifer) that overlies the R-aquifer. The Moenkopi Formation volcanic rocks and unconsolidated sediments overlie the C- and R-aquifers and provide locally important sources of water. A generalized stratigraphic section of the Coconino Plateau that illustrates the relationship between these various units is shown on Figure 6.0-5. Perched aquifer zones in association with volcanic rocks occur primarily in the central and southern part of the basin and in consolidated sedimentary rocks west and northwest of the volcanic fields. These perched aquifers are dependent on recharge

[1] Except as noted, much of the information in this section is taken from the Arizona Water Resources Assessment, Volume II, ADWR August, 1994. (ADWR 1994)

Figure 6.0-4 Surface Geology of the Western Plateau Planning Area
(Based on Reynolds, 1988)

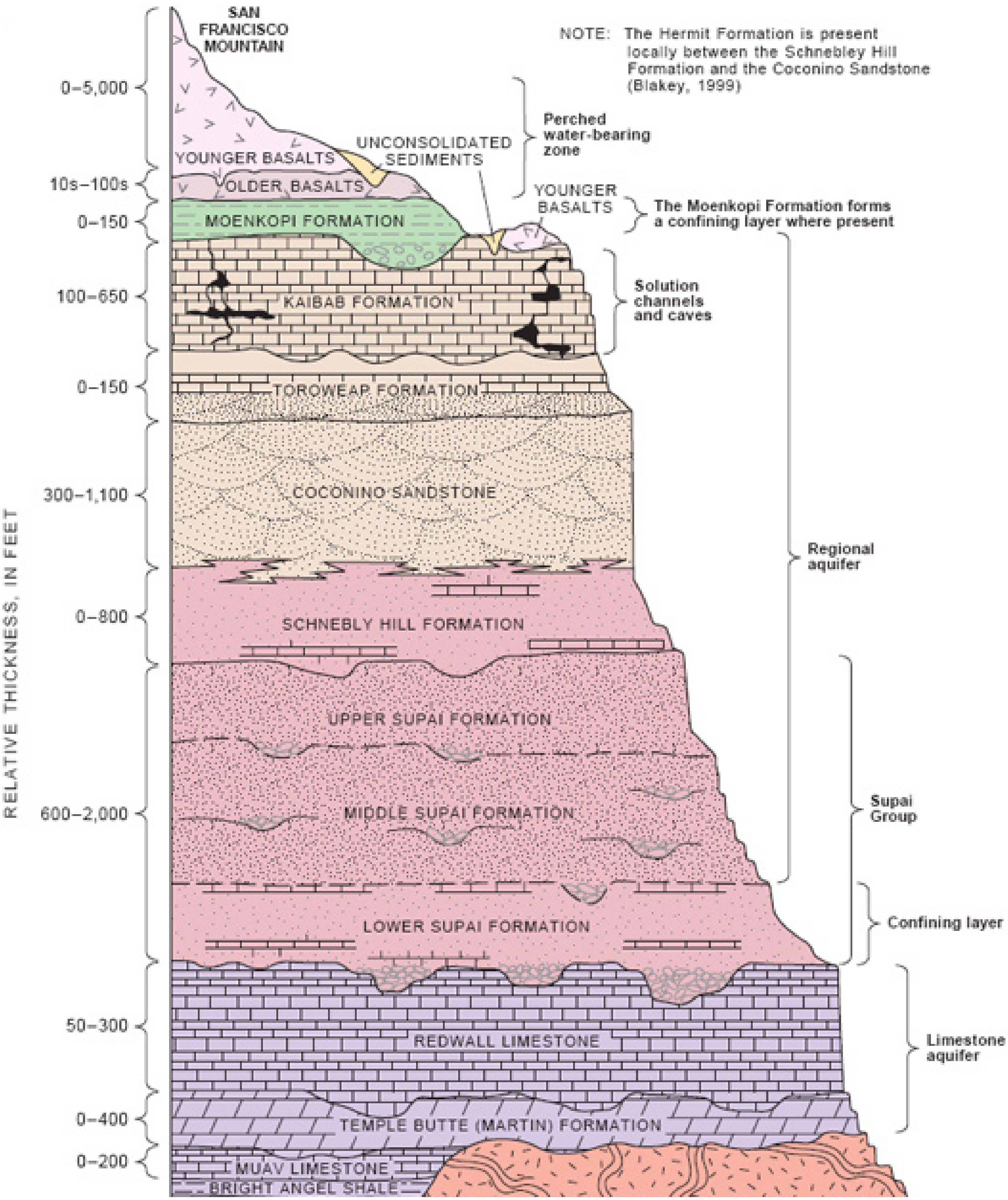


from precipitation and runoff and may be undependable water supplies. An exception is the "Inner Basin Aquifer" of the San Francisco Peaks where a water-bearing zone is contained in glacial outwash and volcanic rocks and is used by the City of Flagstaff as a water supply (USBOR, 2006).

The R-aquifer underlies the entire Coconino Plateau Basin with depths of greater than 3,000 feet below land surface (bls) in most areas (Bills and others, 2007). Relatively few wells have been completed in the R-aquifer in the basin due to its extreme depth. In the northeast part of the basin, the R-aquifer is in partial hydraulic connection with the C-aquifer through faults and other fractures. Shale units within the R-aquifer impede downward flow.

The C-aquifer, consisting of hydraulically connected sandstones, limestones and shales occurs primarily in the eastern portion of the basin. Although perched zones occur, it is largely drained of water in the rest of the

Figure 6.0-5 Generalized stratigraphic section of the Coconino Plateau, Arizona
(Bills and Flynn, 2002)



basin, coincident with the northeast-southwest trending Mesa Butte Fault (Bills and others, 2007). Infiltration of precipitation through volcanic rocks and the Kaibab Formation is the primary source of recharge to the C-aquifer.

Lateral movement of groundwater in the R- and C- aquifers occurs through fracture zones and solution cavities. In the northeastern portion of the Coconino Plateau Basin, groundwater moves relatively rapidly from the C-aquifer to the R-aquifer through solution channels and fractures (USBOR, 2006). Regional flow is generally northward toward the Grand Canyon where springs discharge along the Little Colorado and Colorado rivers and Havasu Creek (see Figure 6.1-7). Widely-spaced faults and folds also affect groundwater movement in the region. The Mesa Butte Fault and the Cataract Syncline direct flow to major discharge areas on the lower Little Colorado River at Blue Springs and in Cataract Canyon (Montgomery and others, 2000). The Blue Springs area is considered the primary groundwater drain from the Little Colorado River Basin, although the primary source of the water is not well known (Hart, and others, 2002). Local flow characteristics are poorly understood because of the complex geologic structure and because aquifer depths limit exploratory drilling and testing. The varying chemistry of springs and residence time for groundwater discharge suggests that water discharging from the R-aquifer is from many different recharge areas and follows different flow paths. (USBOR, 2006)

An annual natural recharge rate is not available for the basin. ADWR estimated that as much as 3.0 million acre-feet (maf) of water may be stored in basin aquifers based on assumptions by Montgomery and others (2000) of the plateau's area of about 10,000 sq. mi., average saturated thickness of 800 feet and an average specific yield of 0.1%. Their study area was larger than the basin but included most of it. Well yields in the basin are relatively low and depend on the occurrence of fractures, faults and solution channels. The median of well yields reported from 16 large diameter (>10 inches) wells was 45.5 gallons per minute (gpm).

Water levels in basin wells are typically quite deep. Tusayan's water supply plan reports water level depths of 2,347 and 2,425 feet in two system wells with well yields of 65-80 gpm (HydroResources, 2007). While water has been found in perched aquifers near Williams at depths less than 950 feet bls, yields from these more shallow wells are generally less than five gpm. At Williams, three of the four water system wells are drilled to depths exceeding 3,500 feet bls. Water level depths in these wells

City of Williams. At Williams, three of four water system wells are drilled to depths exceeding 3,500 feet bls.

are between 2,740 and 2,875 feet. Water in the deepest of the Williams wells is of poor quality with elevated metal concentrations, including arsenic, and high corrosivity (City of Williams, 2007).

Pipe Springs National Monument. Water bearing units in this area include alluvium, Navajo Sandstone, the Kayenta and Moenave formations and the Shinarump Formation

Water quality is generally good in the basin but poor locally where there is leakage from overlying units or other factors. Water quality in the upper and middle parts of the C-aquifer is good, but generally degrades due to salts at increasing depths. Most of the water quality data shown in Table 6.1-7 is from springs where elevated levels of arsenic and total dissolved solids (TDS) were most commonly detected.

<u>Grand Wash Basin</u>

The Grand Wash Basin in the western part of the planning area is located along the boundary of the Colorado Plateau and Basin and Range physiographic regions. Groundwater is found in recent stream alluvium, basin fill, and sedimentary rocks of the Muddy Creek Formation and underlying Cottonwood Wash Formation. The Muddy Creek Formation is composed of siltstones, sandstones and conglomerates with interbedded basaltic lavas in the northern part of the basin. The Cottonwood Wash Formation is composed of sandstones and siltstones.

There is a relatively well-defined basin-fill aquifer interbedded with basalt flows between Grand Wash and Gyp Wash (located west of the Grand Wash Cliffs, see Figure 6.2-1). This aquifer is underlain by the Muddy Creek Formation, which restricts the downward movement of water. This area was identified as favorable for groundwater development in a geohydrologic reconnaissance study of Lake Mead National Recreation Area conducted by the USGS (Bales and Laney, 1992).

Data on groundwater flow direction, annual natural recharge rate and groundwater in storage is not available for the basin. Recharge from precipitation or local surface runoff is assumed to be small. In the southwestern corner of the basin, surface water from Lake Mead has saturated adjacent rocks and deposits in quantities greater than pre-lake conditions. This saturated zone is estimated to extend less than half a mile inland from the lake (Bales and Laney, 1992).

Only 12 wells are registered in the basin. A median well yield is not available. Well yields were estimated to range from 0-500 feet by Anning and Duet (1994). Two wells measured in the basin report water level depths ranging from about 20 feet to over 500 feet bls (see Figure 6.2-6). Water quality is generally good although total dissolved solids concentrations equal or exceed drinking water standards at several springs (Table 6.2-4).

<u>Kanab Plateau Basin</u>

The Kanab Plateau Basin is characterized by high plateaus, plains and incised canyons. The basin contains a flat-lying to gently sloping sequence of alternating sandstones, limestones and shales. Groundwater is found in several aquifers composed of these sedimentary rocks, which are generally isolated and not hydraulically connected. Water bearing units in the vicinity of Pipe Spring National Monument include alluvium, Navajo Sandstone, the Kayenta and Moenave formations, and the Shinarump Formation (Truini and others, 2004). Groundwater also occurs in recent stream alluvium, including the Cane Beds area west of Moccasin.

Within the sedimentary rock aquifers, faults act as conduits for vertical and lateral groundwater movement. Major faults include the Toroweap and Sevier faults. Regional groundwater flow direction, annual natural recharge rate and groundwater storage data are not available for the basin. The median well yield reported for ten large diameter (>10gpm) wells was 70 gpm. Hydrographs are available for two basin wells - one completed in the Kayenta Formation at Moccasin, with a recent water level of 87 feet bls, and a second completed in "sedimentary rock" south of Fredonia with a recent water level of 611 feet bls (Figure 6.3-7). Elevated levels of TDS and lead have been measured at some well and spring sites (Table 6.3-7) although water quality is generally good for most uses.

<u>Paria Basin</u>

The geologic structure of the Paria Basin is typical of the Colorado Plateau with a gently-sloping sequence of limestone, sandstone and shale formations. The principal aquifer is the N-aquifer composed of Navajo Sandstone and the Kayenta and Moenave formations. In places on the Paria Plateau, precipitation collects in sand deposits in limited quantities and may be recovered from shallow wells (Bush and Lane, 1980). Groundwater movement is generally from south to north with discharge at springs in Paria River Canyon. Some groundwater moves south toward the Vermilion Cliffs, which form the southern basin boundary. An annual natural recharge rate is not available for the basin. Groundwater in storage is estimated at 1.5 maf.

Little groundwater development has occurred with only 12 wells registered in the basin. Department data indicate well yields ranging from 30 to 1,400 gpm with a median well yield of 520 gpm for three large diameter (>10gpm) wells. The two largest yields come from wells completed in sedimentary rocks. Water levels in basin wells are relatively deep, ranging from about 480 feet to 1,500 feet bls. Arsenic concentrations above the drinking water standard have been measured at a number of wells in the Wahweap area (see Table 6.3-7).

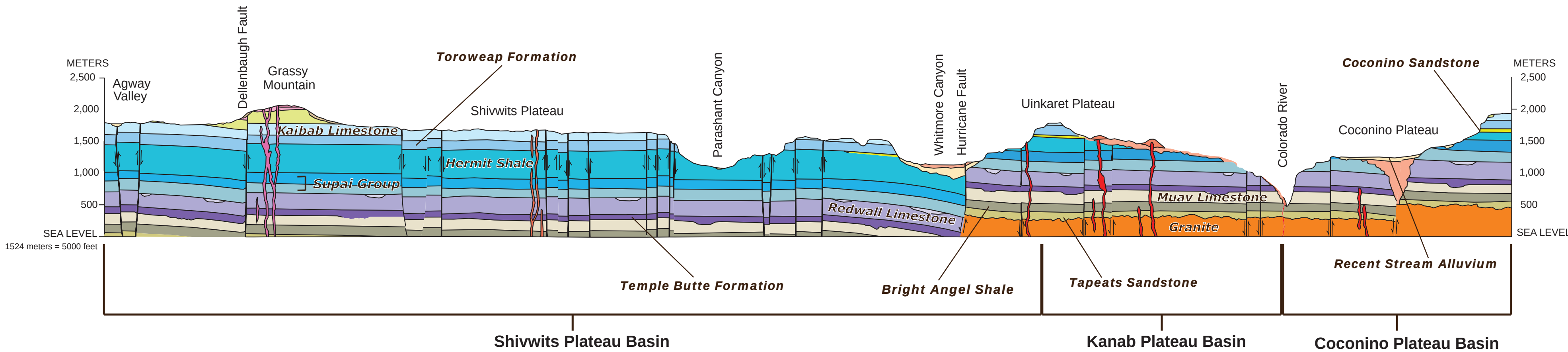
<u>Shivwits Plateau Basin</u>

Most of the Shivwits Plateau Basin is high plateau with elevations of 4,000 to 6,000 feet. The basin contains an alternating sequence of limestones, sandstones and shales with alluvial sands and gravels along larger washes and canyons. Figure 6.0-6 shows a cross section of the geology in the Shivwits Plateau, Kanab Plateau and the western portion of the Coconino Plateau basins. The cross section begins in the west-central portion of the Shivwits Plateau Basin (T33N, R12W) and follows a southeastern diagonal across the Shivwits Plateau and Kanab Plateau basins, ending just across the Colorado River in the Aubrey Cliffs in the Coconino Plateau Basin (T32N, R7W). The cross section provides the general location of the water bearing units beneath the region and their depth and thickness in particular areas. The diagram also shows the impact of the Hurricane Fault on the cross section occurrence of the geologic units.

Stream alluvium is the major aquifer in the basin but well yields are relatively low. A number of dry wells have reportedly been drilled into the sedimentary rocks but some encountered water in faults and fractures. Groundwater recharge occurs from infiltration of rainfall and snowmelt. Data on groundwater flow direction, annual natural recharge rate and groundwater in storage is not available for the basin.

There are only 18 registered wells in the basin. Department data indicate well yields ranging from 0 to 45 gpm with a median well yield of 5

Figure 6.0-6 Geologic cross section of the Shivwits Plateau, Kanab Plateau and Coconino Plateau Basins (modified from Billingsley and Welmeyer, 2003)



gpm for 17 large diameter (>10gpm) wells. Recent water levels in wells range from 10 feet bls to over 960 feet bls (see Figure 6.5-7). Water from springs and seeps is generally of better quality than well water, although the arsenic level at one spring exceeded the drinking water standard (Table 6.5-4).

Virgin River Basin

Located in the northwestern corner of Arizona, the Virgin River Basin contains a broad alluvial valley in the western half and the relatively high elevation Beaver Dam and Virgin Mountains in the south and east. Principal aquifers are basin fill in the Virgin River Valley and Beaver Dam Wash, and the Muddy Creek Formation. The mountainous portions of the basin are underlain by sedimentary and igneous rocks with little groundwater development.

The basin-fill aquifers are composed of a younger floodplain unit and an older underlying unit of semi-consolidated silts, sands, gravels and boulders. In the Virgin River Valley, the basin-fill aquifer contains floodplain and terrace alluvium southwest of Littlefield and includes alluvial-fan deposits from the Virgin Mountains. Groundwater is unconfined and flows toward the southwest. In Beaver Dam Wash, the basin-fill aquifer is largely isolated from other water bearing units in the basin and is also unconfined. Groundwater flow is toward the Virgin River Valley.

The Muddy Creek Formation consists of a series of siltstones, sandstones and conglomerates that is utilized as a water supply in the western part of the basin and by the City of Mesquite, Nevada adjacent to the basin along Interstate 15 (Black and Rascona, 1991). It is several thousand feet thick in places and covers the land surface over much of the basin north of the Virgin River. The Muddy Creek Formation is underlain by saturated Paleozoic carbonate rocks. South of the Virgin River, alluvial deposits from the Virgin Mountains overlie the Muddy Creek Formation.

Fault and fracture zones in the formation control groundwater movement and may have groundwater development potential (Dixon and Katzer, 2002).

Between Littlefield and the Virgin River Mountains and south of the Virgin River, a shallow, basin-fill aquifer overlies a limestone formation known locally as the Littlefield Formation. Few wells are completed in the shallow aquifer but a number of springs emanate from groundwater flowing over or through the Littlefield Formation (Black and Rascona, 1991).

Natural recharge is estimated at less than 30,000 AFA. Groundwater in storage is estimated to total 1.7 maf. Well yields range widely in the basin, as listed on Table 6.6-6, from a reported 10 gpm in the Virgin River basin-fill aquifer to over 5,000 gpm during a pump test in the Beaver Dam Wash basin-fill aquifer (Black and Rascona, 1991). The median of well yields reported from 53 large diameter (>10 inch) wells completed in the basin is 650 gpm. Water quality ranges from very good to poor, the latter due to elevated concentrations of arsenic, chloride, sulfate and total dissolved solids. Salt concentrations in groundwater increase downstream in the floodplain area along the Virgin River. Water quality data collected between 1997 and 2002 listed in Table 6.6-7 show elevated concentrations of arsenic, nitrate and radionuclides.

Virgin River Mountains and Virgin River Valley. Principal aquifers are basin fill in the Virgin River Valley and Beaver Dam Wash, and the Muddy Creek Formation.

Surface Water Hydrology

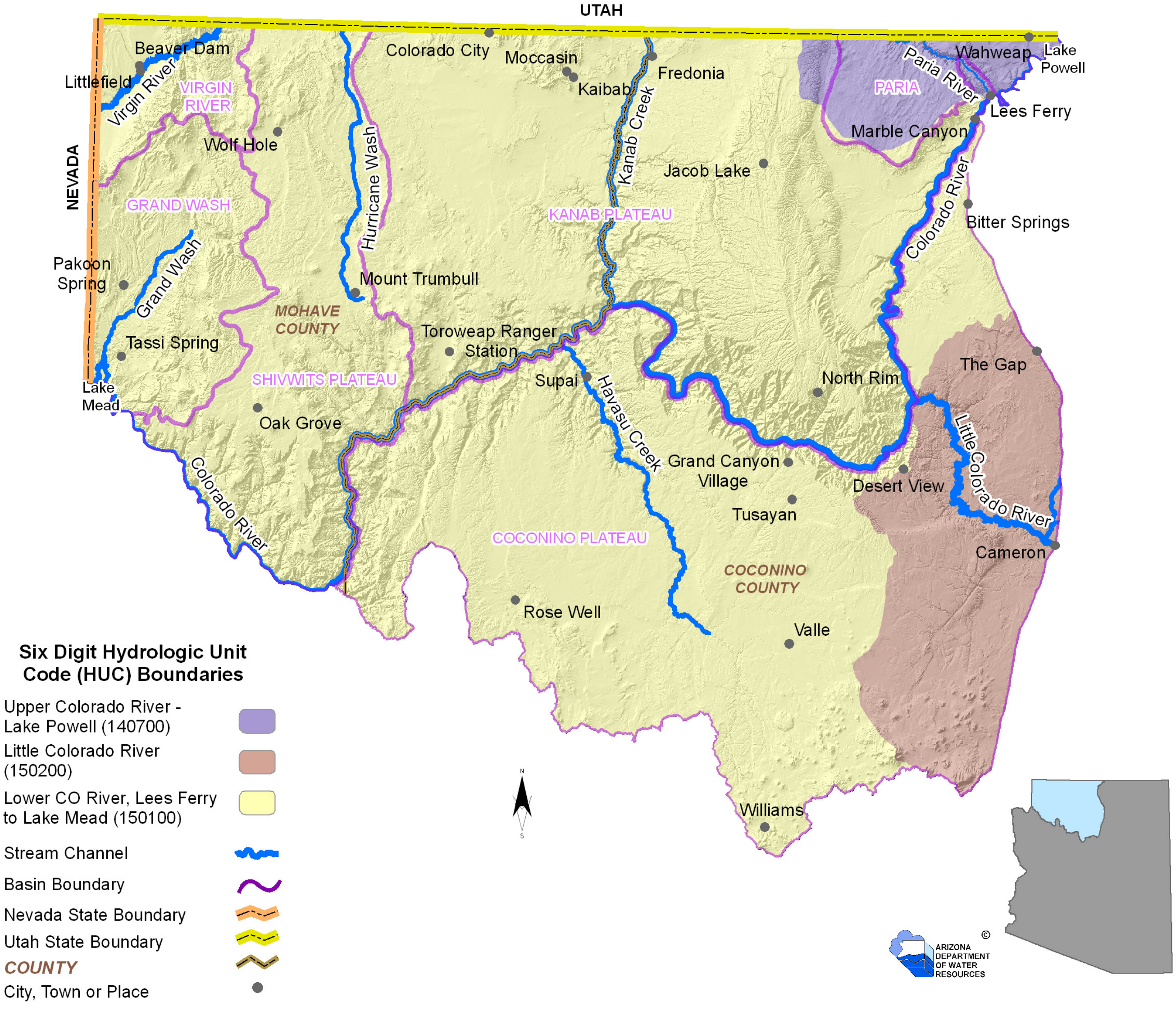
The U.S. Geological Survey (USGS) divides and subdivides the United States into successively smaller hydrologic units based on hydrologic features. These units are classified into four levels. From largest to smallest these are: regions, subregions, accounting units and cataloging units. A hydrologic unit code (HUC) consisting of two digits for each level in the system is used to identify any hydrologic area (Seaber et al., 1987). A 6-digit code corresponds to accounting units, which are used by the USGS for designing and managing the National Water Data Network. There are portions of three watersheds in the planning area at the accounting unit level: Upper Colorado River-Lake Powell; Little Colorado River; and Lower Colorado River, Lees Ferry to Lake Mead (Figure 6.0-7).

<u>Upper Colorado River-Lake Powell Watershed</u>
The boundary of the Upper Colorado River-Lake Powell Watershed in Arizona coincides generally with the Paria Basin boundary. It includes the Paria River Canyon and a small portion of the Kanab Plateau Basin. The Paria River originates in south-central Utah, draining an area of about 1,410 square miles before discharging to the Colorado River north of Lees Ferry. The annual flood series of the Paria River shows a decrease in flood peaks over the period 1909, 1924-2003. There have been no significant changes in basin diversions over this period, suggesting that construction of stockponds may be responsible (Webb and others, 2007).

The Paria River and the Colorado River are the only perennial streams in this portion of the watershed. The single streamflow gage in the watershed is located on the Paria River at Lees Ferry. With 79 years of record, the average annual flow is over 20,000 acre-feet and maximum flow was almost 48,000 acre-feet in 1980 (Table 6.3-2). There are two nearby gages on the west side of the Colorado River in the Eastern Plateau Planning Area; the Colorado River below Glen Canyon Dam and the Colorado River at Lees Ferry. The gage below Glen Canyon Dam was installed after dam construction and reflects regulatory/managed releases from Lake Powell. Prior to construction of the dam in 1963, the average flow was about 12.9 maf per year. The average annual flow at this gage is now 8.4 maf. Downstream, flow records at the gage on the Colorado River at Lees Ferry show an average annual flow of 20.3 maf. This gage has been in operation since 1921.

In May 1983, a heavy snowpack in the Upper Colorado River Basin combined with sudden warming and rainfall caused severe flooding along the Colorado River, forcing use of the Glen Canyon Dam spillways for the first time since dam completion in 1964. The total discharge peaked at 92,000 cubic feet per second (cfs) and the reservoir level topped out on July 15th, six feet below the crest of the dam (Hannon, 2003).

Figure 6.0-7 Western Plateau USGS Watersheds
(USGS, 2005)



By contrast, daily releases from Glen Canyon Dam in August 2009 were 13,000 cfs on average and, due to prolonged drought, the reservoir is projected to be at 65.8% capacity by the end of the water year on September 30, 2009 (USBOR, 2009). From 2000 though 2008, inflow to Lake Powell was below average in all but two years. Further, the average natural flow during this period for the Colorado River at Lees Ferry is the lowest nine-year average in over 100 years of record keeping on the Colorado River (USBOR, 2008).

Lake Powell provides water storage to meet flow obligations at Lees Ferry under the terms of the 1922 Colorado River Compact. (See Volume 1) The Compact apportioned to the Upper and Lower Basin states the beneficial consumptive use of 7.5 maf of water to each basin annually, measured at the Colorado River at the Compact Point near Lees Ferry. The reservoir has a total storage capacity of 27 maf, generally equivalent to the average annual flow of the Colorado River over a two-year period, making it the second largest reservoir in the country. The Glen Canyon Power Plant consists of eight generating units and provides most of the electrical energy generated by the Colorado River Storage Project. Total generating capacity is 1,296,000 kilowatts (USBOR, 2005).

There are no major springs (>10gpm) in the watershed although springs reportedly have supported domestic and stock watering uses in the Paria Basin (Bush and Lane, 1980). The Paria River has been identified as an impaired reach for its entire 29-mile length in Arizona, due to a high concentration of suspended sediments (ADEQ, 2005a), see Figures 6.3-10 and 6.4-9.

<u>The Little Colorado River Watershed</u>

The Little Colorado River Watershed extends over a large portion of northeastern Arizona, including most of the Eastern Plateau Planning Area. Within the Western Plateau Planning Area, this watershed covers the eastern portion of the Coconino Plateau Basin from The Gap and Desert View south toward Flagstaff. The Little Colorado River is the major drainage in the entire Coconino Plateau Basin, flowing east to west to join the Colorado River. The only perennial flow in this portion of the watershed is a 13-mile stretch of the Little Colorado River below Blue Springs.

Lake Powell near Wahweap. From 2000 though 2008, inflow to Lake Powell was below average in all but two years.

An active gage on the Little Colorado River at Cameron has been in operation since 1947. Flow is highest in the winter at this gage, with a median annual flow of over 138,000 acre-feet. Maximum annual flow at this gage was over 603,000 acre-feet in 1993 (see Figures 6.1-4 and 6.1-5 and Table 6.1-2).

The springs in the lower reach of the Little Colorado River, about 13 miles upstream of its confluence with the Colorado River, are sometimes collectively referred to as Blue Springs. Other sources refer to the main spring as Blue Spring. Discharge from the Blue Springs area is estimated at over 101,000 gpm, or about 164,000 AFA (Table 6.1-5). These springs emanate from solution channels in the R-aquifer while the discharge is thought to be downward leakage from the C-aquifer (Leake and others, 2005).

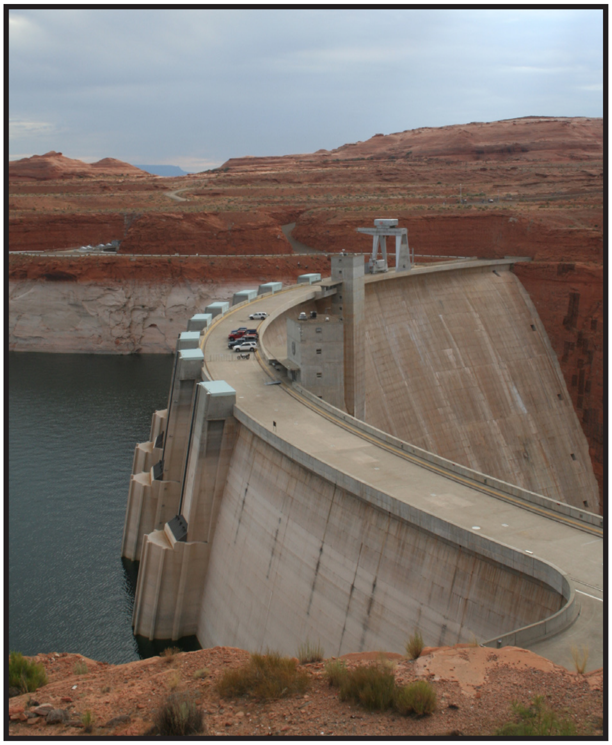
<u>Lower Colorado River, Lees Ferry to Lake Mead Watershed</u>

Most of the Western Plateau Planning Area is included in the Lower Colorado River, Lees Ferry to Lake Mead Watershed, which extends into the Upper Colorado River Planning Area. The watershed is drained by the Colorado River, which flows southwest from Lake Powell to Lake Mead. There are a number of perennial streams in the Kanab Plateau Basin that flow to the Colorado River including Kanab, Bright Angel, Nankoweap, Shinumo and Tapeats Creeks. None of these streams have flow gages. In the Coconino Plateau Basin, major perennial tributaries are Havasu and Diamond creeks. West of Diamond Creek, the only perennial flows are the Virgin River, which flows through the planning area from its headwaters in Utah to Lake Mead in Nevada, and an approximately one-mile reach of a tributary, Beaver Dam Wash.

Flow in the Colorado River downstream from Lake Powell is controlled by releases from Glen Canyon Dam, which has significantly impacted flow volumes and historic seasonal variations in flow as mentioned in the previous watershed discussion. There are five streamflow gages along the Colorado River in this watershed. The three easternmost gages are located above the Little Colorado River and near Bright Angel Creek (see Figure 6.3-5). These gages have varying periods of record and show average annual flows of 8.5 to 11.2 maf a year. A gage with 79 years of record (Colorado River near Grand Canyon, Table 6.3.2), the only pre-dam gage, has the highest mean flow (11.2 maf) and highest maximum flow of 20.5 maf in 1984. The two westernmost gages are located near Havasu Creek and Diamond Creek (see Figure 6.1-5) and are post-dam gages. The only currently operating gage (above Diamond Creek) has a similar flow regime to the other post-dam gages in the watershed with a mean flow of 10.4 maf and a maximum flow of 15.97 maf (Table 6.1-2).

Prior to construction of the Glen Canyon Dam, flow in the Colorado was highly unpredictable with wide year-to-year variability and spring flooding. Operation of the dam for electrical generation requires large water releases with daily and weekly fluctuations and releases during historically low flow seasons. Provisions of the Record of Decision (1996) for the Glen Canyon Dam Final EIS and the Glen Canyon Dam Operating Criteria (1997) set restrictions on daily and hourly flows. The maximum flow may not exceed 25,000 cfs except for beach/habitat-building flows, habitat maintenance flows, or when necessary during above average hydrologic conditions. Minimum flows are restricted to 5,000 to 8,000 cfs depending on the time of day. Further, daily fluctuation limits are 5,000 cfs to 8,000 cfs depending on monthly release volumes. (USBOR, 2008)

A tree-ring-based reconstruction of over 500 years of Colorado River streamflow found as many as eight droughts similar in severity to the



Glen Canyon Dam. Flow in the Colorado River downstream from Lake Powell is controlled by releases from the dam.

2000-2004 drought period. The reconstruction also suggests that the last 100-year period was wetter than the average for the last five centuries, and that average annual flows regularly vary from one decade to the next by more than 1.0 maf. The most severe sustained drought (based on the lowest 20-year average) in the Upper Colorado River basin apparently occurred in the last part of the 16th century. (Meko and others, 2007)

The other major river in the watershed is the Virgin River, which drains an area of about 6,100 square miles. The river flows from its headwaters north of Zion National Park in Utah to Lake Mead. Prior to construction of Hoover Dam it flowed to the Colorado River. Now, its lower 20-30 mile former reach has been inundated by the Overton Arm of Lake Mead. Dixon and Katzer (2002) estimated the Virgin River outflow to Lake Mead at 132,000 AFA.

The entire reach of the Virgin River within Arizona is perennial (AGFD, 1997). Reportedly, there were historic periods of no flow in the Virgin River above the Littlefield Springs (Figure 6.6-6), a collection of eight springs located over a distance of seven miles between the Narrows and Littlefield gages (see Figure 6.6-5 for gage location). These periods of no flow were determined from a gage installed upstream of the Littlefield Springs (1951-1956 and 1976) and were caused by irrigation diversions near St. George, Utah and seepage losses near Bloomington, Utah. (Trudeau and others, 1983) Substantial seepage losses from the Virgin River to the groundwater system between the near St. George and Bloomington gages were reported by Trudeau (1979). This reach begins about a half mile north of the Arizona border and extends to St. George. However, post-1990 gage data and seepage measurements suggest that the historical seepage losses to the groundwater system in Utah are no longer occurring (Cole and Katzer, 2000).

In Arizona, seepage losses between 10 to 35 cfs were estimated upstream of the Narrows gage (Cole and Katzer, 2000). Flow lost from the Virgin River to the groundwater system reenters the river via discharge from the Littlefield Springs. Measuring discharge rates at the springs is difficult because they are located in the Virgin River channel and can only be observed during low flow when the sediment load is near zero (Dixon and Katzer, 2002). An estimated 20 to almost 70 cfs (14,500 to 50,700 AFA) reenters the Virgin River via springs and groundwater discharge between the Narrows and Littlefield gages (Cole and Katzer, 2000). Since 1998 average annual flow in the Virgin River above the Narrows gage has been about 92,600 acre-feet. Below the Narrows gage, average annual flow increases to 174,502 acre-feet at the Littlefield gage, with a 72 year period of record.

The short perennial reach of Beaver Dam Wash is supported by springs that collectively discharge over 1,100 gpm. Beaver Dam Wash discharges to the Virgin River north of the Littlefield gage.

A number of major springs issue from the Redwall and Muav limestones and to a lesser extent, the Tapeats Sandstone, in the vicinity of the Colorado River in the Kanab Plateau

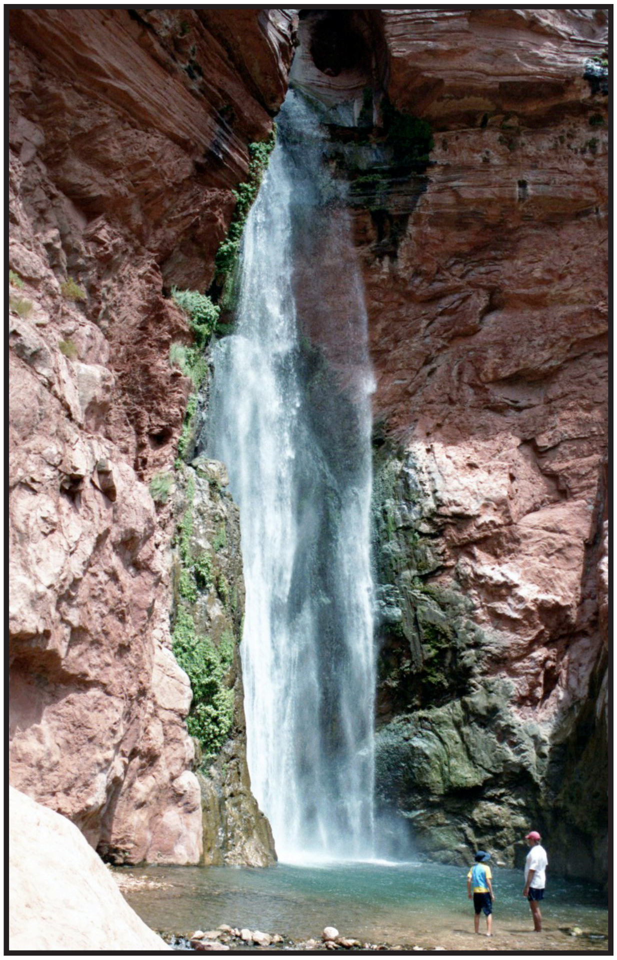
Virgin River near Littlefield. Average annual flow in the Virgin River above the Narrows gage is about 92,600 acre-feet.

and Coconino Plateau basins. The largest are Havasu Springs in the Coconino Plateau Basin with a discharge of about 28,500 gpm, and Tapeats Spring in the Kanab Plateau Basin with a discharge of about 18,700 gpm. Havasu Creek is perennial below Havasu Spring, located upstream of the village of Supai, and contains moderate levels of calcium, magnesium and bicarbonate from the springs. Calcium carbonate precipitates out of the spring water, forming travertine deposits along the creek bottom/bed.

A major flash flood event occurred on Havasu and Cataract Creeks from August15th- 17th, 2008, causing severe damage to Supai Village and nearby campgrounds on the Havasupai Reservation and stranding tourists and residents. Estimated flood flows were 6-7000 cfs. In response, two streamflow and precipitation gages were installed upstream to provide timely and accurate flood warnings to the Havasupai Nation and campgrounds along Havasu Creek.

Roaring Springs, located 3,000 feet below the North Rim, emanates from a cave in the Muav Limestone above the intersection of the Roaring Springs and Bright Angel faults. It has a discharge of almost 2,000 gpm and is the water supply for the North and South Rims of Grand Canyon National Park (USBOR, 2002).

A group of major springs with discharge rates between 11 and 90 gpm are found in the vicinity of Moccasin and Kaibab in the north-central part of the Kanab Plateau Basin. Studies at Pipe Spring National Monument indicate that spring discharge is from a sandstone unit of the Kayenta Formation. Fine-grained sediments below the unit create a confining layer that restricts vertical water movement and forces groundwater to move along bedding planes and fractures in the Navajo Sandstone and the upper unit of the Kayenta Formation. In the monument, discharge at Pipe Spring declined between 1976 and 2003 but increased at Tunnel Spring for reasons that are unclear. The combined spring discharge declined about 0.5 gpm per year between 1986 and 2001 (Truini and others, 2004).



Deer Creek Falls, created by Deer Creek Spring (3,542 gpm) in the Kanab Plateau Basin. A number of major springs issue from the Redwall and Muav limestones and to a lesser extent, the Tapeats Sandstone, in the vicinity of the Colorado River in the Kanab Plateau and Coconino Plateau basins.

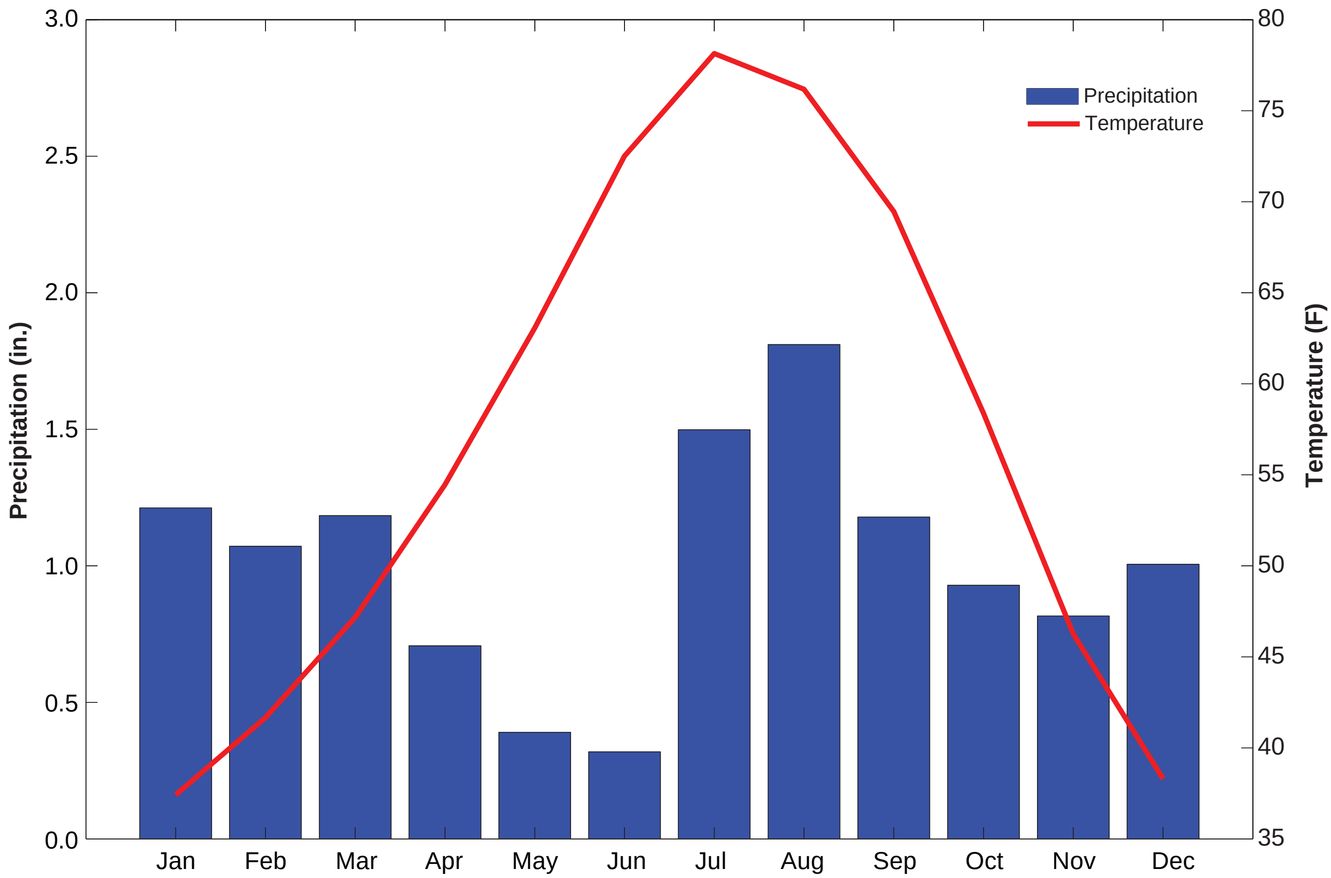
A handful of major springs are found in the other basins in the watershed. In the Grand Wash Basin, three major springs, (Tassi, Whiskey and an unnamed spring) discharge from the basin-fill aquifer where it overlies a confining unit, the Muddy Creek Formation (Bales and Laney, 1992). This may be the case with other springs in the basin. The only major spring in the Shivwits Plateau Basin, with a measured discharge of 331 gpm is found at the mouth of Spring Canyon at the Colorado River.

There are two impaired stream reaches in the watershed. Twenty-eight miles of the Colorado River from Parashant Canyon to Diamond Creek are impaired due to selenium and suspended sediment concentrations (Table 6.1-7). These same constituents are responsible for the impairment designation of ten miles of the Virgin River from Beaver Dam Wash to Big Bend Wash (Figure 6.6-10).

6.0.3 Climate[2]

The average annual temperature of the Western Plateau Planning Area (57.9°F) is somewhat cooler than the statewide average (59.5°F). Average annual precipitation in the planning area is 12.1 inches, the same as the statewide average. Annual totals vary widely across the area, from 6-9 inches at low elevations (less than 5,000 ft.) and rain shadow stations such as Wahweap, Fredonia, and Beaver Dam, to greater than 20 inches at Williams and Bright Angel Ranger Station in Grand Canyon National Park. On average, the Western Plateau Planning Area exhibits the bi-modal precipitation pattern characteristic of Arizona (see Figure 6.0-8); however, the northwestern part of the planning area, near the borders of Nevada and Utah, exhibits a stronger late winter peak, whereas the eastern and southern part of the area shows a stronger summer peak.

Figure 6.0-8 Average monthly precipitation and temperature from 1930-2002



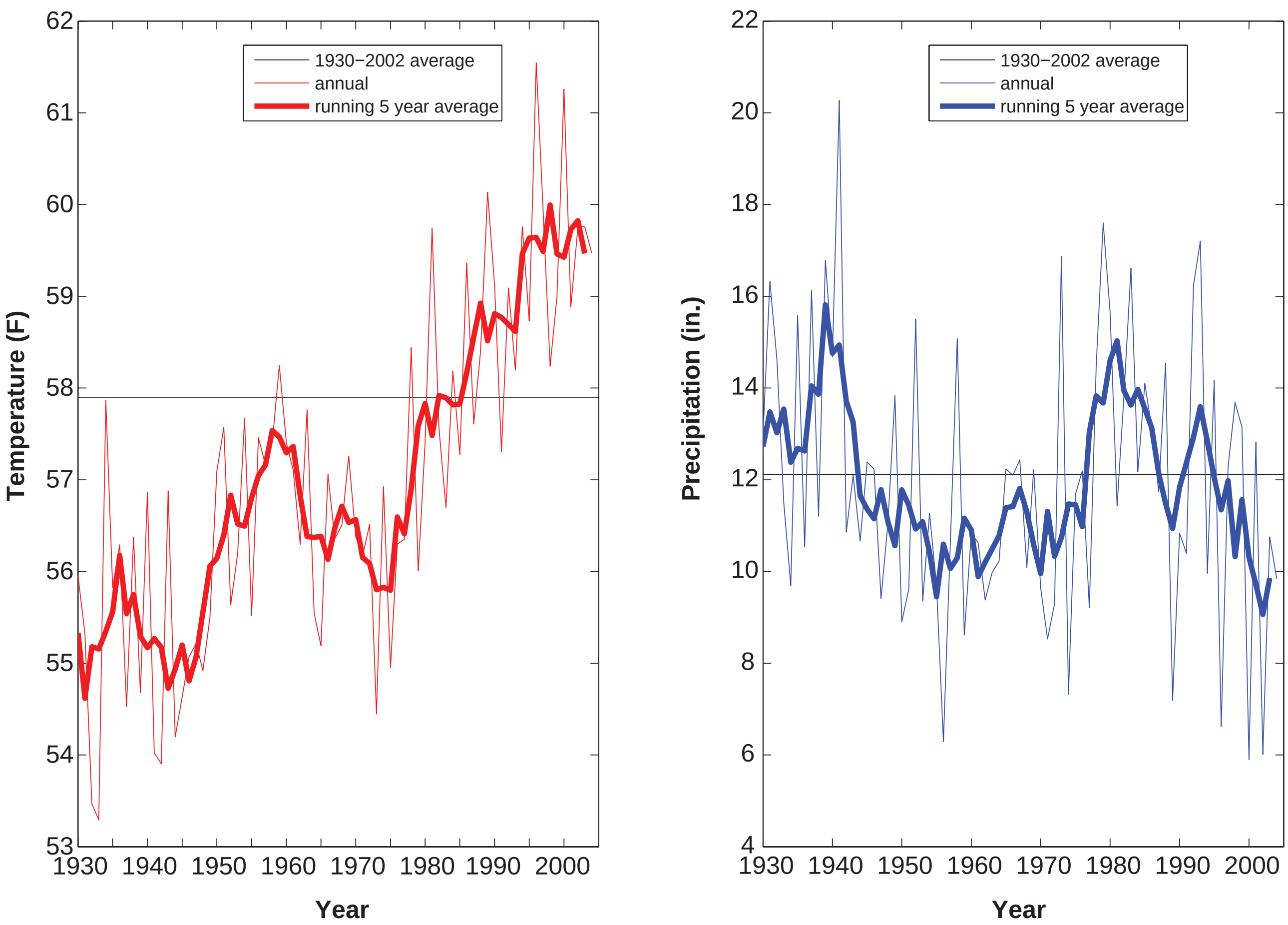
Data are from the Western Regional Climate Center. Figure author: CLIMAS

[2] Information in this section was provided by the Institute for the Study of Planet Earth, Climate Assessment for the Southwest (CLIMAS), University of Arizona, September 2007

Frontal storm systems moving west-to-east, guided by the jet stream, deliver the area's winter and spring precipitation. Summer monsoon thunderstorms arrive later in this part of the state than elsewhere, and August is clearly the peak month, on average, for summer precipitation. However, year-to-year summer precipitation variability is pronounced, with some years showing July peaks. The area shows a strong response to the El Niño-Southern Oscillation, with El Niño winters registering wet conditions 52% of the time and dry conditions less than 30% of the time; La Niña winters are dry 54% of the time and wet only 21% of the time.

Average annual temperatures in the Western Plateau Planning Area have been increasing since the 1930s, and especially rapidly since the mid-1970s (see Figure 6.0-9). The long-term trend is superimposed on decadal variability generated primarily by Pacific Ocean and atmosphere variations. Decadal variations are particularly obvious in the instrumental record of precipitation. Drought conditions are apparent for the decades of the 1940s-early 1970s and since the mid-1990s, whereas the 1930s and mid-1970s through the mid-1990s were relatively wet.

Figure 6.0-9 Average annual temperature and total annual precipitation for the Western Plateau Planning Area from 1930-2002



Horizontal lines are average temperature (57.9 °F) and precipitation (12.1 inches), respectively. Light lines are yearly values and highlighted lines are 5-year moving average values. Data are from the Western Regional Climate Center. Figure author: CLIMAS.

Winter precipitation records dating to 1000 A.D., estimated from tree-ring reconstructions, show extended periods of above and below average precipitation in every century (Figure 6.0-10). Notably dry periods include the late 1500s, which feature the driest decade in this part of the state, and the late 1200s. The Western Plateau Planning Area was relatively wet during the late 1400s, early 1600s, and early 1900s.

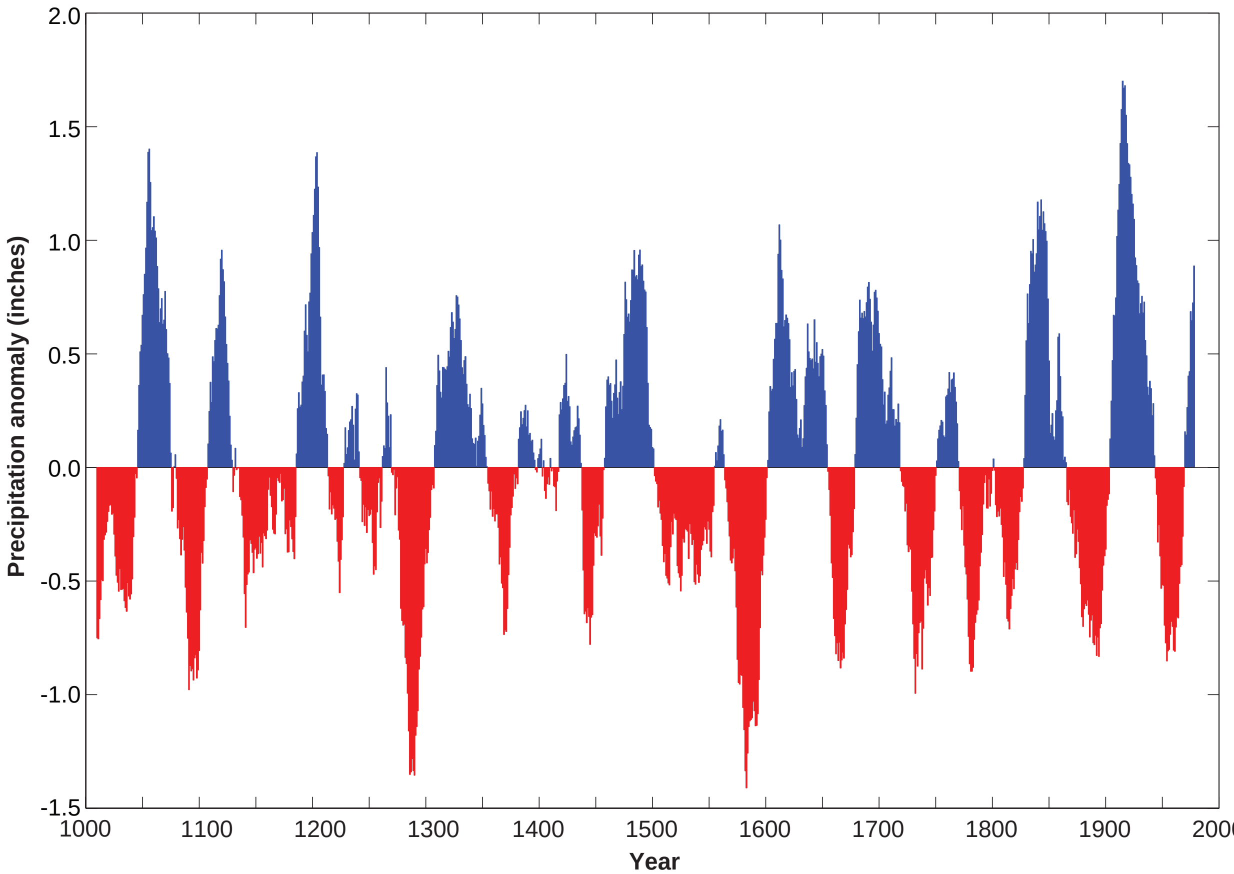
6.0.4 Environmental Conditions

Environmental conditions reflect the geography, climate and cultural activities in an area and may be a critical consideration in water resource management and supply development. Discussed in this section is vegetation, riparian protection through the Arizona Water Protection Fund Program, instream flow claims, threatened and endangered species, public lands protected from development as national parks, monuments, recreation areas and wilderness areas, and managed waters.

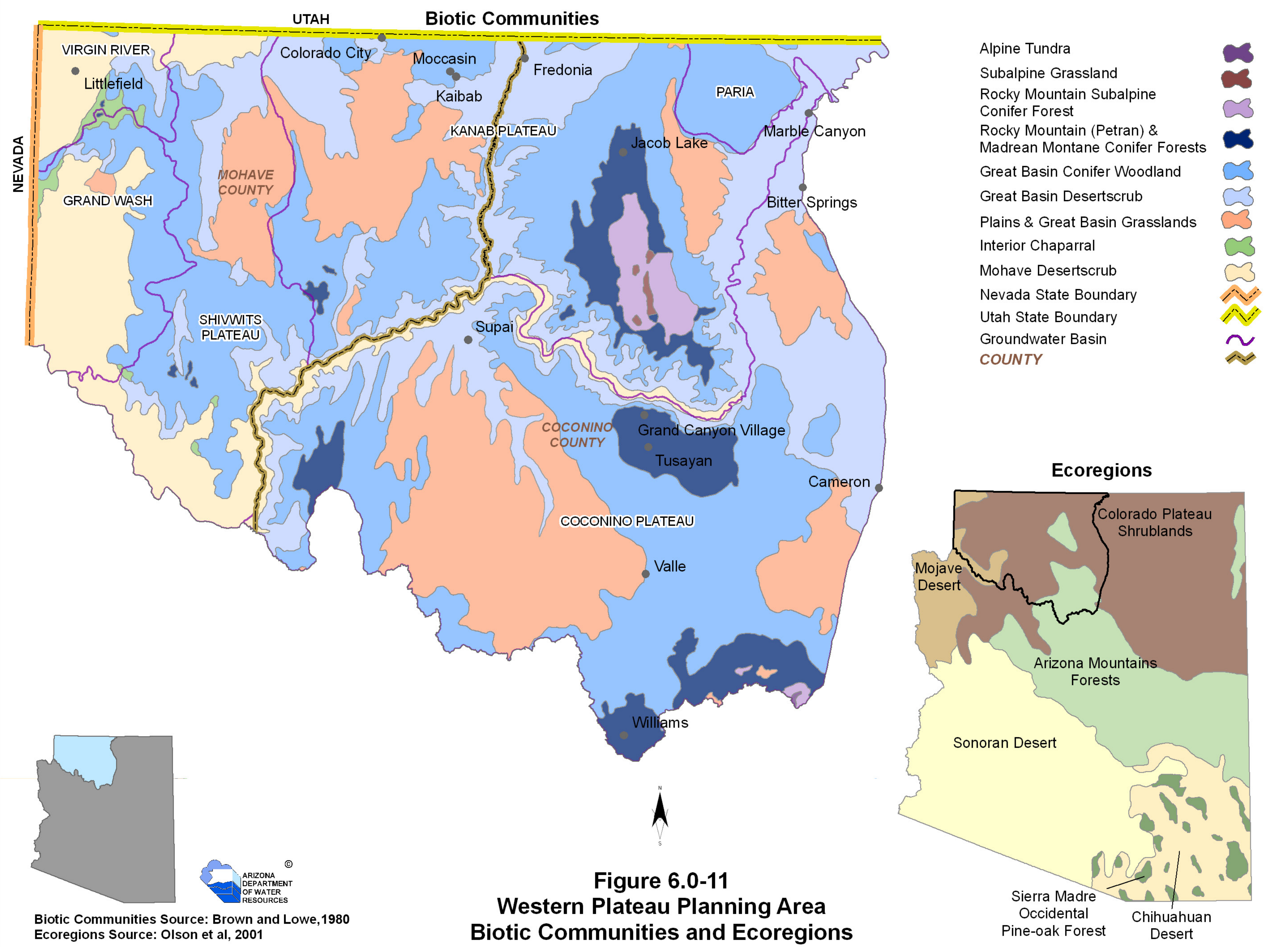
Vegetation

Information on ecoregions and biotic (vegetative) communities in the planning area are shown on Figure 6.0-11. Three of Arizona's six ecoregions are included in the planning area: the Colorado Plateau Shrublands, which covers most of the area, the Mojave Desert in the western portion, and the Arizona Mountains Forests ecoregion in the eastern section. Biotic communities range from Mohave desertscrub in the western part of the planning area and along the Colorado River to a small area of alpine tundra in the Coconino Plateau Basin.

Figure 6.0-10 Winter (November-April) precipitation departures from average, 1000-1988



Data are presented as a 20-year moving average to show variability on decadal time scales. Data: Fenbiao Ni, University of Arizona Laboratory of Tree-Ring Research and CLIMAS. Figure author: CLIMAS.



Biotic Communities Source: Brown and Lowe,1980
Ecoregions Source: Olson et al, 2001

Figure 6.0-11
Western Plateau Planning Area
Biotic Communities and Ecoregions

Much of the planning area is covered by Great Basin conifer woodland and plains and Great Basin grassland.

Alpine tundra communities are found only at the highest elevations on the San Francisco Peaks, generally over 12,000 feet. The Peaks are the southernmost climatic alpine area in the United States. Because of the relatively harsh climate, only specially-adapted species can survive. Plants are commonly small and ground-hugging and include mosses, lichens and herbs. An area of the Peaks has been closed to travel to protect an endemic groundsel (Senecio franciscanus), a threatened species. Small areas of subalpine grassland are also found on the San Francisco Peaks and on the Kaibab Plateau at elevations above 8,500 feet that receive from 30 to 45 inches of annual rainfall (Grahame and Sisk, 2002).

High elevation subalpine conifer forests are limited to relatively small isolated mountaintop stands on the Kaibab Plateau and the San Francisco Peaks area at elevations of 8,500 to almost 12,000 feet with annual precipitation from 30 to 40 inches a year. These forests consist of dense stands of fir, spruce and aspen trees and receive much of their annual precipitation as snow. Summer precipitation is also a substantial component of annual precipitation. Bristlecone pine stands occur at elevations around 11,000 feet on the San Francisco Peaks (Brown, 1982). Significant stands of aspen occur in places, especially in areas that have been burned. Natural fires are relatively uncommon in subalpine conifer forests with patchy crown fires occurring about every several hundred years, and surface fires occurring every 15 to 30 years (Graham and Sisk, 2002).

Rocky Mountain (Petran) and Madrean Montane conifer forests commonly occur between about 7,200 to 8,700 feet. Above 8,000 feet in areas that receive from 25 to 30 inches of annual rainfall, the forest contains a mix of conifers that may include Douglas-fir, white fir, limber pine, blue spruce, and white pine, with ponderosa pine on warmer slopes. Aspen and Gambel oak are prominent in these forests following disturbances. Below 8,000 feet in areas that receive about 18 to 26 inches of annual precipitation, the mix of species gives way to almost pure stands of ponderosa pine, particularly on the Kaibab Plateau and at the south rim of the Grand Canyon. About half of the precipitation occurs during the growing season, which permits forests to exist on less than 25 inches of annual rainfall, making them some of the driest forests in North America (Brown, 1982).

Great Basin conifer (piñon-juniper) woodlands cover large areas below the ponderosa pine forest at elevations between about 5,000 and 7,500

Rocky Mountain (Petran) and Madrean Montane Forest near Jacob Lake, Kanab Plateau Basin.

feet that receive about 10 to 20 inches of annual precipitation. Extensive stands exist throughout the planning area as shown on Figure 6.0-11. Piñon pine dominates at higher elevation while junipers are the dominant species at lower and drier areas that may include open grasslands. Bark beetle infestations have killed large areas of piñon pine southeast of Valle and smaller areas south of the South Rim in the Coconino Plateau Basin.

Plains grasslands, primarily composed of mixed or short-grass communities, are widespread in the planning area at elevations above about 4,000 feet that receive between 11 and 18 inches of annual precipitation. These areas are located primarily in the Coconino Plateau, Kanab Plateau and Shivwits Plateau basins. On the Arizona Strip, Great Plains grassland, which is drier and receives a larger percentage of annual rainfall in the winter and spring, transitions with plains grasslands (Brown, 1982). Native bunchgrasses have been largely replaced by Eurasian annual species such as cheatgrass due to grazing and fire-suppression practices (Grahame and Sisk, 2002).

Interior chaparral occupies mid-elevation foothill, mountain slopes and canyons in the Virgin Mountains in the Virgin River and Grand Wash basins, and in several isolated locations in the southern part of the Shivwits Plateau Basin. It is found in areas between about 3,500 and 6,000 feet in elevation that receive 15 to 25 inches of annual precipitation (Brown, 1982). Chaparral consists of dense shrubs that grow around the same height with occasional taller shrubs or small trees. Typical shrubby species are mountain mahogany, shrub live oak, and manzanita. Chaparral plants are well adapted to drought conditions.

Great Basin desertscrub occurs in northern Arizona mostly at elevations of 4,000 to 6,500 feet where an average of about 7 to 12 inches of rainfall occurs. This vegetative community is dominated by multi-branched, aromatic shrubs with evergreen leaves, primarily sagebrush, blackbrush and shadscale. Great Basin desertscrub is found in all basins in the Western Plateau Planning Area except the Paria Basin. In addition to shrubs, vegetation consists primarily of grasses. Grazing has heavily impacted native grasses in this community, which have been replaced by exotic species including cheatgrass. Cheatgrass is highly flammable, and where it is a significant component of sagebrush stands, the incidence of fire is greatly increased (Brown, 1982).

Mohave desertscrub covers a transitional zone between the higher and cooler Great Basin desert and the lower, hotter Sonoran desert. It is found along the Colorado River and in the western part of the planning area at elevations below about 3,500 feet. While many of the same plants found in the other deserts occur here, some are found only in the Mohave Desert such as the Joshua tree. The Mohave Desert is rich in endemic ephemeral plants, most of which are winter annuals (Brown, 1982).

There are reaches of riparian vegetation along the major watercourses in the planning area including the Colorado River, Kanab Creek, Paria River and Virgin River. Prior to construction of Glen Canyon Dam, the Colorado River supported a “sparse” riparian ecosystem above the high water zone of 100,000 cfs. Following con-

Mohave desertscrub in the Virgin River Basin.

struction, the new high water zone lowered and there was die-off in the upslope areas. However a mix of native and non-native species has increased in the new zone under the more stable conditions and higher year-round low flows. Riparian vegetation has also increased in tributary canyons. (Webb and others, 2007)

Within the alluvial reaches of Kanab Creek, thick stands of coyote willow that historically grew have been replaced by a mix of native and non-native trees growing in the channel. Downstream in Kanab Canyon large floods and low baseflow precludes establishment of significant riparian vegetation. Along the Paria River upstream of its confluence with the Colorado River tamarisk, coyote willow and scattered cottonwood are found. Historically, willow and some cottonwood were present in this reach (Webb and others, 2007). Downstream from the Virgin River Gorge to Lake Mead, extensive stands of native and non-native vegetation exist along the Virgin River. Tamarisk is predominant downstream of Littlefield (Webb and others, 2007). Dixon and Katzer (2000) estimated that nearly 10,000 acre-feet of water is used by phreatophytes along the Virgin River from the Littlefield gage to the state line.

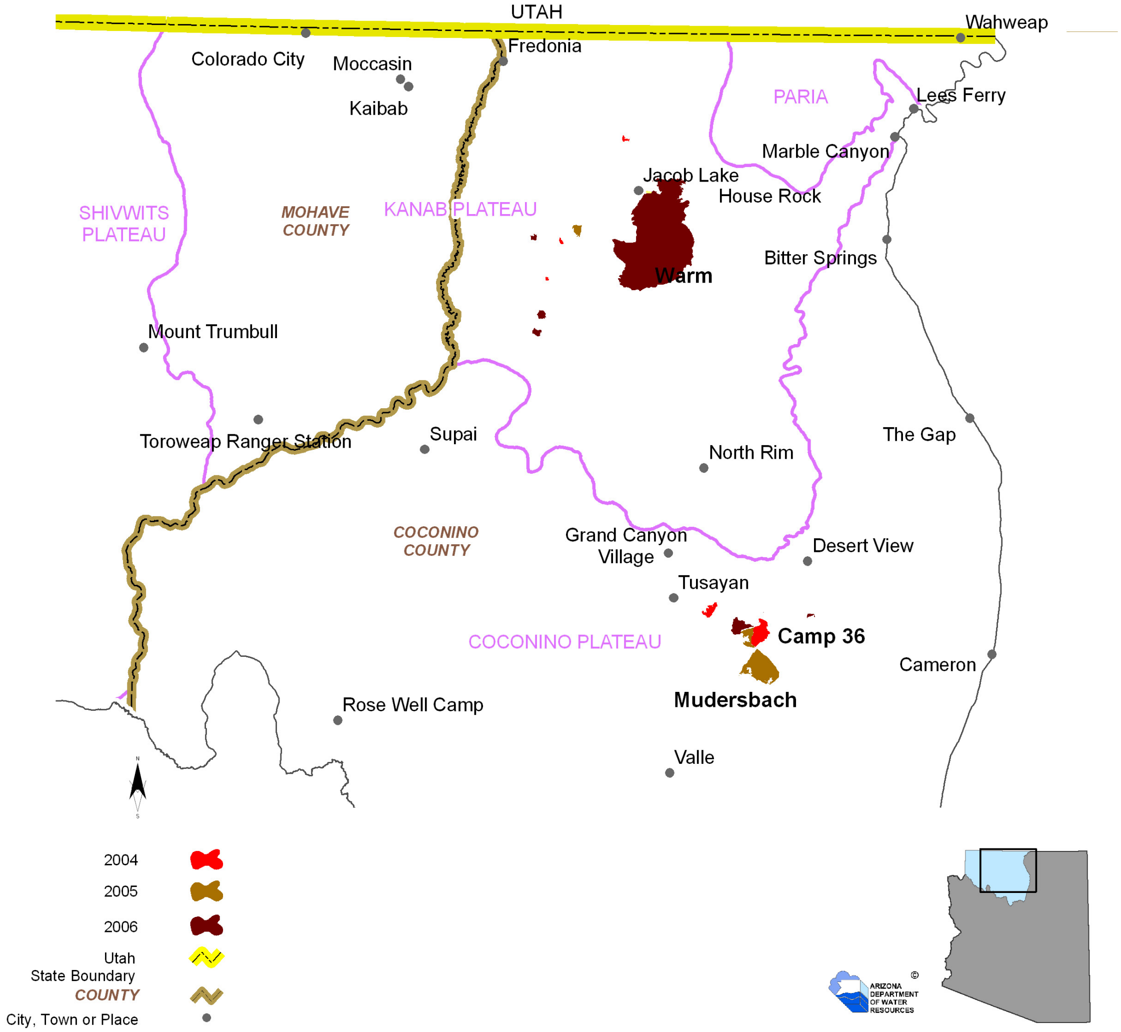
Several years of drought combined with high tree densities resulted in the largest outbreak of pine bark beetle populations ever recorded in Arizona forests during 2002 – 2004. Based on aerial surveys conducted in 2004 by the U.S. Forest Service, substantial bark beetle-caused ponderosa pine mortality occurred in a swath of forest stretching northeast from Williams and on forest lands south of the South Rim of the Grand Canyon. While drought conditions improved in 2004 and 2005, Ponderosa pine mortality due to Ips beetles increased in 2006, with 6,850 acres infested on the Kaibab National Forest. Other beetle species have also attacked trees on the Kaibab Plateau and on the San Francisco Peaks (USDA, 2006). By 2008, bark beetle activity had decreased substantially with only 560 affected acres in the Kaibab National Forest. However, almost 67,000 acres of aspen damage by defoliating insects was observed on the Kaibab in that year. Study plots were established in Arizona in 2003-2004 to monitor the impacts from bark beetle infestations on fuel loading and fire behavior. Preliminary analysis shows that mortality plots have significantly higher fuel loads than areas with no mortality. (USDA, 2008)

Vegetation along the Virgin River south of Beaver Dam/Littlefield.

Mortality rates of 60 to 95 percent in low elevation aspen groves, around 7,000 feet, has been observed on the Kaibab and Coconino national forests. Sudden Aspen Death (SAD) is believed caused by a combination of factors including drought and warmer temperatures that make trees more vulnerable to pests and pathogens. Fire exclusion is also thought to be a factor in longer term decline of aspen throughout the western U.S. Research is being conducted on the Kaibab National Forest to determine the cause of SAD and determine whether aspen are permanently disappearing from its lower elevation range. (Stevens, 2009)

A number of major wildfires occurred in the Western Plateau Planning Area during the severe drought years between 2002 and 2006 (see Figure 6.0-12). The largest was the lightning-

Figure 6.0-12 Wildfires in the Central Highlands Planning Area 2002-2005
(USFS 2007a)



caused Warm Fire, which consumed about 40,000 acres on the central Kaibab Plateau in 2006. Of the area burned, about 30 percent was identified as having high burn severity related to soil and watershed conditions (USFS, 2007b). In the Southwest, fire can be among the most significant watershed disturbance agents, particularly to peak stream flows. Increased peak flows can degrade stream channels and make them unstable, increase sediment production and cause flood damage. (Neary and others, 2003)

Drought, wildfire and long-term climate change involving warmer temperatures with earlier Spring season and less snow cover could result in vegetative changes in the planning area with implications on runoff, infiltration and water supplies.

Arizona Water Protection Fund Programs

The objective of the Arizona Water Protection Fund (AWPF) Program is to provide funds for protection and restoration of Arizona's rivers and streams and associated riparian habitats. Eleven projects have been funded in the planning area through 2008. Six projects were funded in the Coconino Plateau Basin involving research, restoration and exotic species control. Three projects in the Kanab Plateau Basin and one each in the Grand Wash and Paria basins were also funded involving restoration, research, revegetation, exotic species control and watershed enhancement. A list of projects and types of projects funded in the Western Plateau Planning Area through 2008 is found in Appendix A. A description of the program, a complete listing of all projects funded, and a reference map is found in Volume 1 and on the Department's website.

Instream Flow Claims

An instream flow water right is a non-diversionary appropriation of surface water for recreation and wildlife use. An application to appropriate public water for instream flow purposes moves through a number of administrative steps culminating in the Department's approval or rejection of the application. Streamflow measurement data, a study that substantiates the streamflow volume requested and quantifies the relationship between the claimed beneficial use(s) and the requested streamflow rates are required before the Department will issue a permit to appropriate. Following approval of a permit, the permit holder has four years to demonstrate that the instream flow right is being used in a manner consistent with the terms of the issued permit. After the permit holder submits proof of the appropriation, the Department issues the permit holder a Certificate of Water Right (CWR) with a priority date that relates back to the date of the application. A CWR evidences a perfected surface water right that is superior to all other surface water rights with a later priority date, but junior to all rights with an earlier (older) priority date. All permits and certificates are for specific uses at specific places and are endorsed with the priority date and extent and purpose(s) of the right(s). The right must be beneficially used or it may be subject to abandonment and forfeiture.

Seven applications for instream flow claims were filed by the Bureau of Land Management in the Virgin River Basin. Applications are listed in Table 6.0-1 and instream flow reaches are shown on Figure 6.0-13. Six applications have been filed on reaches of the Virgin River and one has been filed on a reach of Beaver Dam Wash. All applications are currently pending.

Threatened and Endangered Species

A number of listed threatened and endangered species[3] may be present in the Western Plateau Planning Area. Those listed by the U.S. Fish and Wildlife Service (USFWS) as of 2008 are shown in Table 6.0-2. Presence of a listed species may be a critical consideration in water resource management and supply development

Table 6.0-1 Instream Flow Claims in the Western Plateau Planning Area

Map Key	Stream	Applicant	Application No.	Permit No.	Certificate No.	Filing Date
1	Beaver Dam Wash	BLM (Arizona Strip)	33-94843.0	Pending	Pending	8/24/1989
2	Virgin River	BLM (Arizona Strip)	33-94819.0	Pending	Pending	6/1/1989
3	Virgin River	BLM (Arizona Strip)	33-94865.0	Pending	Pending	10/20/1989
4	Virgin River	BLM (Arizona Strip)	33-96159.0	Pending	Pending	12/23/1991
5	Virgin River	BLM (Arizona Strip)	33-94866.0	Pending	Pending	10/20/1989
6	Virgin River	BLM (Arizona Strip)	33-96134.0	Pending	Pending	10/30/1991
7	Virgin River	BLM (Arizona Strip)	33-96133.0	Pending	Pending	10/30/1991

Source: ADWR 2008a

[3] An "endangered species" is defined by the USFWS as "an animal or plant species in danger of extinction throughout all or a significant portion of its range," while a "threatened species" is "an animal or plant species likely to become endangered within the foreseeable future throughout all or a significant portion of its range."

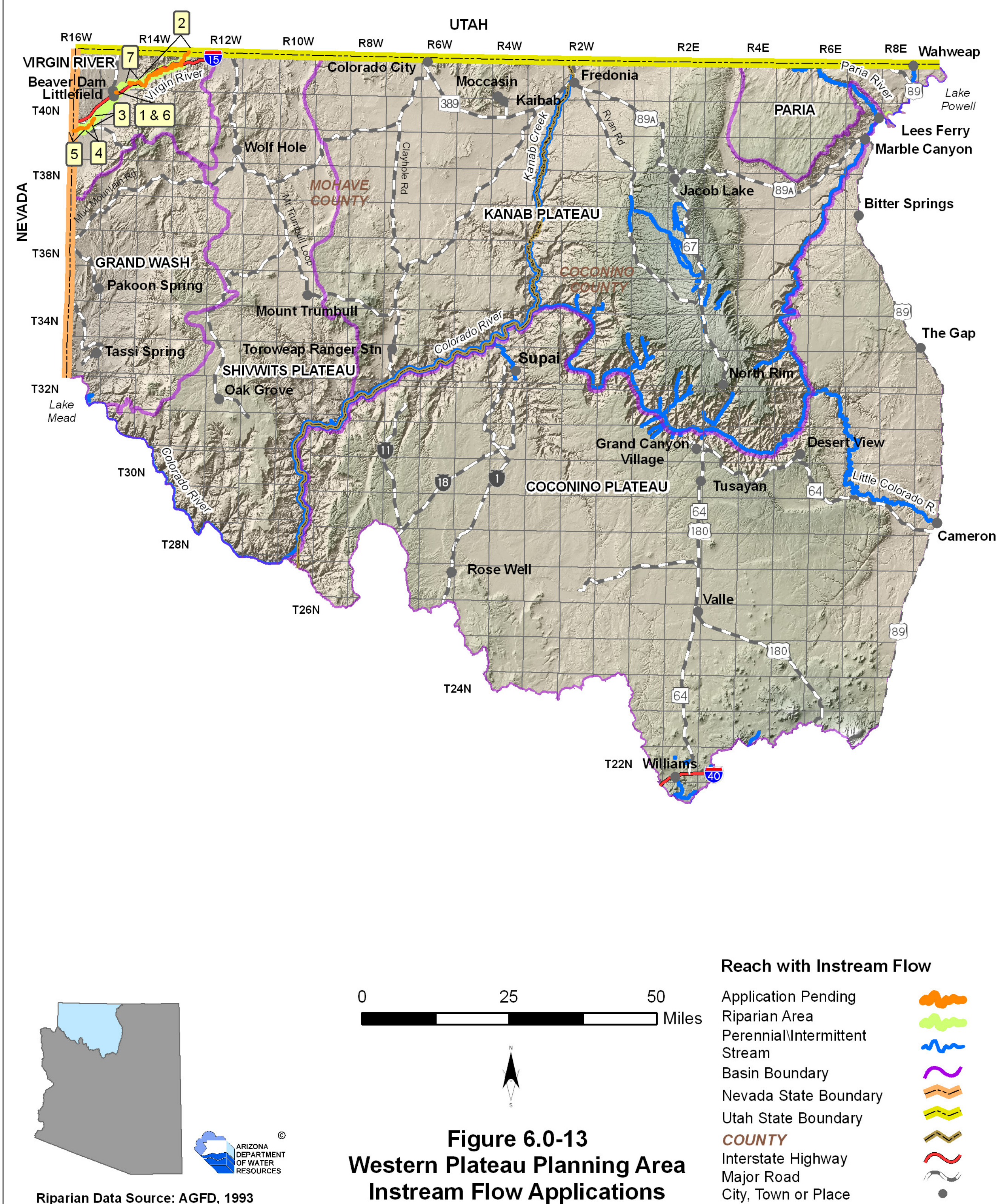


Figure 6.0-13
Western Plateau Planning Area
Instream Flow Applications

Table 6.0-2 Endangered Species in the Western Plateau Planning Area

Common Name	Threatened	Endangered	Elevation/Habitat
Brady Pincushion Cactus		X	3,400-5,200 ft,/Gravelly alluvium with sparse vegetation on gently sloping benches and terraces
Bald Eagle	X		Varies/Large trees or cliffs near water
California Brown Pelican		X	Varies/Lakes and rivers
California Condor		X	2,000-6,500 ft,/Steep terrain with rock outcroppings, cliffs and caves
Desert Tortoise (Mohave Population)	X		1,000-4,000 ft./Sandy loam to rocky soils in valleys, bajadas and hills
Holmgren Milk-Vetch		X	2,480-2,999 ft./Skirt edges of hill and plateau formations slightly above or at the edge of drainage areas
Humpback Chub		X	1,530-4,400 ft,/Turbulent, high gradient, canyon-bound reaches of large rivers
Jones' Cycladenia	X		4,000 to 6,800 ft/ Mixed desert shrub and scattered piñon-juniper communities
Kanab Amber Snail		X	3,200 ft./Marshes watered by springs and seeps at the base of sandstone cliffs or limestone
Mexican Spotted Owl	X		4,100-9,000 ft./Canyons and dense forests with multi-layered foliage structure
Razorback Sucker		X	<6,000 ft./Riverine and lacustrine areas, not in fast moving water
San Francisco Peaks Groundsel	X		>10,900 ft./Alpine tundra
Sentry Milk-Vetch		X	7,000-7,960 ft/Uppermost layer of Kaibab limestone that is weathered in small, shallow pockets and networks of small cracks
Siler Pincushion	X		2,800-5,800 ft./Low red or gray gypsiferous badlands
Southwestern Willow Flycatcher		X	<8,500 ft./Cottonwood-willow and tamarisk along rivers and streams
Virgin River Chub		X	1,540-2,360 ft/Swift but not turbulent reaches of the Virgin River
Welsh's Milkweed	X		4,700-6,250 ft./Open, sparsely vegetated sand dunes or sagebrush, juniper, pine and oak communities
Woundfin		X	1,900-10,000 ft./Swift parts of silty streams
Yuma Clapper Rail		X	<4,500 ft./Fresh water and brackish marshes

Source: USFWS 2008, USDOI 2007

in a particular area. The USFWS should be contacted for details regarding the Endangered Species Act (ESA), designated critical habitat and current listings.

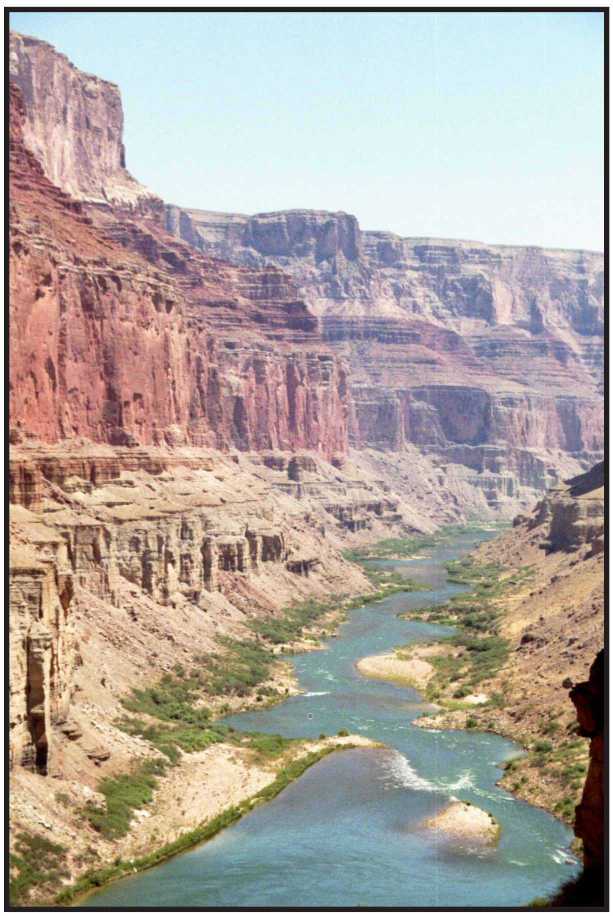
A unique example of endangered species management in the planning area is that of the California condor. Considered one of the most endangered birds in the world, condors were placed on the federal endangered species list in 1967. In 1987, with only 22 individuals known to exist, a controversial decision was made to bring all remaining condors into captivity in order to conduct a captive breeding program with the goal of reintroducing the species to the wild. Beginning in 1996, six to ten birds have been released each year from the Vermilion Cliffs in the Paria Basin. As of July 2009 there were 75 condors in Arizona. This reintroduction was conducted under a special provision of the ESA that allows for the designation of a nonessential experimental population. Under this designation, endangered species protections are relaxed, providing greater flexibility for management of a reintroduction program (AZGF, 2006).

National Parks, Monuments, Recreation Areas and Wilderness Areas

The Western Plateau Planning Area has the greatest acreage of federally protected areas as parks, monuments, recreation areas and wilderness areas of any planning area. It contains almost all of Grand Canyon National Park, three national monuments and small parts of two national recreation areas. In total there are 2.68 million acres of protected federal lands in the planning area, accounting for 31% of the land area. The Grand Canyon and Grand Canyon-Parashant National Monument make up most of the total with more than two million combined acres.

Nine wilderness areas are entirely within the planning area as well as part of two others (see Figure 6.0-14). Wilderness Areas are designated under the 1964 Wilderness Act to preserve and protect the designated area in its natural condition. Designated areas, their size, basin location and a brief description of the area are listed in Table 6.0-3. Five wilderness areas are within the boundaries of national monuments.

Grand Canyon National Park, a World Heritage Site, encompasses 1,218,375 acres. It was given Federal protection in 1893 as a Forest Reserve and later as a National Monument, and achieved National Park status in 1919. It receives almost five million visitors each year. Water for both the North and South Rims of the Park come from Roaring Springs, located 3,000 feet below the North Rim, and transported via pipeline to both rims (see Section 6.0.7) (USBOR, 2002). Park lands exist in every groundwater basin except



Colorado River through the Grand Canyon within Grand Canyon National Park.

Table 6.0-3 Wilderness areas in the Central Highlands Planning Area

Wilderness Area	Acres	Basin	Description
Beaver Dam Mountain	19,600	Virgin River	Rugged mountains, alluvial plains and several miles of the Virgin River
Cottonwood Point	6,860	Kanab Plateau	Navajo sandstone cliffs, canyons and pinnacles, willow and cottonwoods in wetter canyons
Grand Wash Cliffs*	37,030	Grand Wash	Marks transition zone between Colorado Plateau and Basin and Range provinces and contains many canyons
Kachina Peaks	18,615	Coconino Plateau (part)	Mt. Humphreys and only arctic-alpine vegetation in the state
Kanab Creek	68,340	Kanab Plateau	Kanab Creek and a maze of water and wind carved fins, knobs and potholes
Kendrick Mountain	6,510	Coconino Plateau	Remnant of San Francisco Mountain volcanic field
Mt. Logan*	87,900	Grand Wash	Basalt ledges, cinder cones and large eroded amphitheater
Mt. Trumbull*	7,880	Kanab Plateau	Large basalt-capped mesa
Paiute*	87,900	Grand Wash, Virgin River	Virgin Mountains and canyons
Paria Canyon-Vermilion Cliffs*	112,500	Kanab Plateau, Paria (part)	Paria Canyon and Vermilion Cliffs, red rock amphitheaters, sandstone arches, towering walls and hanging gardens
Saddle Mountain	40,610	Kanab Plateau	Nankoweap Rim, narrow drainage bottoms and steep scarp slopes.
Total	**493,745**		

Source: BLM 2006, USFS 2007c
*Wilderness areas are within the boundaries of a National Monument

the Virgin River and Paria basins, stretching from the confluence of the Little Colorado and Colorado Rivers west to Lake Mead. (See land ownership maps in the basin sections).

The Grand Canyon is of great geologic significance, with a record of three of the four eras of geological time, a rich and diverse fossil record, a huge variety of geologic features and rock types, and numerous caves containing extensive geological, paleontological, archeological and biological resources. Incised by the Colorado River, the Canyon is considered one of the finest examples of arid-land erosion in the world, averaging 4,000 feet deep for its entire 277 miles (NPS, 2005).

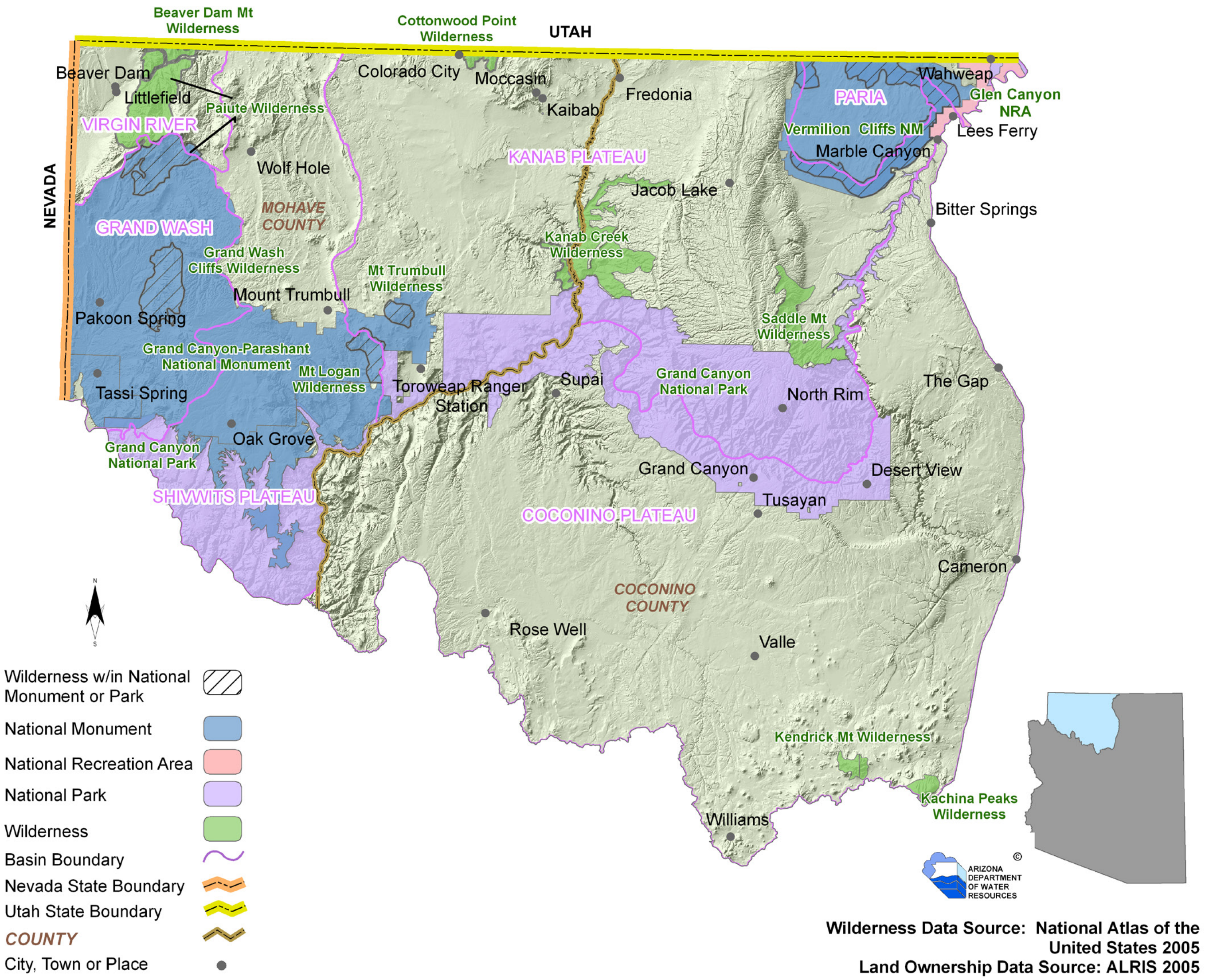
The Park also serves as an ecological refuge, with relatively undisturbed remnants of dwindling ecosystems, including desert riparian communities. It is home to numerous rare, endemic, and federally protected plant and animal species (NPS, 2007).

Construction and operation of Glen Canyon Dam has significantly altered Colorado River flows and sediment deposition, wildlife and habitat along the river in Grand Canyon National Park. A number of studies and actions have been taken and are underway to manage releases from the dam to protect the Park's resources and to mitigate the impact of dam operations (see "Managed Waters" below).

The Grand Canyon-Parashant National Monument was created by Presidential Proclamation in January 2000. At 1.05 million acres, it is described in the Proclamation as a geological treasure and as a "vast, biologically diverse, impressive landscape…" The physical remoteness of the monument has helped preserve important biological and archeological resources. The monument encompasses the lower portion of the Shivwits Plateau Basin, considered an important watershed for the Colorado River and the Grand Canyon, almost all of Grand Wash Basin and a small area north of Toroweap in the Kanab Plateau Basin (USDOI, 2007). The Monument is jointly administered by the National Park Service (NPS), (211,100 acres) and the Bureau of Land Management (BLM), (808,727 acres).

In November 2000, President Clinton also established the Vermilion Cliffs National Monument by proclamation. Encompassing 294,000 acres, the entire monument is within Arizona. Most of the Paria Plateau Basin and adjoining lands in the Kanab Plateau Basin are within the monument boundaries. The monument was established to protect geologic features including the 2,500-foot deep Paria Canyon, the Paria Plateau, the spectacular cross-bedded sandstones at Coyote Buttes and the 3,000-foot Vermilion Cliffs escarpment, the Arizona release site of the endangered California condor.

Figure 6.0-14 Federally Protected Areas in the Western Plateau Planning Area



The Arizona Strip Proposed Plan/Final Environmental Impact Statement (FEIS), released in March 2007, serves multiple functions. It is a revised Resource Management Plan for the Arizona Strip Field Office of the BLM, a new management plan for the Vermilion Cliffs National Monument and a new management plan for the Grand Canyon-Parashant National Monument. It is also a Proposed General Management Plan/Final EIS for the NPS portion of the Grand Canyon-Parashant National Monument, since that monument is jointly administered by the BLM and NPS.

The Proposed Plan/FEIS describes and analyzes five alternatives for managing over 3.3 million acres of lands. Major issues include management of access and management of areas having wilderness characteristics, protection of natural and cultural resources, management of livestock grazing, and recreation (BLM, 2007). Three final management plans and four records of decision signed by the BLM and NPS were completed in 2008. Both national monuments are withdrawn from mineral entry while grazing is allowed with adjustments to meet management objectives. Further evaluation of routes in the entire area will continue for several years (USDOI, 2007).

Pipe Spring National Monument, established in 1923, is located in the Kanab Plateau Basin south of Kaibab and Moccasin. It is a cultural park occupied by several cultures over a period of about 2,000 years due to the occurrence of springs, which have supported farming and ranching activities. There are four springs within the monument boundaries: West Cabin, Main, Spring Room and Tunnel. Main Spring and Spring Room have man-made discharge points constructed by Mormon pioneers and are believed to represent the flow of the original natural spring known as Pipe Spring. Since 1976, NPS staff has measured spring discharge on a monthly basis due to concerns about declines in discharge rates (Truini and others, 2004).

Lake Powell and Wahweap, Paria Basin.

About 3% of the 1.2 million-acre Glen Canyon National Recreation Area is located in the northeastern corner of the Paria Basin. The Recreation area was created by Congress in 1972 to provide for recreational use of Lake Powell and adjacent lands and to preserve scenic, scientific, and historic features. It surrounds and includes Lake Powell from Lees Ferry to the Orange Cliffs in Utah. The principal recreation area development within the planning area is Wahweap, which includes a marina, campground and visitor center. Fluctuations in the lake level affect recreational activities. Since designation of the Grand Canyon-Parashant National Monument, the only remaining portion of the Lake Mead National Recreation Area in the planning area is Lake Mead itself.

Managed Waters

The Colorado River is among the most managed rivers in the United States. The river is impounded behind Glen Canyon Dam, which is managed for both electrical generation purposes and to store water to meet flow obligations at Lees Ferry under the terms of the 1922 Colorado River Compact. As a result, the river's flow and the ecosystem it supports have been fundamentally altered. The Colorado River was a warm, sediment-laden river that historically carried a daily average of 275,000 tons of sediment through the Grand Canyon. Water temperature varied through the year and large spring floods and varying flow patterns deposited sediment along the riverbanks and provided habitat, including calm spawning pools, for a number of native fish species. Operation of the dam for electrical generation requires large water releases during historically low flow seasons with daily and weekly fluctuations. The flow regime is governed by the Record of Decision for the Glen Canyon Dam EIS and the Glen Canyon Operating Criteria (see section 6.0.2). The water released from the bottom of the reservoir is now consistently cold year round and considerably less sediment is now carried downstream, impacting beach building along the riverbank. Vegetative communities, wildlife and native fish have been affected by the modified river flow (Tellman and others, 1997). The Colorado pike minnow and bonytail chub no longer occur in the Grand Canyon, and the humpback chub and razorback sucker are listed as endangered species.

Beginning in 1982, the Bureau of Reclamation initiated the multi-agency interdisciplinary Glen Canyon Dam Environmental Studies to evaluate the impact of Glen Canyon Dam and how its operation could be modified to address wildlife and recreational values downstream of the dam. In 1989, work on an EIS began to consider options for the operation of the dam. The EIS was completed in 1995 and findings indicated that there were a number of uncertainties regarding the downstream impact of water releases from the Dam. While the EIS was being developed, Congress passed the Grand Canyon Protection Act (Act) of 1992 (Public Law 102-575), which required operation of the dam in a manner that would protect and mitigate adverse impacts to Grand Canyon National Park and Glen Canyon National Recreation Area. In compliance with this Act, the EIS proposed an adaptive management process to monitor and assess the effects of dam operations on downstream resources. (USBOR, 2007a)

In 1997, Secretary of Interior (Secretary), Bruce Babbitt, established an Adaptive Management Program (AMP) to "provide an organization and process for cooperative integration of dam operations, downstream resource protection and management, and monitoring and research information…". Critical to the program is the Glen Canyon Adaptive Management Work Group (AMWG), a federal advisory committee. The AMWG incorporates stakeholders into the decision-making process and makes recommendations to the Secretary on how to protect resources. The group completed a draft strategic plan in 2001 and current focus includes recovery of humpback chub, management of sediment resources and experimental releases of water from Glen Canyon Dam (USBOR, 2007a). Before release of the EIS, the Secretary authorized an artificial flood in the Grand Canyon that would mimic historic spring flows,

Colorado River through the Grand Canyon.

in order to help build beaches and habitat. The flood temporarily restored beaches and improved backwater habitat, but pre-flood conditions quickly returned.

As part of the AMP effort, the Bureau of Reclamation completed a scoping report in March 2007 for the Glen Canyon Dam Long-term Experimental Plan EIS. The proposed plan would implement a long-term program in the Colorado River below the dam that could potentially involve dam operations, modifications to the dam's intake structures and other management actions such as removal of non-native fish (USBOR, 2007a).

Unlike the Colorado River, the Virgin River flows uninterrupted from its headwaters above Zion National Park to Lake Mead. Water is diverted from the Virgin River for municipal and agricultural needs in Utah and for agricultural use in Arizona. This river, particularly its upper reaches, is recognized for its recreational and scenic values. Segments of the Virgin River and a number of tributaries totaling 165 miles within Zion National Park were added to the Federal Wild and Scenic River System in March, 2009. It is the only designated system in Utah. Congress adopted the Wild and Scenic Rivers Act in October 1968 to preserve selected rivers that possess "outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural or other similar values" in their free-flowing condition for the benefit of present and future generations. Under the Act the river area must be managed in a manner that protects and enhances its "outstandingly remarkable values" (NWSR, 2007).

6.0.5 Population

The Western Plateau Planning Area is the most sparsely populated planning area in the state although there are some rapidly growing areas. Census data for 2000 show almost 17,500 residents in the planning area. Arizona Department of Economic Security (DES) population projections suggest that the planning area population will more than double by 2030, to about 35,000 residents. Historic, current and projected basin population is shown in the cultural water demand tables for each basin in sections 6.1-6.6.

The 2000 Census populations for each basin and Indian reservation, from highest to lowest, are listed in Table 6.0-4. The most populous basin is the Coconino Plateau with about 9,200 residents in 2000. The Shivwits Plateau and Grand Wash basins have very low populations with 12 and 15 residents in 2000, respectively.

Table 6.0-5 lists incorporated and unincorporated communities in the planning area with 2000 Census populations greater than 500 and growth rates for two time periods. Communities are listed from highest to lowest population in 2000. The planning area population grew by 35% between 1990 and 2000. There are only three incorporated communities in the planning area, Colorado City, Fredonia and Williams. Relatively rapid growth has occurred in several areas including Beaver Dam/Littlefield, Colorado City, Valle and Cameron. The

Table 6.0-4 2000 Census population in the Western Plateau Planning Area

Basin/*Reservation*	2000 Census Population
Coconino Plateau	9,164
Havasupai	*650*
Navajo	*3,068*
Kanab Plateau	6,233
Kaibab-Paiute	*196*
Virgin River	1,532
Paria	528
Grand Wash	15
Shivwits Plateau	12
Total	**17,484**

Table 6.0-5 Communities in the Western Plateau Planning Area with a 2000 Census population greater than 500

Communities	Basin	1990 Census Pop.	2000 Census Pop.	Percent Change 1990-2000	2006 Pop. Estimate	Percent Change 2000-2006	Projected 2030 Pop.
Colorado City*	Kanab Plateau	2,426	3,334	37%	4,150	24%	7,302
City of Williams*	Coconino Plateau	2,532	2,842	12%	3,170	12%	4,068
Grand Canyon Village CDP	Coconino Plateau	1,499	1,460	-3%	1,460	0%	1,460
Cameron CDP[1]	Coconino Plateau	1,011	1,231	22%	1,339	9%	2,236
Beaver Dam/Littlefield	Virgin River	762	1,053	38%	NA	--	NA
Town of Fredonia*	Kanab Plateau	1,207	1,036	-14%	1,120	8%	1,335
Tusayan CDP	Coconino Plateau	NA	562	NA	605	8%	714
Valle	Coconino Plateau	123	534	334%	NA	--	1,010
Total >500		9,560	12,052	26%	NA	--	NA
Other		3,382	5,432	61%	NA	--	NA
Total		**12,942**	**17,484**	35%	**22,894**	--	**35,266**

Source: DES 2006, U.S. Census Bureau 2006, USBOR 2006
NA = not available
CDP = census designated place
* = incorporated communities
[1] = part of population may reside in Eastern Plateau Planning Area

unincorporated areas of Beaver Dam/Littlefield and nearby Scenic, Arizona, are experiencing growth in large part due to their proximity to growth in Mesquite, Nevada. Mesquite experienced an annual growth rate of almost 12% between 2000 and 2008 (Hardcastle, 2008), fueled by development of retirement communities and its growing popularity as a resort destination.

Population Growth and Water Use

Arizona has limited mechanisms to address the connections between land use, population growth and water supply. A legislative attempt to link growth and water management planning is the Growing Smarter Plus Act of 2000 (Act) which requires that counties with a population greater than 125,000 (2000 Census) include planning for water resources in their comprehensive plans. Of the two counties in the planning area, only Mohave County fit the size criteria in 2000. The Mohave County water resources element will develop a water budget for each of the groundwater basins in the county and will prioritize this effort based on growth potential, water availability, number of wells and other factors (Freilich, Leitner & Carlisle, 2005). However, the County's key water issues and planning efforts are related primarily to that part of the County south of the Colorado River. Although not required by law to include a water resources element in the county's comprehensive plan, Coconino County has done so. The County Plan emphasizes conservation in tandem with resource development and recognizes the importance of incorporating climatic variability into water resource planning (Coconino County, 2003).

The Act also requires that twenty-three communities outside AMAs include a water resources element in their general plans. In the Western Plateau Planning Area this requirement applies only to Colorado City. Plans must consider water demand and water resource availability in conjunction with growth, land use and infrastructure.

Beginning in 2007, all community water systems in the state were required to submit Annual Water Use Reports and System Water Plans to the Department. The reports and plans are intended to reduce community water systems' vulnerability to drought, and to promote water resource planning to ensure that water providers are prepared to respond to water shortage conditions. In addition, the information will allow the State to provide regional planning assistance to help communities prepare for, mitigate and respond to drought.

An Annual Water Use Report must be submitted each year by the systems that includes information on water pumped, diverted, and received, water delivered to customers and effluent used or received. The System Water Plan must be updated and submitted every five years and consist of three components, a Water Supply Plan, a Drought Preparedness Plan and a Water Conservation Plan. By January 1, 2008 all systems were required to submit plans. By the end of 2008, plans had been submitted by 18 systems including City of Williams, Colorado City, Fredonia, Grand Canyon National Park and HydroResources-Tusayan and were used to prepare this document. Annual water report information and a list of water plans are found in Appendix B.

Main Street, Williams. City of Williams is one of 18 systems in the planning area that has submitted a water system plan to the Department.

The Department's Water Adequacy Program also relates water supply and demand to growth to some extent, but does not control growth. Developers of subdivisions outside of AMAs are required to obtain a determination of whether there is sufficient water of adequate quality available for 100 years. If the supply is inadequate, lots may still be sold, but the condition of the water supply must be disclosed in promotional materials and in sales documents. Legislation adopted in June 2007 (SB 1575) authorizes a county board of supervisors to adopt a provision, by unanimous vote, which requires a new subdivision to have an adequate water supply in order for the subdivision to be approved by the platting authority. If adopted, cities and towns within the county may not approve a subdivision unless it has an adequate water supply. If the county does not adopt the provision, the legislation allows a city or town to adopt a local adequacy ordinance that requires a demonstration of adequacy before the final plat can be approved. As of September 2009, no counties or towns in the planning area have adopted this provision.

Subdivision adequacy determinations (Water Adequacy Reports), including the reason for the inadequate determination, are provided in basin tables and maps and are summarized in Table 6.0-6. As shown, 86 subdivisions with over 5,400 lots were reviewed for an adequacy determination through 2008. All subdivisions were found to have an inadequate water supply in the Coconino Plateau Basin while all subdivisions were found to have an adequate supply in the Paria Basin.

Shown in the basin sections are approved applications for an Analysis of Adequate Water Supply (AAWS). This application is typically associated with large, master planned communities. The only AAWS determinations in the planning area are in the Virgin River Basin where two applications totaling 27,700 lots have been approved.

No water providers in the planning area are designated as having an adequate water supply for their entire service area as of the date of publication of this document. However, an application for a designation of adequate water supply was pending for Beaver Dam Water Company as of September 2009. A service area designation exempts subdivisions from demonstrating water adequacy if served by the provider.

6.0.6 Water Supply

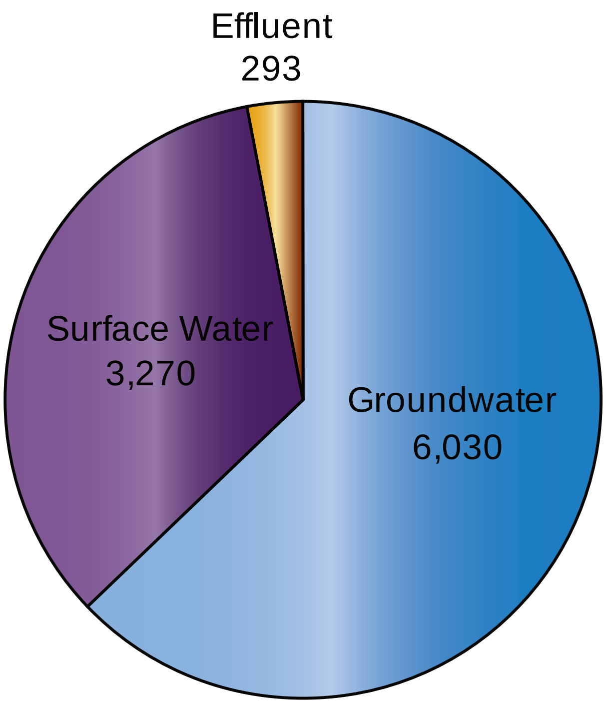
Water supplies in the Western Plateau Planning Area include groundwater, surface water and effluent. As shown on Figure 6.0-15, groundwater is the primary water supply, accounting for about 63% of the demand. Surface water is used for agricultural irrigation in the Virgin River and Kanab Plateau basins and for municipal use in the Coconino Plateau and Kanab Plateau basins. It is estimated that about 34% of the total water demand is met with surface water. Effluent is utilized for golf course irrigation and for landscape irrigation, toilet flushing and other uses in the Coconino Plateau Basin, contributing 3% of the planning area's water supply. For purposes of the Atlas, water diverted from a watercourse or spring is considered surface water and if it is pumped from wells, it is

Table 6.0-6 Water adequacy determinations in the Western Plateau Planning Area as of 12/2008

Basin	Number of Subdivisions	Number of Lots	Lots w/ Adequate Determ.	Lots w/ Inadequate Determ.	Approx. Percent of Lots w/ Percent Inadequate Determ.
Coconino Plateau	53	2,050	0	2,050	100%
Grand Wash	none	none	none	none	none
Kanab Plateau	9	360	201	159	44%
Paria	9	1,356	1,356	0	0%
Shivwits Plateau	none	none	none	none	none
Virgin River	15	1,643	1,617	26	2%
Total	**86**	**5,409**	**3,174**	**2,235**	**41%**

Source: ADWR 2008b

Figure 6.0-15 Average Annual Water Supply Utilized in the Western Plateau Planning Area, 2001-2005 (in acre-feet)



accounted for as groundwater. This is reflected in the cultural water demand tables in each basin section.

Surface Water

About 3,300 AFA of surface water diverted from streams or springs was used on average in the planning area during 2001-2005. Surface water is used primarily for agricultural irrigation but also as a municipal and industrial water supply. Surface water availability is subject to drought and legal access to supplies.

Surface water from Roaring Springs, located 3,000 feet below the North Rim of the Grand Canyon, is the primary water supply for both the North and South Rims. Spring water is pumped to the North Rim from the Roaring Springs pump station and delivered via the Trans-Canyon Pipeline. The Trans-Canyon Pipeline delivers water by gravity flow to Indian Gardens, located below the South Rim, where it is pumped from the Indian Garden pump station through a directional bore hole to water storage tanks on the South Rim. A small portion of the water flowing to Indian Gardens is diverted from the pipeline to Phantom Ranch and Cottonwood Campground. The pipeline has experienced failures an average of 10 to 12 times a year due to washouts during high flow events and bends in the pipeline. For this reason, the Park is studying alternatives to provide reliable, long-term water supplies. Potential alternatives that have been identified include construction of wellfields, diversion of Colorado River water to the South Rim, trucking in water, construction of an infiltration gallery and pumping plant on Bright Angel Creek to supply the South Rim and Phantom Ranch, and other alternatives (USBOR, 2002). There are concerns regarding use of current and future supplies and potential impacts on seeps and springs in the Grand Canyon. Several Arizona Water Protection Fund Projects have funded studies to help research these impacts.

In the Coconino Plateau Basin, the City of Williams historically relied on surface water stored in five small reservoirs with a combined storage capacity of 893 million gallons (2,740 acre-feet). The reservoirs, constructed between 1892 and 1952, collect inflow from snowmelt. Evaporation and seepage from the reservoirs is substantial, with losses greater than the city's annual demand. Two dry years in a row can result in significant stress to the supply system. When surface water supplies were seriously impacted in 1996 the City began a well drilling program to supplement its surface water supplies during periods of shortage (Pinkham and Davis, 2002). As a result and due to ongoing drought, the community utilized primarily groundwater in recent years.

Havasu Creek, which flows from springs emanating from the Redwall-Muav Formations, is a water supply for the Havasupai Tribe at

Agriculture in Havasu Canyon. Surface water is used as both a municipal and agricultural supply on the Havasupai Reservation.

Supai. Surface water is used as both a municipal and agricultural supply on the reservation.

In the Kanab Plateau Basin surface water is a supply at several location. Surface water from Kanab Creek, diverted between Kanab Dam and Fredonia Dam has been used for irrigation in the Fredonia area (ADWR, 1998). The USGS conducted an investigation in 2008 and found 413 acres irrigated with surface water. The Arizona Strip Partnership (now inactive) identified the lack of sufficient surface water supplies for agriculture as an issue in Fredonia. Part of Fredonia's municipal water supply may be surface water delivered from Utah. Jacob Lake Lodge on the Kaibab Plateau uses about seven acre-feet of spring water a year from Warm Spring. Surface water from springs has also been a supply for Twin City Water (Colorado City), although current use is not reported, and for Badger Creek Water in the small community of Vermilion Cliffs. In addition, Marble Canyon Company has a Colorado River diversion entitlement of 70 AFA.

The springs at Pipe Springs National Monument have historically been used for domestic, ranching and farming purposes. A pipeline from Tunnel Spring conveys water outside the monument to maintain water-use agreements with the local cattleman's association. In 1971, a well was drilled outside the monument to meet the growing needs of the monument and the Kaibab-Paiute Indian Tribe (Truini and others, 2004).

In the Virgin River Basin, a small amount of surface water is diverted from Beaver Dam Wash for golf course irrigation. In 2000, about 1,700 acres in the Littlefield area were in cultivation and surface water from the Virgin River was the primary agricultural water supply. However, due to subsequent flood damage and conversion to domestic uses, agricultural acreage has declined significantly. A USGS investigation in 2007 showed only 42 acres of irrigated land in the basin. Surface water was no longer being diverted for agricultural use; all remaining lands were irrigated with groundwater.

In addition to physical availability, the legal availability of a surface water supply is also an important consideration in water management. As described in detail in Appendix C, the legal framework and process under which surface water right applications and claims are administered and determined is complex. Rights to surface water are subject to the doctrine of prior appropriation which is based on the tenet "first in time, first in right". This means that the person who first put the water to a beneficial use acquires a right that is superior to all other surface water rights with a later priority date. Under the Public Water Code, beneficial use is the basis, measure and limit to the use of water. Each type of surface water right filing is assigned a unique number as explained in Appendix C and shown in Table 6.0-7. A Certificate of Water Right (CWR) may be issued if the terms of the permit to appropriate water (3R, 4A, or 33, and in certain cases 38) are met. CWRs retain the original permit application number. The act of filing a statement of claim of rights to use public waters (36) does not in itself create a water right.

Arizona has two general stream adjudications in progress to determine the nature, extent and priority of water rights across the entire river systems of the Gila River and the Little Colorado River. Pertinent to the Western Plateau

Planning Area, the Little Colorado River (LCR) Adjudication area extends into the eastern portion of the Coconino Plateau Basin. The LCR Adjudication is being conducted in the Superior Court of Arizona in Apache County. The LCR Adjudication was initiated by a petition filed by Phelps Dodge Corporation in 1978. It now covers 27,000 square miles and includes three watersheds (Lower Little Colorado River, Upper Little Colorado River and Silver Creek), 5 Indian tribes (Hopi, Navajo, Zuni, Fort Apache and San Juan Southern Paiute) and over 3,000 parties. All parties who claim to have a water right within the river system are required to file a statement of claimant (SOC) (39) or risk loss of their right. This includes reserved water rights for public lands and Indian reservations which for the most part, have not been quantified or prioritized. Results from the Department's investigation of surface water right and adjudication filings are presented in Hydrographic Survey Reports (HSRs); none of which include lands in the Western Plateau Planning Area.

Table 6.0-7 summarizes the number of surface water right and adjudication filings in the planning area. The methodology used to query the Department's surface water right and SOC registries is described in Appendix C. Of the 3,947 filings that specify surface water diversion points and places of use in the planning area, 1,227 CWRs have been issued to date. Figure 6.0-16 shows the general location of surface water diversion points listed in the Department's surface water rights registry. The numerous points reflect the large number of stockponds and reservoirs that have been constructed in the planning area as well as diversions from streams and springs. Locations of registered wells, many of which are referenced as the basis of claim in SOCs are also shown in Figure 6.0-16.

Table 6.0-7 Inventory of surface water right and adjudication filings in the Western Plateau Planning Area[1]

Basin	Type of Filing							Total
	BB[2]	3R[3]	4A[3]	33[3]	36[4]	38[5]	39[6]	
Coconino Plateau	0	73	31	209	468	549	324	**1,654**
Grand Wash	0	16	26	24	97	69	0	**232**
Kanab Plateau	0	199	90	202	309	425	0	**1,225**
Paria	0	32	5	1	34	27	0	**99**
Shivwits Plateau	0	88	33	105	181	172	0	**579**
Virgin River	0	7	22	13	88	28	0	**158**
Total	**0**	**415**	**207**	**554**	**1,177**	**1,270**	**324**	**3,947**

Notes:

[1] Based on a query of ADWR's surface water right and adjudication registries in February 2009. A file is only counted in this table if it provides sufficient information to allow a Point of Diversion (POD) to be mapped within the basin. If a file lists more than one POD in a given basin, it is only counted once in the table for that basin. Several surface water right and adjudication filings are not counted here due to unsufficient locational information. However, multiple filings for the same POD are counted.

[2] Court decreed rights; not all of these rights have been identified and/or entered into ADWR's surface water rights registry.

[3] Application to construct a reservoir, filed before 1972 (3R); application to appropriate surface water, filed before 1972 (4A); and application for permit to appropriate public water or construct a reservoir, filed after 1972 (33).

[4] Statement of claimant of rights to use public waters of the state, filed pursuant to the Water Rights Registration Act of 1974.

[5] Claim of water right for a stockpond and application for certification, filed pursuant to the Stockpond Registration Act of 1977.

[6] Statement of claimant, filed in the Gila or LCR General Stream Adjudications.

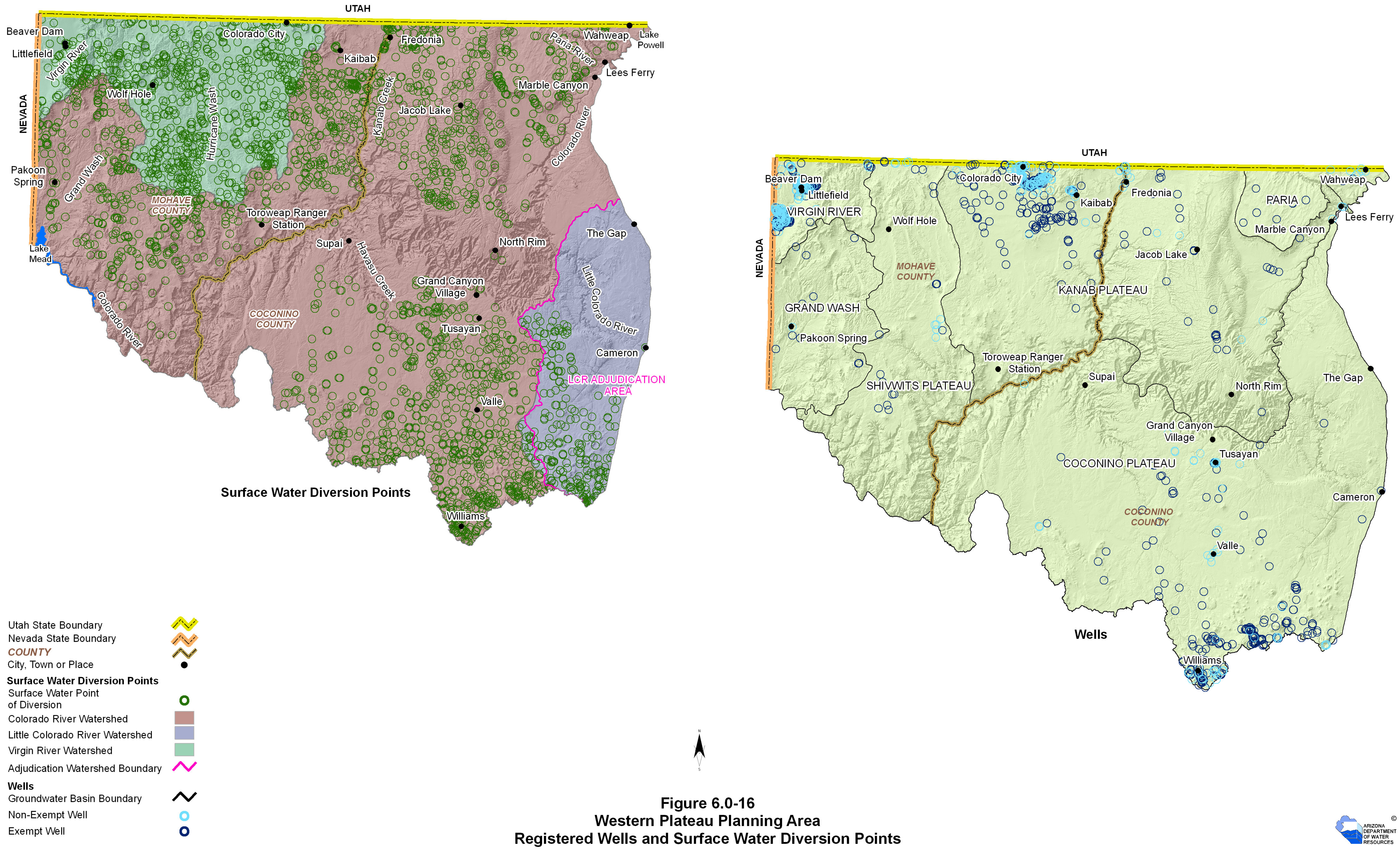


Figure 6.0-16
Western Plateau Planning Area
Registered Wells and Surface Water Diversion Points

As listed in Table 6.0-7, surface water rights may also be determined through judicial action in state or federal court in which the court process establishes or confirms the validity of the rights and claims and ranks them according to priority. Court decreed rights are considered the most certain surface water right. The single major court determination in the planning area is Arizona vs California (1963) which apportioned waters from the mainstem of the Colorado River to the Lower and Upper Basin States and allocated 2.8 maf a year to Arizona. It also reserved water for certain Indian Tribes (none in the planning area) and included provisions for release of water from reservoirs controlled by the United States under normal, surplus and shortage conditions, which includes Lake Powell in the planning area.

Each year, the Secretary is required to declare whether the Colorado River water supply is in a normal, surplus or shortage condition for the Lower Division States (Arizona, California, Nevada). Until 2007, Reclamation lacked specific guidelines to address the operation of Lake Mead and Lake Powell during drought. Following multiple years of drought and decreasing water supplies in storage, in May 2005 the Secretary directed that the Bureau of Reclamation develop guidelines for the operations of Lake Powell and Lake Mead under low reservoir conditions. To address this situation, Reclamation released a Final EIS: Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations of Lakes Powell and Mead (USBOR, 2007b). The Record of Decision was signed in December, 2007. One of the purposes of the guidelines is to provide greater predictability regarding the amount of annual water deliveries to mainstream Colorado River water users in the Lower Division states.

Final EIS reservoir management under shortage conditions includes: adoption of guidelines to identify under what circumstances the Secretary would reduce the annual amount of water available to the Lower Division States from Lake Mead below 7.5 maf/year; define the coordinated operation of Lake Mead and Lake Powell to improve operations under low reservoir conditions; allow for storage and delivery of conserved water in Lake Mead to increase the flexibility of meeting water needs under drought and low storage conditions; and determine those conditions under which the Secretary may declare the availability of surplus water for use within the Lower Division States. (USBOR, 2007b).

Lake Powell, Paria Basin.

The location of surface water resources for each basin in the planning area are shown on surface water condition maps, and maps showing perennial and intermittent streams and major springs. Tables with data on streamflow, flood ALERT equipment, reservoirs, stockponds and springs are also presented in the basin sections (6.1 – 6.6).

Groundwater

Groundwater is the principal water supply for municipal, industrial and agricultural users in the planning area where it is pumped from relatively shallow local aquifers or from deep regional aquifers. Groundwater pumpage averaged about 6,000 AFA during the period 2001 to 2005. Aquifer depth is a significant factor in groundwater availability in the area since it is both expensive to drill wells and to pump water to the surface. Groundwater is pumped from depths exceeding 2,000 feet bls at Tusayan and Williams. In addition, well yields from sedimentary rocks of the deep regional aquifers are generally low unless fractures or faults are encountered. The median well yield of 16 large diameter (>10 inch) wells in the Coconino Plateau Basin completed in sedimentary rock aquifers is about 45 gpm.

Areas of unconsolidated sediments are relatively limited as shown on the groundwater conditions maps for each basin in sections 6.1-6.6. Extensive areas of unconsolidated sediments that comprise basin-fill aquifers are found only in the western portions of the Virgin River and Grand Wash basins. Other basin-fill aquifers in the planning area are generally narrow and bordered by low water yielding consolidated rocks. Areas of relatively high well yield include basin-fill deposits and the Muddy Creek Formation in the Virgin River Basin with a median well yield of 650 gpm based on data from 53 wells (Table 6.6-6).

Few hydrologic studies have been conducted in the planning area and as a result, there is uncertainty regarding groundwater resources including recharge rates and groundwater in storage. Estimates of aquifer recharge are only available for the Virgin River Basin and estimates of groundwater in storage are only available for the Coconino Plateau, Paria and Virgin River basins.

Well data provide information on local groundwater conditions. The Department's Groundwater Site Inventory (GWSI) database, the main repository for statewide groundwater well data, is available on the Department's website (www.azwater.gov). The GWSI database contains over 42,000 records of wells and over 210,000 groundwater level records statewide. GWSI contains spatial and geographical data, owner information, well construction and geologic data and historic groundwater data including water level, water quality, well lift and pumpage records. Included are hydrographs for statewide Index Wells and Automated Groundwater Monitoring Sites (Automated Wells), which can be searched and downloaded to access local information for planning, drought mitigation and other purposes.

Approximately 1,700 wells are designated as Index Wells statewide out of over 43,700 GWSI sites (GWSI sites are primarily wells but include other types of sites such as springs and drains). Typically, Index Wells are visited once each year by the Department's field staff to obtain a long-term record of groundwater level fluctuations. Approximately 200 of the GWSI sites are designated as Automated Wells. These systems measure water levels four times daily

Automated Well in the Virgin River Basin and store the data electronically. Automated wells are established to better understand the water supply situation in areas of the state where data are lacking. These devices are located based on areas of growth, subsidence, type of land use, proximity to river/stream channels, proximity to water contamination sites or areas affected by drought.

Volume 1 of the Atlas shows the location of Index Wells and Automated Wells as of January 2009. At that time there were 14 Index Wells in the planning area, primarily in the Virgin River Basin. Of these, one is an Automated Well located west of Littlefield. Updated maps showing the location of Index and Automated wells may be viewed at the Department's website.

Most large communities in the planning area rely on groundwater supplies. Although groundwater may be difficult to access in many parts of the planning area, it is more reliable than the limited surface water supplies, particularly during drought. Since 1999, the City of Williams has drilled four wells, three of which have static water levels greater than 2,700 feet bls, as a backup to their surface water supplies. Some of the well drilling attempts have been unsuccessful. As of 2002, Williams had spent about seven million dollars to drill six wells, three of which are producing (Pinkham and Davis, 2002). The City currently has four operational wells but one yields only 40 gpm, and another has poor water quality with elevated concentrations of dissolved oxygen, metals and arsenic. Tusayan relies on two 3,000-foot deep wells in the Redwall-Muav Aquifer as its primary water supply but also maintains a fleet of semi-tankers for emergency trucking of water if necessary (HydroResources, 2007). Groundwater is also a supply for two industrial golf courses in the Virgin River Basin.

Santa Fe Reservoir, City of Williams. City of Williams historically relied on surface water stored in five small reservoirs. Since 1999, the city has drilled four wells to supplement surface water supplies.

Groundwater is an agricultural water supply in the Beaver Dam area in the Virgin River Basin and in the Kanab Plateau Basin at Colorado City, Fredonia, and Moccasin/Kaibab. Groundwater use for agricultural irrigation is declining in the planning area.

Information on major aquifers, well yields, estimated natural recharge, estimated water in storage, aquifer flow direction and water level changes are found in groundwater data tables, groundwater conditions maps, hydrographs and well yield maps for each basin in the Water Resource Characteristics sections.

Effluent

Due to the relatively limited groundwater and surface water supplies in the Coconino Plateau Basin, innovative reuse of effluent is occurring at several locations. About 3% of the total water demand was met by effluent during the 2001-2005 time period for golf course irrigation and municipal uses totaling almost 300 AFA. Effluent supplies the water requirements of the Elephant Rock Golf Course at Williams. Effluent treated at the South Grand Canyon Treatment Plant (SGCTP) is used at Tusayan for toilet flushing in hotels and businesses and for landscape irrigation. At Grand Canyon Village, effluent from the SGCTP is reused for toilet flushing, landscape irrigation and other uses including fire fighting in 2007. Effluent generated and treated at Valle is used for landscape irrigation and fire protection (Pinkham and Davis, 2002).

Elephant Rock Golf Course in Williams.

Contamination Sites

Sites of environmental contamination may impact the use of some water supplies. An inventory of Department of Defense (DOD), Resource Conservation and Recovery Act (RCRA), Superfund (Environmental Protection Agency designated sites), Water Quality Assurance Revolving Fund (WQARF, state designated sites), Voluntary Remediation Program (VRP) and Leaking Underground Storage Tank (LUST) sites was conducted for the planning area. Of these various contaminated sites, LUST and VRP sites are found. Table 6.0-8 lists the contaminant and affected media and the basin location of the single VRP site. The location of all contamination sites in the planning area is shown on Figure 6.0-17.

The active VRP site is a heliport site at Tusayan in the Coconino Plateau Basin where soil and groundwater has been contaminated with hydrocarbons and jet fuel. The VRP is a state administered and funded voluntary cleanup program. Any site that has soil and/or groundwater contamination, provided that the site is not subject to an enforcement action by another program, is eligible to participate. To encourage participation, ADEQ provides an expedited process and a single point of contact for projects that involve more than one regulatory program (Environmental Law Institute, 2002). There are also 27 active LUST sites in the planning area including 11 sites at Fredonia, six at Jacob Lake, five at Williams, three at Tusayan, and one each at Cameron and Wahweap.

Table 6.0-8 Contamination site in the Western Plateau Planning Area

SITE NAME	MEDIA AFFECTED AND CONTAMINANT	GROUNDWATER BASIN
Voluntary Remediation Sites		
Heliport Lease Lot #1, Grand Canyon	Soil, Groundwater - Jet A Fuel, Hydrocarbons	Coconino Plateau

Sources: ADEQ 2006a, ADEQ 2006b

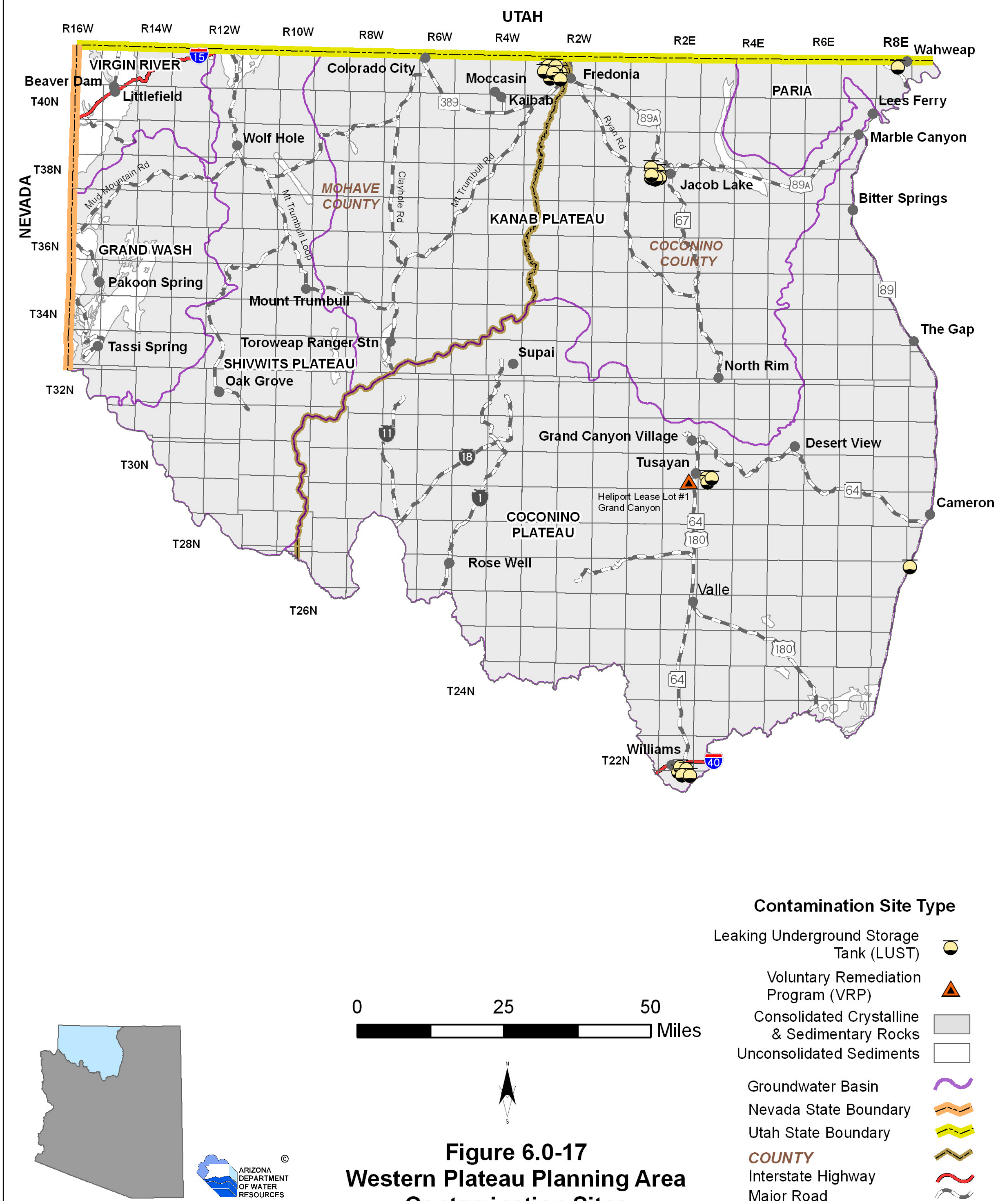


Figure 6.0-17
Western Plateau Planning Area
Contamination Sites

6.0.7 Cultural Water Demand

Total cultural water demand in the Western Plateau Planning Area averaged approximately 9,600 AFA during the period 2001-2005. As shown in Figure 6.0-18, the agricultural demand sector was the largest use sector with approximately 4,600 AFA of demand, 48% of the total. With the exception of small pastures, agricultural demand occurs only in the Kanab Plateau and Virgin River basins. Approximately 57% of agricultural demand was met by groundwater during 2001-2005. Municipal demand represented about 42% of the total planning area demand with an average of approximately 4,000 AFA during the period 2001-2005. Municipal demand was primarily met by groundwater and the municipal sector was the only sector that utilizes effluent. Industrial demand, primarily related to golf course irrigation, accounted for more than 900 AFA, 10% of the total demand during this period. Tribal water demand is included in these totals.

Cultural demand volumes varied substantially between planning area basins, ranging from 150 AFA in several basins to over 4,500 AFA in the Virgin River Basin during 2001-2005 (see Figure 6.0-19).

Tribal Water Demand

The largest Indian reservation in the planning area in terms of size is the western portion of the Navajo Reservation, which is also the largest reservation in Arizona. All of the Havasupai

Figure 6.0-18 Average Annual Western Plateau Planning Area Cultural Water Demand by Sector, 2001-2005 (in acre-feet)

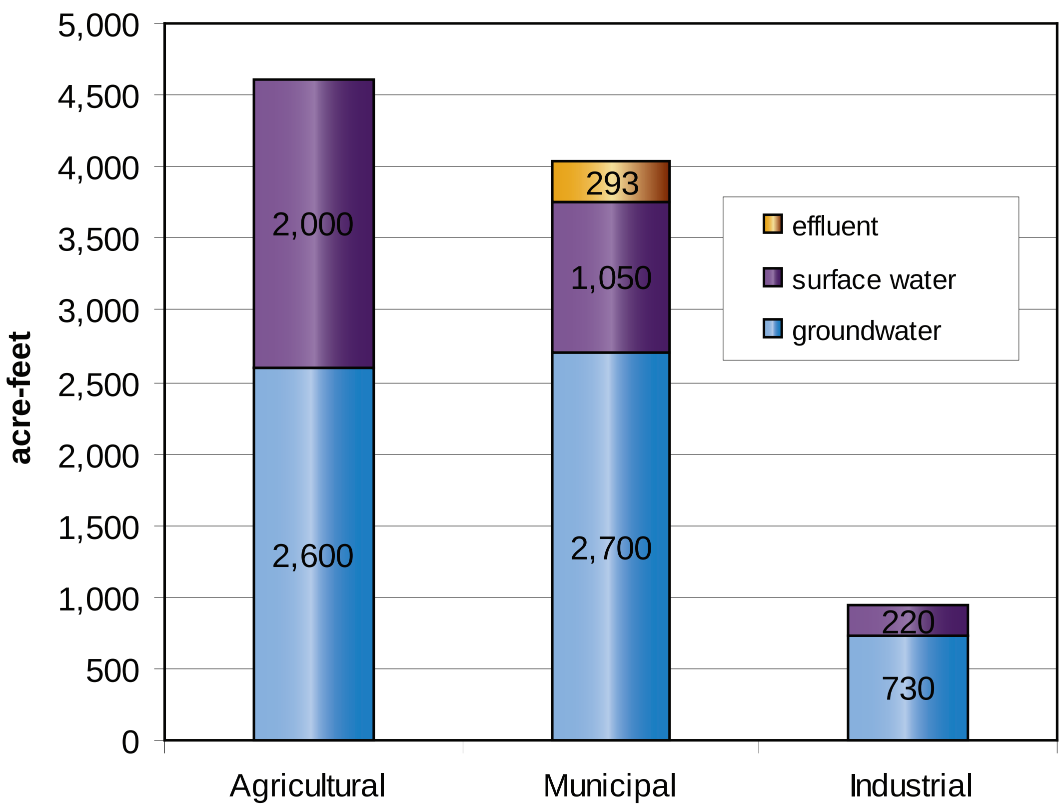
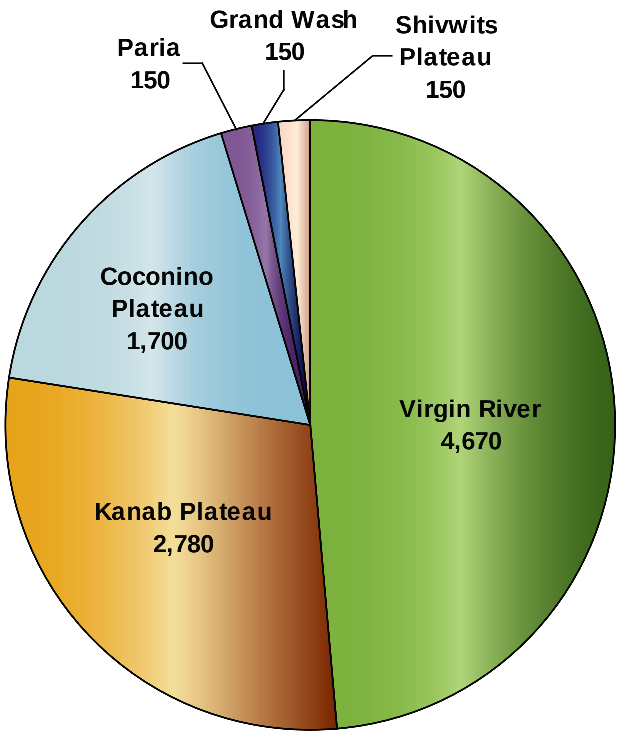


Figure 6.0-19 Average Annual Basin Water Demand, 2001-2005 (in acre-feet)



and Kaibab-Paiute reservations and the eastern portion of the Hualapai Reservation are also within the planning area. The portion of the Hualapai Reservation within the planning area is sparsely populated and its water demand is not known.

Total tribal water demand in the planning area in 2000 was estimated to be approximately 360 AFA with individual tribal estimates listed in Table 6.0-9. More recent demand estimates are not available to the Department. Water demand on the portion of the Navajo Reservation within the planning area is associated with domestic and tourism-related uses at several communities, primarily Cameron but also Gray Mountain, Cedar Ridge and Bodeway (The Gap). Stockwatering is also a likely use. Approximately 250 acre-feet has been used annually in this area (USBOR, 2006).

The Kaibab-Paiute Reservation contains five villages, the largest of which is Kaibab. This Tribe maintains its tribal headquarters, a visitor's center and other services adjacent to Pipe Springs National Monument near the village of Kaibab. The tribal economy is centered on livestock and tourism as well as agriculture. The Tribe owns a 1,300 tree fruit orchard and may expand agricultural activities (ITCA, 2003). Water demand in 2000 is estimated at approximately 56 AFA (ADWR, 2007). The nearby community of Moccasin is not located on reservation land and has been the site of the Mohave County Consolidated Court for over 50 years, serving all of Mohave County north of the Colorado River. The Havasupai use surface water from Havasu Creek and wells completed in shallow stream alluvium along the creek to support the community of Supai and tourism activities. There is also a small amount of farming on the reservation and stock watering. Tourism is the economic base for the tribe with more than 12,000 annual visitors to nearby Havasu Falls (ITCA, 2003). Water demand in 2000 was likely less than 50 AFA (ADWR, 2007).

Municipal Water Demand

Municipal water demand is summarized by groundwater basin and water supply in Table 6.0-10. Average annual demand during 2001-2005 was approximately 4,000 acre-feet. Sixty-seven percent of the municipal demand is met by groundwater. Surface water is used in the

Table 6.0-9 Tribal Water Demand in the Western Plateau Planning Area in 2000 (in acre-feet)

	Agricultural	Municipal
Kaibab-Paiute	46	10
Navajo	0	250
Havasupai	UNK	50
Hualapai	UNK	UNK

UNK= Unknown
Source: ADWR 2007a

Coconino Plateau Basin by Williams and Grand Canyon National Park-South Rim, and in the Kanab Plateau Basin by Grand Canyon National Park-North Rim, Jacob Lake and in the vicinity of Marble Canyon. Effluent is used for golf course irrigation in Williams, toilet flushing and irrigation at Tusayan and Grand Canyon Village and irrigation and fire protection at Valle.

Primary municipal demand centers are Beaver Dam/Littlefield, Colorado City, Fredonia, Grand Canyon National Park, Tusayan and Williams. Five water providers in the planning area served 100 acre-feet or more of water in 2006. These providers and their demand in 1992, 2000 and 2006 are listed in Table 6.0-11. Although Fredonia used about 440 acre-feet of water in 2003, its water supply is from Utah, thus it is not included in the table. It is estimated that about 65% of the planning area population is served by a water provider. In 2006, municipal utilities served the communities of Fredonia and Williams. Municipally-owned systems have more flexible water rate-setting ability than private water companies, which are regulated by the Arizona Corporation Commission. In addition, municipal utilities have the authority to enact water conservation ordinances. These authorities may enable municipal utilities to better manage water resources within water service areas. Water provider issues are discussed in section 6.0.8.

City of Williams

Until recently, the City of Williams was completely reliant on surface water. Due to drought conditions that impacted surface water supplies, Williams has developed a groundwater system to use during periods when reservoir levels are low or to blend with surface water to aid in water treatment. Annual water demand and supply fluctuates from year to year. In 2006, Williams diverted 155 acre-feet of surface water and withdrew 389 acre-feet of groundwater. In 2007, just 85 acre-feet of surface water was diverted and 512 acre-feet of groundwater was pumped.

Municipal uses include residential, commercial and the only municipal golf course in the planning area. In 2006 Williams delivered 184 acre-feet to residential customers and 305 acre-feet to non-residential customers. The Elephant Rock Golf course used 153 acre-feet of effluent

Table 6.0-10 Average annual municipal water demand in the Western Plateau Planning Area, 2001-2005 (in acre-feet)

Basin	Groundwater	Surface Water[1]	Effluent[2]	Total
Coconino Plateau	500	900	293	1,693
Grand Wash	<300			<300
Kanab Plateau	1,600	<300		1,750
Paria	<300			<300
Shivwits Plateau	<300			<300
Virgin River	<300			<300
Total Municipal	2,700	1,050	293	4,043

Sources: USGS 2007, ADWR 2008c

Notes: Volumes <300 acre-feet assumed to be 150 acre-feet for computation purposes

[1] Reflects water utilized within the basin. The Cultural Demand Tables for the Kanab Plateau and Coconino Plateau basins in Sections 6.1.8 and 6.3.8 reflect water withdrawn in the basins.

[2] Includes golf course, turf irrigation and municipal reuse in Tusayan, Grand Canyon Village and Williams in 2006.

Table 6.0-11 Water providers serving 100 acre-feet or more of water per year in 2006, excluding effluent, in the Western Plateau Planning Area

Basin/Water Provider	1992 (acre-feet)	2000 (acre-feet)	2006 (acre-feet)
Coconino Plateau Basin			
City of Williams	450	620[1]	543
Grand Canyon National Park Water Utility	NA	528	574[2]
South Rim System	*NA*	*465*[3]	*510*
North Rim System	*NA*	*63*	*64*
HydroResources-Town of Tusayan	135	125	153
Kanab Plateau Basin			
Centennial Park DWID - Colorado City	NA	NA	346[4]
Twin City Water Company - Colorado City[5]	NA	NA	976
Virgin River Basin			
Beaver Dam Water Company	5	39	160[4]

Sources: CWS annual reports for 2006 & 2007, City of Williams 2007, Coconino County 1997, Pinkham and Davis 2002

[1] Williams began using groundwater in 2000.

[2] Grand Canyon National Park System Water Plan, 2006; from average daily demand for North and South Rim systems. Diversion from Roaring Springs, in the Kanab Plateau Basin was 883 acre-feet.

[3] Based on potable water production, Pinkham and Davis, 2002

[4] 2007 data from CWS annual report

[5] Twin City Water Company may include water from wells in Utah.

NA = Not Available

for irrigation in 2006, its only water supply that year.

As the “Gateway to the Grand Canyon”, tourism is an important part of the local economy with hotels, restaurants, gas stations and other services. Williams maintains a metered standpipe for water haulers, restricted to households built as of June 2000. In 2000, Williams had 495 registered non-commercial water hauling customers. Some of the water used in the unincorporated residential community of Red Lake, located north of Williams, is hauled from Williams. Use of the standpipe service by commercial haulers is restricted during drought (Pinkham and Davis, 2002). Expansion of both its water and wastewater treatment plants may be needed in the near future. Because much of the area surrounding Williams relies on hauled water and delivers septic tank waste to the city wastewater treatment plant, the City is in the position of providing these services outside of its service area.

<u>Grand Canyon National Park</u>

Grand Canyon National Park, with about five million visitors a year and a year round population of almost 1,500 at Grand Canyon Village on the South Rim, is one of the largest municipal users in the planning area. Seasonal employees at Grand Canyon Village increase the summer population by about 40%. The Village includes a school, medical clinic, fire station, administrative offices and other services in addition to hotels, restaurants and campgrounds. The South Rim receives most of the Park’s visitors and uses almost 90% of the water. By contrast, the North Rim is closed from mid-October to mid-May, has limited services compared to the South Rim and receives one-tenth the number of visitors. (Pinkham and Davis, 2002)

Grand Canyon National Park Water Utility services all the developed areas within the Park boundaries using water transported from Roaring Springs located below the North Rim in the Kanab Plateau Basin. The utility serves the

Grand Canyon Village. Photo courtesy of the National Park Service

South Rim, Desert View, North Rim, Roaring Springs, Phantom Ranch and Indian Gardens (NPS, 2006). It also provides a relatively small volume of hauled water to the U.S. Forest Service-Tusayan. In 2006, 883 acre-feet of water was diverted at Roaring Springs, however this was not all delivered. Excess water diverted at Roaring Springs and transported to the South Rim by the Trans-Canyon Pipeline overflows at Indian Gardens and returns to the Colorado River. Of the water diverted, almost 600 acre-feet entered the North and South Rim systems in 2006. Of this, 432 acre-feet was reported delivered to customers on both Rims; 105 acre-feet to residential and 327 acre-feet to commercial customers. In addition, 3 acre-feet was delivered to the U.S. Forest Service-Tusayan Ranger Station. The utility does not separately report North and South Rim water deliveries on its Community Water System annual report. The estimated demand for each system shown in Table 6.0-10 is based on average daily demands reported by the Park in its System Water Plan (NPS, 2006).

The South Rim Wastewater Treatment Plant generated about 463 acre-feet of effluent in 2006. Water is treated to ADEQ A+ standards and has been reused for toilet flushing at the visitor center and employee rest rooms, to wash down portions of a kennel, for the railroad steam engine, dust control, revegetation efforts and on a small amount of turf at the El Tovar Lodge. While the reclaimed water distribution system is relatively extensive, on-site plumbing is incomplete (Pinkham and Davis, 2002). In 2006, 37 acre-feet of effluent was used for firefighting and 140 acre-feet was used for landscaping, toilet flushing and construction.

<u>Tusayan</u>

The small, unincorporated community of Tusayan is located about a mile south of the entrance to the South Rim of Grand Canyon National Park. It is surrounded by public land and has a population of about 600. Tusayan's economy is based on tourism including hotels, restaurants, an airport and visitor service establishments (Pinkham and Davis, 2002).

HydroResources-Tusayan serves approximately three-quarters of the water demand at Tusayan utilizing two 3,000-foot deep wells that produce 65 to 80 gpm. Other water systems are ADOT, which serves the Grand Canyon Airport, and Anasazi Water (HydroResources, 2007). However, both systems received water from HydroResources in 2006 and 2007. The community relied on small local wells and hauled water prior to 1995 when the deep wells and reclaimed water began to be used (Pinkham and Davis, 2002). For example, in 1992 Tusayan water was provided by the Canyon Squire Inn well (64 acre-feet), and water hauled from Williams and Bellemont (40 acre-feet) and Grand Canyon National Park (30 acre-feet) (USDA, 1999).

Anasazi Water has one well, and in addition to receiving water from HydroResources, it may use a relatively small amount of hauled water from Williams or Valle. Both HydroResources and Anasazi Water wholesale water to the Tusayan Water Development Association, which bills water customers, but does not operate the water systems. The two systems are interconnected to ensure uninterrupted service to the community and HydroResources owns a well in Valle from which water may be trucked to Tusayan in an emergency.

HydroResources withdrew 153 acre-feet of water in 2006 and delivered 19 acre-feet to Anasazi Water and 6 acre-feet to ADOT. Within its service area, it served 10 acre-feet to residential customers and 116 acre-feet to non-residential customers. All water used indoors in Tusayan is treated at the South Rim Wastewater Treatment Plant. Effluent is used extensively for toilet flushing and irrigation. In 2001, almost 70 acre-feet of effluent was used at Tusayan (Pinkham and Davis, 2002). Although annual effluent use volumes are not reported by HydroResources on its Community Water System annual report, the utility reported that 30-40% of its former groundwater withdrawals have been replaced by effluent (HydroResources, 2007).

ADOT-Grand Canyon Airport operates a rainwater collection system consisting of 5 acres of Hypalon plastic, which provides potable water to the terminal, office, hangar facilities and a dozen homes. However, ongoing drought conditions have required the purchase of water from HydroResources-Tusayan (GCNP Airport, 2008). The airport has also used reclaimed water for irrigation (Pinkham and Davis, 2002).

Colorado City

Colorado City is located in the Kanab Plateau Basin in Mohave County on the northern border of Arizona, adjacent to Hildale, Utah. The two communities have close cultural and economic ties, with nearly half of the population employed in Hildale. The community was initially settled by ranchers in the early 1900's but around 1930 a religious group from Utah settled in the area and played a major part in shaping the present-day community (USDOI, 2007).

Colorado City is the largest community and municipal demand center in the planning area with a 2006 population of more than 3,300 and water demand of over 1,300 acre-feet served by two systems; Centennial Park Domestic Water Improvement District (DWID) and Twin City Water Works (TCWW). The wastewater treatment plant in Colorado City was closed in 2002 and wastewater is now treated at a plant in Hildale.

Most of Colorado City is served water pumped from wells owned by TCWW, which also serves Hildale Utah. TCWW owns five wells in Arizona and additional system wells may be located in Utah. The City buys water wholesale from TCWW, treats it to drinking water standards, and delivers it to customers through its water delivery infrastructure. Based on verbal communication with system representatives, about two-thirds of the water delivered by TCWW is used in Colorado City, totaling approximately 976 acre-feet in 2006. Municipal uses include residential, commercial and light manufacturing but Colorado City does not separately report these deliveries.

The southeastern part of Colorado City is served by Centennial Park DWID, which operates three wells and serves domestic customers. Centennial Park DWID does not have an interconnection to another system and is not completely metered. In 2007 it reported withdrawals of 346 acre-feet.

Beaver Dam/Littlefield

The communities of Beaver Dam, Littlefield, Scenic and the surrounding area in the Virgin River Basin are experiencing development due primarily to the nearby rapidly growing community of Mesquite, Nevada. These communities provide housing for much of Mesquite's workforce and for retirees (USDOI, 2007). The area is served by private water systems or domestic wells. The largest system is Beaver Dam Water Company, which reported

Beaver Dam, Virgin River Basin

withdrawals of 160 acre-feet from three wells in 2007. (Withdrawals in 2006 were from engineering estimates and are much greater than metered 2007 and 2008 data). It delivered almost 139 acre-feet to residential customers and 21 acre-feet to non-residential customers in 2007. Beaver Dam East DWID withdrew 13 acre-feet of groundwater from one well in 2006 and served residential customers only. The area is anticipated to experience population growth with associated increases in municipal demand.

<u>Other Communities</u>
Fredonia, in the Kanab Plateau Basin, is the largest town in Coconino County on the Arizona Strip. It was founded in 1885 with an economy based on agriculture, timber and mining. A sawmill operation at Fredonia closed in 1995 and tourism, government activities and agriculture are the primary current economic activities. The population of Fredonia declined between 1990 and 2000 by about 14% but is now slowly increasing.

In 2007 Fredonia reported that all water used was transported by pipeline from Utah and did not report the volume or type of water supply delivered. In 2003, about 440 acre-feet of water was served by the Town of which about half was reported delivered from Utah. Approximately 160 acre-feet of effluent is produced at Fredonia but not reused.

Valle, located between Williams and Tusayan, is a small but rapidly growing community that grew by 334% between 1990 and 2000. It is served by two water systems with wells over 3,000 feet deep. One of these systems is owned by the Grand Canyon Inn, which also operates a wastewater treatment plant and a standpipe for water haulers. The Inn uses wastewater to irrigate landscaping at the hotel and for fire protection. Water demand data are not available for this system.

The other system, HydroResources-Valle, serves the Grand Canyon Valle Airport, a mobile home park and operates two standpipes for water haulers. In 2006 it withdrew 35 acre-feet from one well. This system is not interconnected to any other system and emergency water is hauled from Tusayan. A small wastewater treatment plant serves users on this system and effluent is used to irrigate a ballpark.

The area surrounding Valle is primarily composed of large lot development without sewer or water service. Most residents must haul water and use septic systems for wastewater disposal. Despite the lack of services, there has been significant subdivision activity in the area (Pinkham and Davis, 2002).

Agricultural Demand

Agricultural demand in the planning area averaged about 4,600 AFA during 2001-2005, primarily for pasture irrigation (Table 6.0-12). Aside from small domestic pastures and gardens, agricultural irrigation is found only in the Kanab Plateau and Virgin River basins. Note that the data source for the cultural demand maps in the groundwater basin sections is from satellite imagery collected between 1999 and 2001 and may not accurately represent more recent agricultural demands in the planning area.

There is considerably less irrigation in the Kanab Plateau Basin now than historic levels. From 1976 through 1990 approximately 2,000 acre-feet of groundwater was pumped annually (Table 6.3-8) and between 1,400 to 1,850 acres of alfalfa, pasture and a minor amount of grain and corn were historically irrigated with surface water from Kanab Creek. (ADWR, 1998) By 2007, the USGS estimated approximately 1,400 acre-feet of water was used for irrigation.

In the Fredonia area, surface water from Kanab Creek was historically diverted between Kanab Dam and Fredonia Dam, primarily within the boundaries of the Fredonia Consolidated Irrigation and Manufacturing Company District. The District owns and operates the Fredonia Dam, constructed in 1918, and a concrete-lined distribution ditch. District lands are located mainly east of Kanab Creek south of the town (ADWR, 1998). The USGS conducted a field survey of the area in 2007 and found 413 acres flood irrigated with surface water and 65 acres sprinkler irrigated with groundwater with a total demand of 676 AFA (Table 6.0-13).

Table 6.0-12 Agricultural water demand in the Western Plateau Planning Area

	1991-1995 (acre-feet)	1996-2000 (acre-feet)	2001-2005 (acre-feet)
Kanab Plateau			
Groundwater	1,500	1,500	<1,000
Surface Water	<1,000	<1,000	<1,000
Total	2,000	2,000	1,000
Virgin River			
Groundwater	7,800	8,300	2,100
Surface Water	5,800	6,200	1,500
Total	13,600	14,500	3,600

Source: USGS 2007, ADWR 2005a
Note: Volumes <1,000 acre-feet assumed to be 500 acre-feet for computational purposes

The USGS observed 72 acres of irrigation at Colorado City in 2007 with an associated demand of 262 acre-feet (Table 6.0-13). Large fallow areas, previously irrigated with center pivot systems, were observed in the Colorado City area in summer 2007. At Moccasin, the USGS found about 129 acres of irrigation, primarily alfalfa in 2007. There is a small amount of agricultural activity, including a 1,300-tree fruit orchard, on the Kaibab-Paiute Indian Reservation with an estimated groundwater demand of about 50 AFA.

Table 6.0-13 Active agricultural acres in the Kanab Plateau (2008) and Virgin River (2007) basins

Region	Basin	Crop Type	Acres	Irrigation System	Water Type	Water Withdrawal (Acre-Feet)
Colorado City	Kanab Plateau	Rye Grass	60	Sprinkler	Groundwater	232
		Corn	12			30
Fredonia	Kanab Plateau	Rye Grass	413	Flooded	Surface Water	425
			24	Sprinkler	Groundwater	95
		Alfalfa	41			156
Moccasin	Kanab Plateau	Alfalfa	114	Center Pivot	Groundwater	442
		Rye Grass	8	Sprinkler		31
		Oats/Grass Mix	5			19
		Corn	2			4
		Orchard	0.16	Flooded		1
		Vegetables	0.09			1
Beaver Dam/Littlefield	Virgin River	Alfalfa	38	Sprinkler	Groundwater	147
		Pistachio	4	Drip		10

Source: USGS 2009

In the Virgin River Basin, irrigation demand declined from an annual average of 14,500 acre-feet during the period 1996-2000 to an annual average of 3,600 acre-feet during 2001-2005. This decline occurred due to flood damage along the Virgin River and Beaver Dam Wash and to urbanization. By 2005, it was estimated that about 525 acres were still in production in the Littlefield/Beaver Dam area (Kyle Spencer, NRCS, personal communication 3/25/05). However, when the USGS conducted a field investigation of the area in 2006, it found just 42 acres in active production, primarily alfalfa, with an associated demand of 157 acre-feet.

Industrial Demand

Industrial demand in the planning area was relatively low, averaging about 950 AFA during the period 2001-2005. As summarized in Table 6.0-14, quantified industrial demand in the planning area consists of golf courses served by facility water systems and a small dairy. There are two industrial golf courses in the Virgin River Basin. The Meadowayne Dairy, located on the north side of Colorado City in the Kanab Plateau Basin is estimated to have an annual demand of about 30 acre-feet.

Golf course demand is listed in Table 6.0-15. Hamilton Ranch Golf Course is located in the community of Beaver Dam. Flooding in 2006 washed out all but 8 holes. Irrigation of the existing course uses about 220 AFA of groundwater and surface water diverted from Beaver Dam Wash. The other industrial golf course, The Palms, located in Scenic adjacent to the Nevada state line, is an 18-hole course that uses about 440 AFA of groundwater. The only other golf course in the planning area is Elephant Rock, a municipally-served golf course at Williams with an annual demand of about 150 acre-feet of effluent.

There is additional industrial demand in the planning area not reflected in Table 6.0-14, primarily sand and gravel operations in the Virgin River Basin and elsewhere. Some of the operations are identified on the cultural demand maps. Water is used for aggregate washing, dust control, vehicle washing and equipment cooling. Typically, relatively little water is consumed at these sites.

Table 6.0-14 Industrial demand in the Western Plateau Planning Area

	1991-1995	1996-2000	2001-2005
Type	**Water Use (acre-feet)**		
Golf Course Total	**920**	**920**	**920**
Virgin River			
Groundwater	700	700	700
Surface Water	220	220	220
Dairy/Feedlot Total	**30**	**30**	**30**
Kanab Plateau			
Groundwater	30	30	30

Source: ADEQ 2005b, ADWR 2008c, USGS 2007

Table 6.0-15 Golf course demand in the Western Plateau Planning Area (c 2006)

Facility	Basin	# of Holes	Demand (acre-feet)	Water Supply
Elephant Rock Golf Club	Coconino Plateau	18	150	Effluent
Hamilton Ranch*	Virgin River	8	220	Groundwater/ Surface Water
The Palms Golf Course*	Virgin River	18	441	Groundwater

Source: ADWR 2008c
Notes:
* These golf courses are served by their own wells and, therefore, considered to be industrial users
Flooding in 2006 washed out all but eight holes at the Hamilton Ranch Golf Course

The three mines shown on the Kanab Plateau Basin cultural demand map (Figure 6.3-11) are currently (2009) inactive uranium mines owned by Denison Mines that have received aquifer protection permits from ADEQ. The Arizona One Mine, about 35 miles south of Fredonia received its final permit in 2009, allowing mining to resume. The two other mines, Canyon and Pinenut, require additional permits before work can commence. (McKinnon, 2009) A number of mining companies are currently exploring the Arizona Strip and claiming breccia pipes for uranium mining. The highest grade uranium deposits in the United States occur in breccia-pipe environments in northwest Arizona.[4] It is anticipated that if developed, these mining operations would involve minimal water use. Water is used primarily in ore processing, which would occur elsewhere. The minor amount of water needed for mining on site would come from stormwater collection and/or shallow groundwater encountered in perched aquifers on site (Nyals Neimuth, ADMMR, personal communication, 6/07).

There are concerns about uranium mining near the Grand Canyon and the Colorado River due to potential impacts to air and water quality (McKinnon, 2009). In July, 2009 Interior Secretary Salazar enacted a two-year moratorium on new mining claims on almost 1 million acres of federal lands north of the Grand Canyon. The moratorium was imposed to further study the risks associated with mining and evaluate whether to withdraw the lands from new mining claims for an additional 20 years (USDOI, 2009).

6.0.8 Water Resource Issues in the Western Plateau Planning Area

Water resource issues in the Western Plateau Planning Area have been identified in water resource studies, by community watershed groups, through surveys, and from other sources. Studies, planning, conservation activities, watershed groups and results from water provider surveys are discussed in this section.

The Colorado River is a significant political, social and planning barrier, as well as a physical barrier, and the area south of the River has different water resource concerns compared to areas north of the river. North of the River, the Arizona Strip is sparsely populated with few population centers. Colorado City, the largest community, has not identified any significant water resource issues. The Virgin River Basin is somewhat physically isolated from the rest of the Arizona Strip, and while experiencing rapid population growth, contains no incorporated communities. As a result, most of the water resource planning activities have occurred south of the Colorado River in the Coconino Plateau Basin.

Studies, Planning and Conservation

A number of water resource studies have been conducted in the planning area south of the Colorado River. Studies have been conducted in response to environmental concerns, growth and limited water supplies. A primary objective has been to better understand the water supply, water demand and hydrology of the area in order to develop a regional approach to water resource planning. A major effort has been the North Central Arizona Water Supply Study, which was completed in 2006 and involved the cooperation of the Bureau of Reclamation, Navajo Nation, Hopi Tribe, Havasupai Tribe, the Grand Canyon Trust, City of Williams, the City of Flagstaff, the City of Page, Coconino County, the Department of Water Resources, the USGS and USFWS. The next step for

[4] A breccia pipe is a vertical pipe-like column of broken rock. On the Colorado Plateau in northwestern Arizona, these pipes formed when sedimentary rocks collapsed into solution cavities in the underlying Redwall limestone. Mineralizing fluids passing through the pipes deposited metallic minerals, sometimes including uranium. A typical pipe is about 300 feet in diameter and can extend as much as 3,000 feet. (Wenrick, 2007)

this group is to secure funding to conduct a feasibility study to evaluate water supply alternatives. Other notable studies provide detailed information on cultural water supplies and demand in the Coconino Plateau Basin. These include: North Central Arizona Water Demand Study, (Pinkham and Davis, 2002), Grand Canyon National Park Water Supply Appraisal Study (USBOR, 2002) and the EIS for Tusayan Growth (USDA, 1999).

On the Arizona Strip, an EIS for the Grand Canyon-Parashant and Vermilion Cliffs national monuments and for other BLM lands (BLM, 2007) provides a comprehensive study of much of the area north of the Colorado River. While the focus of the EIS is on land management to preserve the objectives of the monuments and other areas, water resources and demands are included as a component of the cooperative management of the area.

The National Park Service has conducted numerous studies and management activities in Grand Canyon National Park and Glen Canyon National Recreation Area. The water resources of the Park have been of particular concern given development on the South Rim and nearby areas and the potential impact of associated water development activities on seeps and springs in the Grand Canyon. Development and implementation of new management strategies through the Adaptive Management Program will affect the environmental conditions downstream of Glen Canyon Dam throughout much of the planning area. (USBOR, 2007a) There is significant interplay between resource development and environmental needs in the planning area given the amount of federally protected lands as parks, monuments, recreation areas and wilderness areas.

Because of relatively scarce water supplies, communities have made extraordinary efforts to develop new water supplies and reuse existing resources such as effluent and graywater. As mentioned previously, Grand Canyon Village and the community of Tusayan have taken extreme measures to conserve existing resources and reuse effluent for multiple purposes, including widespread use of effluent for toilet flushing. The rainwater harvesting system at the Tusayan airport is unprecedented in Arizona. The City of Williams and Tusayan's well drilling programs are excellent examples of local efforts to improve supply reliability and better utilize available resources. The City of Williams water conservation program includes incentives to retrofit old plumbing fixtures and install drought tolerant landscaping and several other water systems in the planning area provide water conservation information to customers.

Shivwits Plateau Basin. Most of the planning area is sparsely populated and as a result, most of the water resource planning activities have occurred south of the Colorado River in the Coconino Plateau Basin.

As mentioned in Section 6.0.5, by January 2008, all large (>1,850 customers) community water systems were required to submit System Water Plans. Small systems were required to submit plans by January 2008. The plans are intended to reduce community water systems' vulnerability to drought, and to promote water resource planning to ensure that water providers are prepared to respond to water shortage conditions. Within the planning area plans have been submitted by 18 systems including the City of Williams, Colorado City, Town of Fredonia, Grand Canyon National Park, HydroResources-Tusayan and Beaver Dam Water Company.

As part of implementation of the State Drought Plan, Local Drought Impact Groups (LDIGs) are being formed, as necessary, at the county level and a Mohave County group has been established. LDIGs are voluntary groups that will coordinate drought public awareness, provide impact assessment information to local and state leaders, and implement and initiate local drought mitigation and response actions. These groups are coordinated by local representatives of Arizona Cooperative Extension and County Emergency Management and supported by ADWR's Statewide Drought program. Information on LDIGs may be found at the Department's website.

The Mohave County Comprehensive Plan water resources element includes development of a water budget for each of the groundwater basins in the county and will prioritize this effort based on growth potential, water availability, number of wells and other factors (Freilich, Leitner & Carlisle, 2005). However, the County's key water issues and planning efforts are focused on the part of the County south of the Colorado River. The Coconino Comprehensive Plan emphasizes conservation in tandem with resource development and recognizes the importance of incorporating climatic variability into water resource planning (Coconino County, 2003). In addition, Coconino County has adopted individual Area Plans including three in the planning area: Tusayan, Valle and Red Lake (located north of Williams) which include a discussion of water and wastewater infrastructure. However, these area plans all date from the 1990s.

An application from Wind River Resources L.L.C. to transport groundwater from the Virgin River Basin to Mesquite Nevada in 2005 was recently an important issue for the area. The application proposed to transport water from Beaver Dam Wash pursuant to A.R.S. § 45-291 et seq. The statute allows for transportation of groundwater out of state, conditional on several criteria. The proposal included construction of three wells in the Mormon Wells area along Beaver Dam Wash. The proposal was to initially withdraw 800 AFA and up to 14,000 AFA by 2045, and transport it to the Virgin Valley Water District in Mesquite. The Director of the Department denied the application in November 2007.

Another issue involving the Virgin River is related to Colorado River shortage sharing as discussed previously in Section 6.0-6. The Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lakes Powell and Mead (Guidelines), provide for the conservation of Colorado River water by creating the Intentionally Created Surplus (ICS) program. The ICS program provides flexibility in the delivery of Colorado River water by allowing Colorado River contractors to add water to the system through conservation, system efficiency improvements, or importation to be released in the future by the Secretary of Interior to the State (Arizona, California or Nevada) that added the water (ADWR, 2009).

One of the categories of ICS is Tributary Conservation ICS. This category allows a water user to fallow water rights in tributaries of the Colorado River that were in use prior to the effective date of the Boulder Canyon Project Act (BCPA) (1929) and transport this water to

Virgin River through Virgin River Gorge.

the Colorado River for credit. This allows an entity to develop some water resources that were formerly identified as "in-state water" by conveying them to the Colorado River for current or future use (SNWA, 2008).

Regarding the Virgin River, an agreement to the Guidelines, the "Southern Nevada Water Authority Virgin and Muddy Rivers Tributary Conservation, Intentional Created Surplus (ICS) Project", allows the Southern Nevada Water Authority to temporarily forego development of Virgin River water rights received after the BCPA was enacted while it pursues long-term Colorado River augmentation. Under the agreement, irrigation rights granted to Nevada prior to the BCPA will be used. SNWA, which has purchased many of these rights, will fallow the land and let the amount not consumed flow into Lake Mead through the Virgin River or its tributaries where the water will be withdrawn directly from the lake, without building a new pipeline (SNWA, 2008). Five percent of the water conserved under the Tributary Conservation ICS program is left in Lake Mead to increase the water supplies for the system. Flow in the Virgin River will not be impacted through Arizona under the SNWA agreement (Gelt, 2004).

Watershed Groups

Several watershed groups affiliated with the Department's Rural Watershed Initiative Program have formed to address water resource issues. The two active groups, the Coconino Plateau Water Advisory Council and the Northern Arizona Municipal Water Users Association, include not only part of the Western Plateau but also part of the Eastern Plateau and Central Highlands planning areas. A watershed group previously existed in the Fredonia area, (the Arizona Strip Partnership), but is no longer active. A list of participants, activities and issues for all watershed groups in the planning area is found in Appendix D.

Primary issues identified by the Arizona Rural Watershed Initiative groups that pertain to the planning area are summarized as follows:

Growth:
- Unregulated lot splits
- Significant projected growth

Water Supplies and Demand:
- Limited and deep groundwater supplies
- Access to water development on public lands
- Limited groundwater data
- Limited supplies to meet current and projected demands
- Numerous water haulers with few hauling stations that are sometimes cut-off during drought

- Brackish groundwater (Arizona Strip)
- Interstate stream issues (Arizona Strip)
- Inadequate surface water supplies for agriculture (Arizona Strip)

Legal:

- Unresolved Indian water rights claims

Funding:

- Limited funding resources for planning, projects, infrastructure and studies
- High cost of water augmentation projects
- Costs associated with hauling water
- Infrastructure needs for private water companies

Drought:

- Drought sensitive surface water supplies

Environmental:

- Potential for groundwater development to impact springs in Grand Canyon and Havasupai and Hualapai Indian Reservation water supplies

Other:

- Unsafe dams (Williams and Fredonia)

Issue Surveys

The Department conducted a rural water resources survey in 2003 to compile information for the public and help identify the needs of growing communities. This survey was also intended to gather information on drought impacts to incorporate into the Arizona Drought Preparedness Plan, adopted in 2004. Questionnaires were sent to almost 600 water providers, jurisdictions, counties and tribes, and a report of the findings from the survey was subsequently completed (ADWR, 2004).

Only one water provider in the planning area responded to the 2003 survey. The Department conducted another, more concise survey of water providers in 2004. This was done to supplement the information gathered in the previous year in support of developing the Arizona Water Atlas, and to reach a wider audience by directly contacting each water provider. Through this effort, ten water providers in the Western Plateau Planning Area, with a total of approximately 2,400 service connections, participated and provided information on water supply, demand, and infrastructure and ranked a list of seven issues. There were five respondents from the Virgin River Basin, three from the Kanab Plateau Basin and two from the Coconino Plateau Basin.

Table 6.0-16 Water resource issues ranked by survey respondents in the Western Plateau Planning Area

Issue	Percent of 2004 respondents reporting issue was a moderate or major concern
Inadequate storage capacity to meet peak demand	43%
Inadequate well capacity to meet peak demand	14
Inadequate water supplies to meet current demand	43
Inadequate water supplies to meet future demand	43
Infrastructure in need of replacement	29
Inadequate capital to pay for infrastructure improvements	71
Drought related water supply problems	29

Source: ADWR, 2005b

Water providers were asked in the 2004 survey to rank seven issues from 0 to 3 with 0 = no concern, 1 = minor concern, 2 = moderate concern and 3 = major concern. All water providers responded, but two reported no concerns. Results are summarized in Table 6.0-16 for the eight providers that ranked issues of concern. The most highly ranked issue, inadequate capital for infrastructure improvements, was identified primarily by respondents located in the Virgin River Basin. Inadequate storage was primarily an issue in the Kanab Plateau Basin.

6.0.9 Groundwater Basin Water Resource Characteristics

Sections 6.1 through 6.6 present data and maps on water resource characteristics of the six groundwater basins in the Western Plateau Planning Area. A description of the data sources and methods used to derive this information is found in Appendix A of Volume 1 of the Atlas. This section briefly describes general information that applies to all of the basins and the purpose of the information. This information is organized in the order in which the characteristics are discussed in Sections 6.1 through 6.6.

Geographic Features

Geographic features maps are included to present a general orientation to principal land features, roads, counties and cities, towns and places in the groundwater basin.

Land Ownership

The distribution and type of land ownership in a basin has implications for land and water use. Large amounts of private land typically translate into opportunities for land development and associated water demand, whereas federal lands are typically maintained for a purpose with little associated water use. State owned land may be sold or traded, and is often leased for grazing and farming. The extent of state owned lands is due to a number of legislative actions. The State Enabling Act of 1910 and the Act that established the Territory of Arizona in 1863 set aside sections 2, 16, 32 and 36 in each township to be held in trust by the state for specified purposes, which are identified for each basin (ASLD, 2006).

Climate

Climate data including temperature, rainfall, evaporation rates and snowfall are critical components of water resource planning and management. Averages and year to year variability, seasonality of precipitation and long-term climate trends are all important factors in demand and supply planning.

Surface Water Conditions

Depending on physical and legal availability, surface water may be a potential supply in a basin. Stream gage, flood gage, reservoir, stockpond and runoff contour data provide information on physical availability of this supply. Seasonal flow information is relevant to seasonal supply availability. Annual flow volumes provide an indication of potential volumetric availability.

Surface water maps display runoff contours and the location of reservoirs and gages. Also shown are 1st and 2nd order streams, and 3rd order streams with gages. The stream order used is the Cartographic order, similar to ‘stream level’ used by the USGS to categorize streams in its National Hydrography Dataset (NHD). This method assigns Level 1 to the principal stream in a drainage area, major tributaries are assigned Level 2, minor tributaries are assigned Level 3, etc.

Criteria for including stream gage stations in the basin tables are that there is at least one year of record, and annual streamflow statistics are included only if there are at least three years of record. There are different types of stations and those that only serve repeater functions were not included.

Flood gage information is presented to direct the reader to sources of additional precipitation and flow information that can be used in water resource planning. Large reservoir storage information provides data on the amount of water stored in the basin, its uses, and ownership. Because of the large number of small reservoirs, and less reliable data, individual small reservoir data is not provided. The number of stockponds is a general indicator of small scale surface water capture and livestock demand. Runoff contours reflect the average annual runoff in tributary streams. They provide a generalized indication of the amount of runoff that can be expected at a particular geographic location.

Perennial and Intermittent Streams and Major Springs

A map of perennial and intermittent streams is provided for each basin. For some basins, more than one source of information was used. Stream designations may not accurately reflect current conditions in some cases. Spring data was compiled from a number of sources in an effort to develop as comprehensive a list as possible. Spring data is important to many researchers and to the environmental community due to their importance in maintaining habitat, even from small discharges.

Groundwater Conditions

Several indicators of groundwater conditions are presented for each basin. Aquifer type can be a general indicator of aquifer storage potential, accessibility of the supply, aquifer productivity, water quality and aquifer flux. Well yield information for large diameter wells is provided and is generally measured when the well is drilled and reported on completion reports. It was assumed that large diameter wells were drilled to produce a maximum amount of water and, therefore, their reported pump capacities are indicative of the aquifer's potential to yield water to a well. However, many factors can affect well yields including well design, pump size and condition and the age of the well. Reported well yields are only a general indicator of aquifer productivity and specific information is available from well measurements conducted as part of basin investigations.

Natural recharge is typically the least well known component of a water budget. Many of the estimates in the Atlas are derived from studies of larger geographic areas and all deserve further study. Similarly, estimates of storage are based on rough estimates and considerably more studies are needed in most basins. Components of storage include aquifer depth and specific yield.

Water level data is from measured wells, usually collected during the period when the wells were not actively being pumped or only minimally pumped. Depth to water measurements are shown on mapped wells if there was a measurement taken during 2003-2004. The basin hydrographs show water-level trends for selected wells over the 30-year period from January 1975 to January 2005. Not all basins have a sufficient number of representative hydrographs.

The flow directions that are shown generally reflect long-term, regional aquifer flow in the basin and are not meant to depict temporary or local-scale conditions. However, flow directions in some basins indicate how localized pumping has altered regional flow patterns.

Water Quality

Water quality conditions impact the availability of water supplies. Water quality data were compiled from a variety of sources as described in Volume 1 Appendix A. The data indicate areas where water quality exceedences have previously occurred, however additional areas of concern may currently exist where water quality samples have not been collected or sample results were not reviewed by the Department (e.g. samples collected in conjunction with the

ADEQ Aquifer Protection Permit programs). It is important to note also that the exceedences presented may or may not reflect current aquifer or surface water conditions.

Cultural Water Demand

Cultural water demand is an important component of a water budget. However, without mandatory metering and reporting of water uses, accurate demand data is difficult to acquire. Municipal demand includes water company and domestic (self-supplied) demand estimates. Basin demand information is from several sources in order to prepare as accurate an estimate as possible. Annual demand estimates have been averaged over a specific time period. This provides general trend information without focusing on potentially inaccurate annual demand estimates due to incomplete data.

Locations of major cultural water uses are primarily from a 2004 USGS land cover study using older satellite imagery that may not represent recent changes. The cultural demand maps provide only general information about the location of water users.

Effluent generation data was compiled from several sources to provide an estimate of how much of this renewable resource might be available for use. However, effluent reuse is often difficult both logistically and economically since a potential user may be far from the wastewater treatment plant.

Water Adequacy Determinations

Information on water adequacy and inadequacy determinations for subdivisions, with the reason for the inadequacy determination provides information on the number and status of subdivision lots. Listing the reason for the inadequacy identifies which subdivisions have a demonstrated physical or legal lack of water or may have elected not to provide the necessary information to the Department. Briefly, developers of subdivisions outside of AMAs are required to obtain a determination of whether there is sufficient water of adequate quality available for 100 years. If the supply is determined to be inadequate, lots may still be sold, but the condition of the water supply must be disclosed in promotional materials and in sales documents.

In addition to these subdivision determinations for which a water adequacy report is issued, water providers may apply for adequacy designations for their entire service area. If a subdivision is to be served water from one of these water providers, then a separate adequacy determination is not required. (See Section 6.0-5).

Developers of large, master-planned communities outside of AMAs may apply for an Analysis of Adequate Water Supply (AAWS). This type of application is generally used to prove that water will be physically available for the master-planned community. AAWS are issued based on the development plan or plat. If an AAWS is issued for groundwater, it reserves a specific volume of water for 10 years (for purposes of further adequacy reviews) only for the specific property that is the subject of the AAWS.

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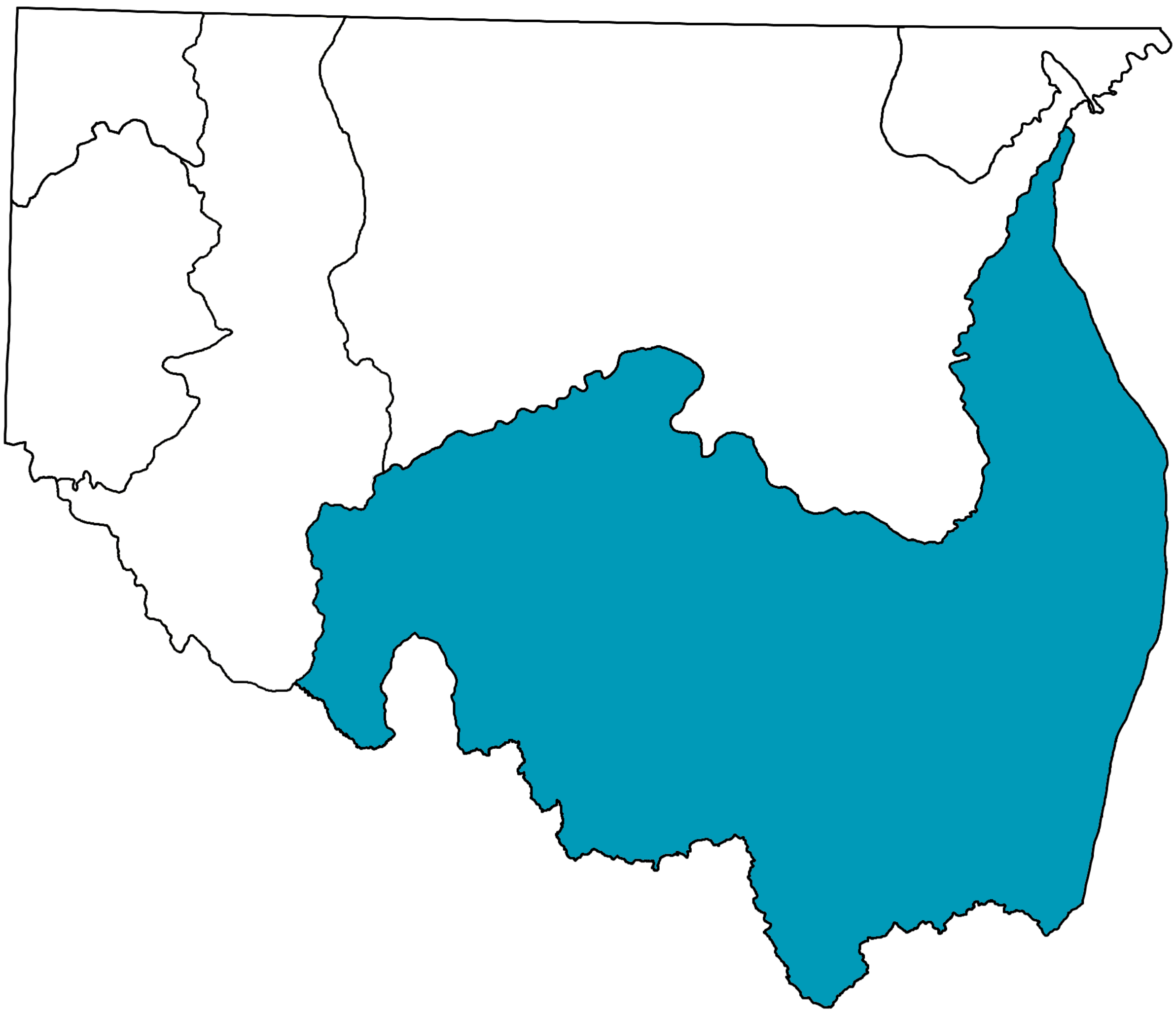
Section 6.1
Coconino Plateau Basin



6.1.1 Geography of the Coconino Plateau Basin

The Coconino Plateau Basin, located in the southeastern part of the planning area is 5,812 square miles in area and the largest basin in the planning area. Geographic features and principal communities are shown on Figure 6.1-1. The basin is characterized by high-elevation mountain ranges, plateaus and canyons. Vegetation types include Mohave and Great Basin desertscrub, Plains and Great Basin grasslands, Great Basin conifer woodland and Rocky Mountain and madrean montane conifer forest. There are small areas of subalpine conifer forest and alpine tundra in the San Francisco Mountains in the southeast corner of the basin. (See Figure 6.0-11)

- Principal geographic features shown on Figure 6.1-1 are:
    - The Colorado River and Grand Canyon forming the northern basin boundary
    - Numerous streams that flow into the Colorado River including Diamond Creek, Havasu Creek and the Little Colorado River
    - Coconino Plateau in the center of the basin
    - Aubrey Cliffs in the western portion of the basin
    - San Francisco Peaks in the southeastern portion of the basin, including the highest peak in the basin and planning area, Mt. Humphries at 12,633 feet.
    - The lowest point at approximately 2,100 feet where the Colorado River exits the basin.

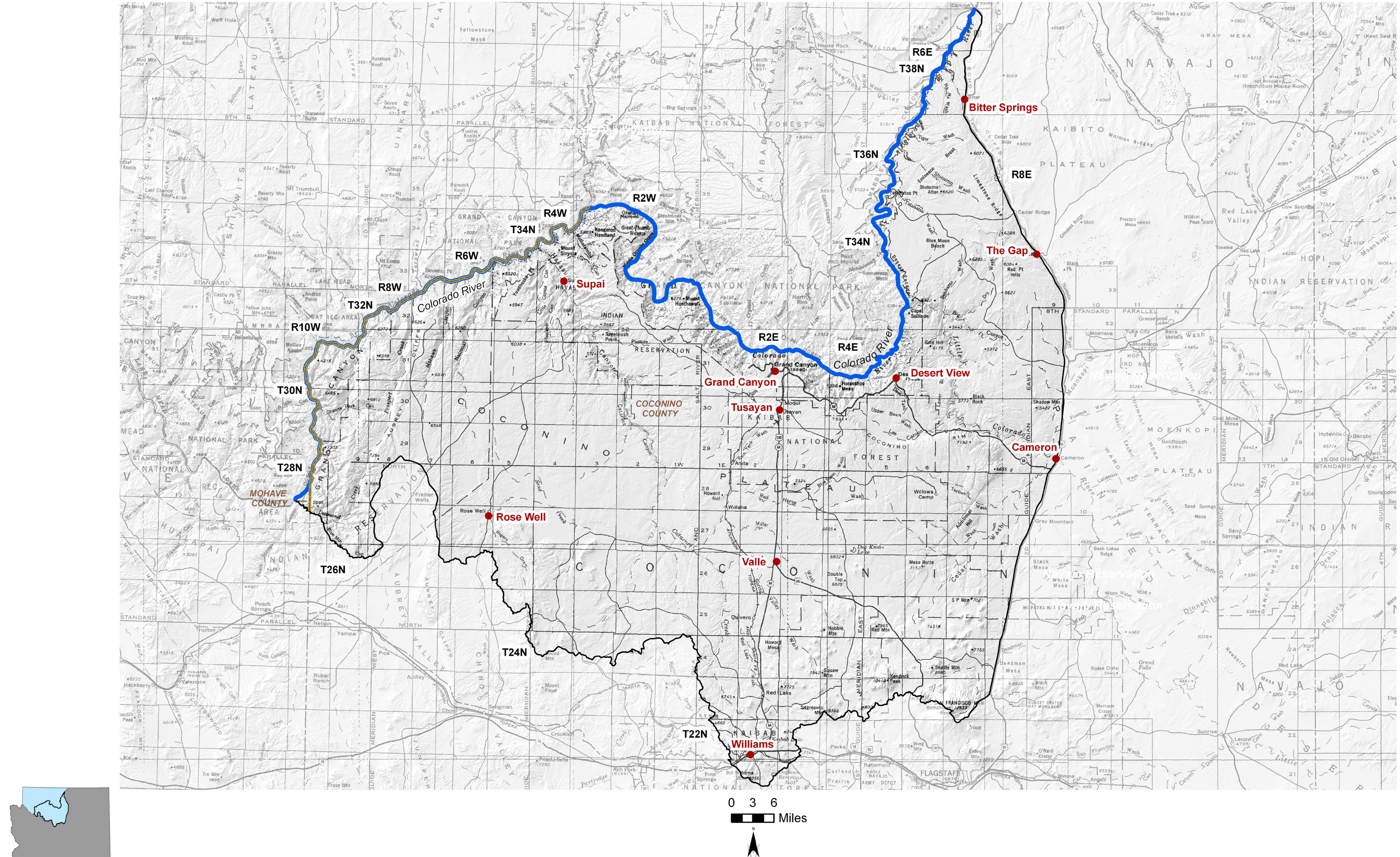


Figure 6.1-1
Coconino Plateau Basin
Geographic Features

Base Map: USGS 1:500,000, 1981

COUNTY
City, Town or Place

6.1.2 Land Ownership in the Coconino Plateau Basin

Land ownership, including the percentage of ownership by category, for the Coconino Plateau Basin is shown in Figure 6.1-2. Principal features of land ownership in this basin are the large blocks of tribal lands and the checkerboard pattern of state trust and private land. A description of land ownership data sources and methods is found in Volume 1, Appendix A. More detailed information on protected areas is found in Section 6.0.4. Land ownership categories are discussed below in the order from largest to smallest percentage in the basin.

Indian Reservation

- 37.3% of the land is under tribal ownership.
- The basin includes all of the Havasupai Indian Reservation and parts of the Hualapai Indian Reservation and the Navajo Indian Reservation.
- This basin contains the largest percentage of tribal lands in the planning area.
- Land uses include domestic, commercial, recreation and ranching.

Private

- 22.0% of the land is private.
- The majority of the private land is in the center of the basin and is interspersed with state trust lands.
- Land uses include domestic, commercial and ranching.

National Forest

- 17.8% of the land is federally owned and managed by the United States Forest Service (USFS).
- Forest lands in the basin are part of the Kaibab and Coconino National Forests.
- The basin contains approximately 25,000 acres in two wilderness areas, Kendrick Mountain in the Coconino and Kaibab National Forests and Kachina Peaks in the Coconino National Forest. (see Figure 6.0-14)
- Land uses include recreation, grazing and timber production.

State Trust Land

- 15.4% of the land is held in trust for the public schools and seven other beneficiaries under the State Trust Land system.
- Most state land is located in the center of the basin interspersed in a checkerboard pattern with private land.
- Primary land use is grazing.

National Park Service (NPS)

- 7.4% of the land is federally owned and managed by the National Park Service as the Grand Canyon National Park.
- Land uses include resource conservation and recreation.

U.S. Bureau of Land Management (BLM)

- 0.1% of the land is federally owned and managed by the Hassayampa Field Office of the

Bureau of Land Management.

- The small portion of BLM land is southwest of Grand Canyon Village.
- Primary land use is grazing.

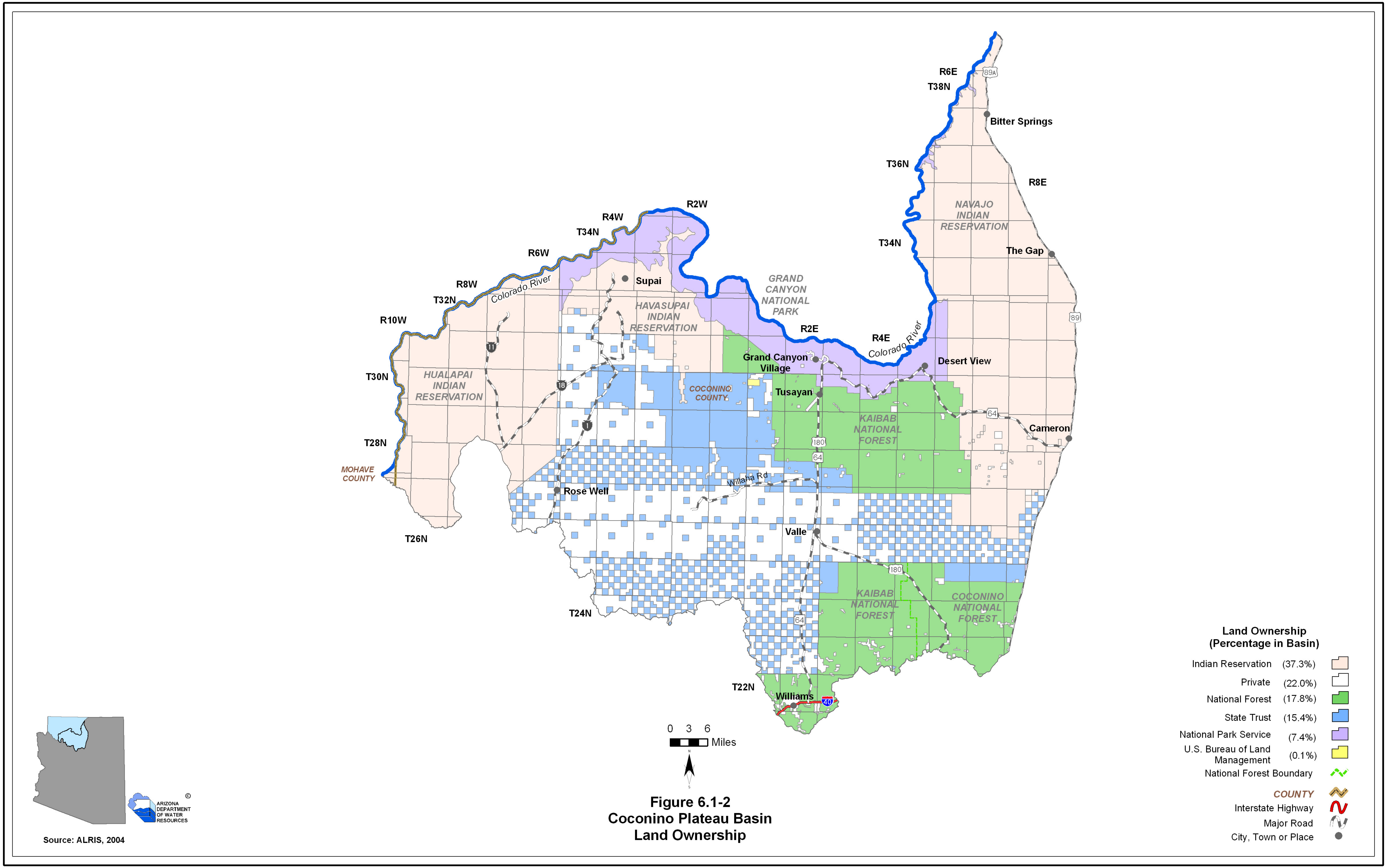


Figure 6.1-2
Coconino Plateau Basin
Land Ownership

6.1.3 Climate of the Coconino Plateau Basin

Climate data from NOAA/NWS Co-op Network, Evaporation Pan and SNOTEL/Snowcourse stations are complied in Table 6.1-1 and the locations are shown on Figure 6.1-3. Figure 6.1-3 also shows precipitation contour data from the Spatial Climate Analysis Service (SCAS) at Oregon State University. The Coconino Plateau Basin does not contain AZMET stations. More detailed information on climate in the planning area is found in Section 6.0.3. A description of the climate data sources and methods is found in Volume 1, Appendix A.

NOAA/NWS Co-op Network

- Refer to Table 6.1-1A
- There are five NOAA/NWS Co-op network climate stations in the basin. The average monthly maximum temperature occurs in July and ranges between 83.0°F at Supai and 67.2°F at Grand Canyon #2. The average monthly minimum temperature occurs in January and ranges between 40.7°F at Supai and 29.3°F at Grand Canyon National Park.
- Highest average seasonal rainfall occurs at all stations in the summer (July-September). For the period of record used, the highest annual rainfall is 21.37 inches at Williams and the lowest is 8.76 inches at Supai.

Evaporation Pan

- Refer to Table 6.1-1B
- There is one evaporation pan station in the basin, Grand Canyon National Park 2. This pan is at 6,790 feet and has an annual evaporation rate of 44.04 inches.

SNOTEL/Snowcourse

- Refer to Table 6.1-1D
- There are four SNOTEL/Snowcourse stations in the basin, one at the Grand Canyon and the others located in the San Francisco Peaks area.
- The highest average monthly snowpack at most stations is in April.

SCAS Precipitation Data

- See Figure 6.1-3
- Additional precipitation data shows average annual rainfall as high as 40 inches at the southeastern tip of the basin and as low as four inches along the Colorado River and in the vicinity of Cameron.

Table 6.1-1 Climate Data for the Coconino Plateau Basin

A. NOAA/NWS Co-op Network:

Station Name	Elevation (in feet)	Period of Record Used for Averages	Average Temperature Range (in °F)		Average Precipitation (in inches)				
			Max/Month	Min/Month	Winter	Spring	Summer	Fall	Annual
Grand Canyon N.P.	6,890	1971-2000	69.2/Jul	29.3/Jan	4.38	1.92	5.73	3.65	15.68
Grand Canyon N.P. 2	6,970	1971-2000	67.0/Jul	30.4/Jan	5.20	2.17	5.40	3.73	16.50
Grand Canyon N.P. 3	6,960	1957-1977[1]	69.0/Jul	30.5/Jan	2.92	1.84	3.89	3.87	12.51
Supai	3,200	1956-1987[1]	83.0/Jul	40.7/Jan	2.36	1.20	3.02	2.18	8.76
Williams	6,750	1971-2000	68.3/Jul	33.4/Jan	6.77	2.28	7.28	5.04	21.37

Source: WRCC, 2005b

Notes:
N.P. = National Park
[1] Average temperature for period of record shown; average precipitation from 1971-2000

B. Evaporation Pan:

Station Name	Elevation (in feet)	Period of Record Used for Averages	Avg. Annual Evap (in inches)
Grand Canyon N P. 2	6,790	1976 - 2002	44.04

Source: WRCC, 2005a

C. AZMET:

Station Name	Elevation (in feet)	Period of Record	Average Annual Reference Evaportranspiration, in inches (*Number of years to calculate averages*)
None			

D. SNOTEL/Snowcourse:

Station Name	Elevation (in feet)	Period of Record	Average Snowpack, as Snow Water Content, at the Beginning of the Month, in Inches *(Number of measurements to calculate average)*					
			Jan.	Feb.	March	April	May	June
Bear Paw	10,100	1968 - current	9.8 *(16)*	11.6 *(27)*	17.7 *(36)*	20.5 *(37)*	18.1 *(20)*	7.1 *(11)*
Grand Canyon	7,500	1947 - current	1.2 *(24)*	2.3 *(58)*	2.0 *(59)*	0.7 *(56)*	0 *(0)*	0 *(0)*
Snowslide Canyon	9,750	1968 - current	6.7 *(16)*	9.0 *(27)*	13.4 *(36)*	15.2 *(37)*	9.1 *(20)*	0.7 *(10)*
Snowslide Canyon (SNOTEL)	9,730	1998 - current	*6.8 (9)*	*9.9 (9)*	*14.16 (9)*	*16.4 (9)*	*10.8 (9)*	0.7 *(9)*

Source: Natural Resources Conservation Service 2006a and 2006b

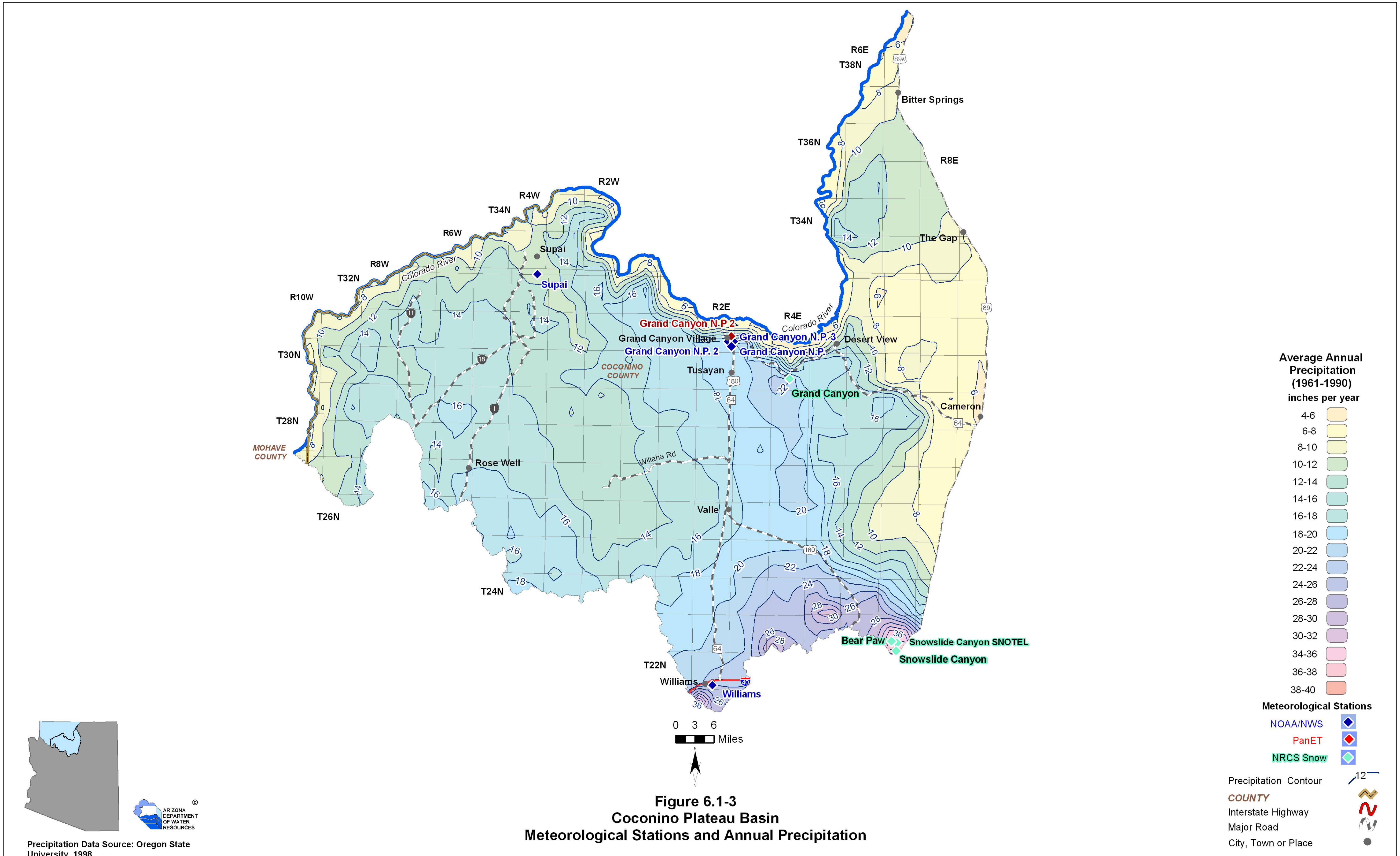


Figure 6.1-3
Coconino Plateau Basin
Meteorological Stations and Annual Precipitation

6.1.4 Surface Water Conditions in the Coconino Plateau Basin

Streamflow data, including average seasonal flow, average annual flow and other information are shown in Table 6.1-2. Flood ALERT equipment in the basin is shown in Table 6.1-3. Reservoir and stockpond data, including maximum storage or maximum surface area, are shown in Table 6.1-4. The location of streamflow gages identified by USGS number, flood ALERT equipment, USGS runoff contours and large reservoirs are shown on Figure 6.1-5. Descriptions of stream, reservoir and stockpond data sources and methods are found in Volume 1, Appendix A.

Streamflow Data

- Refer to Table 6.1-2.
- Data from 12 stations located at eight watercourses are shown in the table and on Figure 6.1-5. Six of the 12 stations have been discontinued and five of the six remaining stations are real-time stations.
- Average seasonal flow is relatively similar in all seasons at more than half of the stations due to regulated flow on the Colorado River or proximity to springs. Exceptions are, Moenkopi Wash near Cameron and Bright Angel Creek near Grand Canyon.
- The largest annual flow recorded in the basin is 15.97 million acre feet (maf) in 1997 at the Colorado River above Diamond Creek near Peach Springs station with a contributing drainage area of more than 149,000 square miles.
- Most streams in this basin have a mean and median annual flow of over 10,000 acre-feet. The Colorado River and the Little Colorado River have a mean annual flow of over 100,000 acre-feet.
- The main tributary to the Colorado River, the Little Colorado River has a mean annual flow of more than 162,000 acre-feet near Cameron. As shown on Figure 6.1-4, there is significant variability in year to year flow at this station.

Flood ALERT Equipment

- Refer to Table 6.1-3.
- As of October 2005 there were two stations in the basin.

Reservoirs and Stockponds

- Refer to Table 6.1-4.
- The basin contains 12 large reservoirs. The largest is Dogtown with a maximum storage capacity of 1,390 acre-feet.
- The most common use of the large reservoirs is for fire protection or as a stock or farm pond. Dogtown, Kaibab and Cataract Reservoirs provide water supply for the City of Williams.
- Half of the large reservoirs in this basin are either dry or intermittent lakes.
- Surface water is stored or could be stored in 45 small reservoirs in the basin.
- There are 757 registered stockponds in this basin.

Runoff Contour

- Refer to Figure 6.1-5.
- Average annual runoff is highest, two inches per year or 106.6 acre-feet per square mile, in the southeastern portion of the basin and decreases to 0.1 inches, or 5.33 acre-feet per square mile, along most of the Colorado River.

Figure 6.1-4 Annual Flows (acre-feet) at Little Colorado River near Cameron, water years 1948-2006 (Station #9402000)

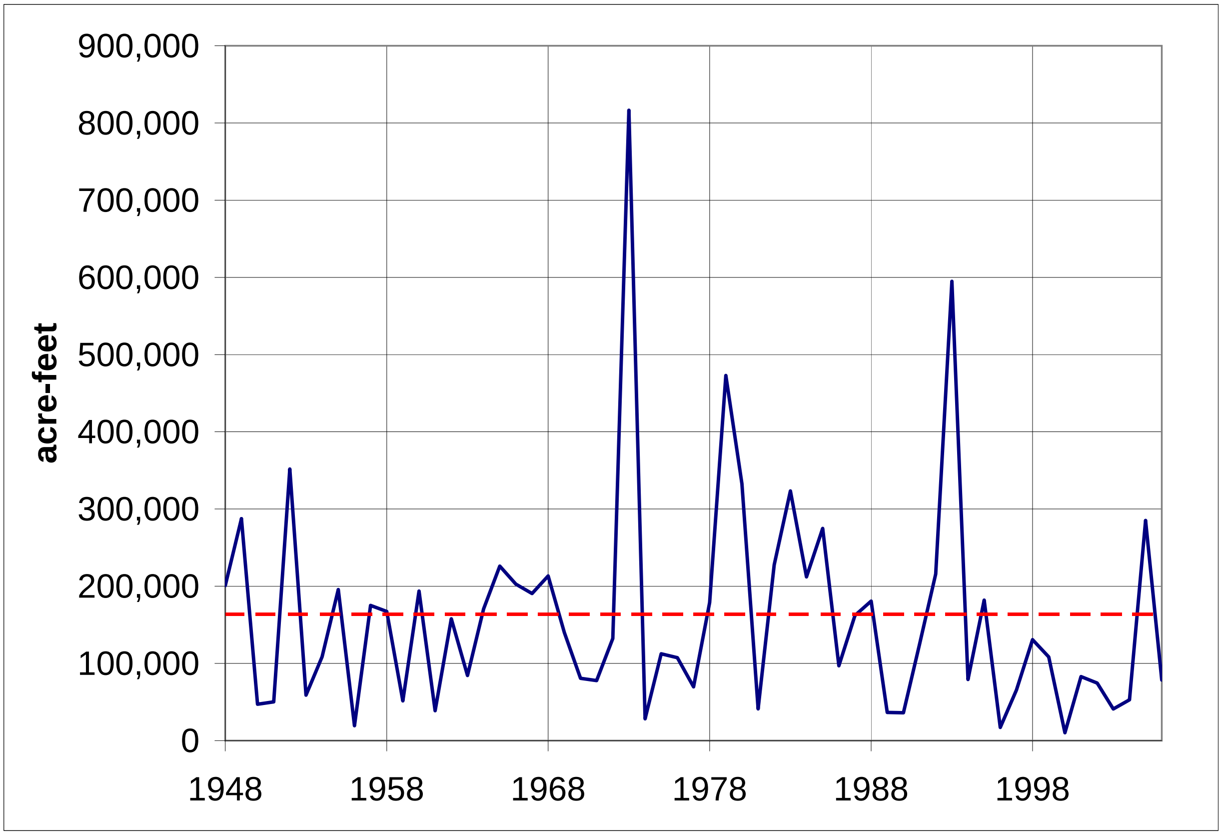


Table 6.1-2 Streamflow Data for the Coconino Plateau Basin

Station Number	USGS Station Name	Drainage Area (in mi^2)	Gage Elevation (in feet)	Period of Record	Average Seasonal Flow (% of annual flow)				Annual Flow/Year (in acre-feet)				Years of Annual Flow Record
					Winter	Spring	Summer	Fall	Minimum	Median	Mean	Maximum	
9401500	Moenkopi Wash near Cameron	2,662	4,161	10/1953-1/1965 (discontinued)	6	3	78	13	3,671 (1960)	6,936	9,981	19,909 (1963)	11
9402000	Little Colorado River near Cameron	26,459	3,979	6/1947-current (real time)	34	26	27	14	10,215 (2000)	138,315	162,519	816,449 (1973)	55
9402300	Little Colorado River above the mouth near Desert View	NA	2,760	5/1990-current (real time)	31	34	18	7	No statistics run; less than 3 years of data				2
9402450	Cottonwood Spring above confluence with Cottonwood Creek near Grand Canyon	NA	3,920	10/1994-1/2003 (discontinued)	40	16	9	35	No statistics run; less than 3 years of data				2
9403000	Bright Angel Creek near Grand Canyon	101	2,495	10/1923-4/1993 (discontinued)	18	50	16	16	11,366 (1972)	21,502	25,165	65,737 (1941)	51
9403043	Hermit Creek above Tonto Trail near Grand Canyon	NA	2,920	10/1994-1/2003 (discontinued)	26	26	25	24	No statistics run; less than 3 years of data				1
9404110	Havasu Creek at Supai	2,809	3,240	9/1995-current (real time)	25	25	26	24	46,985 (1996)	47,421	47,514	47,930 (1998)	7
9404112	Havasu Creek above Havasu Falls near Supai	2,898	2,900	9/1995-6/2000 (discontinued)	25	24	27	25	39,022 (1996)	39,964	40,090	41,412 (1998)	4
9404115	Havasu Creek above the mouth near Supai	NA	1,800	11/1990-current	25	24	27	24	50,474 (2002)	52,176	52,574	55,471 (1992)	4
9404120	Colorado River above National Canyon near Supai	147,931	1,760	7/1983-4/1996 (discontinued)	24	22	32	22	8,246,104 (1990)	8,542,935	8,526,042	8,789,087 (1991)	3
9404200	Colorado River above Diamond Creek near Peach Springs	149,316	1,340	8/1983-current (real time)	25	25	28	23	8,450,947 (2002)	9,254,765	10,426,177	15,974,970 (1997)	13
9404208	Diamond Creek near Peach Springs	280	1,440	5/1993-current (real time)	29	18	31	22	2,209 (2002)	2,629	2,967	5,026 (1999)	9

Source: USGS (NWIS) 2005 & 2008

Notes:
NA = Not available
Statistics based on Calendar Year
Annual Flow statistics based on monthly values
Annual Flow/Year statistics were only completed for those gages that had at least 3 year of 12 month records
Summation of Average Annual Flows may not equal 100 due to rounding
Period of record may not equal Year of Record used for annual Flow/Year statistics due to only using years with a 12 month record
In Period of Record, current equals November 2008
Seasonal and annual flow data used for statisitics current through 12/2004

Table 6.1-3 Flood ALERT Equipment in the Coconino Basin

Station ID	Station Name	Station Type	Install Date	Responsibility
3920	City Dam in Williams	Precipitation/Stage	9/23/2005	ADWR
7540	Manzanita Repeater	Repeater/Precipitation	NA	Mohave County FCD

Source: ADWR 2005a

Notes:
ADWR = Arizona Department of Water Resources
FCD = Flood Control District
NA = Information is not available at this time

Table 6.1-4 Reservoirs and Stockponds in the Coconino Plateau Basin

A. Large Reservoirs (500 acre-feet capacity and greater)

MAP KEY	RESERVOIR/LAKE NAME *(Name of dam, if different)*	OWNER/OPERATOR	MAXIMUM STORAGE (AF)	USE[1]	JURISDICTION
1	Dogtown	City of Williams	1,390	F,R,S	State
2	Kaibab	City of Williams	967	F,R,S	State
3	Long Point	AZ Land Dept/ Babbitt Ranches	946[2]	P	State
4	Cataract *(West Cataract Creek)*	City of Williams	860[2]	R,S	State
5	Gonzales[3,5]	Private	776	O	Landowner

B. Other Large Reservoirs (50 acre surface area or greater)[4]

MAP KEY	RESERVOIR/LAKE NAME *(Name of dam, if different)*	OWNER/OPERATOR	MAXIMUM SURFACE AREA (acres)	USE[1]	JURISDICTION
6	Davenport	Kaibab NF	252	P	Federal
7	Red Lake Tank[5]	Private	200	P	Landowner
8	Dog Knob[6]	Private	178	P	Landowner
9	Stone[5]	AZ Land Dept.	153	P	State
10	Tule[6]	Private	108	P	Landowner
11	Laguna[5]	Hualapai Tribe	89	P	Tribal
12	Smoot	Private	50	P	Landowner

Source: Compilation of databases from ADWR & others

C. Small Reservoirs (greater than 15 acre-feet and less than 500 acre-feet capacity)

Total number: 8
Total maximum storage: 892 acre-feet

D. Other Small Reservoirs (between 5 and 50 acres surface area)[4]

Total number: 37
Total surface area: 521 acres

E. Stockponds (up to 15 acre-feet capacity)

Total number: 757

[1] F=fish & wildlife pond; O=Other; P=fire protection, stock or farm pond; R=recreation; S=water supply
[2] Normal capacity < 500acre-feet
[3] The height of this dam is less than 6 feet. It is not regulated by State or Federal government.
[4] Capacity data not available to ADWR
[5] Intermittent lake
[6] Dry

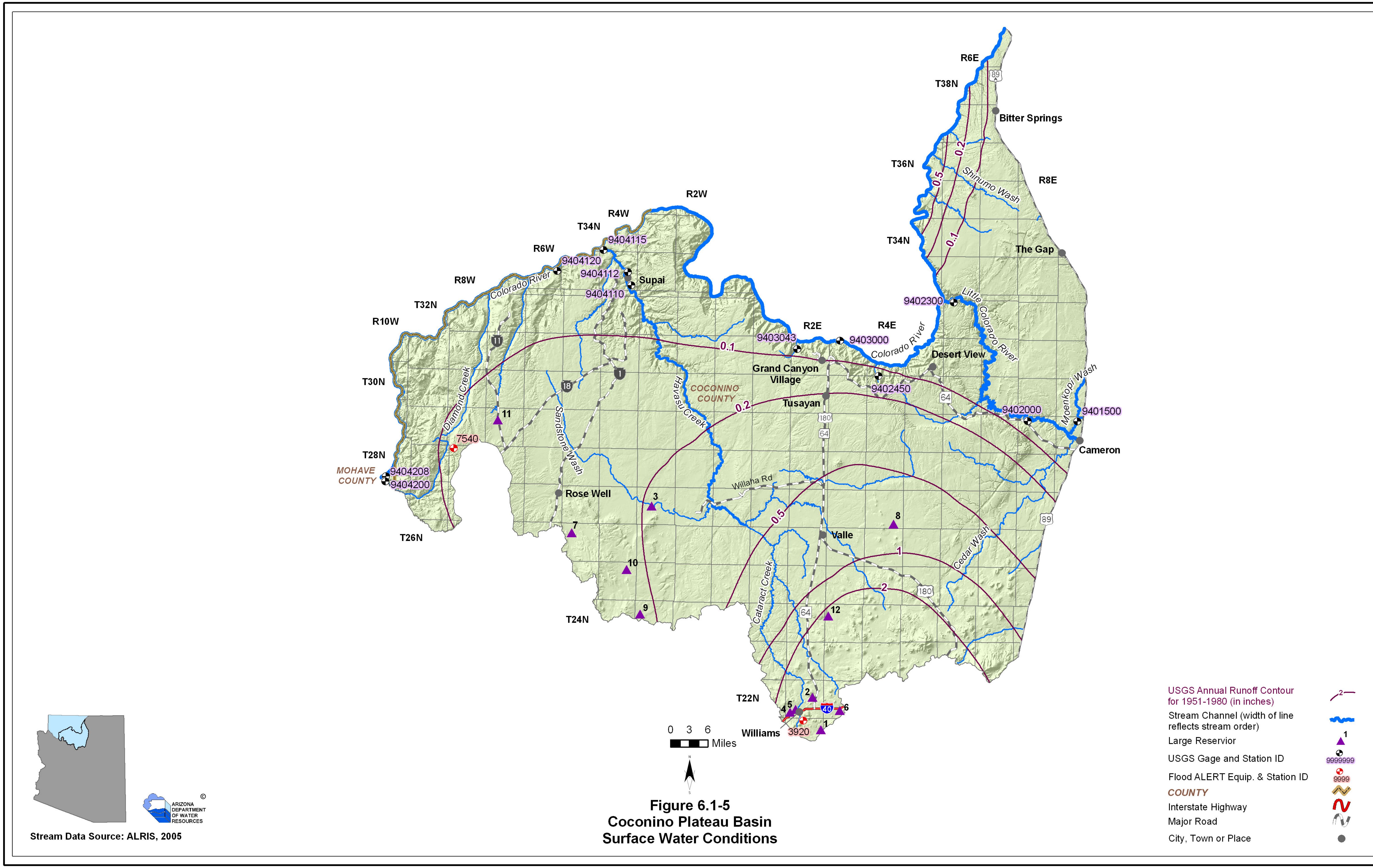


Figure 6.1-5
Coconino Plateau Basin
Surface Water Conditions

6.1.5 Perennial/Intermittent Streams and Major Springs in the Coconino Plateau Basin

Major and minor springs with discharge rates and date of measurement, and the total number of springs in the basin are shown in Table 6.1-5. The locations of major springs and perennial and intermittent streams are shown on Figure 6.1-6. Descriptions of data sources and methods for intermittent and perennial reaches and springs are found in Volume 1, Appendix A.

- Most of the perennial streams are located along and in the vicinity of the northern basin boundary. All perennial reaches, aside from the Colorado River, are short, spring fed and flow into the Colorado River.
- Intermittent streams are found along the Colorado River and in the vicinity of Williams. The Little Colorado River is intermittent for most of its length in the basin.
- There are 30 major springs with a measured discharge of 10 gallons per minute (gpm) or greater at any time. The largest discharge rate is 101,600 gpm at the Blue springs area which supports perennial flow in the Little Colorado River.
- Springs with measured discharge of 1 to 10 gpm are not mapped but coordinates are given in Table 6.1-5B. There are 27 minor springs in this basin.
- Listed discharge rates may not be indicative of current conditions. Many of the measurements were taken during or prior to 1995.
- The total number of springs, regardless of discharge, identified by the USGS varies from 71 to 80, depending on the database reference.

Table 6.1-5 Springs in the Coconino Plateau Basin

A. Major Springs (10 gpm or greater):

Map Key	Name	Location		Discharge (in gpm)[1]	Date Discharge Measured
		Latitude	Longitude		
1	Blue-springs area[2]	360700	1114137	101,600	1950-1993
2	Havasu	361303	1124112	28,500	8/23/1994
3	Artesian at River Mile 182	361025	1130711	2,230	5/28/1995
4	Hawaii	360414	1121305	398	4/11/2001
5	Warm (multiple)	361148	1130459	390	5/28/1995
6	Hermit Creek	360417	1121307	328	11/21/2002
7	Diamond	354248	1131538	251	5/19/1993
8	Diamond Creek	354311	1131352	244	6/9/1994
9	Unnamed[3,4]	361627	1124331	200	5/20/1950
10	Hance at campground[3]	360106	1115732	179	4/8/2001
11	Three Springs[3]	355308	1131829	170	3/24/2004
12	Blue Mountain Canyon[3]	354302	1131747	100	6/9/1994
13	Unnamed[3,4]	361535	1124226	100	5/20/1950
14	Big Canyon	361048	1114218	100	3/15/1967
15	Beecher	360957	1130802	90	5/28/1995
16	West Elk	352248	1115917	70	6/6/1979
17	Granite Spring Canyon[3]	354855	1131833	57[5]	5/19/1993
18	Matkatamiba	362032	1124017	54	11/10/2003
19	Salt Trail Canyon	361119	1114221	50	3/15/1967
20	East Elk	352236	1115912	47	6/6/1979
21	Garden Creek below Tonto Trail	360440	1120740	45	11/9/2000
22	National Canyon (total flow)	361518	1125239	33	10/21/1997
23	Colorado River Mile 140[3]	362338	1123516	25[6]	6/22/1950
24	Newman	352418	1115149	20	6/5/1979
25	Monument[3]	360356	1121032	18	11/21/2002
26	Unnamed	362837	1115042	15	4/29/1976
27	Granite Park[3]	355750	1131836	14	10/13/1993
28	Monument Creek[3]	360455	1121110	13	8/23/2003
29	Pipe Creek	360409	1120557	12[5]	12/7/2000
30	Unnamed[2,3]	361627	1124226	10	5/20/1950

Table 6.1-5 Springs in the Coconino Plateau Basin (Cont)

B. Minor Springs (1 to 10 gpm):

Name	Location		Discharge (in gpm)[1]	Date Discharge Measured
	Latitude	Longitude		
Fern	361524	1124204	8	8/24/1994
Boucher east	360609	1121414	8	4/12/2001
Tappen	355129	1112633	8	9/26/2001
Royal Arch	361119	1122715	7	3/23/2002
Mohawk Canyon	361246	1125815	5	5/19/2002
Cottonwood	360128	1115912	5	11/29/2000
Miner's	360059	1115817	5[7]	11/20/1981
Burro	360436	1120604	4	4/8/2001
Honga above mouth	361237	1130257	4[7]	10/10/1993
Pipe	360415	1120606	4	5/22/2000
Raspberry	352030	1113852	4	8/30/1978
222 Mile Canyon	354815	1131920	3	5/31/1995
Big	355959	1131227	3	5/20/1993
Unnamed	355502	1131959	2	10/13/1993
Unnamed	355502	1131959	2	5/31/1995
Red Canyon	360020	1115604	2	6/3/2002
Pumphouse	360440	1120731	2[7]	11/19/2001
Grapevine East	360232	1120042	2[7]	11/29/2000
Grapevine Main	360039	1120009	1	11/15/2001
Forester Canyon 2	361403	1123142	1	1/20/2002
National Canyon	361346	1125215	1	11/6/2002
Salt Creek	360436	1120940	1	4/1/2001
Clover	351351	1121211	1	8/5/1976
Sapphire	360711	1121846	1	10/23/2003
Horn	360450	1120836	1	11/22/2002
Hockey Puck	355602	1131032	1	6/9/1994
Unnamed[3,4]	351509	113524	1	11/1950

Source: Compilation of databases from ADWR & others

C. Total number of springs, regardless of discharge, identified by USGS (see ALRIS, 2005a and USGS, 2006b): 71 to 80

Notes:
[1] Most recent measurement identified by ADWR
[2] Discharge is average for all springs in the lower 13 mile reach of the Little Colorado River, date measured varies by spring
[3] Spring is not displayed on current USGS topo maps
[4] Location approximated by ADWR
[5] Discharge measurements vary. Shown is greatest measured discharge; most recent measurement < 10 gpm
[6] Average discharge
[7] Discharge measurements vary. Shown is greatest measured discharge; most recent measurement < 1 gpm

Figure 6.1-6
Coconino Plateau Basin
Perennial\Intermittent Streams
and Major (>10 gpm) Springs

6.1.6 Groundwater Conditions of the Coconino Plateau Basin

Major aquifers, well yields, estimated water in storage, number of index wells and date of last water-level sweep are shown in Table 6.1-6. Figure 6.1-7 shows aquifer flow direction and water-level change between 1990-1991 and 2003-2004. Figure 6.1-8 contains hydrographs for selected wells shown on Figure 6.1-7. Figure 6.1-9 shows well yields in four yield categories. A description of aquifer data sources and methods as well as well data sources and methods, including water-level changes and well yields are found in Volume 1, Appendix A.

Major Aquifers

- Refer to Table 6.1-6 and Figure 6.1-7.
- Major aquifers in the basin include volcanic rocks, basin fill and sedimentary rocks (C- and R-aquifers and Moenkopi and Chinle Formations).
- Almost all of the basin geology consists of consolidated crystalline and sedimentary rock.
- Flow direction is toward the Little Colorado River in the eastern portion of the basin and generally toward the west and north in the western portion of the basin.

Well Yields

- Refer to Table 6.1-6 and Figure 6.1-9.
- As shown on Figure 6.1-9, well yields in this basin are generally less than 100 gallons per minute (gpm). However, there are several relatively high yield wells owned by the City of Flagstaff in the southeast part of the basin.
- One source of well yield information, based on 16 reported wells, indicates that the median well yield in this basin is 45.5 gpm.

Water Level

- Refer to Figure 6.1-7. Water levels are shown for wells measured in 2003-2004.
- The Department annually measures three index wells in this basin. Hydrographs for two of these wells (B and C) and one other well are shown in Figure 6.1-8.
- All water level information is from the southern portion of the basin. Although not shown on the map, there are three wells with a depth to water of over 2,700 feet in the vicinity of Williams. The shallowest water level shown on the map is five feet in a perched aquifer south of Williams.

Table 6.1-6 Groundwater Data for the Coconino Plateau Basin

Basin Area, in square miles:	5,812	
Major Aquifer(s):	**Name and/or Geologic Units**	
	Volcanic Rock	
	Basin Fill	
	Sedimentary Rock (Moenkopi and Chinle Formations)	
	Sedimentary Rock (C Aquifer)	
	Sedimentary Rock (R Aquifer)	
Well Yields, in gal/min:	44 (1 well measured)	Measured by ADWR (GWSI) and/or USGS
	Range 4-1,500 Median 45.5 (16 reported)	Reported on registration forms for large (>10-inch) diameter wells (Wells55)
	Range 30-100	ADWR (1990)
	Range 0-10	Anning and Duet (1994)
Estimated Natural Recharge, in acre-feet/year:	N/A	
Estimated Water Currently in Storage, in acre-feet:	3,000,000*	Montgomery et al, 2000
Current Number of Index Wells:	2	
Date of Last Water-level Sweep:	1964 (5 wells measured)	

* Estimated by ADWR based on the assumptions by Montgomery et al (2000) of an average specific yield (drainage porosity) of 0.1%. Montgomery et al's study area extended beyond and did not include all of the Coconino Plateau Basin.
N/A = Not Available

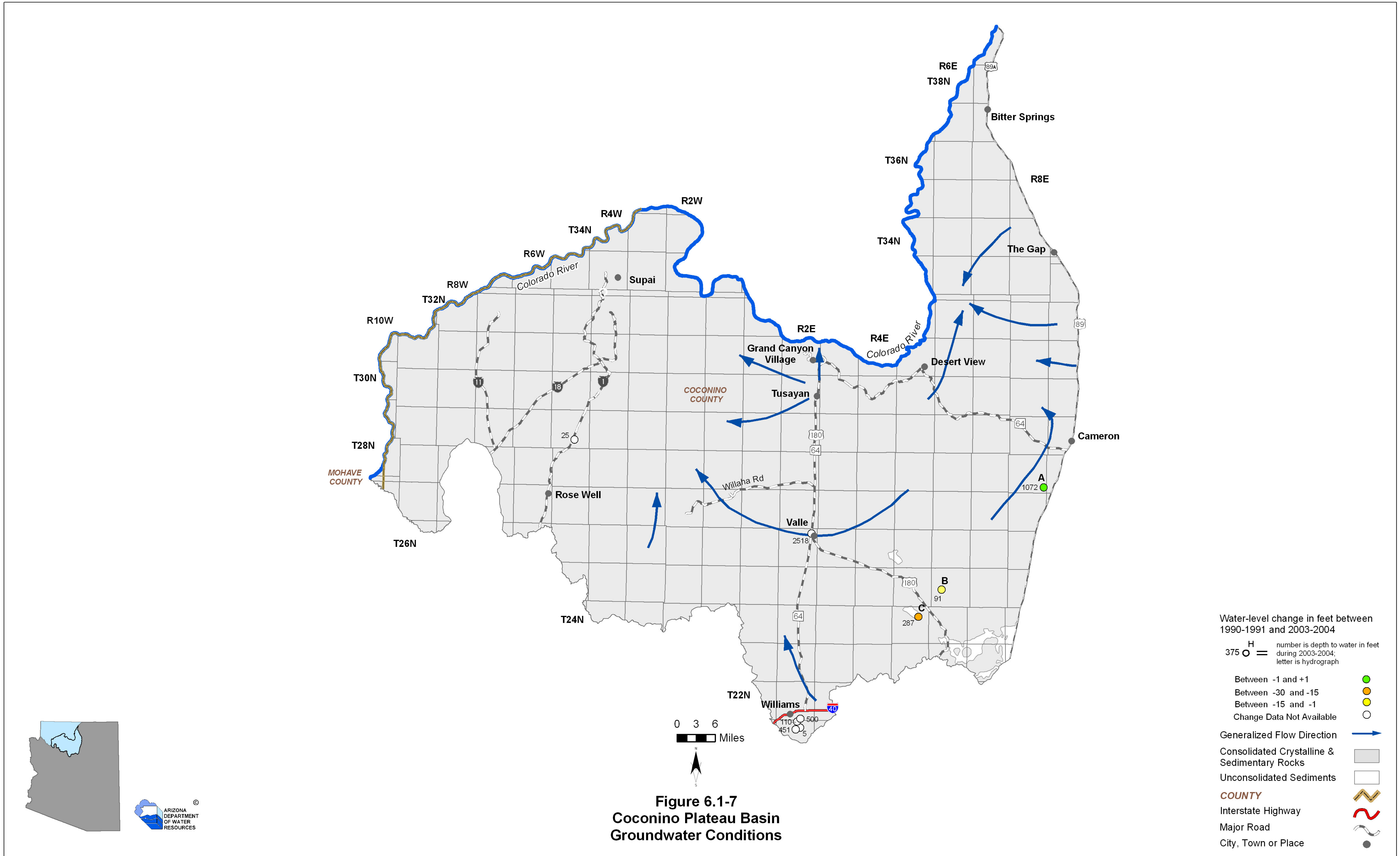
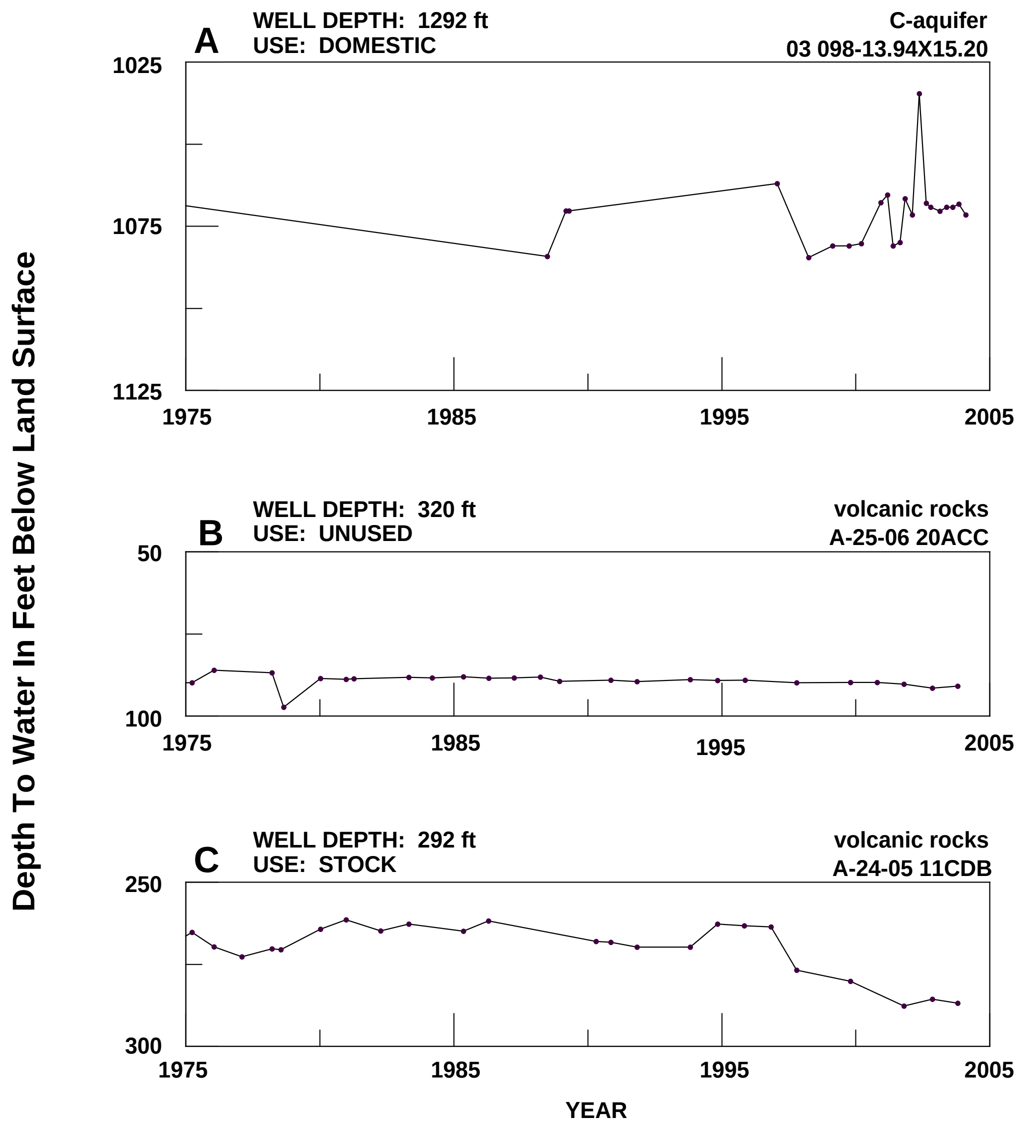


Figure 6.1-7
Coconino Plateau Basin
Groundwater Conditions

Figure 6.1-8
Coconino Plateau
Hydrographs Showing Depth to Water in Selected Wells



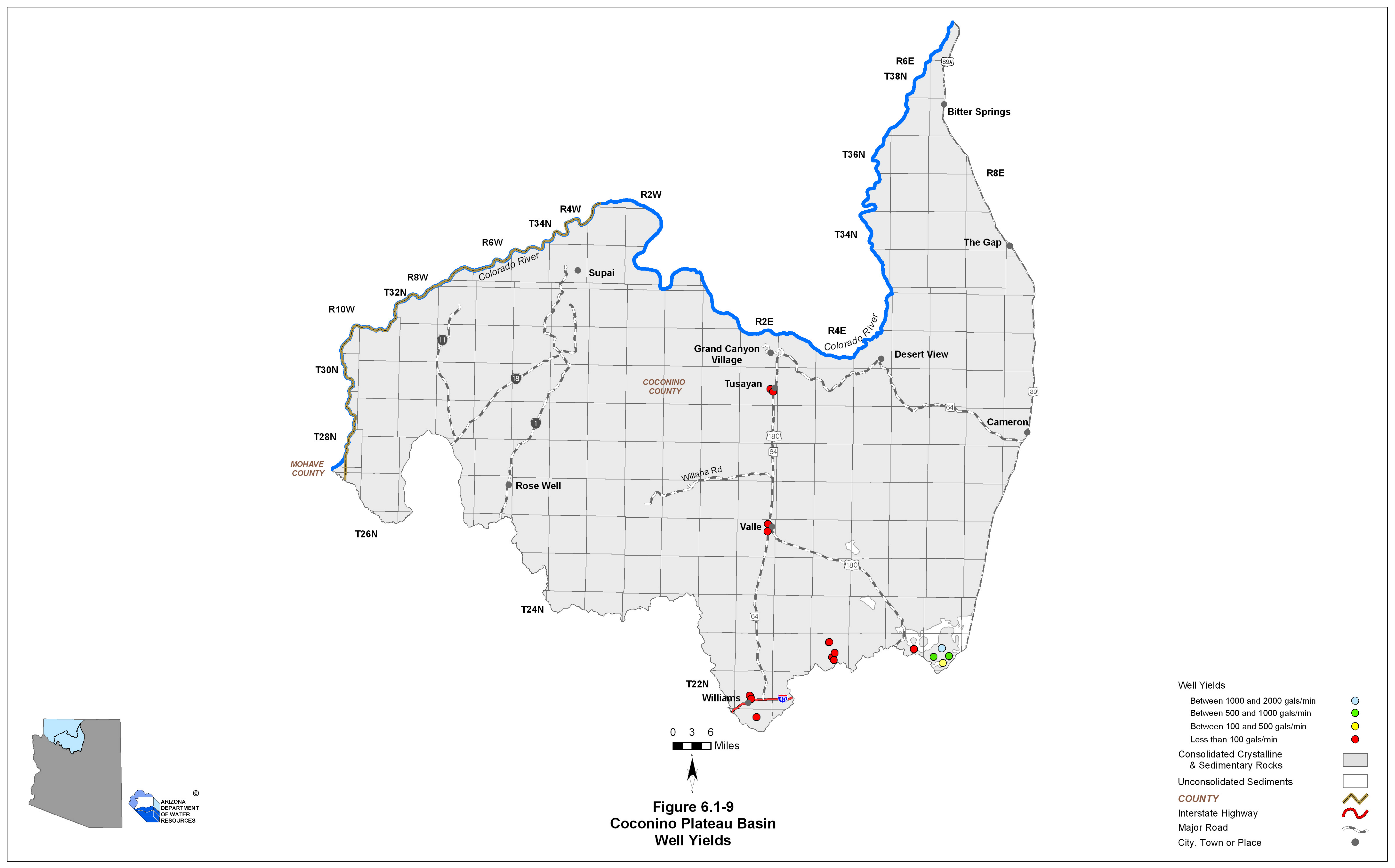


Figure 6.1-9
Coconino Plateau Basin
Well Yields

6.1.7 Water Quality of the Coconino Plateau Basin

Wells, springs and mine sites with parameter concentrations that have equaled or exceeded drinking water standard(s), including location and parameter(s) are shown in Table 6.1-7A. Impaired lakes and streams with site type, name, length of impaired reach, area of impaired lake, designated use standard and parameter(s) exceeded is shown in Table 6.1-7B. Figure 6.1-10 shows the location of water quality occurrences keyed to Table 6.1-7. All community water systems are regulated under the Safe Drinking Water Act and treat water supplies to meet drinking water standards. Not all parameters were measured at all sites; selective sampling for particular constituents is common. A description of water quality data sources and methods is found in Volume 1, Appendix A.

Well, Mine or Spring sites that have equaled or exceeded drinking water standards (DWS)

- Refer to Table 6.1-7A.
- Twenty-two wells or springs have parameter concentrations that have equaled or exceeded drinking water standards.
- The parameter most frequently equaled or exceeded in the sites measured was arsenic. Other parameters equaled or exceeded include total dissolved solids, radionuclides, thallium, nitrates, mercury and lead.

Lakes and Streams with impaired waters

- Refer to Table 6.1-7B and Figure 6.1-10
- The water quality standard for suspended sediment concentration was exceeded in one 28-mile stream reach, the Colorado River from Parashant Canyon to Diamond Creek. This impaired reach is located along part of the border with the Shivwits Plateau Basin.
- This reach is not part of the ADEQ water quality improvement effort called the Total Maximum Daily Load (TMDL) Program at this time.

Effluent Dependent Reaches

- Refer to Figure 6.1-10
- There is one effluent dependent reach in this basin, which receives discharged effluent from the South Rim Wastewater Treatment Plant.

Table 6.1-7 Water Quality Exceedences in the Coconino Plateau Basin[1]

A. Wells, Springs and Mines

Map Key	Site Type	Site Location			Parameter(s) Concentration has Equaled or Exceeded Drinking Water Standard (DWS)[2]
		Township	Range	Section	
1	Spring	33 North	5 East	NA	TDS
2	Spring	32 North	7 East	31	TDS
3	Spring	31 North	2 East	15	Rad
4	Well	31 North	9 East	33	Tl
5	Spring	30 North	4 East	4	As
6	Spring	29 North	9 East	15	NO3
7	Well	25 North	2 East	27	TDS
8	Spring	33 North	4 West	11	Pb
9	Well	33 North	4 West	22	As
10	Spring	33 North	4 West	35	As, Pb
11	Spring	33 North	7 West	31	As
12	Spring	33 North	8 West	36	As, Hg
13	Spring	33 North	8 West	36	As, Hg
14	Spring	32 North	8 West	22	As
15	Spring	30 North	10 West	25	As
16	Spring	29 North	9 West	19	As
17	Spring	29 North	10 West	14	As, TDS
18	Spring	29 North	10 West	14	As
19	Spring	29 North	10 West	25	As
20	Well	27 North	6 West	12	Pb
21	Spring	27 North	9 West	15	As
22	Spring	27 North	10 West	24	As

Source: Compilation of databases from ADWR & others

B. Lakes and Streams

Map Key	Site Type	Site Name	Length of Impaired Stream Reach (in miles)	Area of Impaired Lake (in acres)	Designated Use Standard[3]	Parameter(s) Exceeding Use Standard[2]
a	Stream	Colorado River (Parashant Canyon to Diamond Creek)	28[4]	NA	A&W	Se, suspended sediment concentration

Source: ADEQ 2005e

Notes:

[1] Water quality samples collected between 1951 and 1994.
[2]As = Arsenic
Pb = Lead
Hg = Mercury
NO3 = Nitrate
Rad = One or more of the following radionuclides - Gross Alpha, Gross Beta, Radium, and Uranium
Se = Selenium
Tl = Thallium
TDS = Total Dissolved Solids
[3] A&W = aquatic and wildlife
[4] Total length of the impaired reach. This reach is located along part of the border with the Shivwits Plateau Basin.
NA = Not Applicable

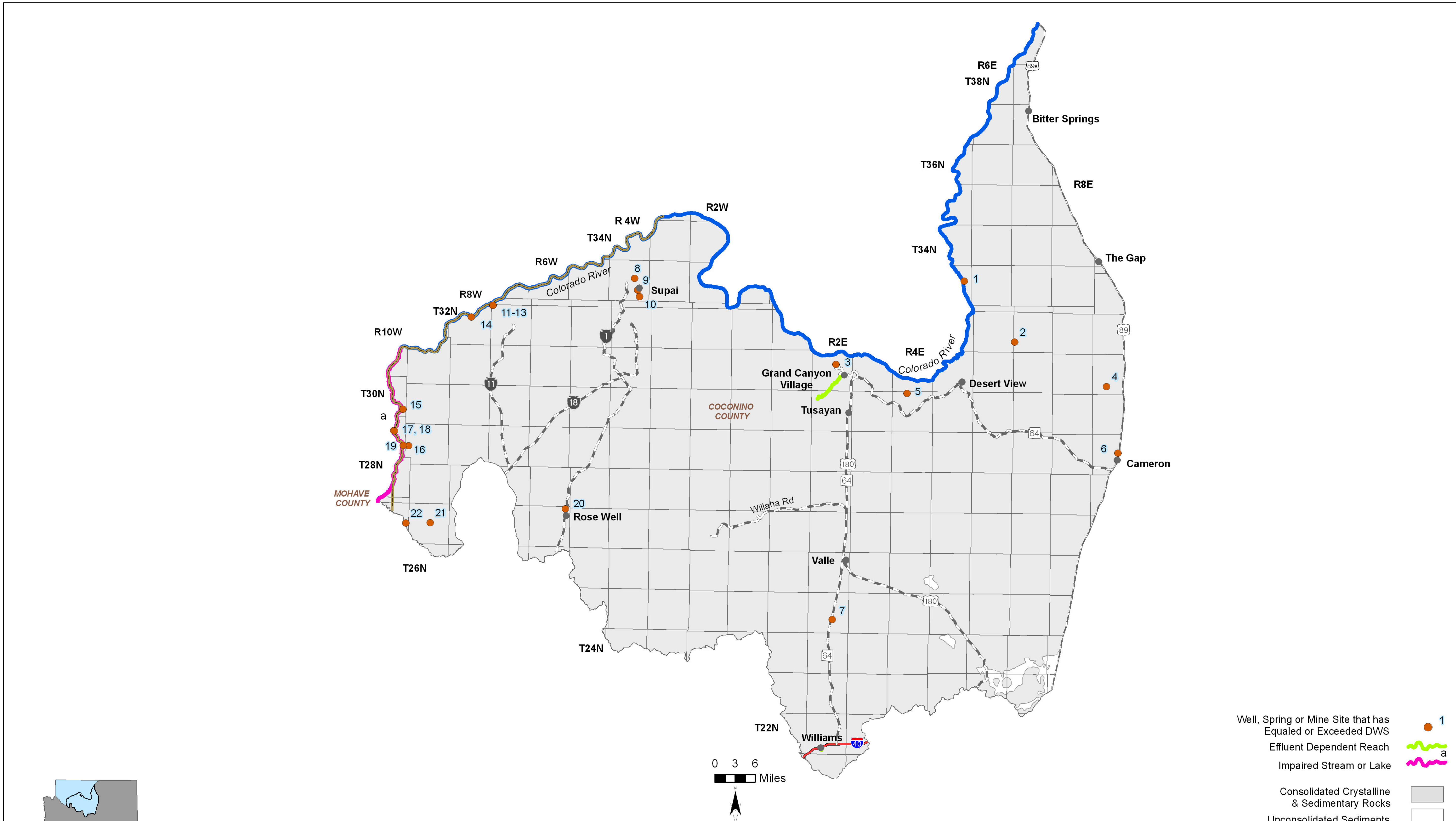


Figure 6.1-10
Coconino Plateau Basin
Water Quality Conditions

6.1.8 Cultural Water Demand in the Coconino Plateau Basin

Cultural water demand data including population, number of wells and the average well pumpage and surface water diversions by the municipal, industrial and agricultural sectors are shown in Table 6.1-8. Effluent generation including facility ownership, location, population served and not served, volume treated, disposal method and treatment level is shown in Table 6.1-9. Figure 6.1-11 shows the location of demand centers. A description of cultural water demand data sources and methods is found in Volume 1, Appendix A. More detailed information on cultural water demand is found in Section 6.0.7.

Cultural Water Demand

- Refer to Table 6.1-8 and Figure 6.1-11.
- Population in this basin increased from 6,977 in 1980 to 9,164 in 2000 and is projected to reach 17,500 by 2030. This is the most populous basin in the planning area.
- All cultural water use in this basin is for municipal demand. Municipal demand centers include Williams, Tusayan, Grand Canyon Village, Valle, Supai and Cameron.
- Groundwater demand is small and has remained relatively constant from 1971-2005. In 2000 the City of Williams started using groundwater because surface water supplies were unavailable due to drought. Groundwater use in Williams increased to 389 acre-feet in 2006.
- Data on municipal surface water use prior to 1991 is not available. From 1991-2005 municipal surface water use decreased from 500 acre-feet per year (AFA) to 300 AFA due to surface water shortages in Williams.
- As of 2005 there were 172 registered wells with a pumping capacity of less than or equal to 35 gallons per minute and 38 wells with a pumping capacity of more than 35 gallons per minute.

Effluent Generation

- Refer to Table 6.1-9.
- There are eight wastewater treatment facilities in this basin.
- Information on population served was available for two facilities and information on effluent generation was available for five facilities. These facilities serve over 4,200 people and generate over 1,700 acre-feet of effluent per year.
- Four facilities discharge to watercourses, one discharges to an evaporation pond, one discharges for irrigation, four discharge to golf course or landscape irrigation, two discharge for municipal uses such as toilet flushing and two discharge to an unlined impoundments that recharge the aquifer.

Table 6.1-8 Cultural Water Demand in the Coconino Plateau Basin[1]

Year	Estimated and Projected Population	Number of Registered Water Supply Wells Drilled		Average Annual Demand (in acre-feet)						Data Source
				Well Pumpage			Surface-Water Diversions			
		Q ≤ 35 gpm	Q > 35 gpm	Municipal	Industrial	Agricultural	Municipal	Industrial	Agricultural	
1971										
1972										
1973					<500			NR		
1974										
1975										
1976		93[2]	18[2]							
1977										
1978					<500			NR		
1979										
1980	6,977									ADWR (1994a)
1981	7,051									
1982	7,126									
1983	7,200	7	0		<500			NR		
1984	7,275									
1985	7,349									
1986	7,424									
1987	7,498									
1988	7,573	18	7		<500			NR		
1989	7,647									
1990	7,722									
1991	7,866									
1992	8,010									
1993	8,155	14	6	370	NR	NR	500	NR	NR	
1994	8,299									
1995	8,443									
1996	8,587									
1997	8,731									
1998	8,876	19	7	400	NR	NR	600	NR	NR	USGS (2007) ADWR (2008b) ADWR (2008c)
1999	9,020									
2000	9,164									
2001	9,636									
2002	10,109									
2003	10,581	21	0	500	NR	NR	300	NR	NR	
2004	11,053									
2005	11,525									
2010	13,886									
2020	16,081									
2030	17,500									
WELL TOTALS:		**172**	**38**							

[1] Does not include effluent or evaporation losses from stockponds and reservoirs.
[2] Includes all wells through 1980.
NR - Not reported
Note: Surface water diverted in the Kanab Plateau Basin is delivered to the Coconino Plateau Basin for use at the Grand Canyon South Rim. This diversion is not included in the table.

Table 6.1-9 Effluent Generation in the Coconino Plateau Basin

Facility Name	Ownership	City/Location Served	Population Served	Volume Treated/Generated (acre-feet/year)	Disposal Methods									Current Treatment Level	Population Not Served	Year of Record
					Water-course	Evaporation Pond	Irrigation	Golf Course/Turf/ Landscape	Municipal Reuse	Wildlife Area	Discharged to Another Facility	Infiltration Basins	Other			
Cameron WWTP	Navajo Tribe	Cameron	190	11								X		Secondary	380	2000
Desert View WWTP	National Park Service	Campground	NA	11		X								NA		2004
Grand Canyon Inn	Private	Hotel	Varies	NA				X					X	NA		
Valle Airport WRF	Private	Valle	400	7	Unnamed Wash			X						Secondary	250	2008
South Rim WWTP	National Park Service	Park	NA	448	Bright Angel Wash			X	X				X	Tertiary	NA	2004
Supai Village Sewer System	Havasupai Tribe	Supai	1,000	56								X		Secondary	NA	2001
Tusayan WWTP	South Grand Canyon Sanitary District	Tusayan	NA	68	Coconino Wash		X		X					NA		2004
Williams WWTP	Williams	Williams	2,690	1,138	Mohawk Canyon			Elephant Rock						Secondary	NA	2000
Total			**4,280**	**1,739**												

Source: Compilation of databases from ADWR & others

Notes:
Year of Record is for the volume of effluent treated/generated
NA: Data not currently available to ADWR
WWTP: Waste Water Treatment Plant
WRF: Water Reclamation Facility

Figure 6.1-11
Coconino Plateau Basin
Cultural Water Demand

6.1.9 Water Adequacy Determinations in the Coconino Plateau Basin

Water adequacy determination information including the subdivision name, location, number of lots, adequacy determination, reason for the inadequacy determination, date of determination and subdivision water provider are shown in Table 6.1-10. Figure 6.1-12 shows the locations of subdivisions keyed to the Table. A description of the Water Adequacy Program is found in Volume 1, Appendix C. Adequacy determination data sources and methods are found in Volume 1, Appendix A.

- All subdivisions receiving an adequacy determination are in the vicinity of Williams and Valle. Fifty-three water adequacy determinations for 2,050 lots have been made in this basin through December 2008; all were determinations of inadequacy.
- The most common reason for a determination of inadequacy was because the applicant chose not to submit necessary information and/or available hydrologic data were insufficient to make a determination.

Table 6.1-10 Adequacy Determinations in the Coconino Plateau Basin[1]

Map Key	Subdivision Name	County	Location: Township	Location: Range	Location: Section	No. of Lots	ADWR File No.[2]	ADWR Adequacy Determination	Reason(s) for Inadequacy Determination[3]	Date of Determination	Water Provider at Time of Application
1	Bally Mountain	Coconino	23 North	2 East	35	19	53-500306	Inadequate	A3	1/14/1993	Dry Lot Subdivision
2	Canyon Vista Ranch	Coconino	23 North	2 East	21	11	53-400438	Inadequate	A1,A2	12/5/2000	Water Hauler
3	Cataract Creek Estates	Coconino	22 North	2 East	21	82	53-700394	Inadequate	A1	2/25/2008	City of Williams
4	Chaparral Heights	Coconino	23 North	2 East	16	44	53-500440	Inadequate	A2,A3	12/1/1986	Dry Lot Subdivision
5	Escalante at Williams Mountain	Coconino	21 North 22 North	2 East 2 East	6 31	52	53-402197	Inadequate	A1	6/14/2006	City of Williams
6	Escalante at Williams Mountain Phase 2a & 2b	Coconino	21 North	2 East	6	53	53-700309	Inadequate	A1	6/18/2007	City of Williams
7	Forest Canyon Estates	Coconino	22 North	2 East	32	70	53-700510	Inadequate	A1	5/7/2008	City of Williams
8	Grand Canyon Airpark Subdivision	Coconino	26 North	2 East	11	41	53-700502	Inadequate	A1	4/2/2008	Valle Domestic Water District
9	Grand Canyon Subdivision Unit 11	Coconino	26 North	3 East	18	29	53-402219	Inadequate	A1	7/10/2006	Dry Lot Subdivision
10	Grand Canyon Subdivision Unit 12	Coconino	26 North 26 North	2 East 3 East	24 19	64	53-402216	Inadequate	A1 A1	7/10/2006	Dry Lot Subdivision
11	Grand Canyon Subdivision Unit 12	Coconino	26 North	3 East	19	24	53-401972	Inadequate	A1	1/26/2006	Dry Lot Subdivision
12	Grand Canyon Subdivision Unit 16	Coconino	26 North	3 East	22	9	53-700254	Inadequate	A1	4/17/2007	Dry Lot Subdivision
13	Grand Canyon Subdivision Unit 17	Coconino	26 North	3 East	9	7	53-402239	Inadequate	A1	8/21/2006	Dry Lot Subdivision
14	Grand Canyon Subdivision Unit 3	Coconino	26 North	3 East	28	5	53-402221	Inadequate	A1	7/10/2006	Dry Lot Subdivision
15	Grand Canyon Subdivision Unit 6	Coconino	26 North	3 East	20	5	53-700255	Inadequate	A1	4/4/2007	Dry Lot Subdivision
16	Grand Canyon Subdivision Unit 7	Coconino	26 North	3 East	21	8	53-402217	Inadequate	A1	7/10/2006	Dry Lot Subdivision
17	Grand Canyon Subdivision Unit 8	Coconino	26 North	3 East	17	7	53-700228	Inadequate	A1	3/14/2007	Dry Lot Subdivision
18	Grand Canyon Subdivision Unit 9	Coconino	26 North	3 East	7	9	53-402218	Inadequate	A1	7/10/2006	Dry Lot Subdivision
19	Highland Meadows North	Coconino	22 North	2 East	30	105	53-401783	Inadequate	A1	7/22/2005	City of Williams
20	Highland Meadows Place, Phase 2	Coconino	22 North	2 East	31	16	53-401318	Inadequate	A1	1/18/2005	City of Williams
21	Highland Meadows Place, Phase 3	Coconino	22 North	2 East	31	37	53-401833	Inadequate	A1	8/15/2005	City of Williams
22	Highland Meadows West	Coconino	22 North	1 East	36	20	53-402279	Inadequate	A1	8/31/2006	City of Williams
23	Highland Meadows at Williams #1	Coconino	22 North	2 East	31	29	53-300384	Inadequate	A1	12/19/1997	City of Williams
24	Highland Meadows at Williams #2	Coconino	22 North	2 East	31	125	53-400042	Inadequate	A1	4/14/1999	City of Williams
25	Highland Meadows at Williams Phase 4	Coconino	22 North	1 East	36	66	53-401786	Inadequate	A1	7/7/2005	City of Williams
26	Highland Meadows at Williams, Phase 3, Unit 1	Coconino	22 North	1 East	31, 36	38	53-401256	Inadequate	D	4/26/2004	City of Williams
27	Highland Meadows at Williams, Phase 3, Unit 2	Coconino	22 North	2 East	31	39	53-401476	Inadequate	D	11/24/2004	City of Williams
28	Howard Mesa Ranch, Phase 2	Coconino	25 North	2 East	33	63	53-300584	Inadequate	A2	12/22/1998	Dry Lot Subdivision

Table 6.1-10 Adequacy Determinations in the Coconino Plateau Basin[1] (Cont)

Map Key	Subdivision Name	County	Location			No. of Lots	ADWR File No.[2]	ADWR Adequacy Determination	Reason(s) for Inadequacy Determination[3]	Date of Determination	Water Provider at Time of Application
			Township	Range	Section						
29	Howard Mesa Subdivision, Units 2 & 3	Coconino	25 North	2 East	27, 35	75	53-400073	Inadequate	A2	5/14/1999	Dry Lot Subdivision
30	Junipine Estates #2,3	Coconino	23 North	2 East	20	238	53-500831	Inadequate	A2,A3	9/25/1973	Dry Lot Subdivision
31	Kiabab Estates West	Coconino	22 North	2 East	11	9	NA	Inadequate	A2,A3	2/3/1992	Dry Lot Subdivision
32	Lake Kaibab Park	Coconino	23 North	2 East	15, 22, 23	4	53-500877	Inadequate	A3	4/8/1991	D&D Water Company
33	Lake Kaibab Park #1	Coconino	23 North	2 East	27, 35	14	53-500878	Inadequate	A3	4/27/1990	City of Williams
34	Lake Kaibab Park #2	Coconino	23 North	2 East	35	7	53-500879	Inadequate	A3	4/6/1994	A-1 Water Service
35	Lake Kaibab Park Unit One	Coconino	23 North	2 East	27, 35	4	53-401801	Inadequate	A1	7/14/2005	Dry Lot Subdivision
36	Lake Kaibab Park Unit Two	Coconino	23 North	2 East	27, 35	10	53-401836	Inadequate	A1	8/11/2005	Dry Lot Subdivision
37	Lake Kaibab Park Unit Two, Lots 380, 562 & 573	Coconino	23 North	2 East	27, 35	3	53-402250	Inadequate	A1	9/29/2006	Dry Lot Subdivision
38	Lake Kaibab Park and Lake Kaibab Park Unit Two	Coconino	23 North	2 East	15, 22, 23, 26, 35	8	53-700204	Inadequate	A1	1/16/2007	Dry Lot Subdivision
39	Lazy "E"	Coconino	22 North	2 East	30	20	53-500901	Inadequate	D	11/23/1981	Dry Lot Subdivision
40	Lazy "E" #2	Coconino	22 North	2 East	30, 31	18	53-500902	Inadequate	A2,A3	7/3/1986	Dry Lot Subdivision
41	Lazy "E" #3	Coconino	22 North	2 East	31	39	53-500903	Inadequate	A2,A3	6/18/1993	Dry Lot Subdivision
42	Mason Commercial Center #01	Coconino	22 North	2 East	28	4	53-500938	Inadequate	A1,A2	8/26/1993	City of Williams
43	Mi Casa	Coconino	22 North	2 East	31	5	53-500973	Inadequate	A1	1/16/1987	City of Williams
44	Mountain Shadows	Coconino	22 North	2 East	15, 22	14	53-400126	Inadequate	A2,A3	7/21/1999	Dry Lot Subdivision
45	Pinecrest Estates	Coconino	22 North	2 East	29	51	53-300067	Inadequate	A1	11/20/1995	City of Williams
46	Pinecrest Estates II	Coconino	22 North	2 East	29	84	53-400737	Inadequate	A1,A2	7/1/2002	City of Williams
47	Red Lake Estates Unit 1	Coconino	23 North	2 East	1	120	53-400401	Inadequate	A2,A3	10/30/2000	A-1 Water Service
48	Red Lake Estates, Unit II	Coconino	23 North	2 East	1	23	53-400932	Inadequate	A2,A3	5/5/2003	A-1 Water Service
49	Red Lake Mountain Ranch	Coconino	23 North	2 East	3	54	53-501287	Inadequate	A1	3/21/1989	Dry Lot Subdivision
50	Spring Flower Ranch	Coconino	23 North	2 East	24	64	53-402038	Inadequate	A1	3/16/2006	Dry Lot Subdivision
51	Sycamore Point Estates	Coconino	22 North	2 East	27	40	53-401830	Inadequate	A1	8/15/2005	City of Williams
52	Timber Canyon	Coconino	23 North	2 East	33	24	53-300249	Inadequate	A3	2/4/1997	A-1 Water Service
53	Williams Pine Meadows Estates	Coconino	21 North	2 East	3, 4	41	53-501688	Inadequate	A1	1/9/1995	Dry Lot Subdivision

Source: ADWR 2008a

Notes:

[1]Each determination of the adequacy of water supplies available to a subdivision is based on the information available to ADWR and the standards of review and policies in effect at the time the determination was made. In some cases, ADWR might make a different determination if a similar application were submitted today, based on the hydrologic data and other information currently available, as well as current rules and policies.

[2] Prior to February 1995, ADWR did not assign file numbers to applications for adequacy. Between 1995-2006 all applications for adequacy were given a file number with a 22 prefix. In 2006 a 53 prefix was assigned to all water adequacy reports and applications regardless of their issue date.

[3] A. Physical/Continuous
1) Insufficient Data (applicant chose not to submit necessary information, and/or available hydrologic data insufficient to make determination)
2) Insufficient Supply (existing water supply unreliable or physically unavailable; for groundwater, depth-to-water exceeds criteria)
3) Insufficient Infrastructure (distribution system is insufficient to meet demands or applicant proposed water hauling)

B. Legal (applicant failed to demonstrate a legal right to use the water or failed to demonstrate the provider's legal authority to serve the subdivision)
C. Water Quality
D. Unable to locate records

NA = Not available to ADWR at this time

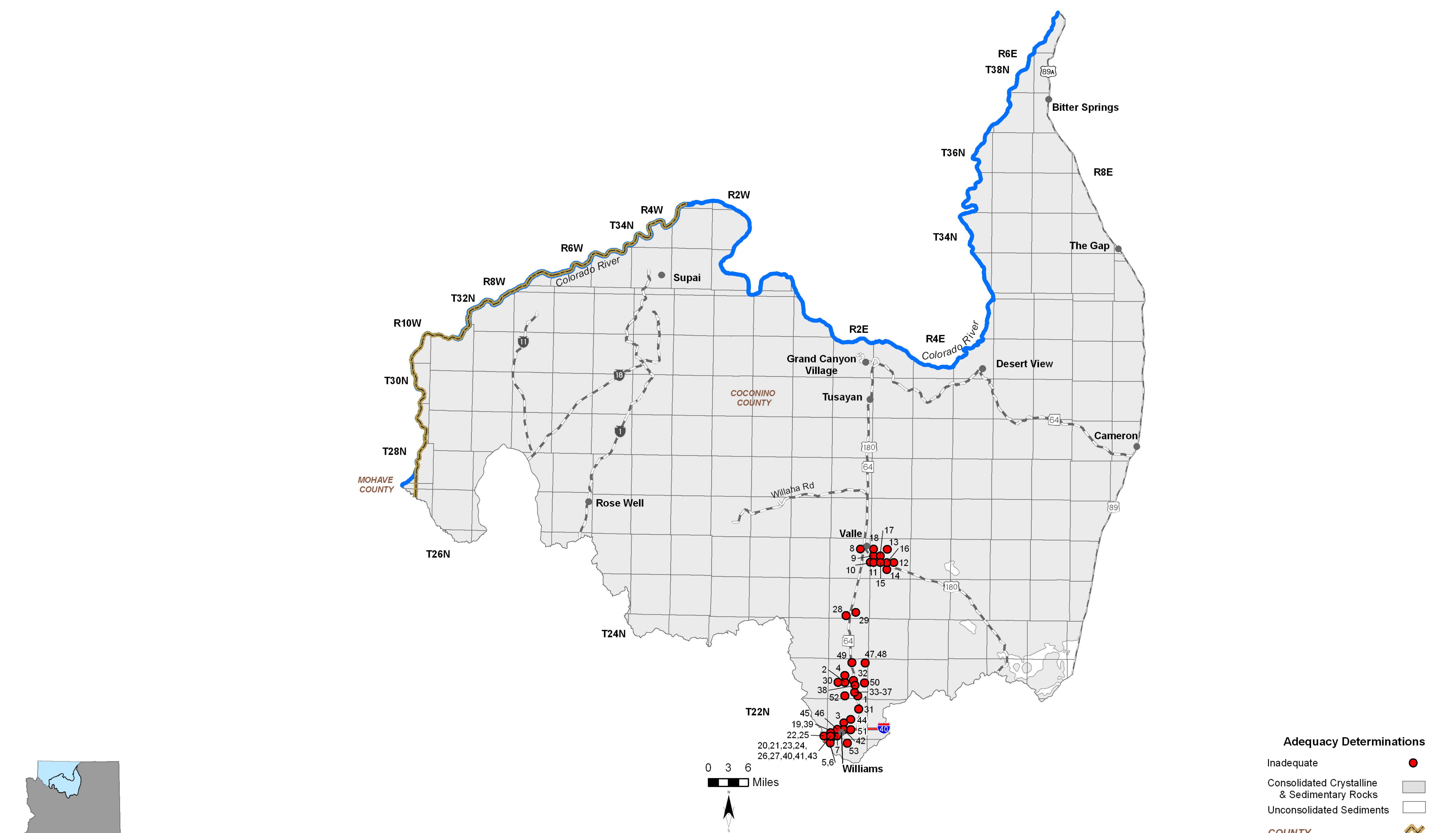


Figure 6.1-12
Coconino Plateau Basin
Adequacy Determinations

Coconino Plateau Basin

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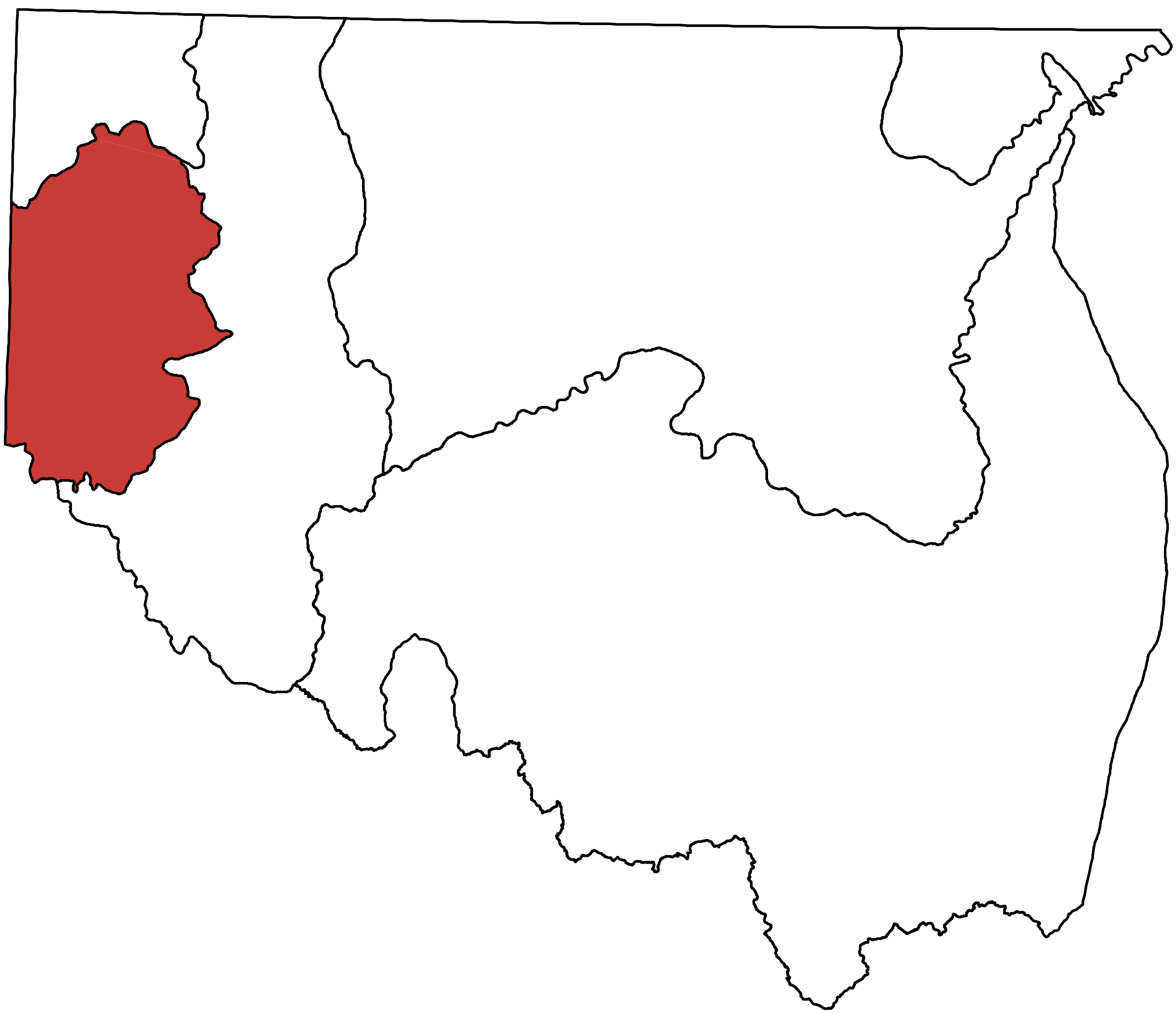
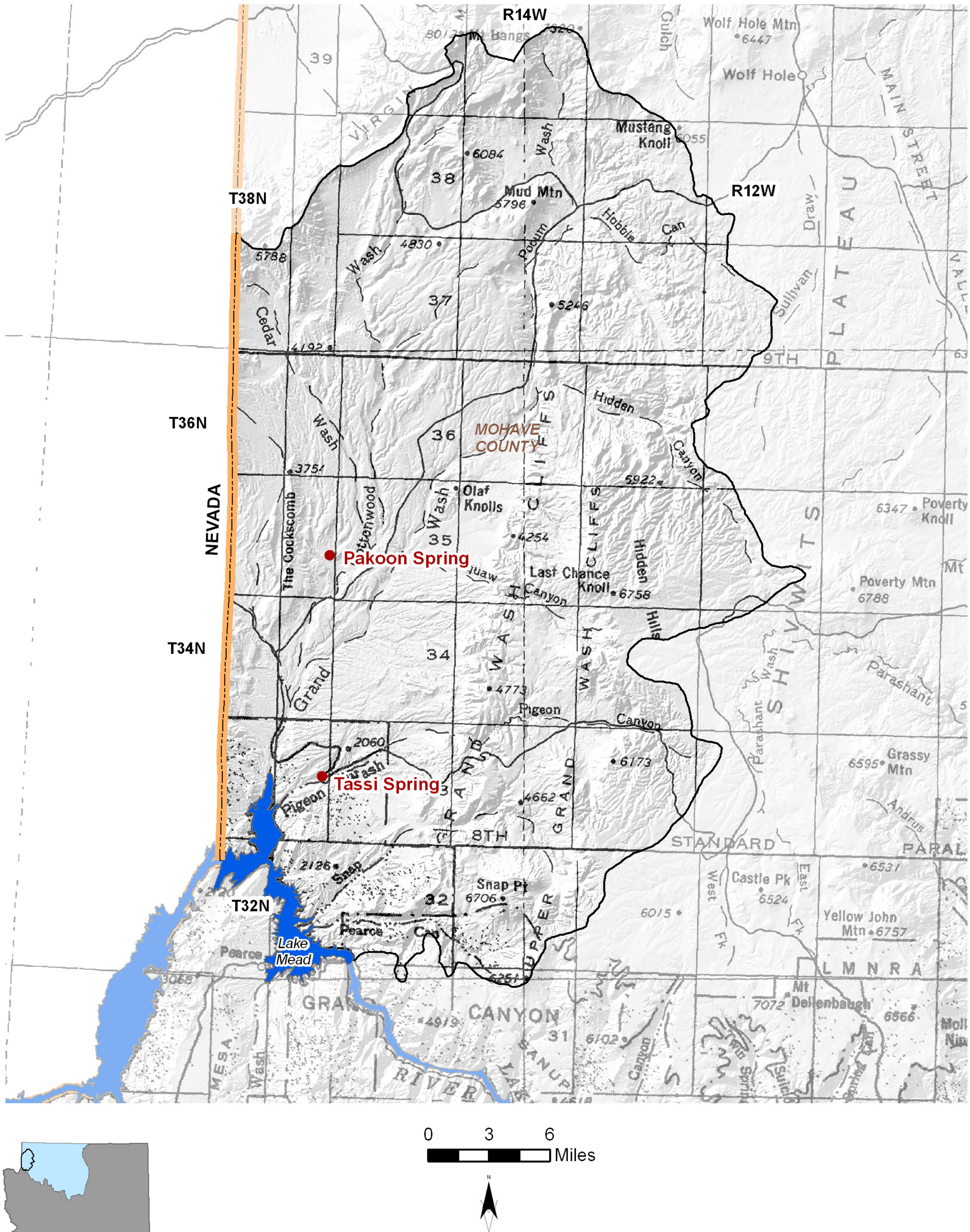
Section 6.2
Grand Wash Basin

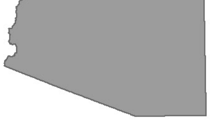


6.2.1 Geography of the Grand Wash Basin

The Grand Wash Basin, located in the western part of the planning area is 959 square miles in area. Geographic features and principal communities are shown on Figure 6.2-1. The basin is characterized by cliffs and washes. Vegetation is primarily Mohave desertscrub and Great Basin conifer woodland with small areas of Great Basin desertscrub, interior chaparral and Plains and Great Basin grassland. (See Figure 6.0-11)

- Principal geographic features shown on Figure 6.2-1 are:
    - Lake Mead forming the southwestern basin boundary and the lowest point in the basin at 1,100 feet
    - Grand Wash in the western portion of the basin
    - Grand Wash and Upper Grand Wash Cliffs running north-south through the basin
    - Mud Mountain in the northern portion of the basin
    - The highest point in the basin, Last Chance Knoll in the east central part of the basin at 6,758 feet





Base Map: USGS 1:500,000, 1981

Figure 6.2-1
Grand Wash Basin
Geographic Features

Nevada State Boundary

City, Town or Place

6.2.2 Land Ownership in the Grand Wash Basin

Land ownership, including the percentage of ownership by category, for the Grand Wash Basin is shown in Figure 6.2-2. The principal feature of land ownership in this basin is the large portion of land, 96% of the total basin area, within the Grand Canyon-Parashant National Monument managed by the U.S. Bureau of Land Management and the National Park Service. A description of land ownership data sources and methods is found in Volume 1, Appendix A. More detailed information on protected areas is found in Section 6.0.4. Land ownership categories are discussed below in the order from largest to smallest percentage in the basin.

U.S. Bureau of Land Management (BLM)

- 86.4% of the land is federally owned and managed by the Arizona Strip Field Office of the Bureau of Land Management.
- Most of the BLM lands in this basin are part of the Grand Canyon-Parashant National Monument, which also includes two wilderness areas, Grand Wash Cliffs (37,030 acres, entire) and Paiute (87,900 acres, portion).
- Land uses include resource conservation, recreation and grazing.

National Park Service (NPS)

- 11.8% of the land is federally owned and managed by the National Park Service as the Grand Canyon-Parashant National Monument and Grand Canyon National Park.
- Land uses include resource conservation and recreation.

State Trust Land

- 1.8% of the land is held in trust for the public schools under the State Trust Land system.
- All state land is interspersed with BLM land and is included within the boundaries of the Grand Canyon-Parashant National Monument.
- Primary land use is grazing.

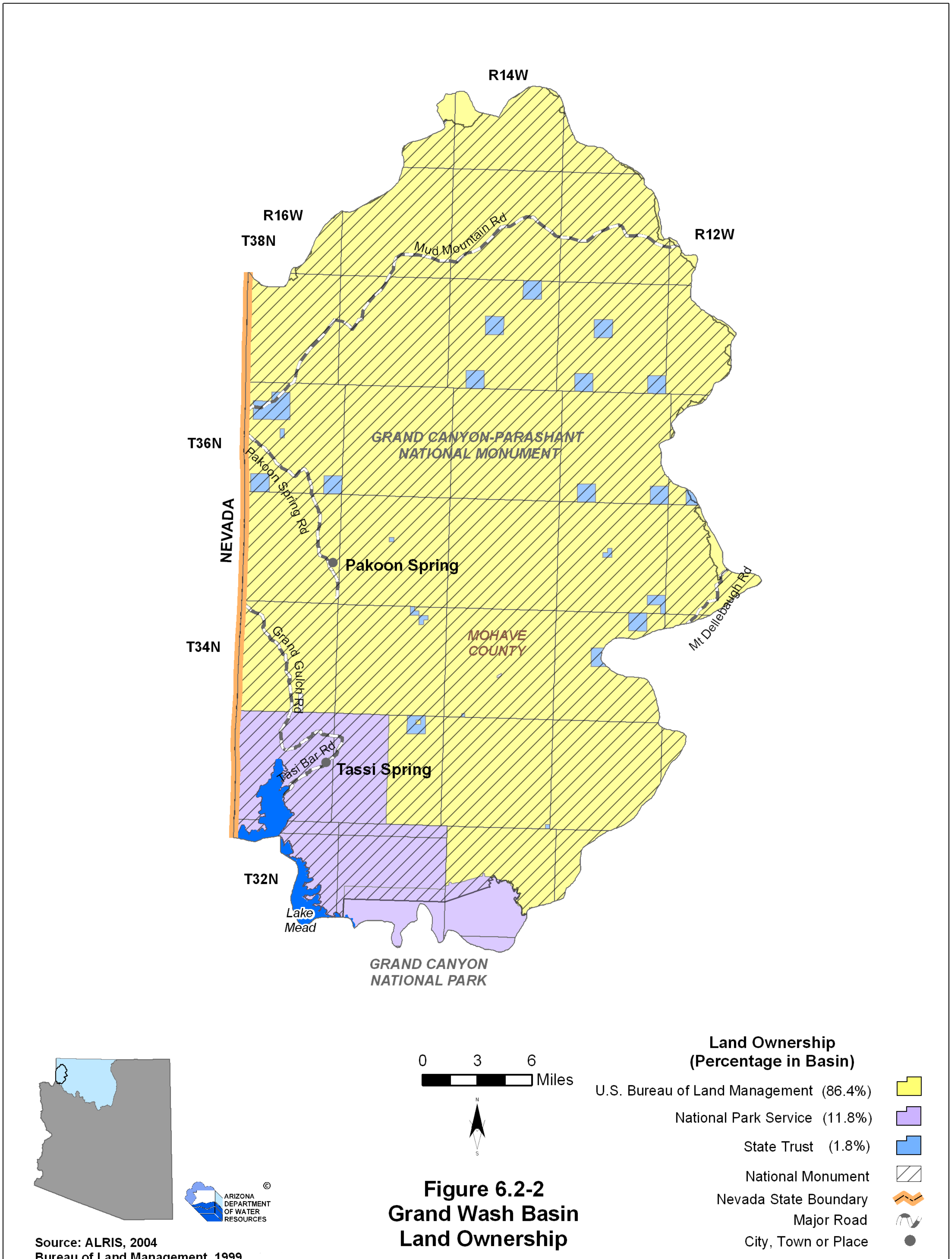


Figure 6.2-2
Grand Wash Basin
Land Ownership

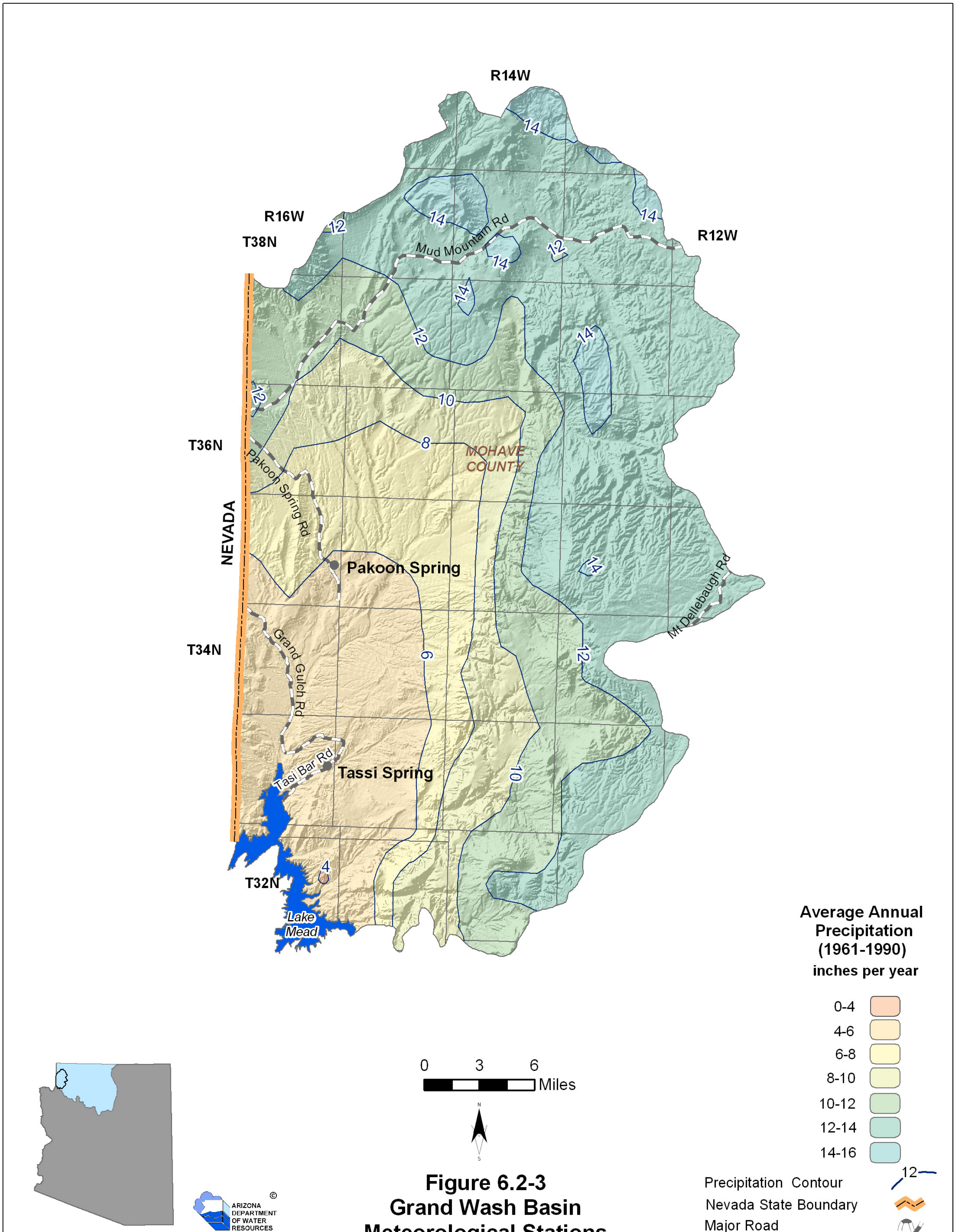
Source: ALRIS, 2004
Bureau of Land Management, 1999

6.2.3 Climate of the Grand Wash Basin

The Grand Wash Basin does not contain NOAA/NWS, Evaporation Pan, AZMET or SNOTEL/ Snowcourse stations. Figure 6.2-3 shows precipitation contour data from the Spatial Climate Analysis Service (SCAS) at Oregon State University. More detailed information on climate in the planning area is found in Section 6.0.3. A description of the climate data sources and methods is found in Volume 1, Appendix A.

SCAS Precipitation Data

- See Figure 6.2-3
- Average annual rainfall is as high as 16 inches in the northern portion of the basin and four inches or less near Lake Mead.



Precipitation Data Source: Oregon State University, 1998

Figure 6.2-3
Grand Wash Basin
Meteorological Stations
and Annual Precipitation

6.2.4 Surface Water Conditions in the Grand Wash Basin

There are no streamflow data or flood ALERT equipment in this basin. Reservoir and stockpond data are shown on Table 6.2-1. USGS runoff contours are shown on Figure 6.2-4. Descriptions of stream, reservoir and stockpond data sources and methods are found in Volume 1, Appendix A.

Reservoirs and Stockponds

- Refer to Table 6.2-1
- The basin borders one large reservoir, Lake Mead, with a maximum capacity of 29,755,000 acre-feet. The dam that creates Lake Mead, Hoover Dam, is in the Lake Mohave Basin in the Upper Colorado River Planning Area.
- There are 109 registered stockponds in the basin.

Runoff Contour

- Refer to Figure 6.2-4.
- Average annual runoff is highest, one inch per year, or 53.3 acre-feet per square mile, in the northern portion of the basin near Mud Mountain Road and decreases to 0.1 inches, or 5.33 acre-feet per square mile, in most of the southern portion of the basin.

Table 6.2-1 Reservoirs and Stockponds in the Grand Wash Basin

A. Large Reservoirs (500 acre-feet capacity and greater)

MAP KEY	RESERVOIR/LAKE NAME (Name of dam, if different)	OWNER/OPERATOR	MAXIMUM STORAGE (AF)	USE[1]	JURISDICTION
None	Mead (Hoover Dam)[2]	Bureau of Reclamation	29,755,000[3]	C,H,I,RR,S,R	Federal

B. Other Large Reservoirs (50 acre surface area or greater)

MAP KEY	RESERVOIR/LAKE NAME *(Name of dam, if different)*	OWNER/OPERATOR	MAXIMUM SURFACE AREA (acres)	USE	JURISDICTION
None identified by ADWR at this time					

Source: Compilation of databases from ADWR & others

C. Small Reservoirs (greater than 15 acre-feet and less than 500 acre-feet capacity)

Total number: 0
Total maximum storage: 0 acre-feet

D. Other Small Reservoirs (between 5 and 50 acres surface area)

Total number: 0
Total surface area: 0 acres

E. Stockponds (up to 15 acre-feet capacity)

Total number: 109

Notes:

[1]C=flood control; F=fish & wildlife pond; H=hydroelectric; I=irrigation; R=recreation; RR=river regulation; S=water supply
[2] Dam is located in Lake Mohave Basin and lake storage is located in Lake Mohave, Detrital Valley, Hualapai Valley and Meadview Basins.
[3] Includes 2,378,000 acre-feet of dead storage.

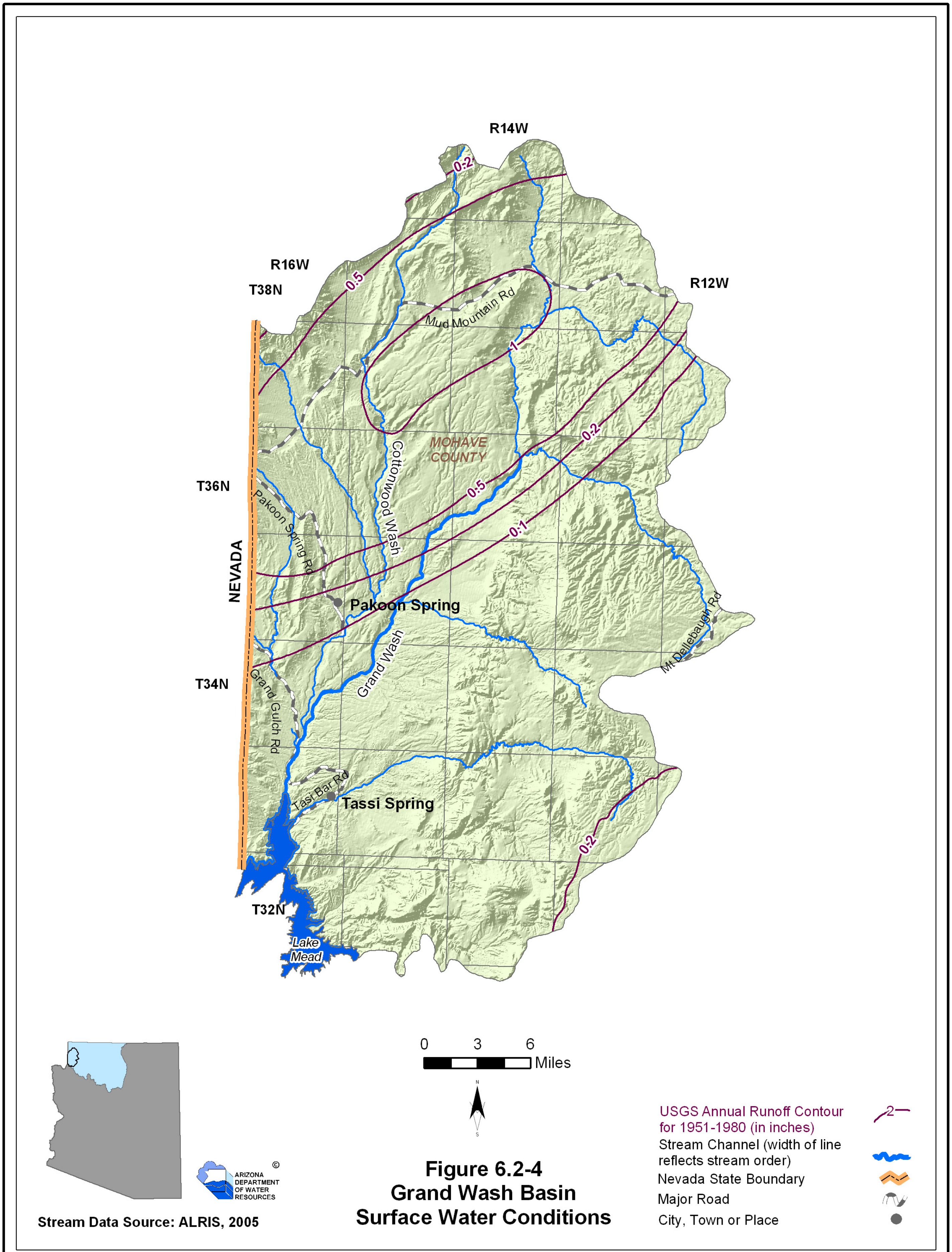


Figure 6.2-4
Grand Wash Basin
Surface Water Conditions

6.2.5 Perennial/Intermittent Streams and Major Springs in the Grand Wash Basin

Major and minor springs with discharge rates and date of measurement, and the total number of springs in the basin are shown in Table 6.2-2. The locations of major springs and one perennial stream are shown on Figure 6.2-5. Descriptions of data sources and methods for intermittent and perennial reaches and springs are found in Volume 1, Appendix A.

- There are no intermittent streams and the only perennial stream is the Colorado River, which is impounded at Hoover Dam, and forms Lake Mead in this basin.
- There are six major springs with a measured discharge of 10 gallons per minute (gpm) or greater at any time. The largest discharge rate is 75 gpm at Tassi spring.
- Springs with measured discharge of 1 to 10 gpm are not mapped but coordinates are given in Table 6.2-2B. There are nine minor springs in this basin.
- Listed discharge rates may not be indicative of current conditions.
- The total number of springs, regardless of discharge, identified by the USGS varies from 47 to 52, depending on the database reference.

Table 6.2-2 Springs in the Grand Wash Basin

A. Major Springs (10 gpm or greater):

Map Key	Name	Location		Discharge (in gpm)[1]	Date Discharge Measured
		Latitude	Longitude		
1	Tassi	361523	1135728	75	5/9/2000
2	Pakoon	362457	1135726	58	5/11/2000
3	Whiskey	361848	1135851	40	2/6/1980
4	Chill Heal	361301	1135917	25	3/12/1980
5	Unnamed	361817	1135855	20	2/6/1980
6	Unnamed	361314	1135944	13	3/12/1980

B. Minor Springs (1 to 10 gpm):

Name	Location		Discharge (in gpm)[1]	Date Discharge Measured
	Latitude	Longitude		
Middle	363205	1140230	9	5/11/2000
Burro	361700	1140013	3	5/9/2000
Unnamed	361752	1135906	4	9/22/1976
Cane -south	363916	1134705	2	5/14/2000
Hidden	362812	1133741	2	5/15/2000
Mud	364145	1134644	2	5/13/2000
Unnamed	361544	1135614	2	3/12/1980
Red Rock	363303	1140124	2	5/12/2000
#106	364100	1134526	2	5/13/2000

Source: Compilation of databases from ADWR & others

C. Total number of springs, regardless of discharge, identified by USGS (see ALRIS, 2005a and USGS, 2006b): 47 to 52

Notes:
[1] Most recent measurement identified by ADWR

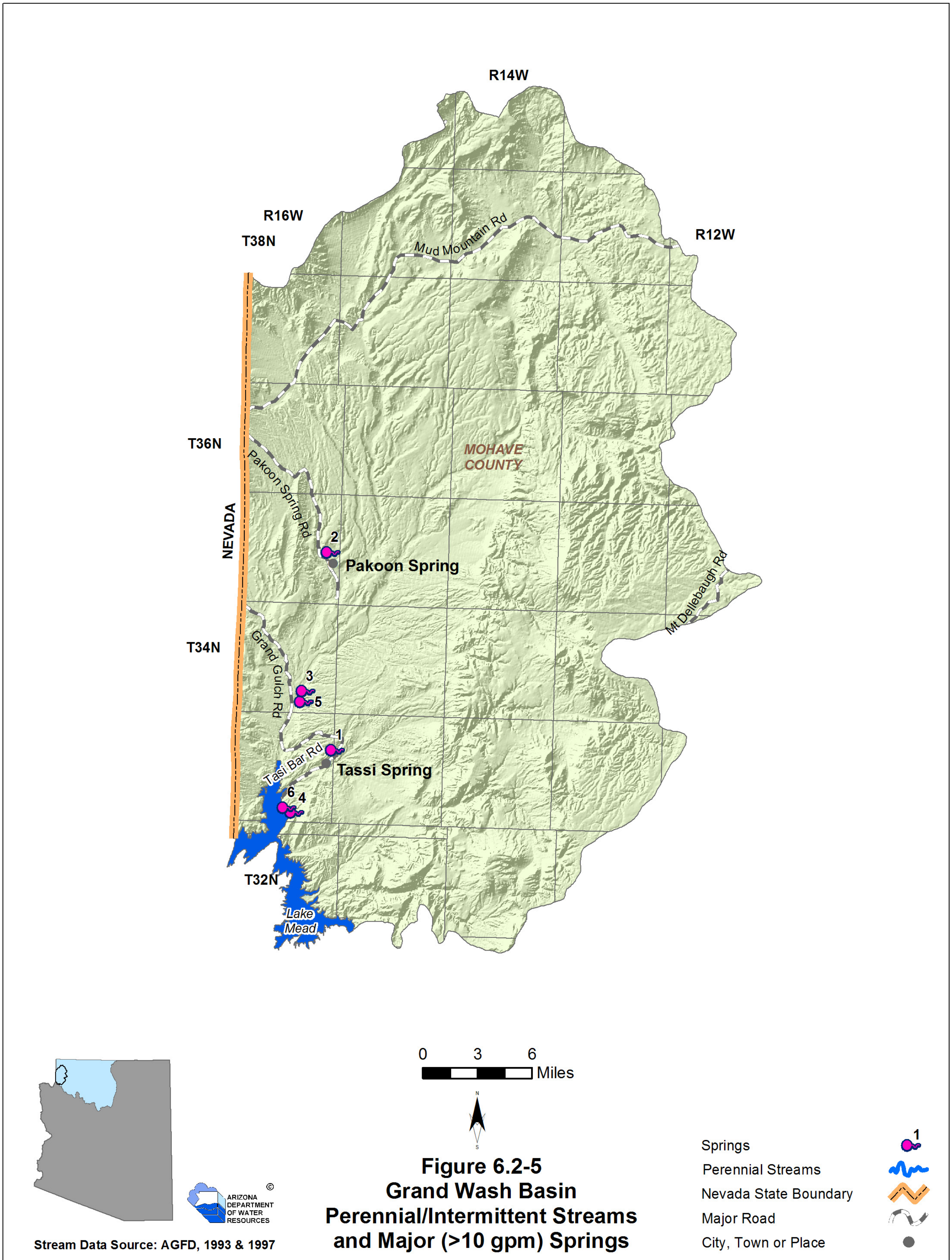


Figure 6.2-5
Grand Wash Basin
Perennial/Intermittent Streams and Major (>10 gpm) Springs

6.2.6 Groundwater Conditions of the Grand Wash Basin

Major aquifers, well yields, number of index wells and date of last water-level sweep are shown in Table 6.2-3. Figure 6.2-6 shows water-level change between 1990-1991 and 2003-2004. Figure 6.2-7 contains hydrographs for selected wells shown on Figure 6.2-6. Figure 6.2-8 shows well yield for one well. A description of aquifer data sources and methods as well as well data sources and methods, including water-level changes and well yields are found in Volume 1, Appendix A.

Major Aquifers

- Refer to Table 6.2-3 and Figure 6.2-6.
- Major aquifers in the basin include recent stream alluvium, basin-fill and sedimentary rock (Cottonwood Wash and Muddy Creek formations).
- Most of the basin geology consists of consolidated crystalline and sedimentary rock.
- Data on natural recharge, groundwater in storage and groundwater flow direction is not available for this basin.

Well Yields

- Refer to Table 6.2-3 and Figure 6.2-8.
- As shown on Figure 6.2-8 well yield data are only available for one well, which yields less than 100 gallons per minute (gpm).

Water Level

- Refer to Figure 6.2-6. Water levels are shown for wells measured in 2003-2004.
- The Department annually measures two index wells in this basin. Hydrographs for these two wells are shown in Figure 6.2-7.
- The water level in one well was at a depth of 21 feet and rose by more than 30 feet between 1990-1991 and 2003-2004. Water level in the other well is at a depth of 508 feet and was generally stable between 1990-1991 and 2003-2004.

Table 6.2-3 Groundwater Data for the Grand Wash Basin

Basin Area, in square miles:	959	
Major Aquifer(s):	**Name and/or Geologic Units**	
	Recent Stream Alluvium	
	Basin Fill with Interbedded Volcanic Rock	
	Sedimentary Rock (Cottonwood Wash Formation)	
	Sedimentary Rock (Muddy Creek Formation)	
Well Yields, in gal/min:	10 (1 well reported)	Reported on registration forms for large (>10-inch) diameter wells (Wells55)
	300	ADWR (1990)
	Range 0-500	Anning and Duet (1994)
Estimated Natural Recharge, in acre-feet/year:	N/A	
Estimated Water Currently in Storage, in acre-feet:	N/A	
Current Number of Index Wells:	2	
Date of Last Water-level Sweep:	1976 (6 wells measured)	

N/A = Not Available

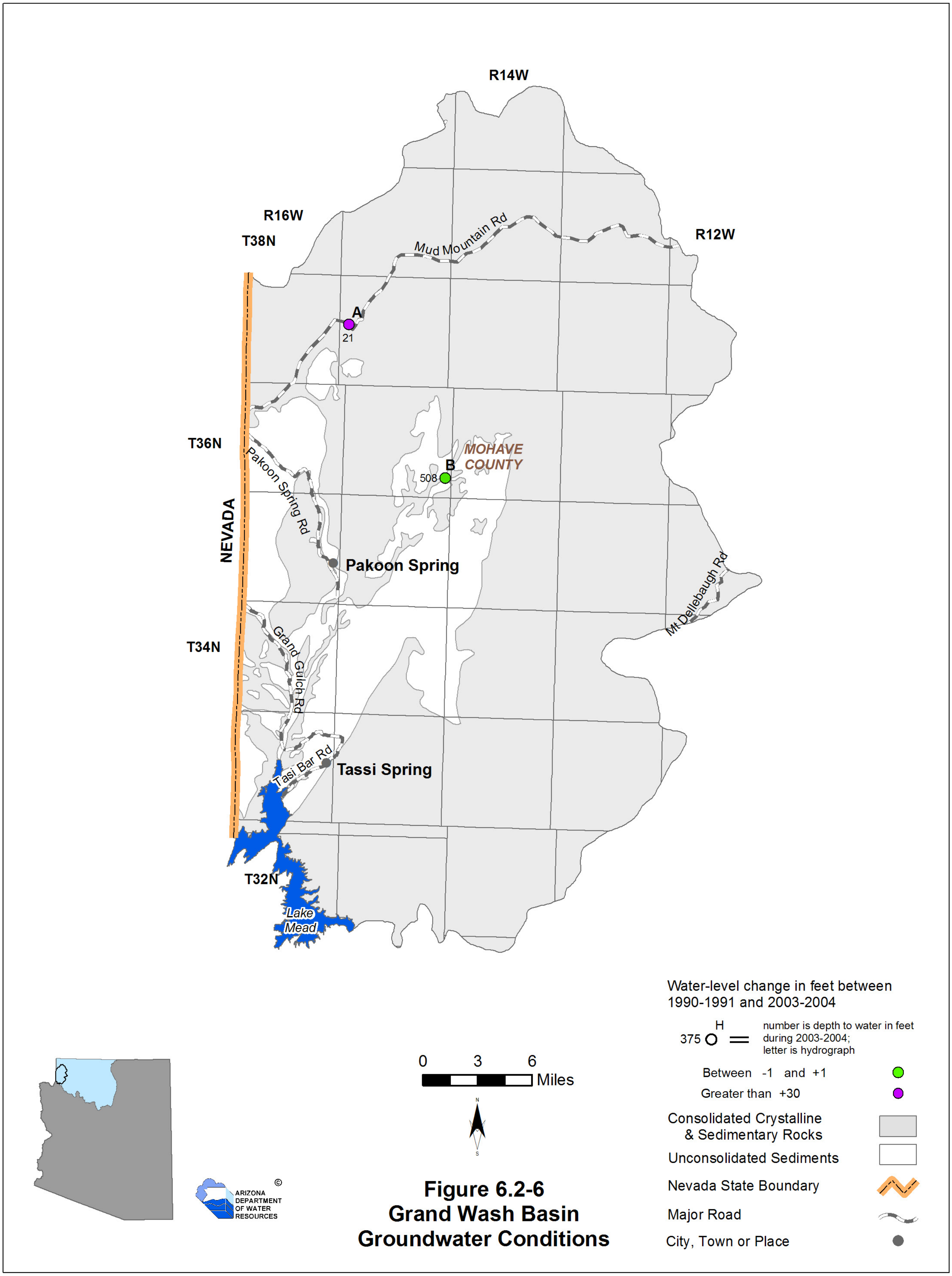
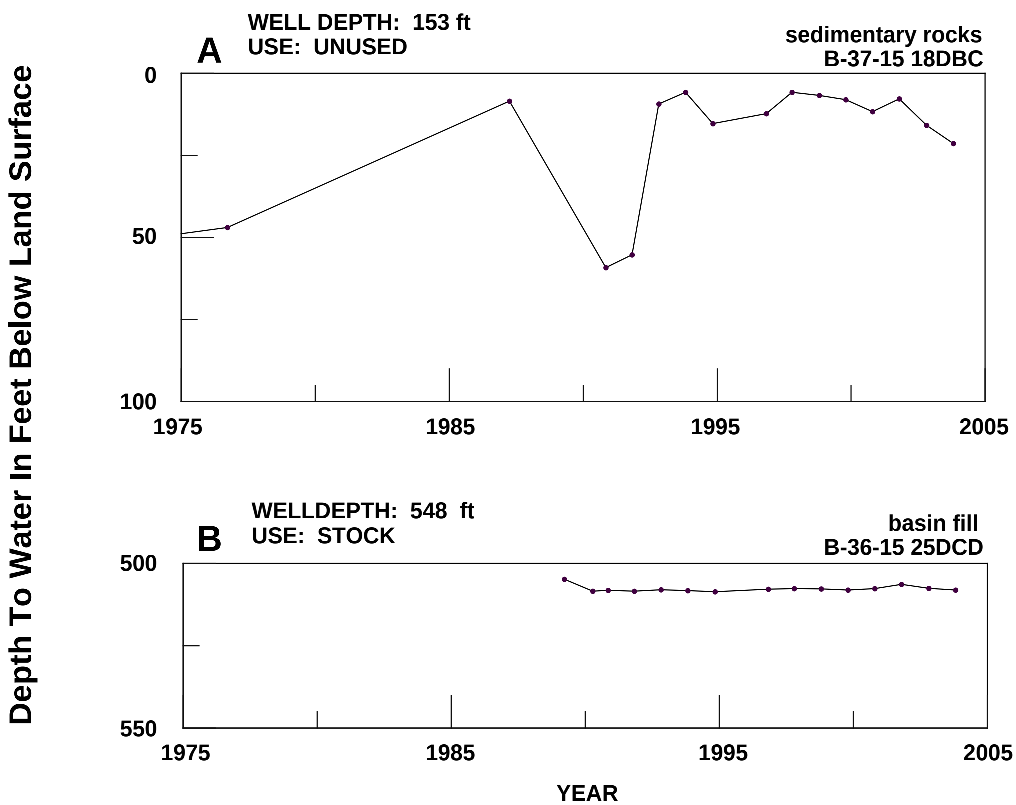


Figure 6.2-6
Grand Wash Basin
Groundwater Conditions

Figure 6.2-7
Grand Wash Basin
Hydrographs Showing Depth to Water in Selected Wells



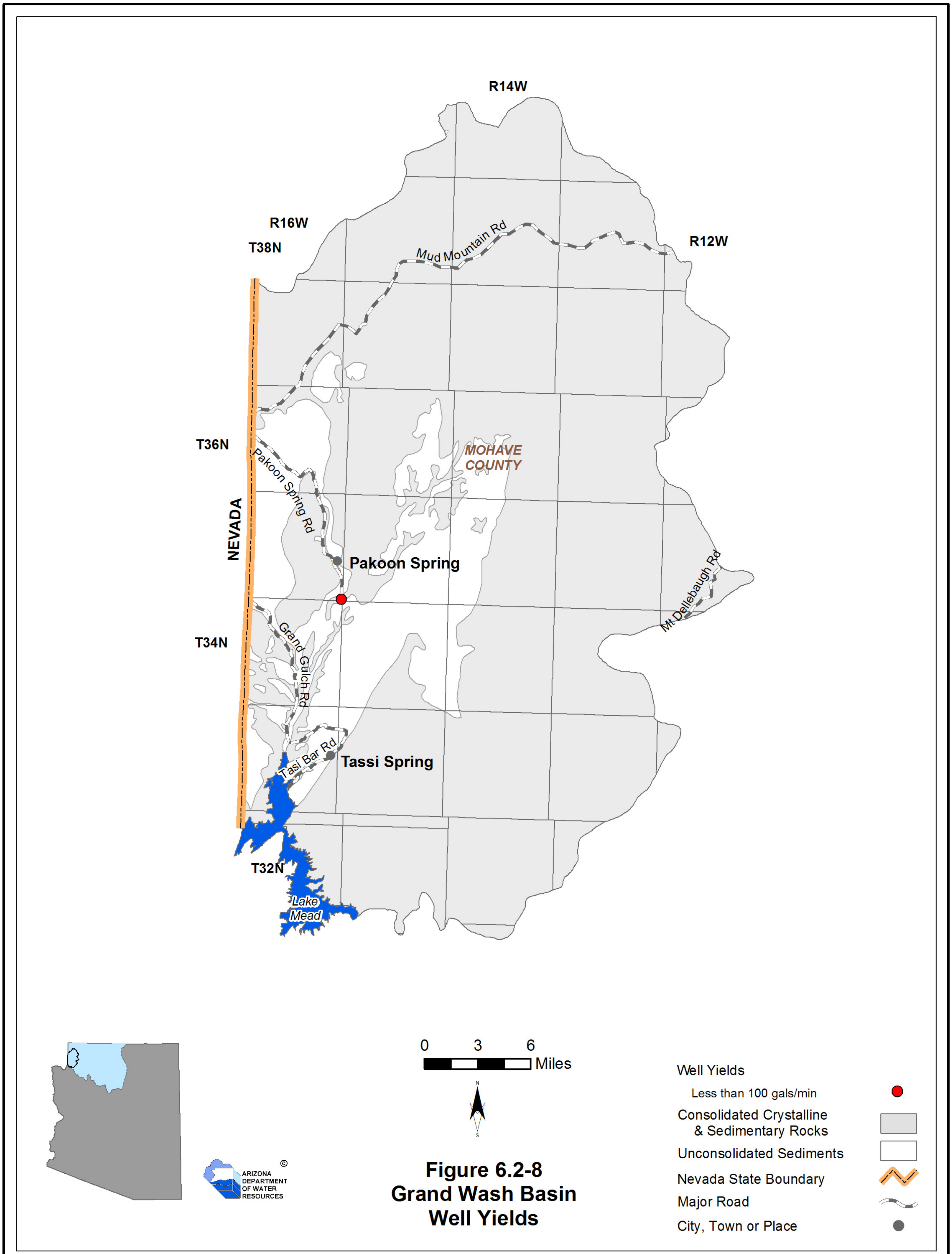


Figure 6.2-8
Grand Wash Basin
Well Yields

6.2.7 Water Quality of the Grand Wash Basin

Wells, springs and mine sites with parameter concentrations that have equaled or exceeded drinking water standard(s), including location and parameter(s) are shown in Table 6.2-4A. There are no impaired lakes and streams in this basin. Figure 6.2-9 shows the location of water quality occurrences keyed to Table 6.2-4. Not all parameters were measured at all sites; selective sampling for particular constituents is common. A description of water quality data sources and methods is found in Volume 1, Appendix A.

Well, Mine or Spring sites that have equaled or exceeded drinking water standards (DWS)

- Refer to Table 6.2-4A.
- All seven springs have parameter concentrations of total dissolved solids that have equaled or exceeded drinking water standards.

Table 6.2-4 Water Quality Exceedences in the Grand Wash Basin[1]

A. Wells, Springs and Mines

Map Key	Site Type	Site Location			Parameter(s) Concentration has Equaled or Exceeded Drinking Water Standard (DWS)[2]
		Township	Range	Section	
1	Spring	38 North	14 West	14	TDS
2	Spring	33 North	15 West	8	TDS
3	Spring	33 North	15 West	9	TDS
4	Spring	33 North	15 West	9	TDS
5	Spring	33 North	15 West	18	TDS
6	Spring	33 North	16 West	3	TDS
7	Spring	33 North	16 West	4	TDS

Source: Compilation of databases from ADWR & others

B. Lakes and Streams

Map Key	Site Type	Site Name	Length of Impaired Stream Reach (in miles)	Area of Impaired Lake (in acres)	Designated Use Standard	Parameter(s) Exceeding Use Standard
None identified by ADWR at this time						

Notes:

[1] Water quality samples collected between 1980 and 2000.

[2] TDS = Total Dissolved Solids

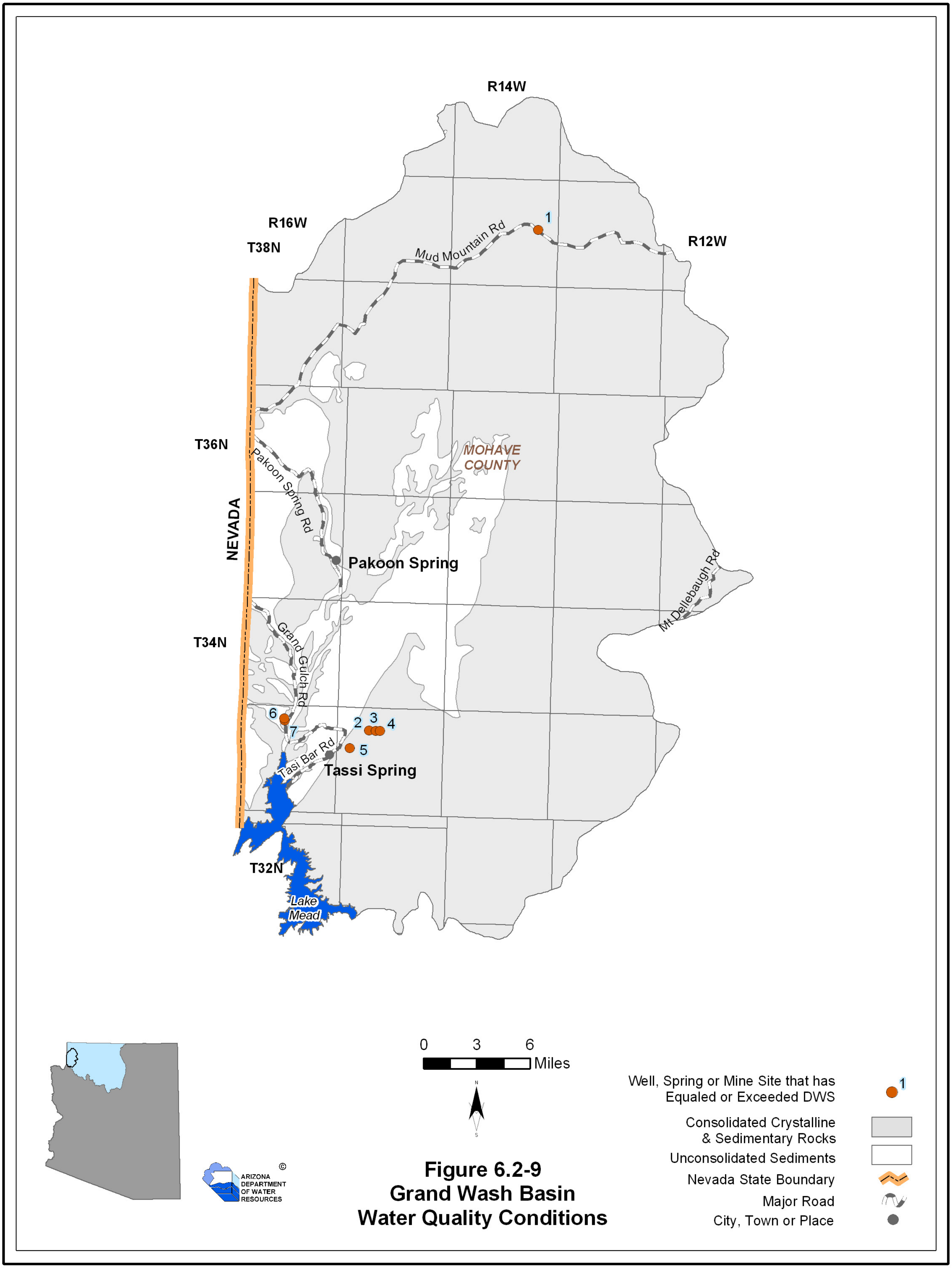


Figure 6.2-9
Grand Wash Basin
Water Quality Conditions

6.2.8 Cultural Water Demand in the Grand Wash Basin

Cultural water demand data including population, number of wells and the average well pumpage and surface water diversions by the municipal, industrial and agricultural sectors are shown in Table 6.2-5. There is no recorded effluent generation in this basin. The USGS National Gap Analysis Program, the primary source of cultural demand map data, showed no demand centers for this basin. A description of cultural water demand data sources and methods is found in Volume 1, Appendix A. More detailed information on cultural water demand is found in Section 6.0.7.

Cultural Water Demand

- Refer to Table 6.2-5
- Population in this basin is very small, with 15 residents in 2000.
- There are no recorded surface water uses in this basin. All groundwater use is for municipal demand and has remained relatively constant since 1971.
- As of 2005 there were 11 registered wells with a pumping capacity of less than or equal to 35 gallons per minute (gpm) and one well with a pumping capacity of more than 35 gpm.

Table 6.2-5 Cultural Water Demand in the Grand Wash Basin[1]

Year	Estimated and Projected Population	Number of Registered Water Supply Wells Drilled		Average Annual Demand (in acre-feet)						
				Well Pumpage			Surface-Water Diversions			Data Source
		Q ≤ 35 gpm	Q > 35 gpm	Municipal	Industrial	Agricultural	Municipal	Industrial	Agricultural	
1971										
1972										
1973				<500			NR			
1974										
1975		3[2]	0[2]							
1976										
1977										
1978				<500			NR			
1979										
1980	10									ADWR (1994a)
1981	10									
1982	10									
1983	11	5	0	<500			NR			
1984	11									
1985	11									
1986	11									
1987	11									
1988	12	0	1	<500			NR			
1989	12									
1990	12									
1991	12									
1992	13									
1993	13	2	0	<300	NR	NR	NR			
1994	13									
1995	14									
1996	14									
1997	14									
1998	14	1	0	<300	NR	NR	NR			USGS (2007)
1999	15									
2000	15									
2001	15									
2002	15									
2003	15	0	0	<300	NR	NR	NR			
2004	15									
2005	15									
2010	15									
2020	15									
2030	15									
WELL TOTALS:		**11**	**1**							

[1] Does not include evaporation losses from stockponds and reservoirs.
[2] Includes all wells through 1980.
NR - Not reported

6.2.9 Water Adequacy Determinations in the Grand Wash Basin

There are no water adequacy applications on file with the Department as of December 2008 for the Grand Wash Basin. A description of the Water Adequacy Program is found in Volume 1, Appendix C. Adequacy determination data sources and methods are found in Volume 1, Appendix A.

Grand Wash Basin
References and Supplemental Reading

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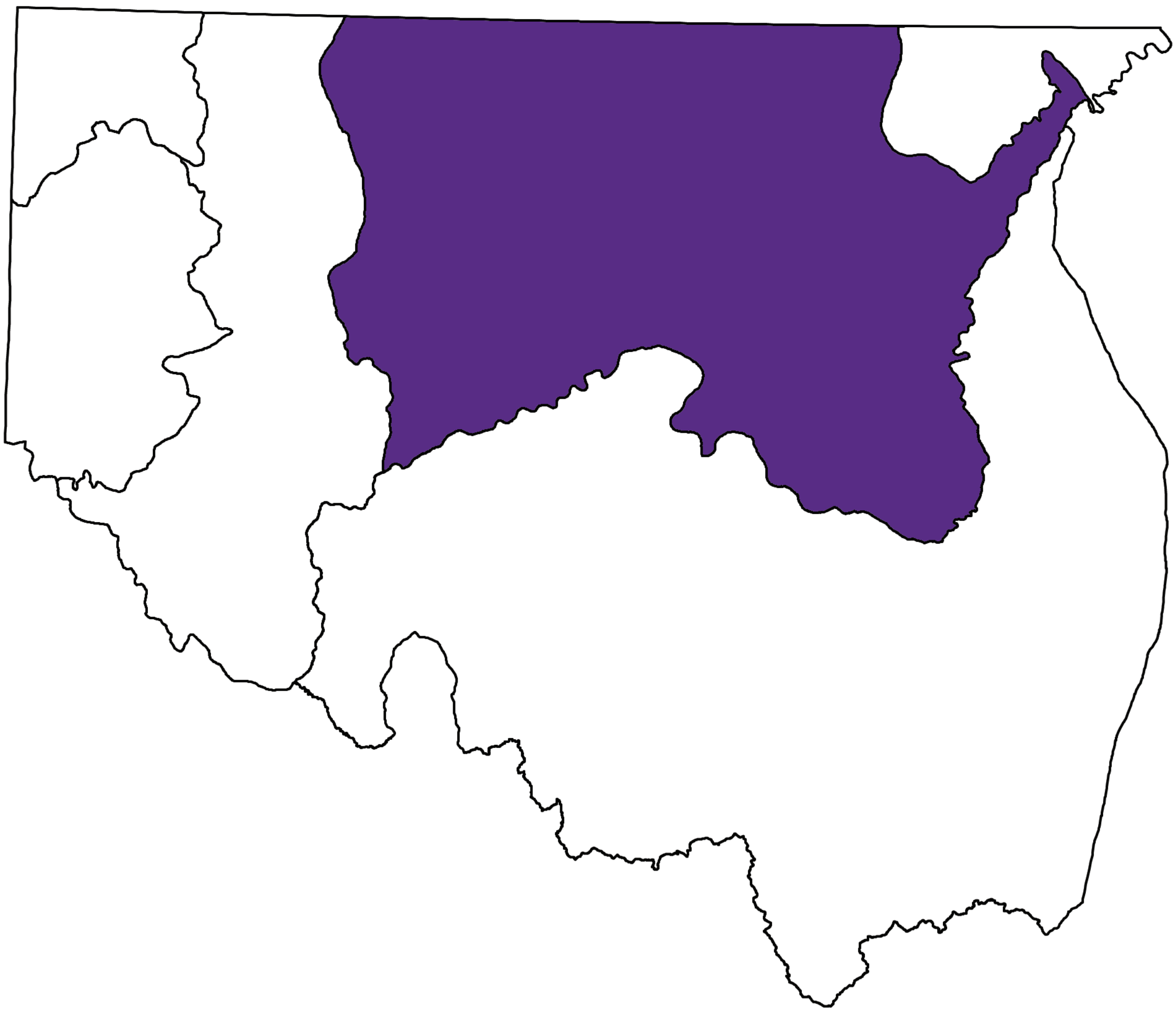
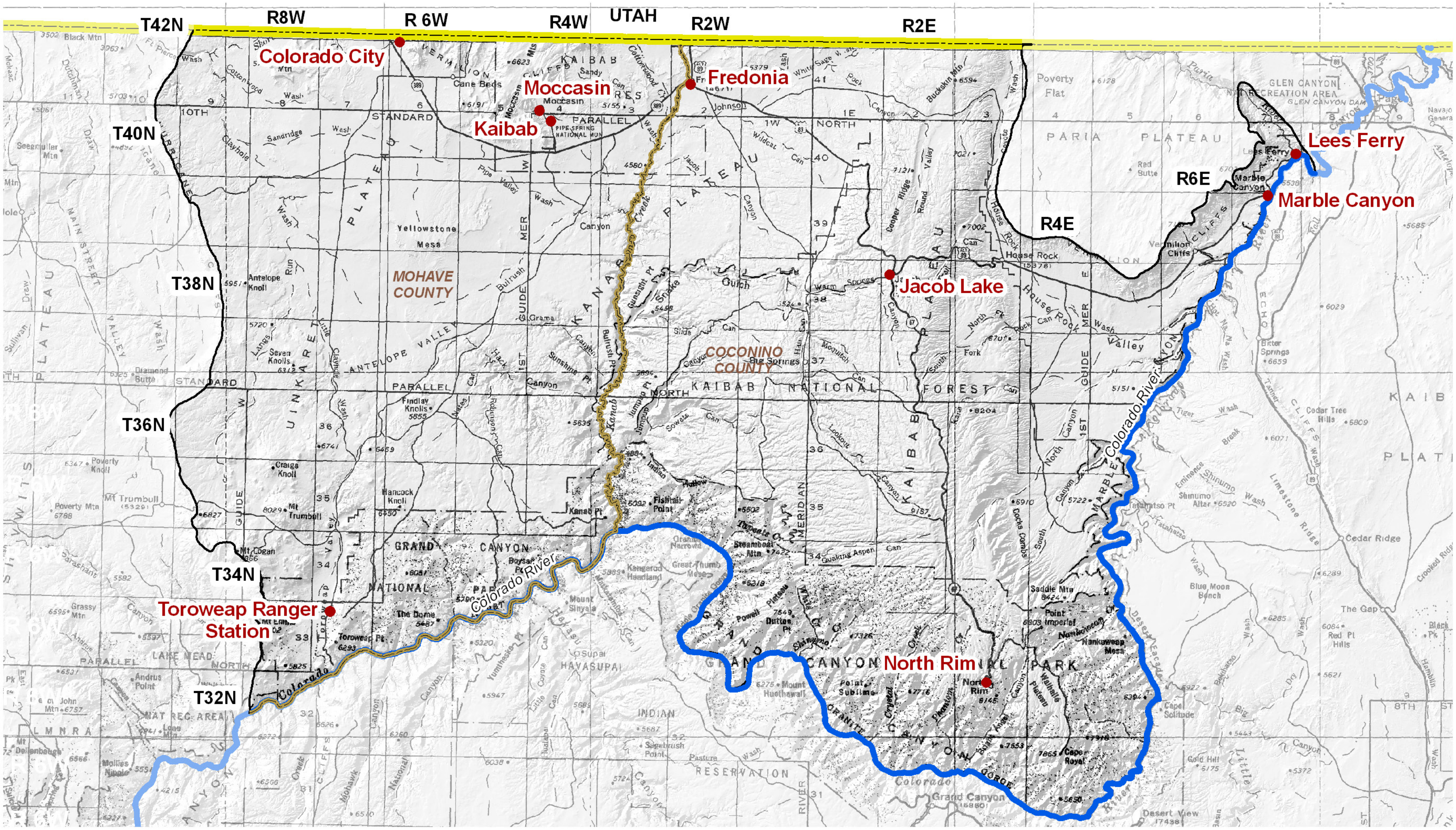
Section 6.3
Kanab Plateau Basin

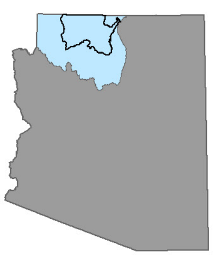


6.3.1 Geography of the Kanab Plateau Basin

The Kanab Plateau Basin, located in the north central part of the planning area is 4,247 square miles in area. Geographic features and principal communities are shown on Figure 6.3-1. The basin is characterized by plateaus and canyons. Vegetation types include Mohave and Great Basin desertscrub, Plains and Great Basin grassland, Great Basin conifer woodland, Great Basin subalpine conifer forest and Rocky Mountain and madrean montane conifer forest. There are small areas of subalpine grassland on the Kaibab Plateau south of Jacob Lake. (See Figure 6.0-11)

- Principal geographic features shown on Figure 6.3-1 are:
    - The Colorado River and Grand Canyon forming the southern basin boundary and the lowest point at 1,600 feet where the river exits the basin.
    - A series of plateaus running north-south; the Kaibab, Kanab and Uinkaret plateaus
    - Vermillion Cliffs in the northeast portion of the basin, Hurricane Cliffs on the northwestern basin boundary and Marble Canyon on the eastern basin boundary.
    - Granite Gorge on the southeastern basin boundary
    - Antelope Valley between the Uinkaret and Kanab Plateaus
    - Point Imperial, the highest point in the basin at 8,803 feet, located northeast of the North Rim





0 3 6
Miles

Base Map: USGS 1:500,000, 1981

ARIZONA DEPARTMENT OF WATER RESOURCES

Figure 6.3-1
Kanab Plateau Basin
Geographic Features

Utah State Boundary
COUNTY
City, Town or Place

6.3.2 Land Ownership in the Kanab Plateau Basin

Land ownership, including the percentage of ownership by category, for the Kanab Plateau Basin is shown in Figure 6.3-2. Principal features of land ownership in this basin are the large parcels of U.S. Bureau of Land Management (BLM), National Forest Service and National Park Service (NPS) lands. Three percent is managed as the Vermilion Cliffs National Monument by the BLM and 2% is managed as the Grand Canyon-Parashant National Monument by the BLM and NPS. A description of land ownership data sources and methods is found in Volume 1, Appendix A. More detailed information on protected areas is found in Section 6.0.4. Land ownership categories are discussed below in the order from largest to smallest percentage in the basin.

U.S. Bureau of Land Management (BLM)

- 41.6% of the land is federally owned and managed by the Arizona Strip Field Office of the Bureau of Land Management.
- BLM land in the basin includes portions of the Grand Canyon-Parashant and Vermilion Cliffs National Monuments as well as the 7,880 acre Mt. Trumbull Wilderness, 6,860 acre Cottonwood Point Wilderness and a portion of the 79,000 acre Paria Canyon Wilderness. (see Figure 6.0-14)
- Land uses include grazing, recreation and resource conservation.

National Forest

- 24.1% of the land is federally owned and managed by the United States Forest Service (USFS).
- Forest lands are part of the Kaibab National Forest and include the 40,610-acre Saddle Mountain Wilderness and the 68,340 acre Kanab Creek Wilderness. (see Figure 6.0-14)
- Land uses include recreation, resource conservation, grazing and timber production.

National Park Service (NPS)

- 22.2% of the land is federally owned and managed by the National Park Service.
- This basin includes portions of Grand Canyon National Park, Grand Canyon-Parashant National Monument and Glen Canyon National Recreation Area.
- Land uses include resource conservation and recreation.

Indian Reservation

- 4.4% of the land is under tribal ownership of the Kaibab-Paiute Indian Tribe.
- Land uses include domestic, commercial, agricultural and ranching.

State Trust Land

- 4.3% of the land is held in trust for the public schools under the State Trust Land system.
- State land is located throughout the basin interspersed with BLM and private land.
- Primary land use is grazing.

Private

- 3.4% of the land is private.
- The majority of the private land is in the northern portion of the basin in the vicinity of

Colorado City and Fredonia.

- Land uses include domestic, commercial, agriculture and ranching.

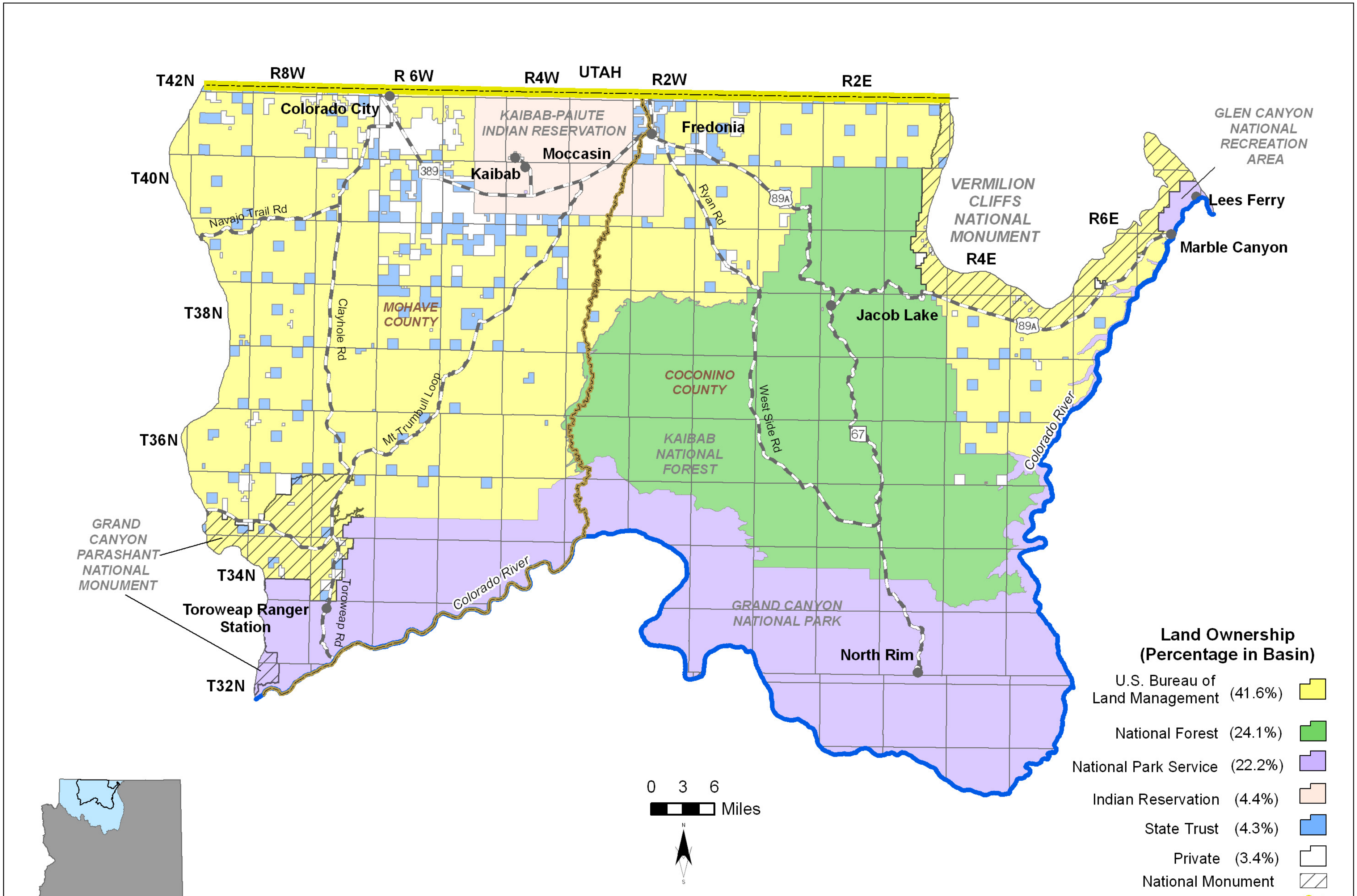


Figure 6.3-2
Kanab Plateau Basin
Land Ownership

6.3.3 Climate of the Kanab Plateau Basin

Climate data from NOAA/NWS Co-op Network and SNOTEL/Snowcourse stations are complied in Table 6.3-1 and the locations are shown on Figure 6.3-3. Figure 6.3-3 also shows precipitation contour data from the Spatial Climate Analysis Service (SCAS) at Oregon State University. The Kanab Plateau Basin does not contain Evaporation Pan or AZMET stations. More detailed information on climate in the planning area is found in Section 6.0.3. A description of the climate data sources and methods is found in Volume 1, Appendix A.

NOAA/NWS Co-op Network

- Refer to Table 6.3-1A
- There are nine NOAA/NWS Co-op network climate stations in the basin. The average monthly maximum temperature occurs in July and ranges between 91.5°F at Inner Canyon USGS and 61.8°F at Bright Angel Ranger Station. The average monthly minimum temperature occurs in January or December and ranges between 23.2°F at Colorado City and 47.0°F at Phantom Ranch.
- Highest average seasonal rainfall occurs in the summer (July-September) or winter (January-March). For the period of record used, the highest annual rainfall is 25.70 inches at Bright Angel Ranger Station and the lowest is 6.55 inches at Lees Ferry

SNOTEL/Snowcourse

- Refer to Table 6.3-1D
- There is one SNOTEL/Snowcourse station (Bright Angel) in the basin located at the north rim of the Grand Canyon.
- The highest average monthly snowpack is in March with an average of 9.9 inches.

SCAS Precipitation Data

- See Figure 6.1-3
- Additional precipitation data shows average annual rainfall as high as 30 inches north of the North Rim and as low as four inches along the Colorado River.

Table 6.3-1 Climate Data for the Kanab Plateau Basin

A. NOAA/NWS Co-op Network:

Station Name	Elevation (in feet)	Period of Record Used for Averages	Average Temperature Range (in F)		Average Precipitation (in inches)				
			Max/Month	Min/Month	Winter	Spring	Summer	Fall	Annual
Bright Angel Ranger Station	8,400	1971-2000	61.8/Jul	27.2/Jan	10.79	2.80	5.76	6.35	25.70
Colorado City	5,010	1971-2000	76.8/Jul	23.2/Jan, Dec	4.41	2.70	4.04	3.02	14.17
Fredonia	4,680	1948-2005[1]	74.2/Jul	32.4/Jan	2.79	1.40	2.79	3.34	10.32
Inner Canyon USGS	2,570	1948-1966	91.5/Jul	45.8/Jan	2.13	1.23	3.21	1.82	8.38
Jacob Lake	7,830	1950-1987[1]	64.9/Jul	27.9/Jan	5.71	3.64	7.08	6.67	23.10
Lees Ferry	3,210	1971-2000	87.3/Jul	37.8/Jan, Dec	1.64	0.91	2.33	1.67	6.55
Phantom Ranch	2,570	1971-2000	91.4/Jul	47.0/Jan	3.12	1.09	3.13	2.43	9.77
Pipe Springs National Monument	4,920	1971-2000	76.7/Jul	34.8/Jan	3.81	1.59	3.30	2.56	11.26
Tuweep	4,780	1948-1985[1]	79.6/Jul	38.5/Jan	3.93	1.46	3.97	2.98	12.34

Source: WRCC, 2005

Notes:

[1] Average temperature for period of record shown; average precipitation from 1971-2000

B. Evaporation Pan:

Station Name	Elevation (in feet)	Period of Record Used for Averages	Avg. Annual Evap (in inches)
None			

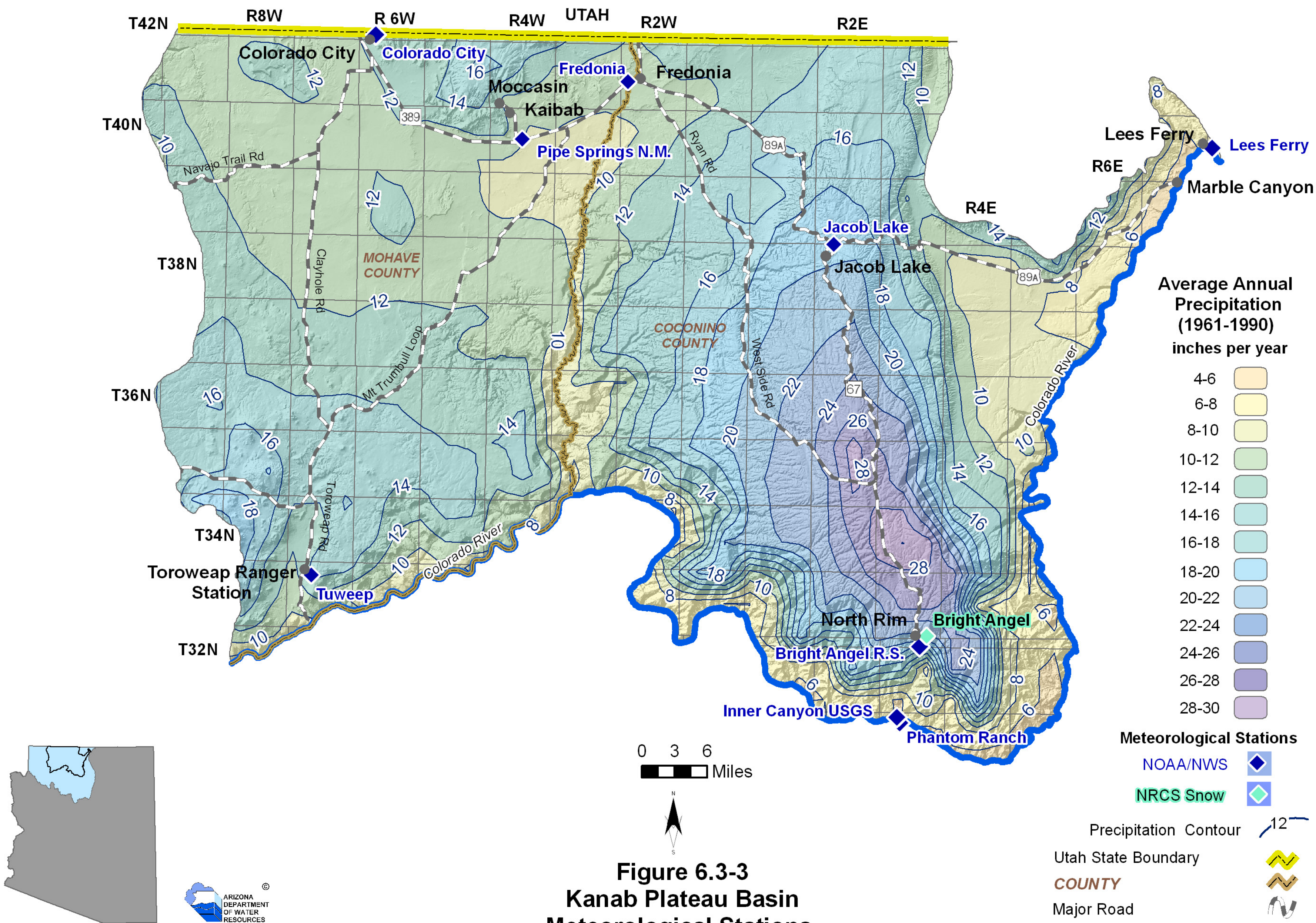
C. AZMET:

Station Name	Elevation (in feet)	Period of Record	Average Annual Reference Evaportranspiration, in inches (*Number of years to calculate averages*)
None			

D. SNOTEL/Snowcourse:

Station Name	Elevation (in feet)	Period of Record	Average Snowpack, as Snow Water Content, at the Beginning of the Month, in Inches *(Number of measurements to calculate average)*					
			Jan.	Feb.	March	April	May	June
Bright Angel	8,400	1947 - current	3.3 *(28)*	*7.0 (50)*	*9.9 (49)*	9.1 *(44)*	16.2 *(1)*	0 *(0)*

Source: Natural Resources Conservation Service, 2006



Precipitation Data Source: Oregon State University, 1998

Figure 6.3-3
Kanab Plateau Basin
Meteorological Stations
and Annual Precipitation

6.3.4 Surface Water Conditions in the Kanab Plateau Basin

Streamflow data, including average seasonal flow, average annual flow and other information are shown in Table 6.3-2. Flood ALERT equipment in the basin is shown in Table 6.3-3. Reservoir and stockpond data, including maximum storage or maximum surface area, are shown in Table 6.3-4. The location of streamflow gages identified by USGS number, flood ALERT equipment, USGS runoff contours and large reservoirs are shown on Figure 6.3-5. Descriptions of stream, reservoir and stockpond data sources and methods are found in Volume 1, Appendix A.

Streamflow Data

- Refer to Table 6.3-2.
- Data from six stations located at three watercourses are shown in the table and their location is shown on Figure 6.3-5. Three stations have been discontinued and two stations are real-time stations.
- The Colorado River near Grand Canyon station receives highest seasonal flow in the spring (April-June). Unlike the other two stations on the Colorado River in this basin, the period of record for this station predates Glen Canyon Dam upstream on the Colorado River, and therefore more closely reflects the river's unaltered average seasonal flow.
- The largest annual flow recorded in the basin is 20.6 million acre feet (maf) in 1984 at the Colorado River near Grand Canyon station with a contributing drainage area of 141,600 square miles.
- The Colorado River in the basin has a mean and median annual flow of over eight maf at all three gages. The Paria River is a major tributary to the Colorado River, with a median annual flow of over 18,000 acre-feet.
- Figure 6.3-4 shows the annual flow in the Colorado River near Grand Canyon station. Flood events/Glen Canyon Dam releases are shown in 1983-84 and in 1998. Otherwise, the data show below average flow, and less variability in year-to-year flow after construction of Glen Canyon Dam in 1964.

Flood ALERT Equipment

- Refer to Table 6.3-3.
- As of October 2005 there was one station in the basin.

Reservoirs and Stockponds

- Refer to Table 6.3-4.
- The basin contains three large reservoirs. Two of the three large reservoirs are dry or intermittent lakes.
- Surface water is stored or could be stored in ten small reservoirs.
- There are 705 registered stockponds in this basin.

Runoff Contour

- Refer to Figure 6.3-5.
- Average annual runoff is highest, two inches per year or 106.6 acre-feet per square mile, below the Kaibab Plateau in the western portion of the basin and decreases to 0.1 inches, or 5.33 acre-feet per square mile, east and west of the Kaibab Plateau.

Figure 6.3-4 Annual Flows (acre-feet) Colorado River near Grand Canyon 1923-2005 (Station # 9402500)

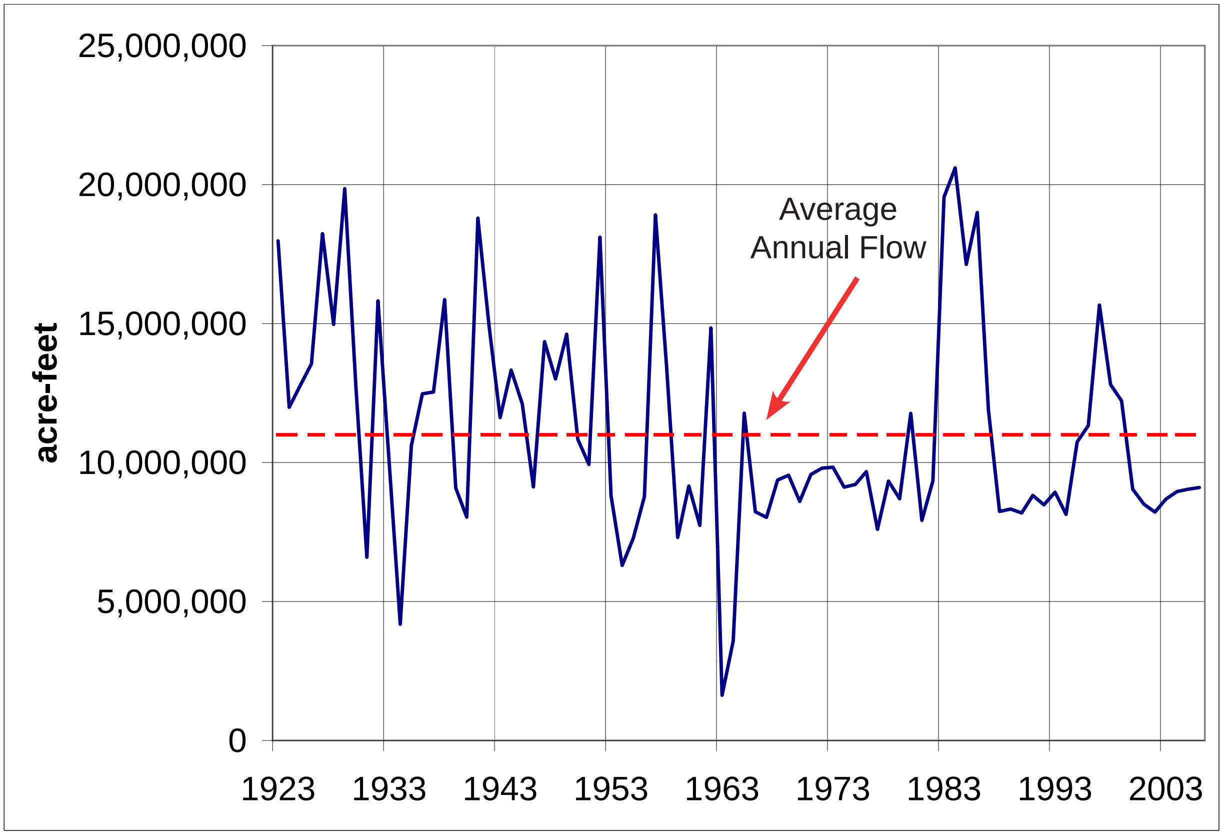


Table 6.3-2 Streamflow Data for the Kanab Plateau Basin

Station Number	USGS Station Name	Drainage Area (in mi^2)	Gage Elevation (in feet)	Period of Record	Average Seasonal Flow (% of annual flow)				Annual Flow/Year (in acre-feet)				Years of Annual Flow Record
					Winter	Spring	Summer	Fall	Minimum	Median	Mean	Maximum	
9382000	Paria River at Lees Ferry	1,410	3,124	10/1923-current (real time)	29	11	38	22	9,052 (1977)	18,104	20,606	47,867 (1980)	79
9383000[1]	Colorado River at Compact Point near Lees Ferry	112,000	NA	10/1980-9/2007	24	25	28	22	7,833,437 (1988)	8,383,659	9,876,067	18,699,615 (1986)	20
9383100	Colorado River above Little Colorado River near Desert View	114,272	2,687	9/1989-1/2002 (discontinued)	25	25	27	23	8,188,186 (1990)	9,610,439	10,357,150	15,420,721 (1997)	10
9402500	Colorado River near Grand Canyon	141,600	2,419	10/1922-current (real time)	17	43	24	16	1,629,360 (1963)	9,884,422	11,234,437	20,551,661 (1984)	79
9402501	Colorado River near Grand Canyon (Stonehouse)	NA	2,419	11/2001- 1/2006 (discontinued)	27	25	28	20	No statistics run; less than 3 years data				2
9403780	Kanab Creek near Fredonia	1,085	4,500	10/1963-9/1980 (discontinued)	40	27	20	14	608 (1964)	3,743	4,603	11,728 (1979)	16

Source: USGS (NWIS) 2005 & 2008

Notes:
[1] This gage is not an actual gage but a compilation of data from the Paria River gage 09392000 and the Lees Ferry gage 09380000 in the Little Colorado River Basin and is used for accounting purposes.
NA = Not available
Average seasonal flow and annual flow/year data are current as of water year 2003
Statistics based on Calendar Year
Annual Flow statistics based on monthly values
Summation of Average Annual Flows may not equal 100 due to rounding
Period of record may not equal Year of Record used for annual Flow/Year statistics due to only using years with a 12 month record
In Period of Record, current equals November 2008
Seasonal and annual flow data used for the statistics was retrieved in 2005

Table 6.3-3 Flood ALERT Equipment in the Kanab Plateau Basin

Station ID	Station Name	Station Type	Install Date	Responsibility
7580	Colorado City	Weather Station	NA	Mohave County FCD

Source: ADWR 2005a

Notes:
FCD = Flood Control District
NA = Information is not available at this time

Table 6.3-4 Reservoirs and Stockponds in the Kanab Plateau Basin

A. Large Reservoirs (500 acre-feet capacity and greater)

MAP KEY	RESERVOIR/LAKE NAME *(Name of dam, if different)*	OWNER/OPERATOR	MAXIMUM STORAGE (AF)	USE[1]	JURISDICTION
1	Fredonia[2]	Fredonia	2,710	C	State

Source: U.S. Army Corps of Engineers 2005

B. Other Large Reservoirs (50 acre surface area or greater)[3]

MAP KEY	RESERVOIR/LAKE NAME *(Name of dam, if different)*	OWNER/OPERATOR	MAXIMUM SURFACE AREA (acres)	USE[1]	JURISDICTION
2	Lakes of Short Creek	Short Creek Southside Irrigation Co.	200	I	State
3	Toroweap[4]	National Park Service	83	P	Federal

Source: Compilation of databases from ADWR & others

C. Small Reservoirs (greater than 15 acre-feet and less than 500 acre-feet capacity)

Total number: 1
Total maximum storage: 104 acre-feet

D. Other Small Reservoirs (between 5 and 50 acres surface area)[3]

Total number: 9
Total surface area: 112 acres

E. Stockponds (up to 15 acre-feet capacity)

Total number: 705

[1] C=flood control; I=irrigation, P=fire protection, stock or farm pond
[2] Intermittent lake
[3] Capacity data not available to ADWR
[4] Dry lake

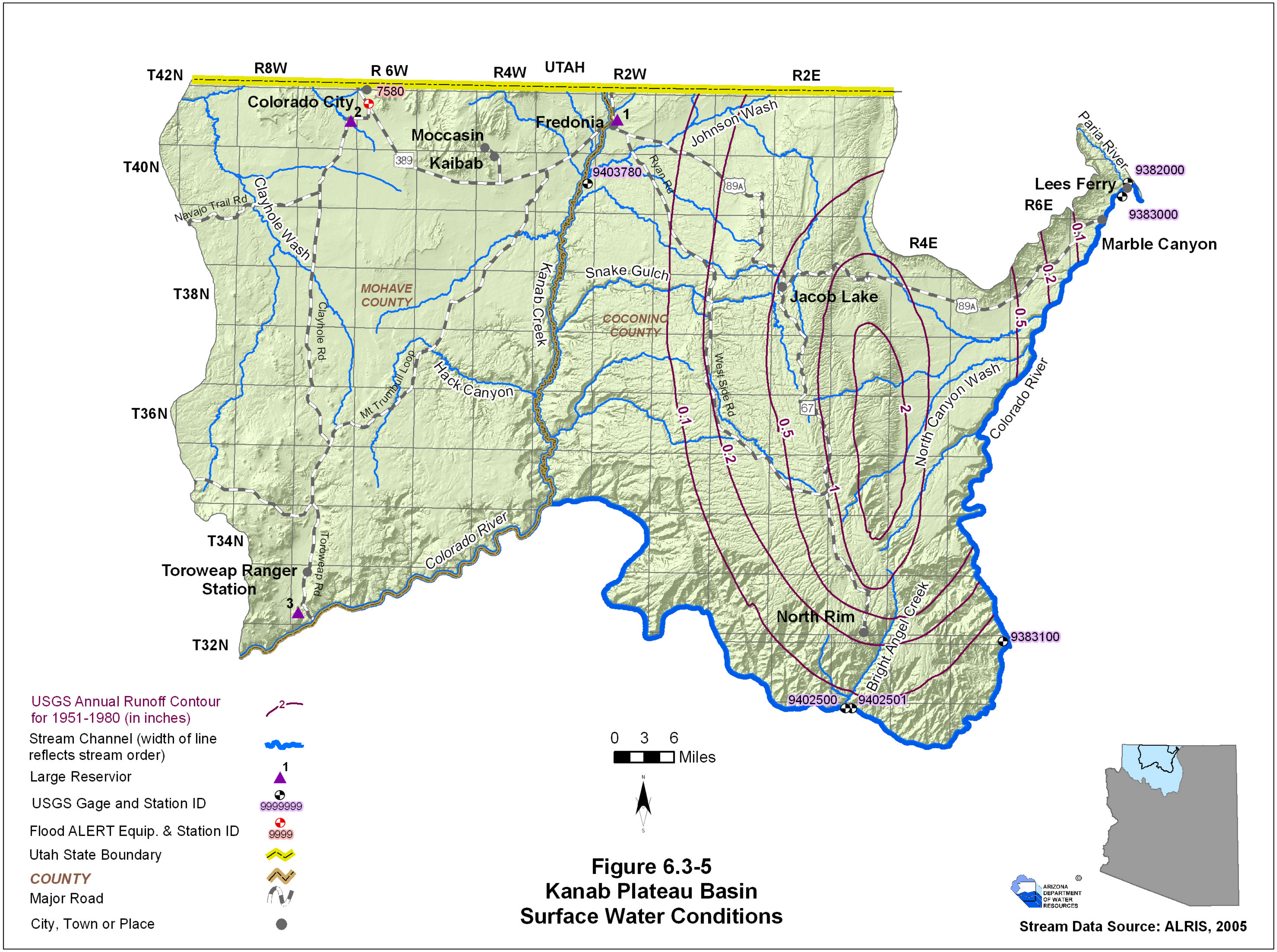


Figure 6.3-5
Kanab Plateau Basin
Surface Water Conditions

6.3.5 Perennial/Intermittent Streams and Major Springs in the Kanab Plateau Basin

Major and minor springs with discharge rates and date of measurement, and the total number of springs in the basin are shown in Table 6.3-5. The locations of major springs and perennial and intermittent streams are shown on Figure 6.3-6. Descriptions of data sources and methods for intermittent and perennial reaches and springs are found in Volume 1, Appendix A.

- The basin contains numerous perennial streams; most are located along and in the vicinity of the southern basin boundary. Significant perennial streams include the Colorado River, the Paria River and Kanab Creek.
- Intermittent streams are found south of Jacob Lake and in the vicinity of the Colorado River. Most of Kanab Creek is also intermittent in the basin.
- There are 39 major springs with a measured discharge of 10 gallons per minute (gpm) or greater at any time.
- Springs with measured discharge of 1 to 10 gpm are not mapped but coordinates are given in Table 6.3-5B. There are 23 minor springs in this basin.
- Listed discharge rates may not be indicative of current conditions. Many of the measurements were taken during or prior to 1996.
- The total number of springs, regardless of discharge, identified by the USGS varies from 181 to 190, depending on the database reference.

Table 6.3-5 Springs in the Kanab Plateau Basin

A. Major Springs (10 gpm or greater):

Map Key	Name	Location		Discharge (in gpm)[1]	Date Discharge Measured
		Latitude	Longitude		
1	Tapeats (above Thunder)	362425	1122546	18,763	11/9/2003
2	Thunder at Tapeats	362346	1122728	9,741	11/9/2003
3	Angel	361317	1120040	7,810	10/14/92
4	Shinumo	361808	1121808	4,058	4/27/2002
5	Deer Creek	362322	1123027	3,542	5/31/2000
6	Roaring	361143	1120207	1,952	7/13/2003
7	Kanab Creek	362335	1123745	1,619	10/5/1993
8	Clear Creek	360454	1120208	772	4/24/2002
9	Dragon	361043	1121055	627	7/30/1969
10	Haunted	360935	1120636	430	8/15/1969
11	Abyss River	361721	1121528	403	7/13/1969
12	Fence Fault North	363139	1115044	300	3/26/2001
13	Stone Creek (below falls)	362050	1122708	265	3/1/2002
14	At Last	361716	1115745	260	7/29/1969
15	Crystal	361153	1121215	247	3/18/2004
16	Emmett[2]	361257	1120135	215	7/22/1969
17	Nankoweap Creek	361809	1115205	193	4/22/2002
18	Big	363608	1122054	185	7/2/2000
19	Ribbon[2]	361012	1120435	184	8/16/1969
20	Clear Water	364606	1123712	155	1/25/1997
21	Kwagunt Creek near Colorado R.	361542	1114948	137	10/14/1995
22	Vasey's Paradise	362957	1115126	119	3/14/2004
23	North Canyon (multiple)	362354	1120500	108	6/28/2000
24	Chuar Creek[2]	361000	1115147	100	10/12/1997
25	Long Res	365438	1124535	90	9/9/1976
26	Sand	365424	1124429	81	6/18/1997
27	Butte Fault-Upper	361658	1115318	76	3/27/2001
28	Phantom	360906	1120749	72	8/15/1969
29	Robber's Roost	361650	1120516	56[3]	7/7/1998
30	Noble[2]	361740	1121755	54	7/13/1969
31	Transcept[2]	361125	1120340	54	8/17/1969
32	Pipe	365149	1124422	35[3]	7/27/1976
33	Cottonwood	365829	1123601	25	11/15/1996
34	Mangum	363720	1122022	25	8/8/1976

Table 6.3-5 Springs in the Kanab Plateau Basin (Cont)

Map Key	Name	Location		Discharge (in gpm)[1]	Date Discharge Measured
		Latitude	Longitude		
35	Two Mile Seep	365047	1123942	21	11/14/1996
36	Mocassin	365437	1124546	20	During or Prior to 1997
37	Soap Creek[2]	364645	1114613	18	8/4/1976
38	Tunnel	365147	1124420	11	8/8/2000
39	Kanabownits	361714	1121246	10	6/1/1976

B. Minor Springs (1 to 10 gpm):

Name	Location		Discharge (in gpm)[1]	Date Discharge Measured
	Latitude	Longitude		
South Big	361906	1121537	9	06/1975
Sprayfield	361302	1120405	8	06/1975
Warm	364141	1121842	6	7/3/2000
Unnamed	362044	1124015	5	4/4/2001
Castle	363509	1122027	4	7/2/2000
Sowats	363139	1122718	4	7/1/2000
Cliff Dweller	361221	1120340	3	07/1976
Unnamed[2,4]	361257	1120403	3	6/1/1976
Riggs	365655	1123729	2	11/15/1996
Little	362038	1130901	2	8/16/1950
Quaking Aspen	362243	1121654	2	6/29/2000
Milk Creek	361616	1120835	2	8/5/2000
Fern Glen[2]	361543	1125503	2	5/8/1976
Nixon	362408	1130846	1	6/20/2000
Sowats B	363127	1122718	1	7/1/2000
Timp	362316	1121743	1	8/8/2000
Coyote	365707	1120203	1	8/6/1976
Watts	362247	1121631	1	6/29/2000
Wolf	365853	1123809	1	11/15/1996
Saddle Horse	361345	1130317	1	8/9/1976
Unnamed	362047	1124329	1	5/7/1976
Yellowstone	364352	1125633	1	8/15/1951
Point	365516	1124322	1	11/15/1996

Source: Compilation of databases from ADWR & others

C. Total number of springs, regardless of discharge, identified by USGS (see ALRIS, 2005a and USGS, 2006b): 181 to 190

Notes:
[1] Most recent measurement identified by ADWR
[2] Spring is not displayed on current USGS topo map
[3] Discharge measurements vary. Shown is greatest measured discharge; most recent measurement < 10 gpm
[4] Location approximated by ADWR

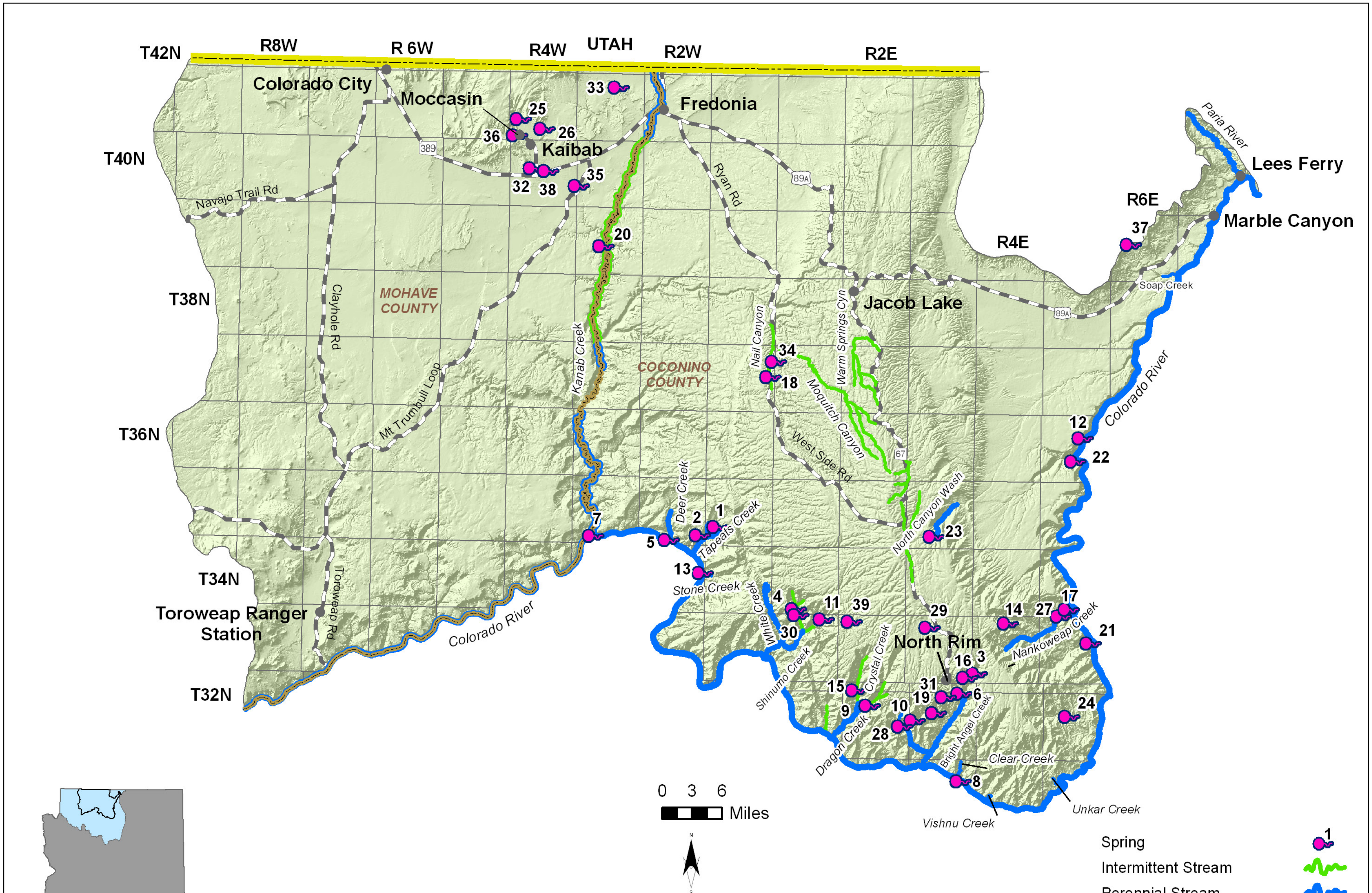


Figure 6.3-6
Kanab Plateau Basin
Perennial\Intermittent Streams
and Major (>10 gpm) Springs

6.3.6 Groundwater Conditions of the Kanab Plateau Basin

Major aquifers, well yields, number of index wells and date of last water-level sweep are shown in Table 6.3-6. Figure 6.3-7 shows water-level change between 1990-1991 and 2003-2004. Figure 6.3-8 contains hydrographs for the wells shown on Figure 6.3-7. Figure 6.3-9 shows well yields in three yield categories. A description of aquifer data sources and methods as well as well data sources and methods, including water-level changes and well yields are found in Volume 1, Appendix A.

Major Aquifers

- Refer to Table 6.3-6 and Figure 6.3-7.
- Major aquifers in the basin include recent stream alluvium and sedimentary rock.
- Almost all of the basin geology consists of consolidated crystalline and sedimentary rock.
- Data on natural recharge, groundwater in storage and groundwater flow direction are not available for this basin.

Well Yields

- Refer to Table 6.3-6 and Figure 6.3-9.
- As shown on Figure 6.3-9, well yields in this basin range from less than 100 gallons per minute (gpm) to 1,000 gpm.
- One source of well yield information, based on 10 reported wells, indicates that the median well yield in this basin is 70 gpm.

Water Level

- Refer to Figure 6.3-7. Water levels are shown for wells measured in 2003-2004.
- The Department annually measures three index wells in this basin. Hydrographs for two of these wells are shown in Figure 6.3-8.
- For the two wells shown on Figure 6.3-7 depth to water was 87 feet at one well and 611 feet at the other. Water level change was minimal between 1990-1991 and 2003-2004.

Table 6.3-6 Groundwater Data for the Kanab Plateau Basin

Basin Area, in square miles:	4,247	
Major Aquifer(s):	**Name and/or Geologic Units**	
	Recent Stream Alluvium	
	Sedimentary Rock	
Well Yields, in gal/min:	Range 236-480 Median 358 (2 wells measured)	Measured by ADWR (GWSI) and/or USGS
	Range 3-500 Median 70 (10 wells reported)	Reported on registration forms for large (>10-inch) diameter wells (Wells55)
	Range 30-200	ADWR (1990 and 1994b)
	Range 0-500	Anning and Duet (1994)
Estimated Natural Recharge, in acre-feet/year:	N/A	
Estimated Water Currently in Storage, in acre-feet:	N/A	
Current Number of Index Wells:	3	
Date of Last Water-level Sweep:	1976 (62 wells measured)	

N/A = Not Available

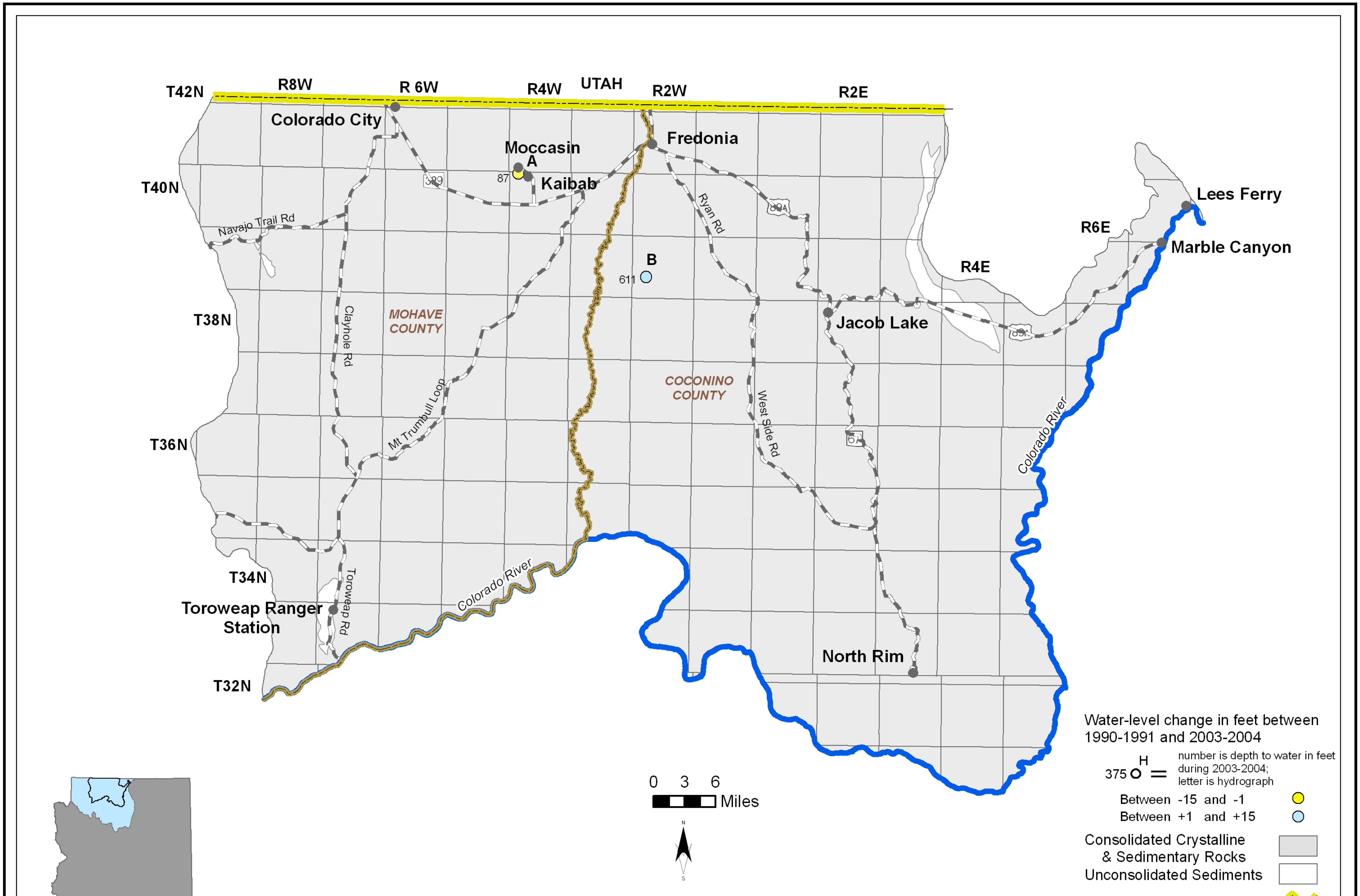
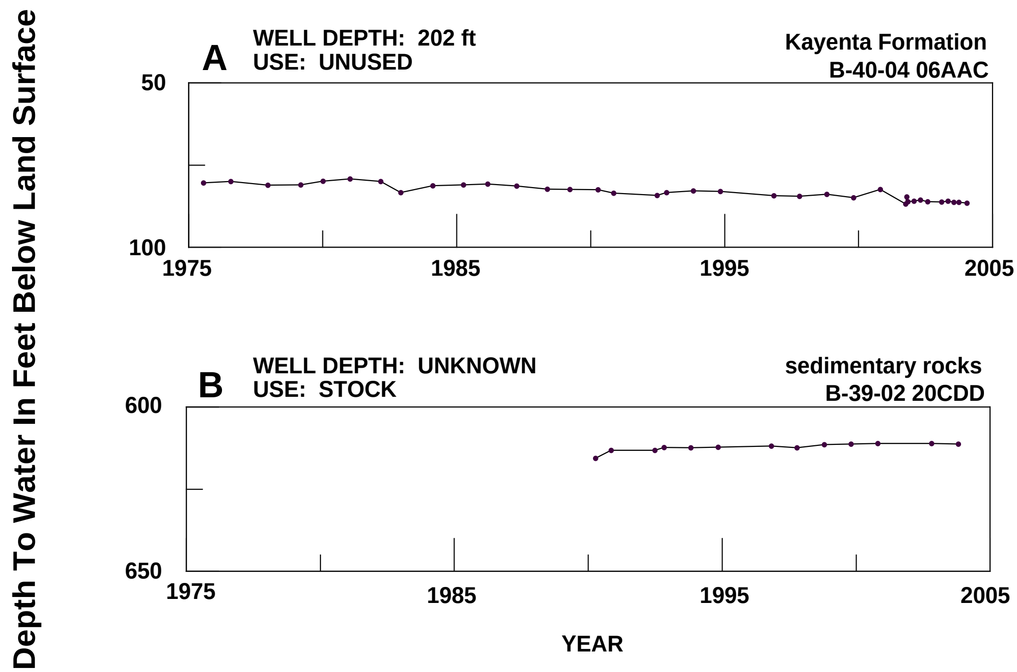


Figure 6.3-7
Kanab Plateau Basin
Groundwater Conditions

Figure 6.3-8
Kanab Plateau Basin
Hydrographs Showing Depth to Water in Selected Wells



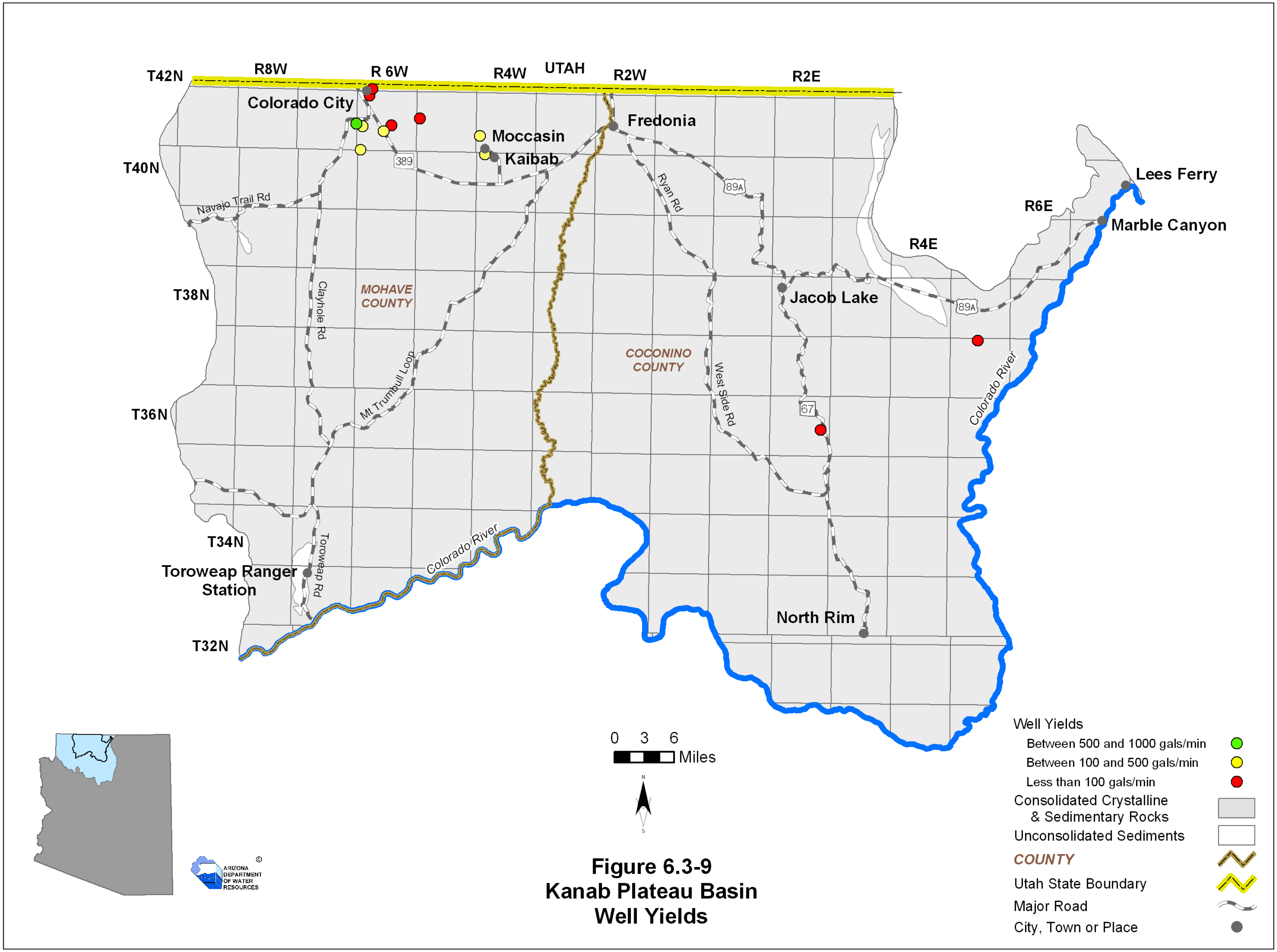


Figure 6.3-9
Kanab Plateau Basin
Well Yields

6.3.7 Water Quality of the Kanab Plateau Basin

Wells, springs and mine sites with parameter concentrations that have equaled or exceeded drinking water standard(s), including location and parameter(s) are shown in Table 6.3-7A. Impaired lakes and streams with site type, name, length of impaired reach, area of impaired lake, designated use standard and parameter(s) exceeded is shown in Table 6.3-7B. Figure 6.3-10 shows the location of water quality occurrences keyed to Table 6.3-7. A description of water quality data sources and methods is found in Volume 1, Appendix A. Not all parameters were measured at all sites; selective sampling for particular constituents is common.

Well, Mine or Spring sites that have equaled or exceeded drinking water standards (DWS)

- Refer to Table 6.3-7A.
- Eight wells or springs have parameter concentrations that have equaled or exceeded drinking water standards.
- The parameter most frequently equaled or exceeded in the sites measured was total dissolved solids. Other parameters equaled or exceeded are lead and nitrates.

Lakes and Streams with impaired waters

- Refer to Table 6.3-7B and Figure 6.3-9
- The water quality standard for suspended sediment concentration was exceeded in one 29-mile stream reach, the Paria River from the Utah border to the Colorado River. A portion of this impaired reach is located in the Paria Basin.
- This reach is not part of the ADEQ water quality improvement effort called the Total Maximum Daily Load (TMDL) Program at this time.

Effluent Dependent Reaches

- Refer to Figure 6.3-9
- There is one effluent dependent reach in this basin, Transect Canyon. This reach receives effluent from the North Rim Wastewater Treatment Plant.

Table 6.3-7 Water Quality Exceedences in the Kanab Plateau Basin[1]

A. Wells, Springs and Mines

Map Key	Site Type	Site Location			Parameter(s) Concentration has Equaled or Exceeded Drinking Water Standard (DWS)[2]
		Township	Range	Section	
1	Well	37 North	5 East	4	TDS
2	Well	41 North	1 West	15	TDS
3	Well	41 North	4 West	31	Pb
4	Well	41 North	7 West	23	NO3
5	Spring	40 North	4 West	17	Pb
6	Well	40 North	7 West	4	TDS
7	Well	40 North	8 West	17	TDS
8	Well	39 North	4 West	24	TDS

Source: Compilation of databases from ADWR & others

B. Lakes and Streams

Map Key	Site Type	Site Name	Length of Impaired Stream Reach (in miles)	Area of Impaired Lake (in acres)	Designated Use Standard[3]	Parameter(s) Exceeding Use Standard
a	Stream	Paria River (Utah border to Colorado River)	29[4]	NA	A&W	suspended sediment concentration

Source: ADEQ 2005e

Notes:

NA = Not Applicable
[1] Water quality samples collected between 1976 and 2001.
[2] Pb = Lead
NO3 = Nitrate
TDS = Total Dissolved Solids
[3] A&W = Aquatic and Wildlife
[4] Total length of the impaired reach. A portion of this reach is in the Paria Basin.

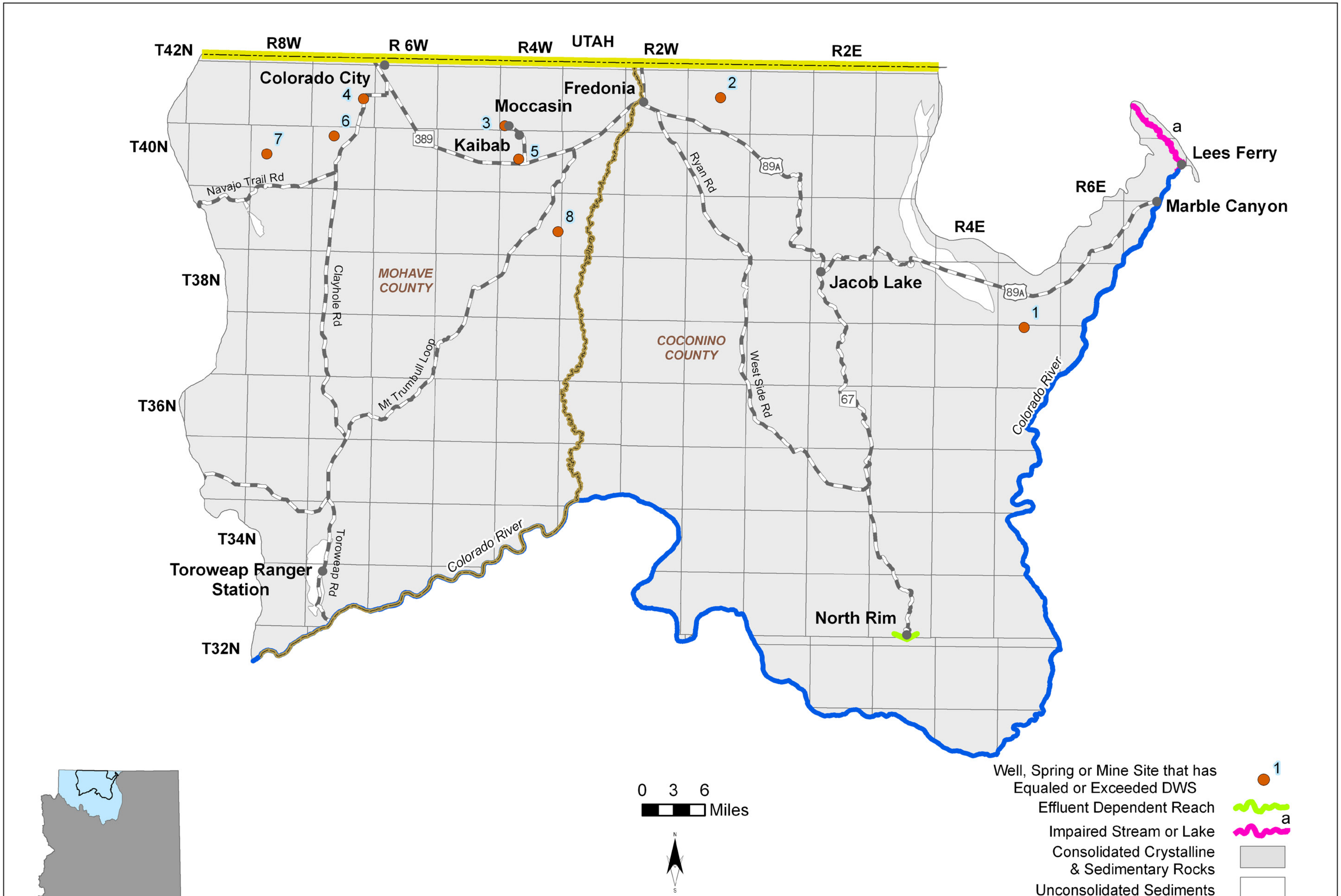


Figure 6.3-10
Kanab Plateau Basin
Water Quality Conditions

6.3.8 Cultural Water Demand in the Kanab Plateau Basin

Cultural water demand data including population, number of wells and the average well pumpage and surface water diversions by the municipal, industrial and agricultural sectors are shown in Table 6.3-8. Effluent generation including facility ownership, location, population served and not served, volume treated, disposal method and treatment level is shown in Table 6.3-9. Figure 6.3-11 shows the location of demand centers. A description of cultural water demand data sources and methods is found in Volume 1, Appendix A. More detailed information on cultural water demand is found in Section 6.0.7.

Cultural Water Demand

- Refer to Table 6.3-8 and Figure 6.3-11.
- Population in this basin increased from 2,815 in 1980 to 6,233 in 2000 and is projected to reach 14,688 by 2030.
- Groundwater demand has decreased in this basin and was less than 2,600 acre-feet in 2001-2005.
- Groundwater is used for both municipal and agricultural demand. Municipal and agricultural demand centers are located in the vicinity of Fredonia, Colorado City, Moccasin and Kaibab.
- Data on surface water use prior to 1991 is not available. The table includes approximately 600 acre-feet of surface water diverted from Roaring Spring in this basin for use at the Grand Canyon South Rim in the Coconino Plateau Basin. Less than 1,000 acre-feet of water is diverted from Kanab Creek for agriculture in the Fredonia area.
- As of 2009 there were no active mines in the basin, however, exploration for uranium is on going.
- As of 2005 there were 220 registered wells with a pumping capacity of less than or equal to 35 gpm and 119 wells with a pumping capacity of more than 35 gpm.

Effluent Generation

- Refer to Table 6.3-9.
- There are five wastewater treatment facilities in this basin.
- Information on population served was available for two facilities and information on effluent generation was available for four facilities. These facilities serve almost 2,900 people and generate over 400 acre-feet of effluent per year. At one time Colorado City operated a wastewater treatment facility that served over 5,000 people and generated 403 acre-feet per year. The plant closed in 2002 and Colorado City now sends sewage to Hildale, Utah for treatment.
- Of the four facilities with information on the effluent disposal method: one discharges to evaporation ponds; two discharge for irrigation; and one discharges to unlined impoundments that recharge the aquifer.

Table 6.3-8 Cultural Water Demand in the Kanab Plateau Basin[1]

Year	Estimated and Projected Population	Number of Registered Water Supply Wells Drilled		Average Annual Demand (in acre-feet)						
				Well Pumpage			Surface-Water Diversions			Data Source
		Q ≤ 35 gpm	Q > 35 gpm	Municipal	Industrial	Agricultural	Municipal	Industrial	Agricultural	
1971										
1972										
1973				<500			NR[4]			
1974										
1975										
1976		149[3]	66[3]							
1977										
1978				2,000			NR			
1979										
1980	2,815									ADWR (1994a)
1981	2,985									
1982	3,155									
1983	3,324	3	4	2,000			NR			
1984	3,494									
1985	3,664									
1986	3,834									
1987	4,004									
1988	4,174	10	17	2,000			NR			
1989	4,343									
1990	4,513									
1991	4,655									
1992	4,797									
1993	4,938	9	6	900	<300	1,500	700	NR	<1,000	
1994	5,080									
1995	5,222									
1996	5,364									
1997	5,505									USGS (2007) ADWR (2008b)
1998	5,647	20	19	1,200	<300	1,500	700	NR	<1,000	
1999	5,789									
2000	6,233									
2001	6,602									
2002	6,971									
2003	7,339	29	7	1,600	<300	<1,000	700	NR	<1,000	
2004	7,708									
2005	8,077									
2010	9,921									
2020	12,552									
2030	14,688									
WELL TOTALS:		**220**	**119**							

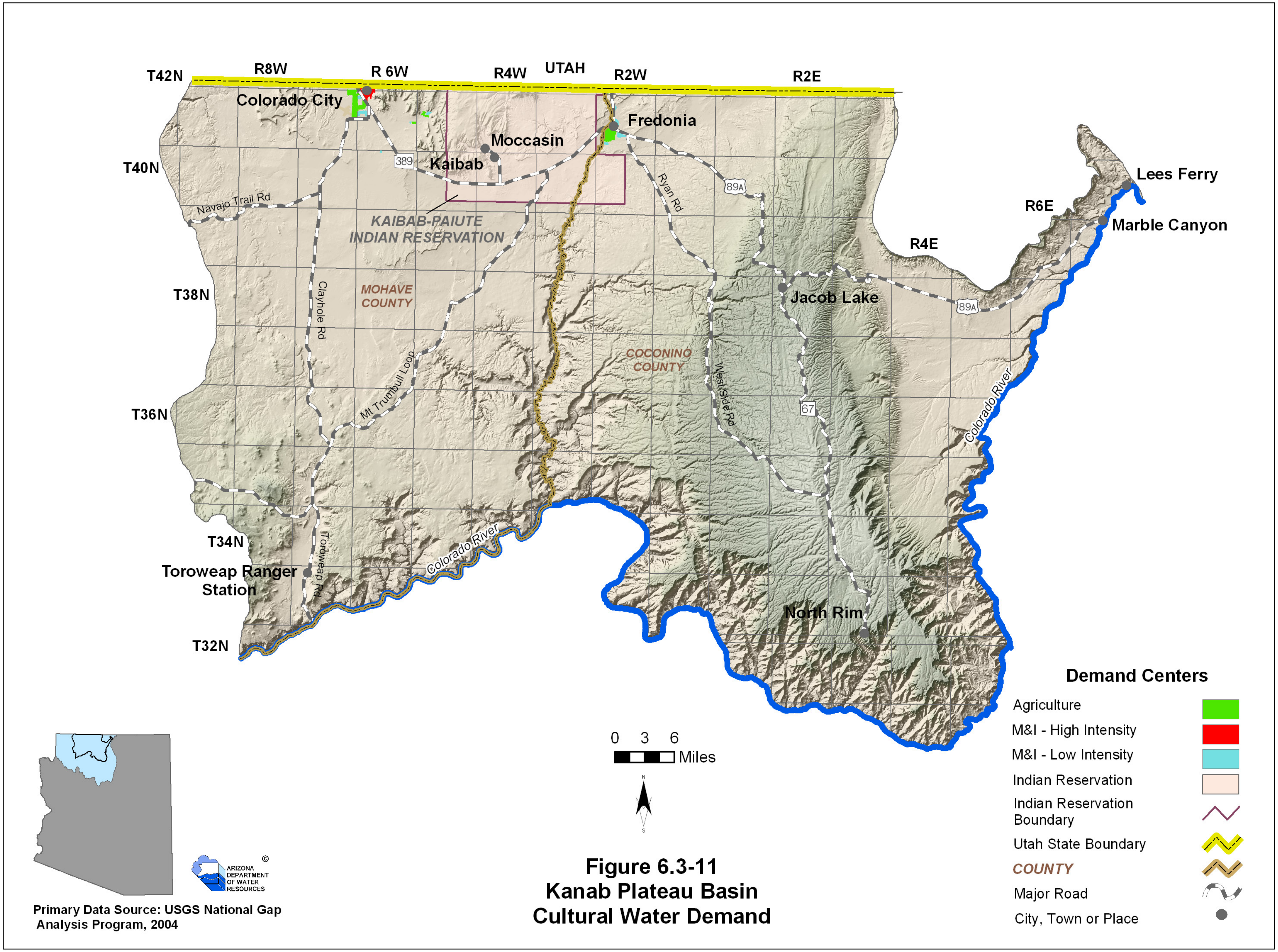
[1] Does not include effluent or evaporation losses from stockponds and reservoirs.
[2] Surface water diverted in the Kanab Plateau Basin is delivered to the Coconino Plateau Basin for use at the Grand Canyon South Rim.
[3] Includes all wells through 1980.
[4] Surface water diversions for irrigation occurred in the Fredonia area prior to 1990 however data on the volume of recent surface water diversions is not available.
NR - Not reported

Table 6.3-9 Effluent Generation in the Kanab Plateau Basin

Facility Name	Ownership	City/Location Served	Population Served	Volume Treated/ Generated (acre-feet/year)	Disposal Method									Current Treatment Level	Population Not Served	Year of Record
					Water-course	Evaporation Pond	Irrigation	Wildlife Area	Golf Course/Turf/ Landscape	Municipal Reuse	Discharged to Another Facility	Infiltration Basins	Other			
Fredonia WWTF	Fredonia	Fredonia	1,395	157		X								Secondary w/ Nutrient Removal	1,025	1998
Jacob Lake	Private	Jacob Lake	NA													
Kaibab Lagoons	NA	NA	1,500	168								X		Secondary	NA	2000
North Rim-Grand Cayon WWTP	National Park Service	Park	NA	112	Trancept Canyon		X							NA		2002
Phantom Ranch	National Park Service	Park	NA	10			X							NA		2002
Total			**2,895**	**447**												

Source: Compilation of databases from ADWR & others

Notes:
Year of Record is for the volume of effluent treated/generated



Primary Data Source: USGS National Gap Analysis Program, 2004

Figure 6.3-11
Kanab Plateau Basin
Cultural Water Demand

6.3.9 Water Adequacy Determinations in the Kanab Plateau Basin

Water adequacy determination information including the subdivision name, location, number of lots, adequacy determination, reason for the inadequacy determination, date of determination and subdivision water provider are shown in Table 6.3-10. Figure 6.3-12 shows the locations of subdivisions keyed to the Table. A description of the Water Adequacy Program is found in Volume 1, Appendix C. Adequacy determination data sources and methods are found in Volume 1, Appendix A.

- Nine water adequacy determinations for 360 lots have been made in this basin through December 2008.
- Six determinations of inadequacy have been made; the most common reason for a determination of inadequacy was because the applicant chose not to submit the necessary information and/or the available hydrologic data were insufficient to make a determination.
- The number of lots receiving a water adequacy determination, by county, are:

County	Number of Subdivision Lots	Number of Lots Determined to be Adequate	Percent Adequate
Coconino County	229	70	31%
Mohave County	131	131	100%

Table 6.3-10 Adequacy Determinations in the Kanab Plateau Basin[1]

Map Key	Subdivision Name	County	Location			No. of Lots	ADWR File No[2]	ADWR Adequacy Determination	Reason(s) for Inadequacy Determination[3]	Date of Determination	Water Provider at Time of Application
			Township	Range	Section						
1	Centennial Park Unit 1	Mohave	41 North	6 West	18	66	53-300320	Adequate		08/16/99	Centennial Park Utilities
2	Cliff Dweller's Homelands	Coconino	39 North	6 East	28, 33	6	53-500473	Inadequate	A1	07/11/88	Dry Lot Subdivision
3	Cowboy Butte Estates	Coconino	41 North	2 West	5, 8	13	53-500539	Inadequate	A1	06/23/88	Town of Fredonia
4	Gateway Mobile Home Park	Mohave	41 North	2 West	17, 21	65	53-500701	Adequate		03/17/78	Town of Fredonia
5	Gateway Mobile Park	Coconino	41 North	2 West	17	70	53-500702	Inadequate	A1, B	4/24/1986	Town of Fredonia
6	Heaton Subdivision	Coconino	41 North	2 West	16	28	53-500779	Inadequate	A1	03/18/85	Town of Fredonia
7	Lewis Estates Subdivision	Coconino	41 North	2 West	16, 21	16	53-400613	Inadequate	C	10/29/01	Town of Fredonia
8	Roadrunner Estates	Coconino	41 North	2 West	20	26	53-501339	Inadequate	A1	03/26/84	Town of Fredonia
9	Shiprock Estates	Coconino	41 North	2 West	17, 21	70	53-501389	Adequate		03/17/78	Town of Fredonia

Source: ADWR 2008a

Notes:

[1]Each determination of the adequacy of water supplies available to a subdivision is based on the information available to ADWR and the standards of review and policies in effect at the time the determination was made. In some cases, ADWR might make a different determination if a similar application were submitted today, based on the hydrologic data and other information currently available, as well as current rules and policies.

[2] Prior to February 1995, ADWR did not assign file numbers to applications for adequacy. Between 1995-2006 all applications for adequacy were given a file number with a 22 prefix. In 2006 a 53 prefix was assigned to all water adequacy reports and applications regardless of their issue date.

[3] A. Physical/Continuous
1) Insufficient Data (applicant chose not to submit necessary information, and/or available hydrologic data insufficient to make determination)
2) Insufficient Supply (existing water supply unreliable or physically unavailable; for groundwater, depth-to-water exceeds criteria)
3) Insufficient Infrastructure (distribution system is insufficient to meet demands or applicant proposed water hauling)

B. Legal (applicant failed to demonstrate a legal right to use the water or failed to demonstrate the provider's legal authority to serve the subdivision)

C. Water Quality

D. Unable to locate records

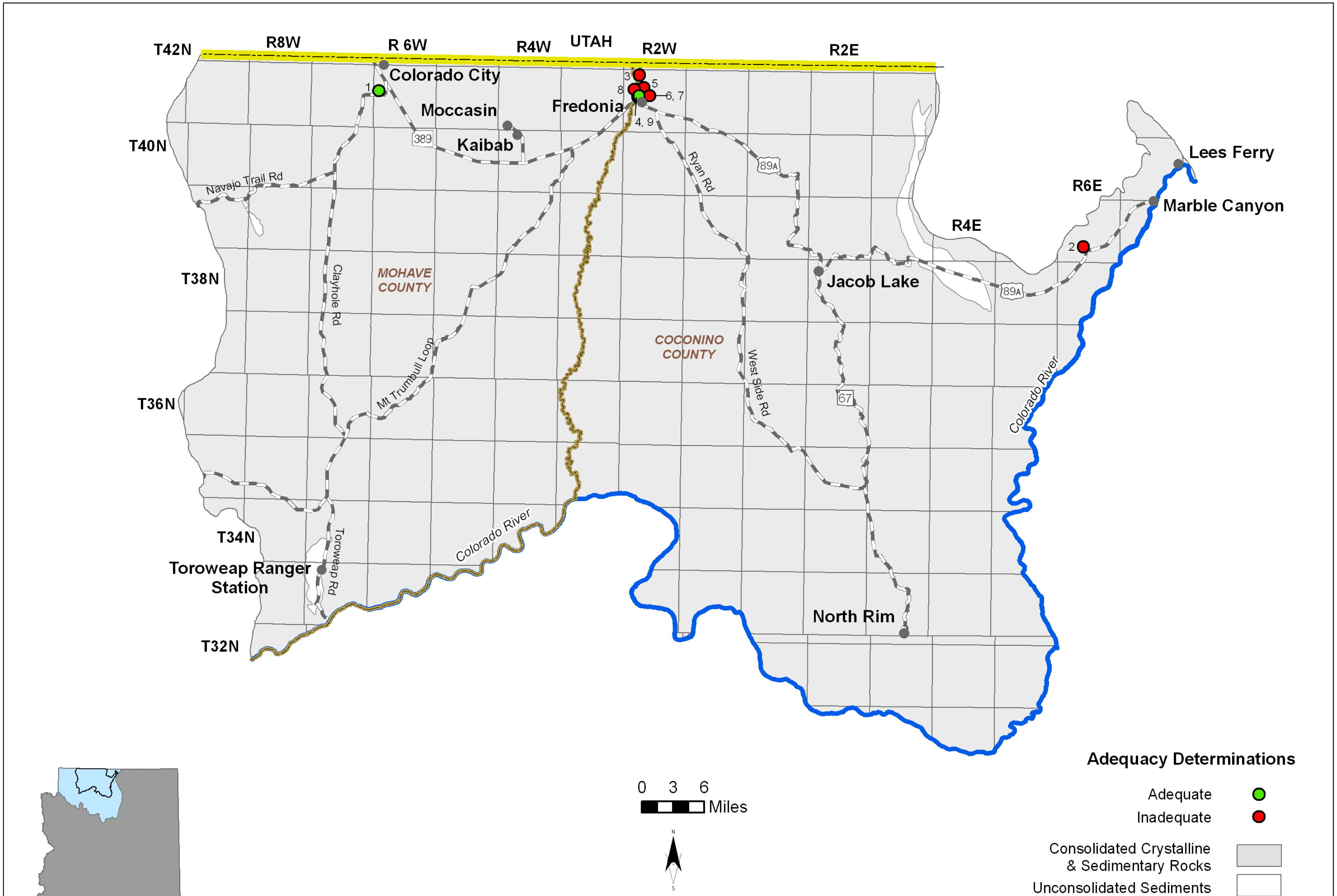


Figure 6.3-12
Kanab Plateau Basin
Adequacy Determinations

Kanab Plateau Basin

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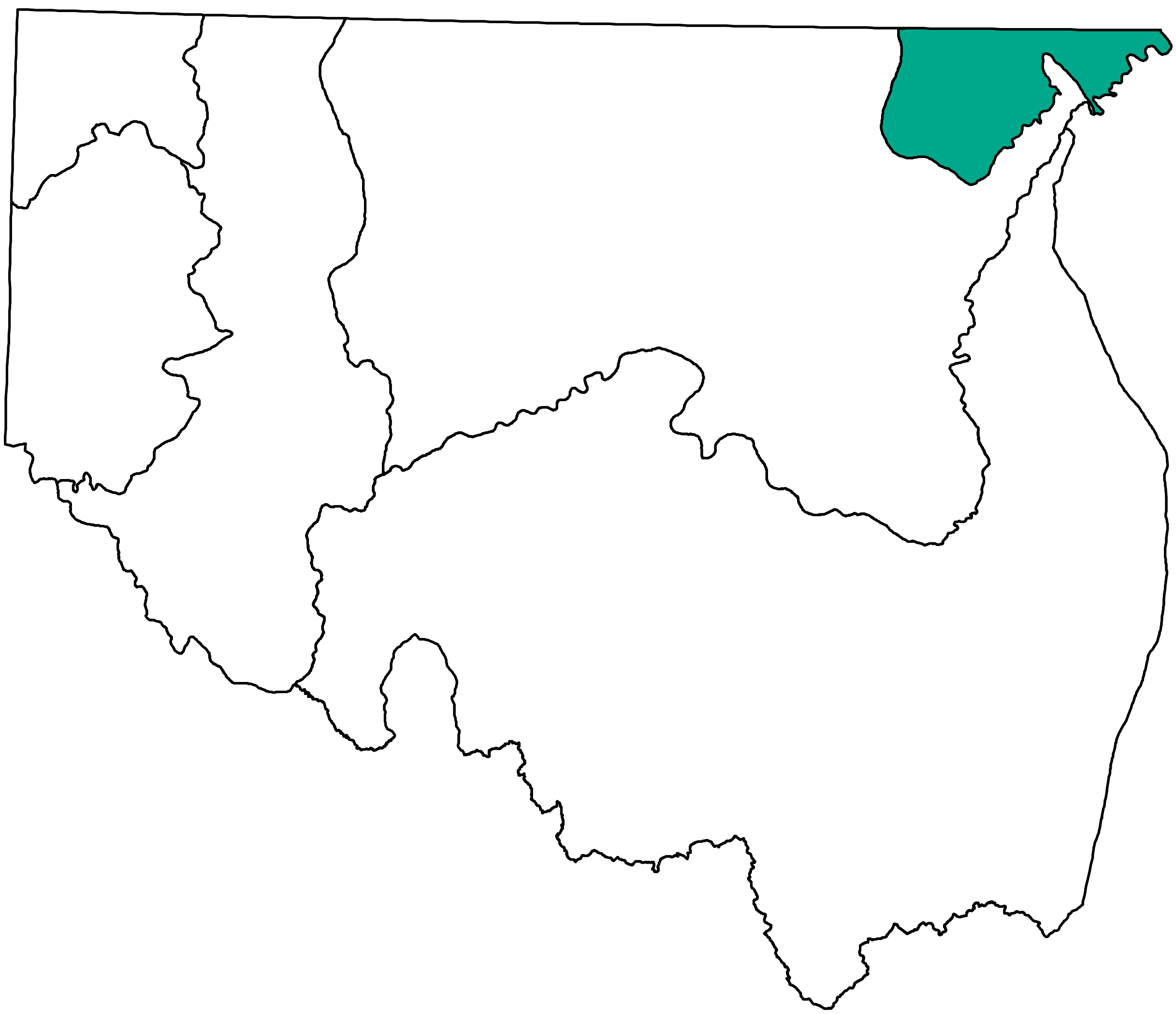
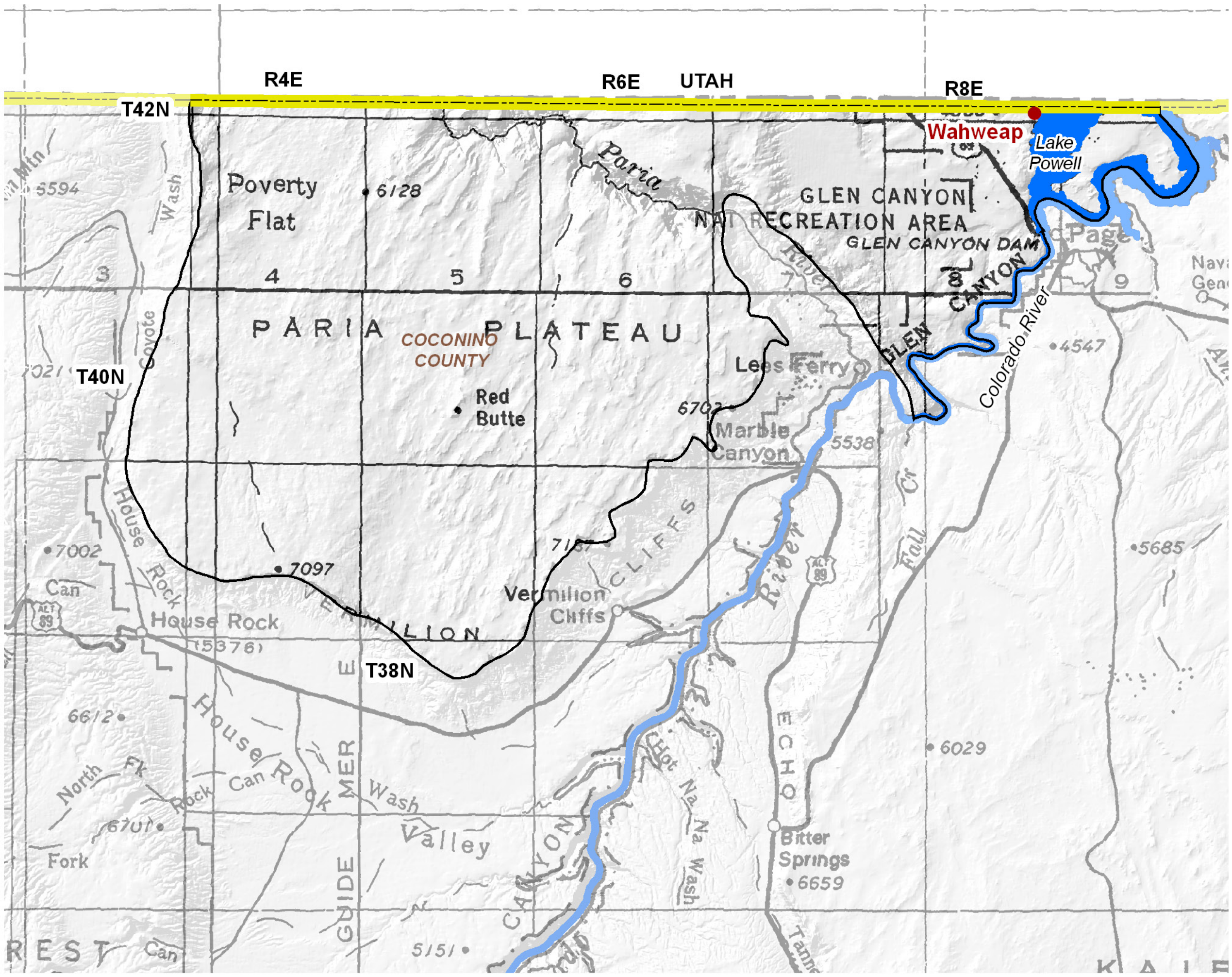
Section 6.4
Paria Basin

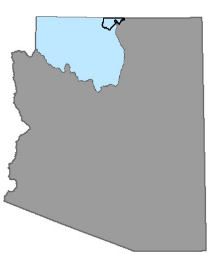


6.4.1 Geography of the Paria Basin

The Paria Basin, located in the northeastern part of the planning area is 408 square miles in area, the smallest basin in the planning area. Geographic features and principal communities are shown on Figure 6.4-1. The basin is characterized by a plateau and canyons. Vegetation types include Great Basin desertscrub and Great Basin conifer woodland. (See Figure 6.0-11)

- Principal geographic features shown on Figure 6.4-1 are:
    - The Paria Plateau
    - The Colorado River and Lake Powell on the eastern basin boundary and the lowest point at 3,100 feet where the River exits the basin.
    - Paria River in the north central portion of the basin
    - Vermilion Cliffs, which form the southern basin boundary with the highest point in the basin at 7,326 feet.





0 3 6 Miles

Base Map: USGS 1:500,000, 1981

Figure 6.4-1
Paria Basin
Geographic Features

Utah State Boundary
City, Town or Place

6.4.2 Land Ownership in the Paria Basin

Land ownership, including the percentage of ownership by category, for the Paria Basin is shown in Figure 6.4-2. The principal feature of land ownership in this basin is the large portion of land, 86% of the total basin area, in the Vermilion Cliffs National Monument. A description of land ownership data sources and methods is found in Volume 1, Appendix A. More detailed information on protected areas is found in Section 6.0.4. Land ownership categories are discussed below in the order from largest to smallest percentage in the basin.

U.S. Bureau of Land Management (BLM)

- 83.7% of the land is federally owned and managed by the Arizona Strip Field Office of the Bureau of Land Management.
- Most of the BLM land in the basin is within the Vermilion Cliffs National Monument and includes a portion of the 79,000 acre Vermilion Cliffs Wilderness. (see Figure 6.0-14)
- Land uses include resource conservation, recreation and grazing.

National Park Service (NPS)

- 10.9% of the land is federally owned and managed by the National Park Service as the Glen Canyon National Recreation Area.
- Primary land use is recreation.

State Trust Land

- 5.2% of the land is held in trust for the public schools under the State Trust Land system.
- State land is located throughout the basin interspersed with BLM land.
- Primary land use is grazing.

Private

- 0.2% of the land is private, consisting of two small parcels.
- Private land is located in the vicinity of Wahweap and a small parcel is surrounded by state trust land in the central portion of the basin.
- Land uses include domestic, commercial and ranching.

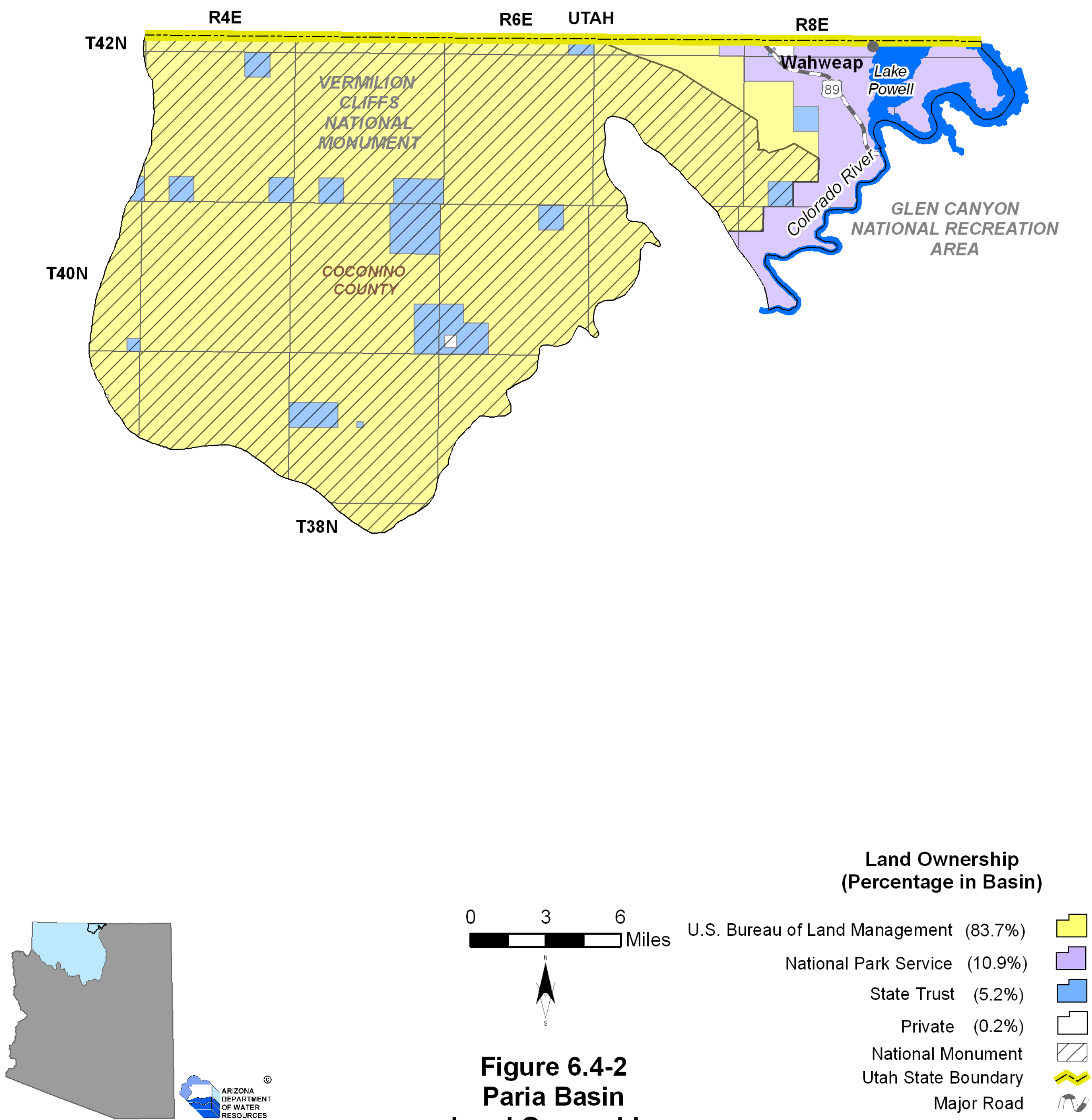


Figure 6.4-2
Paria Basin
Land Ownership

Source: ALRIS, 2004
Bureau of Land management, 1999

6.4.3 Climate of the Paria Basin

Climate data from NOAA/NWS Co-op Network and Evaporation Pan stations are complied in Table 6.4-1 and the locations are shown on Figure 6.4-3. Figure 6.4-3 also shows precipitation contour data from the Spatial Climate Analysis Service (SCAS) at Oregon State University. The Paria Basin does not contain AZMET or SNOTEL/ Snowcourse stations. More detailed information on climate in the planning area is found in Section 6.0.3. A description of the climate data sources and methods is found in Volume 1, Appendix A.

NOAA/NWS Co-op Network

- Refer to Table 6.4-1A
- Temperatures at the one NOAA/NWS Co-op Network station range from an average annual high of 84.5°F in July to an average annual low of 37.5°F in January.
- The highest average seasonal rainfall occurs in the summer season (July-September) when 30% of the annual rainfall occurs. Average annual rainfall is 6.78 inches.

Evaporation Pan

- Refer to Table 6.4-1B
- There is one evaporation pan station in the basin. This pan is at 3,720 feet and has an average annual evaporation rate of 100.18 inches.

SCAS Precipitation Data

- See Figure 6.4-3
- Additional precipitation data shows average annual rainfall as high as 16 inches in the southern portion of the basin and as low as four inches along the Colorado River.

Table 6.4-1 Climate Data for the Paria Basin

A. NOAA/NWS Co-op Network:

Station Name	Elevation (in feet)	Period of Record Used for Averages	Average Temperature Range (in F)		Average Precipitation (in inches)				
			Max/Month	Min/Month	Winter	Spring	Summer	Fall	Annual
Wahweap	3,730	1971-2000	84.5/Jul	37.5/Jan	1.70	1.09	2.02	1.97	6.78

Source: WRCC, 2005

Notes:

[1]Average temperature for period of record shown; average precipitation from 1971-2000

B. Evaporation Pan:

Station Name	Elevation (in feet)	Period of Record Used for Averages	Avg. Annual Evap (in inches)
Wahweap	3,720	1961 - 2000	100.18

Source: WRCC, 2005

C. AZMET:

Station Name	Elevation (in feet)	Period of Record	Average Annual Reference Evaportranspiration, in inches (*Number of years to calculate averages*)
None			

D. SNOTEL/Snowcourse:

Station Name	Elevation (in feet)	Period of Record	Average Snowpack, at Beginning of the Month, as Inches Snow Water Content *(Number of measurements to calculate average)*					
			Jan.	Feb.	March	April	May	June
None								

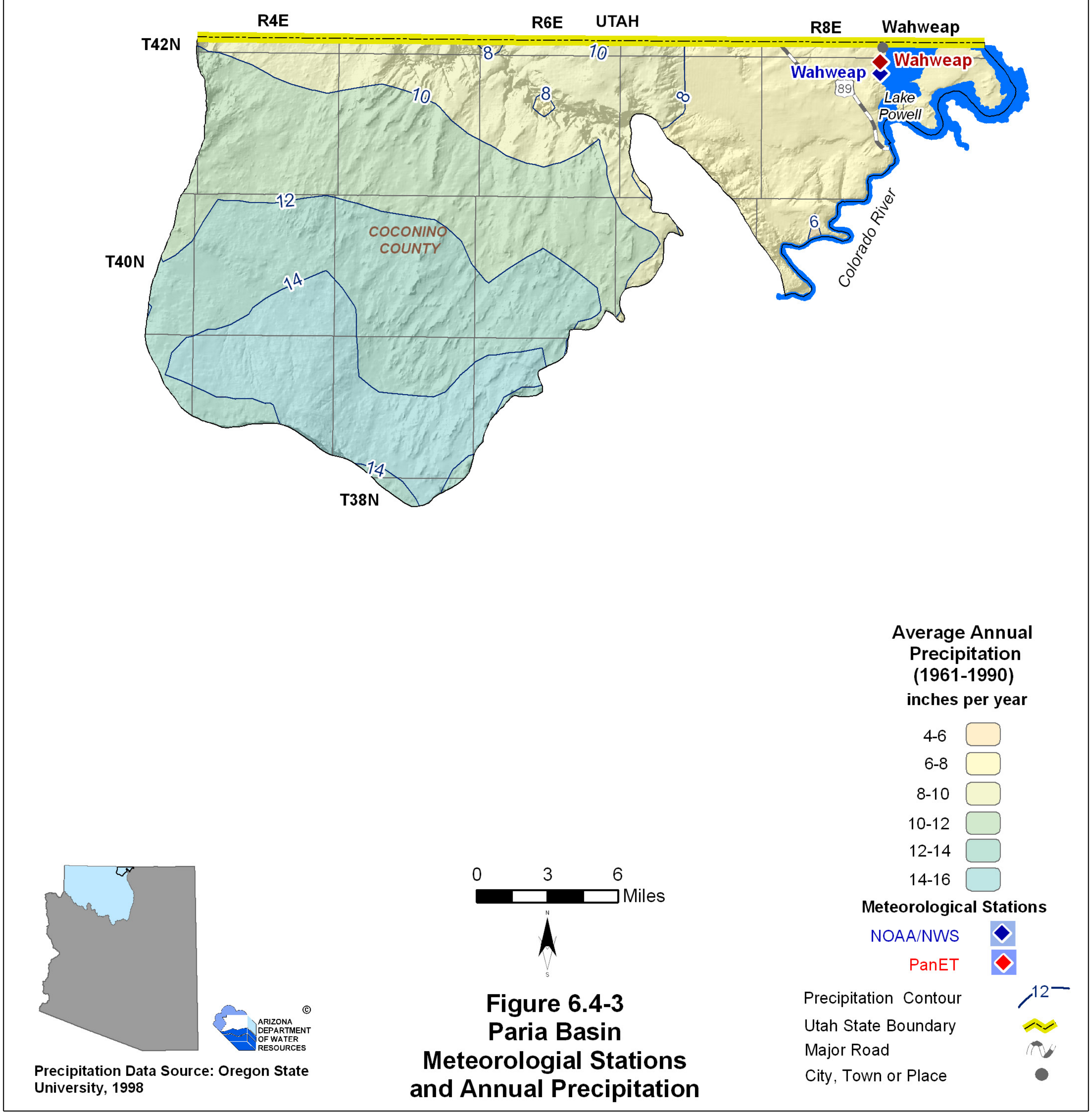


Figure 6.4-3
Paria Basin
Meteorologial Stations
and Annual Precipitation

6.4.4 Surface Water Conditions in the Paria Basin

There are no streamflow data or flood ALERT equipment in this basin. Reservoir and stockpond data, including maximum storage or maximum surface area, are shown in Table 6.4-2. The USGS runoff contours and large reservoirs are shown on Figure 6.4-4. Descriptions of stream, reservoir and stockpond data sources and methods are found in Volume 1, Appendix A.

Reservoirs and Stockponds

- Refer to Table 6.4-2.
- The only large reservoir in the basin is Lake Powell with a maximum storage capacity of 20.3 million acre-feet (maf). Most of the storage is in Utah.
- Lake Powell is used for hydroelectric, irrigation, recreation and other uses.
- There are 57 registered stockponds in this basin.

Runoff Contour

- Refer to Figure 6.4-4.
- Average annual runoff is highest, 0.5 inches per year or 26.65 acre-feet per square mile, in the southwestern portion and decreases to 0.1 inches, or 5.33 acre-feet per square mile, in the eastern portion of the basin.

Table 6.4-2 Reservoirs and Stockponds in the Paria Basin

A. Large Reservoirs (500 acre-feet capacity and greater)

MAP KEY	RESERVOIR/LAKE NAME *(Name of dam, if different)*	OWNER/OPERATOR	MAXIMUM STORAGE (AF)	USE[1]	JURISDICTION
1	Powell (Glen Canyon Dam)	Bureau of Reclamation	20,325,000	H,I,O,R	Federal

B. Other Large Reservoirs (50 acre surface area or greater)

MAP KEY	RESERVOIR/LAKE NAME *(Name of dam, if different)*	OWNER/OPERATOR	MAXIMUM SURFACE AREA (acres)	USE	JURISDICTION
None identified by ADWR at this time					

Source: Compilation of databases from ADWR & others

C. Small Reservoirs (greater than 15 acre-feet and less than 500 acre-feet capacity)

Total number: 0
Total maximum storage: 0 acre-feet

D. Other Small Reservoirs (between 5 and 50 acres surface area)

Total number: 0
Total surface area: 0 acres

E. Stockponds (up to 15 acre-feet capacity)

Total number: 57

[1] H=hydroelectric; I=irrigation; O=other; R=recreation

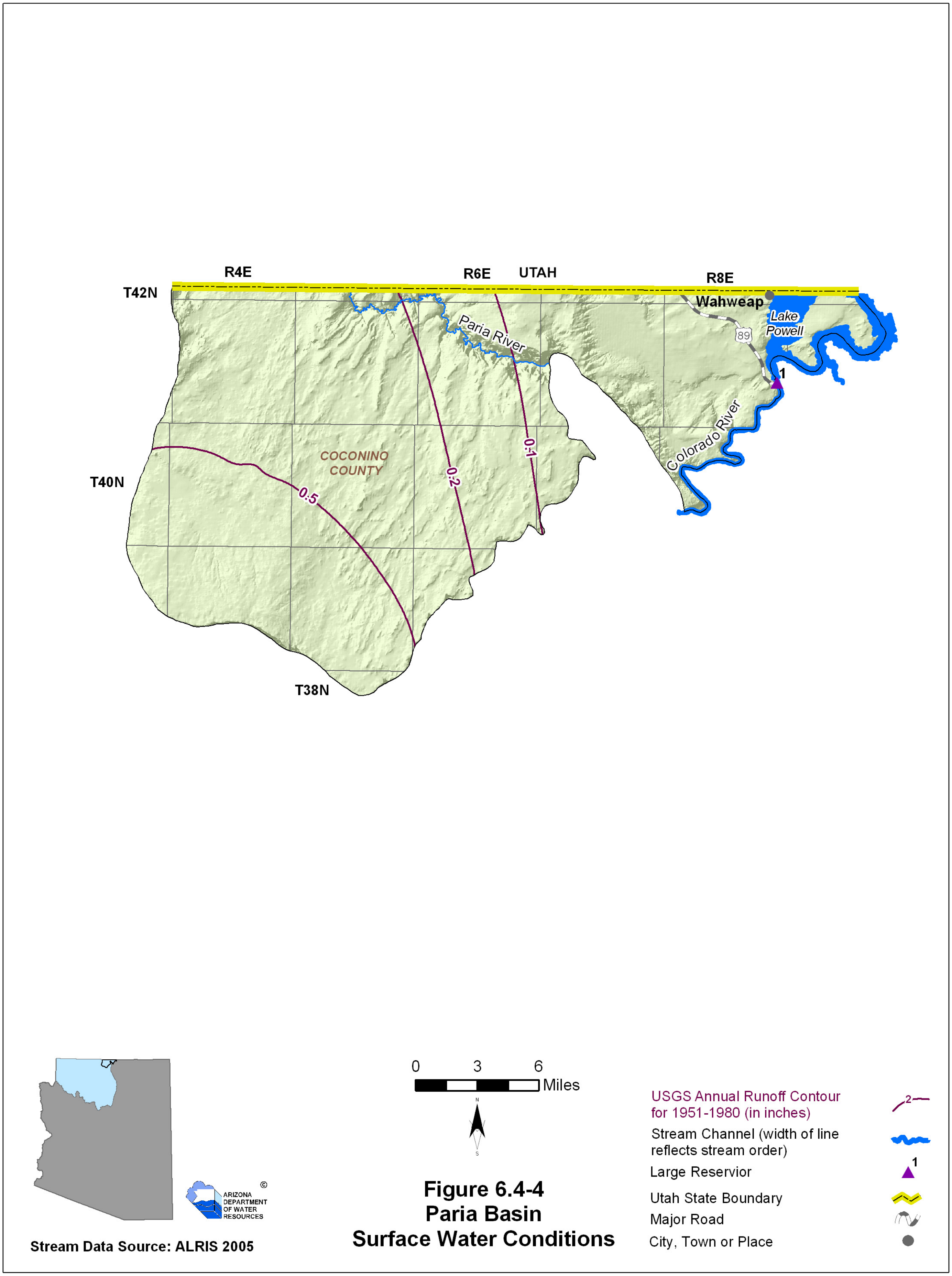


Figure 6.4-4
Paria Basin
Surface Water Conditions

6.4.5 Perennial/Intermittent Streams and Major Springs in the Paria Basin

The total number of springs in the basin are shown in Table 6.4-3. The locations of perennial streams are shown on Figure 6.4-5. Descriptions of data sources and methods for intermittent and perennial reaches and springs are found in Volume 1, Appendix A.

- There are no intermittent streams and the only perennial streams are the Colorado River and the Paria River.
- There are no major or minor springs.
- The total number of springs, regardless of discharge, identified by the USGS varies from two to three, depending on the database reference.

Table 6.4-3 Springs in the Paria Basin

A. Major Springs (10 gpm or greater):

Map Key	Name	Location		Discharge (in gpm)	Date Discharge Measured
		Latitude	Longitude		
None identified by ADWR at this time					

B. Minor Springs (1 to 10 gpm):

Name	Location		Discharge (in gpm)	Date Discharge Measured
	Latitude	Longitude		
None identified by ADWR at this time				

C. Total number of springs, regardless of discharge, identified by USGS (see ALRIS, 2005a and USGS, 2006b): 2 to 3

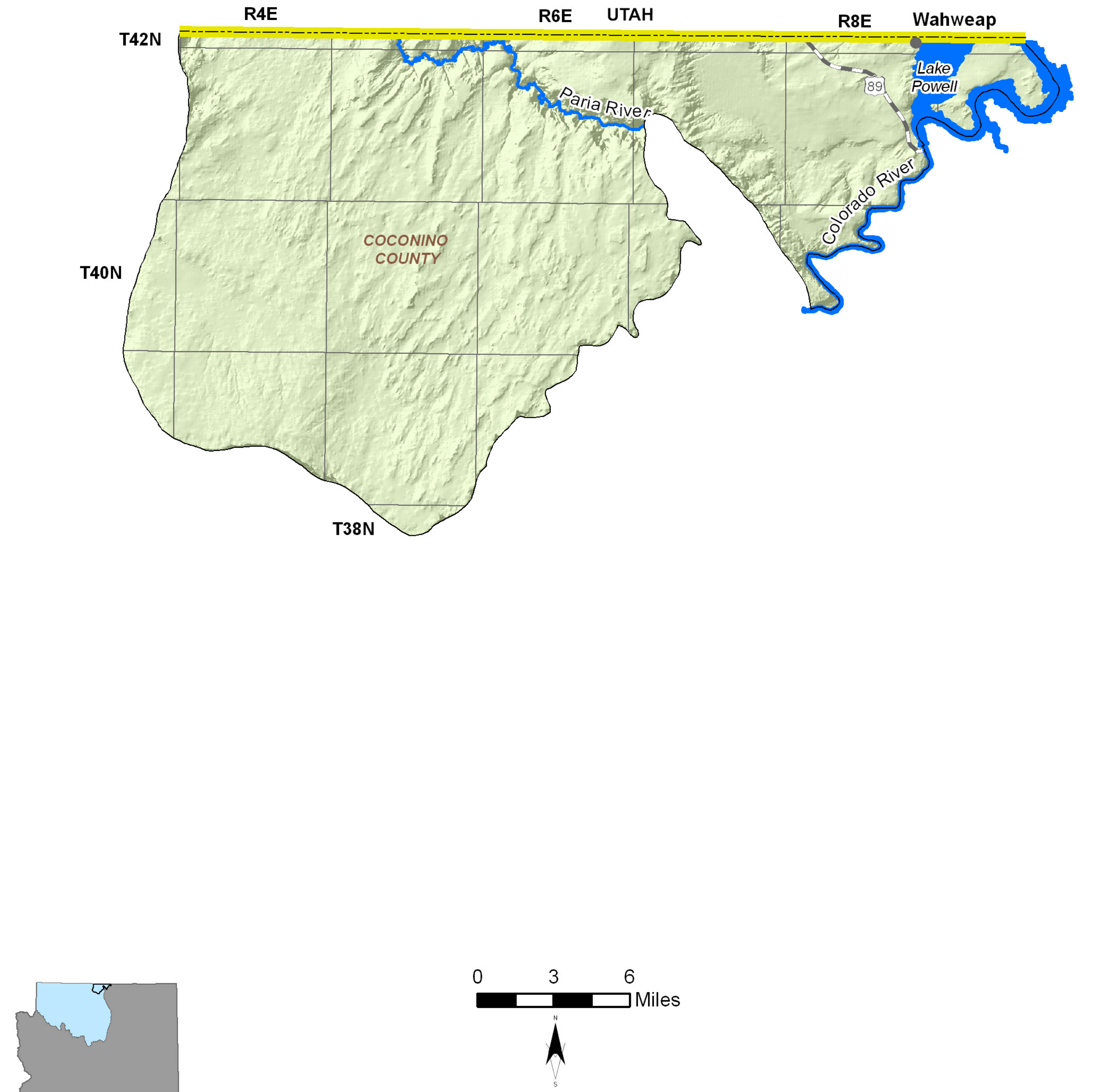


Figure 6.4-5
Paria Basin
Perennial\Intermittent Streams and Major (>10 gpm) Springs

6.4.6 Groundwater Conditions of the Paria Basin

Major aquifers, well yields, estimated water in storage, number of index wells and date of last water-level sweep are shown in Table 6.4-4. Figure 6.4-6 shows water-level change between 1990-1991 and 2003-2004. Figure 6.4-7 contains the hydrograph for the selected well shown on Figure 6.4-6. Figure 6.4-8 shows well yields in two yield categories. A description of aquifer data sources and methods as well as well data sources and methods, including water-level changes and well yields are found in Volume 1, Appendix A.

Major Aquifers

- Refer to Table 6.4-4 and Figure 6.4-6.
- The major aquifer in the basin is sedimentary rock (N Aquifer).
- Almost all of the basin geology consists of consolidated crystalline and sedimentary rock.
- Data on natural recharge and groundwater flow direction is not available for this basin.

Well Yields

- Refer to Table 6.4-4 and Figure 6.4-8.
- As shown on Figure 6.4-8, well yields in this basin range from less than 100 gallons per minute (gpm) to 1,000 gpm. All well yield data is from the northeastern portion of the basin near Wahweap.
- One source of well yield information, based on three reported wells, indicates that the median well yield in this basin is 520 gpm in the vicinity of Wahweap.

Water in Storage

- Refer to Table 6.4-4.
- The storage estimate for this basin is 1.5 maf of water to a depth of 1,200 feet.

Water Level

- Refer to Figure 6.4-6. Water levels are shown for a well measured in 2003-2004.
- The Department annually measures one index well in this basin. A hydrograph for this well is shown in Figure 6.4-7.

Table 6.4-4 Groundwater Data for the Paria Basin

Basin Area (in square miles):	408	
Major Aquifer(s):	**Name and/or Geologic Units**	
	Sedimentary Rock (N Aquifer)	
Well Yields, in gal/min:	Range 30-600 Median 520 (3 wells reported)	Reported on registration forms for large (>10-inch) diameter wells (Wells55)
	Range 30-1,400	ADWR (1990 and 1994b)
	Range 0-500	Anning and Duet (1994)
Estimated Natural Recharge, in acre-feet/year:	N/A	
Estimated Water Currently in Storage, in acre-feet:	1,500,000 (to 1,200 ft)	ADWR (1994b)
Current Number of Index Wells:	1	
Date of Last Water-level Sweep:	1976 (34 wells measured)	

N/A = Not Available

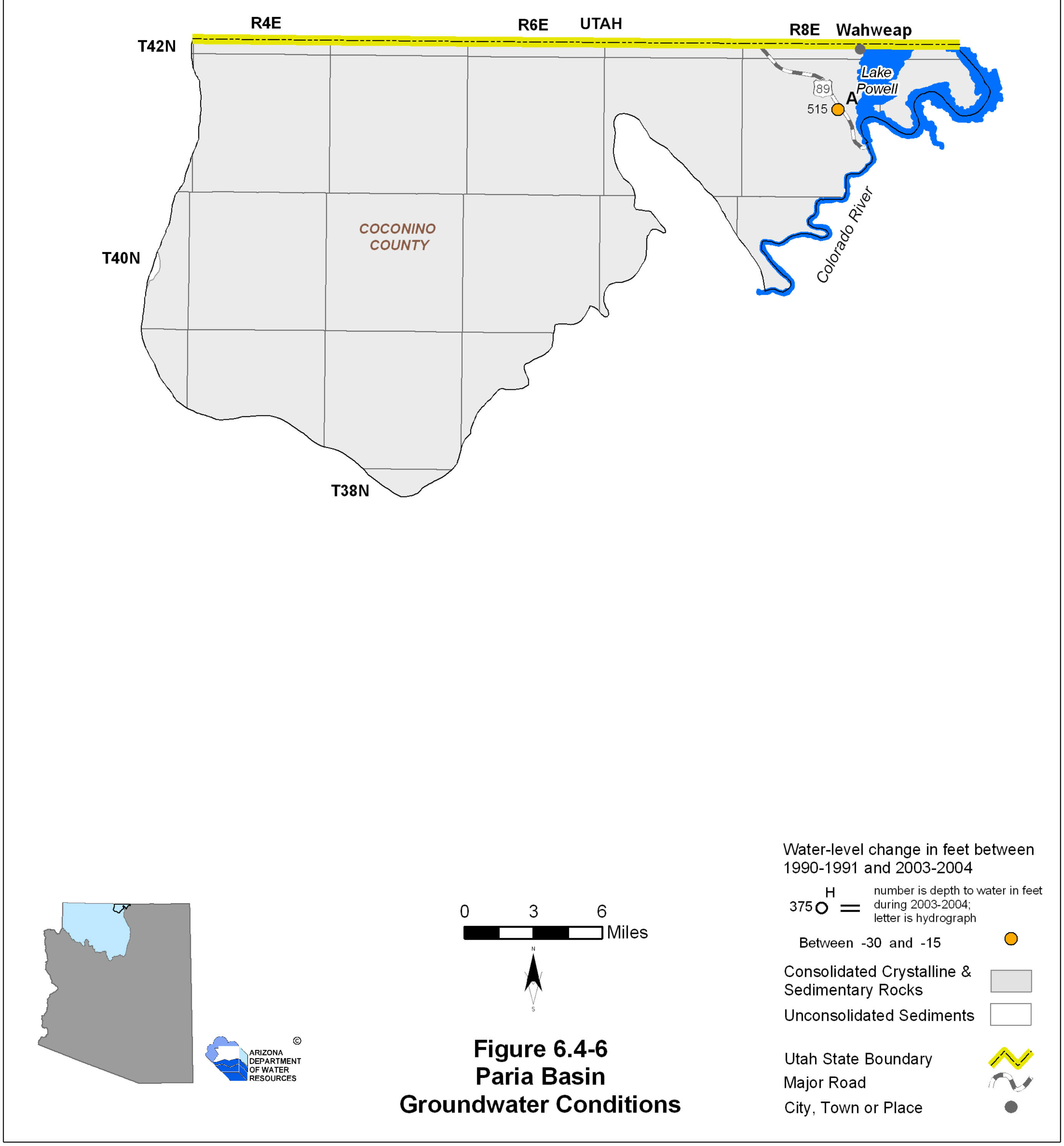
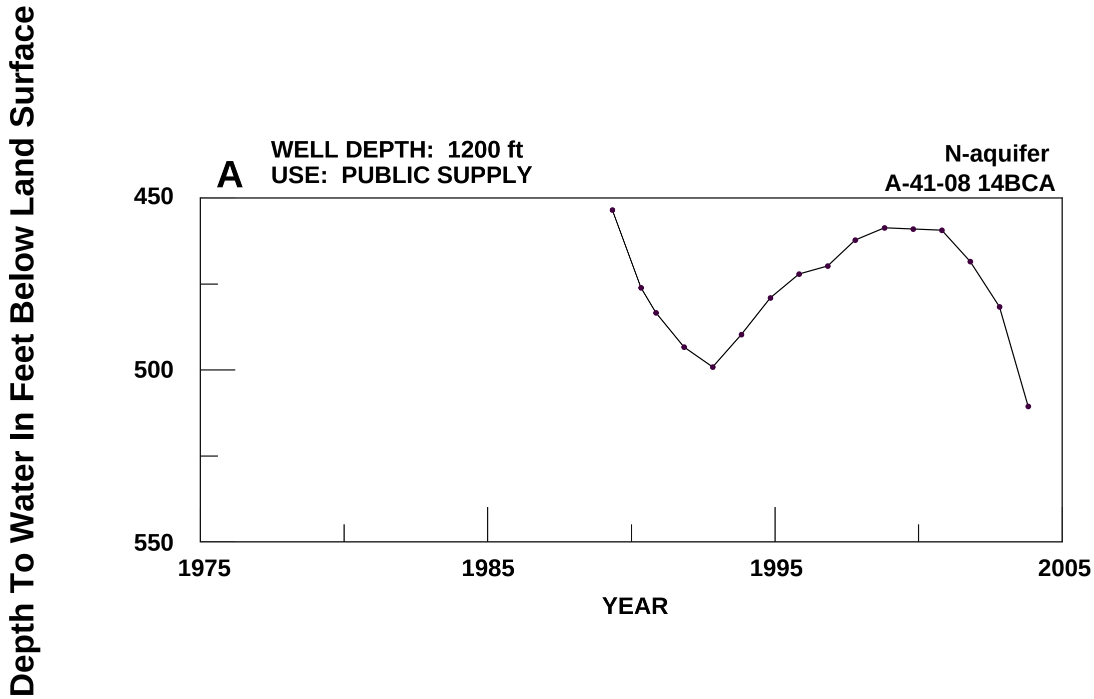


Figure 6.4-6
Paria Basin
Groundwater Conditions

Figure 6.4-7
Paria Basin
Hydrographs Showing Depth to Water in Selected Wells



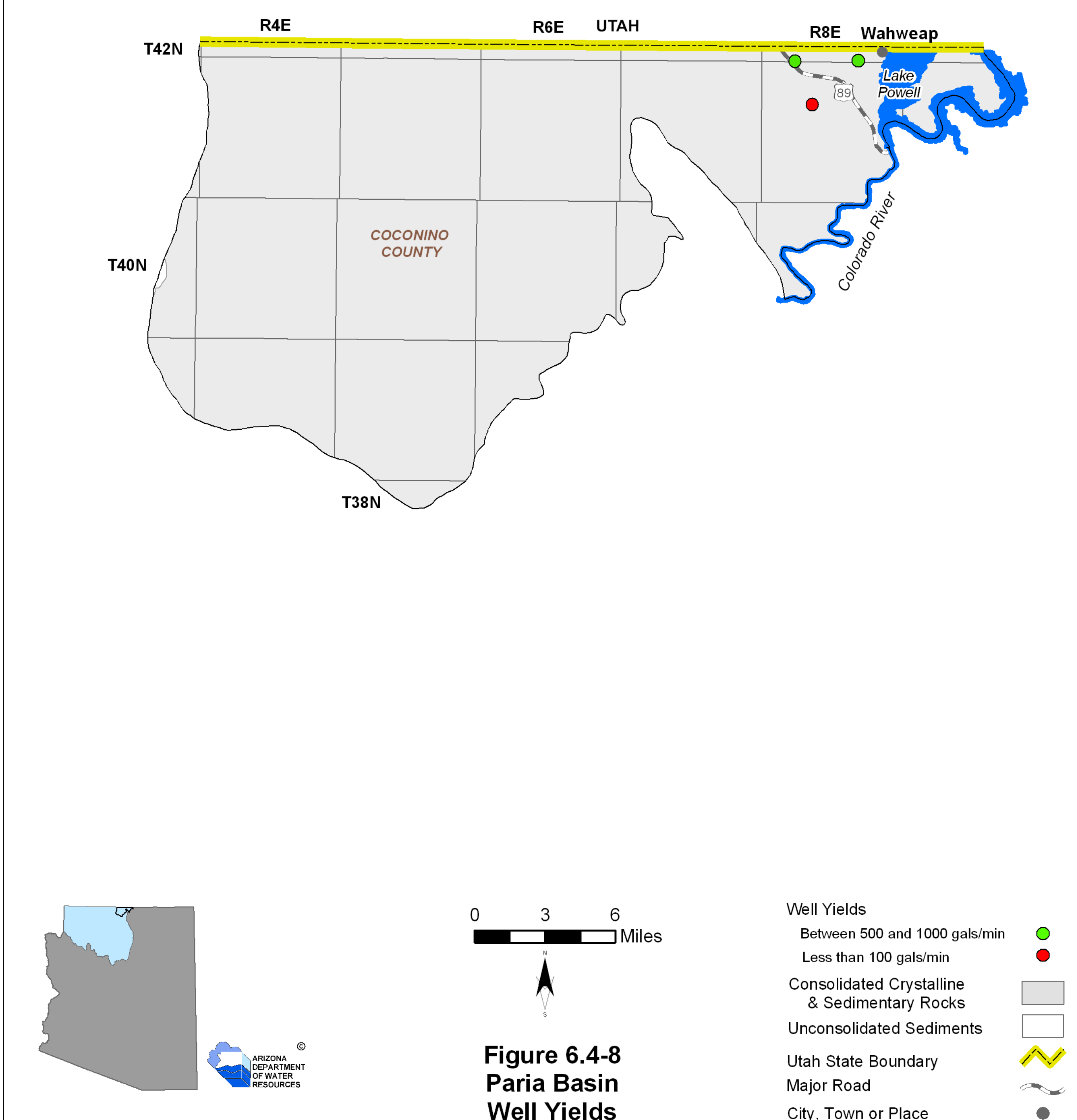


Figure 6.4-8
Paria Basin
Well Yields

6.4.7 Water Quality of the Paria Basin

Wells, springs and mine sites with parameter concentrations that have equaled or exceeded drinking water standard(s), including location and parameter(s) are shown in Table 6.4-5A. Impaired lakes and streams with site type, name, length of impaired reach, area of impaired lake, designated use standard and parameter(s) exceeded is shown in Table 6.4-5B. Figure 6.4-9 shows the location of water quality occurrences keyed to Table 6.4-5. Not all parameters were measured at all sites; selective sampling for particular constituents is common. A description of water quality data sources and methods is found in Volume 1, Appendix A.

Well, Mine or Spring sites that have equaled or exceeded drinking water standards (DWS)

- Refer to Table 6.4-5A.
- Seven wells have parameter concentrations that have equaled or exceeded the drinking water standard for arsenic.

Lakes and Streams with impaired waters

- Refer to Table 6.4-5B.
- The water quality standard for suspended sediment concentration was exceeded in one 29-mile stream reach, the Paria River from the Utah border to the Colorado River. A portion of this impaired reach is located in the Kanab Plateau Basin.
- This reach is not part of the ADEQ water quality improvement effort called the Total Maximum Daily Load (TMDL) Program at this time.

Table 6.4-5 Water Quality Exceedences in the Paria Basin[1]

A. Wells, Springs and Mines

Map Key	Site Type	Site Location			Parameter(s) Concentration has Equaled or Exceeded Drinking Water Standard (DWS)[2]
		Township	Range	Section	
1	Well	42 North	8 East	32	As
2	Well	42 North	8 East	35	As
3	Well	42 North	8 East	35	As
4	Well	42 North	8 East	36	As
5	Well	41 North	8 East	4	As
6	Well	41 North	8 East	14	As
7	Well	41 North	8 East	14	As

Source: Compilation of databases from ADWR & others

B. Lakes and Streams

Map Key	Site Type	Site Name	Length of Impaired Stream Reach (in miles)	Area of Impaired Lake (in acres)	Designated Use Standard[3]	Parameter(s) Exceeding Use Standard
a	Stream	Paria River (Utah border to Colorado River)	29[4]	NA	A&W	suspended sediment concentration

Source: ADEQ 2005

Notes:

NA = Not Applicable
[1] Water quality samples collected between 1977 and 2001.
[2] As = Arsenic
[3] A&W = Aquatic and Wildlife
[4] Total length of the impaired reach. A portion of this reach is in the Kanab Plateau Basin.

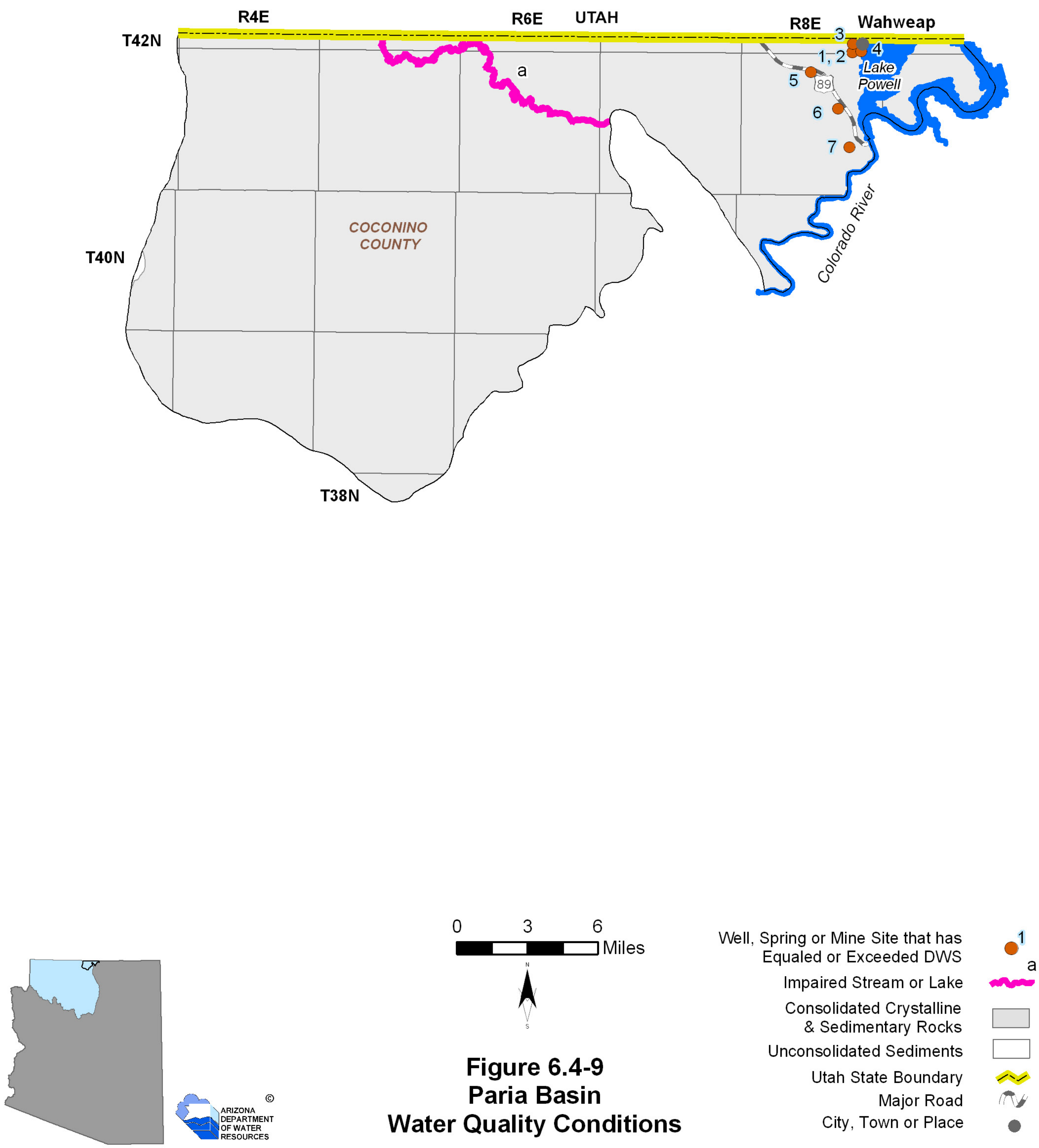


Figure 6.4-9
Paria Basin
Water Quality Conditions

6.4.8 Cultural Water Demand in the Paria Basin

Cultural water demand data including population, number of wells and the average well pumpage and surface water diversions by the municipal, industrial and agricultural sectors are shown in Table 6.4-6. There is no recorded effluent generation in this basin. Figure 6.4-10 shows the location of demand centers. A description of cultural water demand data sources and methods is found in Volume 1, Appendix A. More detailed information on cultural water demand is found in Section 6.0.7.

Cultural Water Demand

- Refer to Table 6.4-6 and Figure 6.4-10.
- Population in this basin increased from 237 in 1980 to 528 in 2000 and is projected to increase to 695 in 2030.
- All water use is for municipal demand in the vicinity of Wahweap.
- There is no reported surface water use in this basin. Groundwater demand was reported as 1,000 acre-feet per year (AFA) on average from 1971-1990 and less than 300 AFA from 1991-2005.
- As of 2005 there were 12 registered wells with a pumping capacity of less than or equal to 35 gpm and four wells with a pumping capacity of more than 35 gpm.

Table 6.4-6 Cultural Water Demand in the Paria Basin[1]

<table>
<tr><th rowspan="3">Year</th><th rowspan="3">Estimated and Projected Population</th><th colspan="2" rowspan="2">Number of Registered Water Supply Wells Drilled</th><th colspan="7">Average Annual Demand (in acre-feet)</th></tr>
<tr><th colspan="3">Well Pumpage</th><th colspan="3">Surface-Water Diversions</th><th rowspan="2">Data Source</th></tr>
<tr><th>Q ≤ 35 gpm</th><th>Q > 35 gpm</th><th>Municipal</th><th>Industrial</th><th>Agricultural</th><th>Municipal</th><th>Industrial</th><th>Agricultural</th></tr>
<tr><td>1971</td><td></td><td rowspan="10">9[2]</td><td rowspan="10">2[2]</td><td colspan="3" rowspan="5">1,000</td><td colspan="3" rowspan="5">NR</td><td rowspan="20">ADWR (1994a)</td></tr>
<tr><td>1972</td><td></td></tr>
<tr><td>1973</td><td></td></tr>
<tr><td>1974</td><td></td></tr>
<tr><td>1975</td><td></td></tr>
<tr><td>1976</td><td></td><td colspan="3" rowspan="5">1,000</td><td colspan="3" rowspan="5">NR</td></tr>
<tr><td>1977</td><td></td></tr>
<tr><td>1978</td><td></td></tr>
<tr><td>1979</td><td></td></tr>
<tr><td>1980</td><td>237</td></tr>
<tr><td>1981</td><td>262</td><td rowspan="5">0</td><td rowspan="5">1</td><td colspan="3" rowspan="5">1,000</td><td colspan="3" rowspan="5">NR</td></tr>
<tr><td>1982</td><td>287</td></tr>
<tr><td>1983</td><td>312</td></tr>
<tr><td>1984</td><td>337</td></tr>
<tr><td>1985</td><td>362</td></tr>
<tr><td>1986</td><td>387</td><td rowspan="5">0</td><td rowspan="5">0</td><td colspan="3" rowspan="5">1,000</td><td colspan="3" rowspan="5">NR</td></tr>
<tr><td>1987</td><td>412</td></tr>
<tr><td>1988</td><td>437</td></tr>
<tr><td>1989</td><td>462</td></tr>
<tr><td>1990</td><td>487</td></tr>
<tr><td>1991</td><td>494</td><td rowspan="5">3</td><td rowspan="5">0</td><td rowspan="5"><300</td><td rowspan="5">NR</td><td rowspan="5">NR</td><td colspan="3" rowspan="5">NR</td><td rowspan="15">USGS (2007)</td></tr>
<tr><td>1992</td><td>500</td></tr>
<tr><td>1993</td><td>507</td></tr>
<tr><td>1994</td><td>514</td></tr>
<tr><td>1995</td><td>521</td></tr>
<tr><td>1996</td><td>528</td><td rowspan="5">0</td><td rowspan="5">1</td><td rowspan="5"><300</td><td rowspan="5">NR</td><td rowspan="5">NR</td><td colspan="3" rowspan="5">NR</td></tr>
<tr><td>1997</td><td>535</td></tr>
<tr><td>1998</td><td>541</td></tr>
<tr><td>1999</td><td>548</td></tr>
<tr><td>2000</td><td>528</td></tr>
<tr><td>2001</td><td>532</td><td rowspan="5">0</td><td rowspan="5">0</td><td rowspan="5"><300</td><td rowspan="5">NR</td><td rowspan="5">NR</td><td colspan="3" rowspan="5">NR</td></tr>
<tr><td>2002</td><td>536</td></tr>
<tr><td>2003</td><td>539</td></tr>
<tr><td>2004</td><td>543</td></tr>
<tr><td>2005</td><td>547</td></tr>
<tr><td>2010</td><td>566</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>2020</td><td>637</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>2030</td><td>695</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">WELLS TOTALS:</td><td>12</td><td>4</td><td colspan="7"></td></tr>
</table>

[1] Does not include effluent or evaporation losses from stockponds and reservoirs.
[2] Includes all wells through 1980.
NR - Not reported

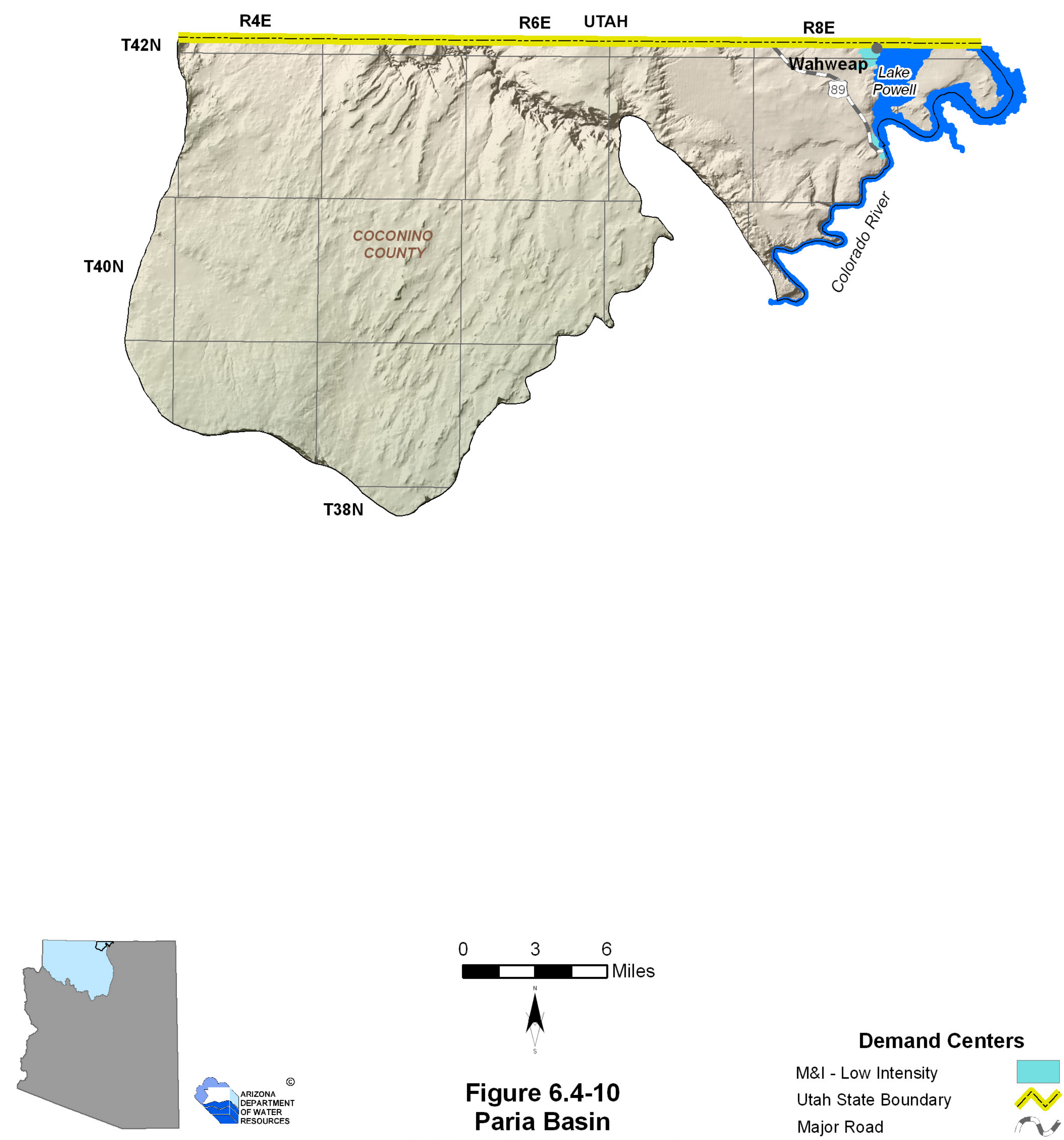


Figure 6.4-10
Paria Basin
Cultural Water Damand

Primary Data Source: USGS National Gap Analysis Program, 2004

6.4.9 Water Adequacy Determinations in the Paria Basin

Water adequacy determination information including the subdivision name, location, number of lots, adequacy determination, reason for the inadequacy determination, date of determination and subdivision water provider are shown in Table 6.4-7. Figure 6.4-11 shows the locations of subdivisions keyed to the Table. A description of the Water Adequacy Program is found in Volume 1, Appendix C. Adequacy determination data sources and methods are found in Volume 1, Appendix A.

- All subdivisions reviewed for an adequacy determination are in the vicinity of Wahweap. Nine water adequacy determinations for 1,356 lots total have been made in this basin through December 2008; all were determined to be adequate.

Table 6.4-7 Adequacy Determinations in the Paria Basin

Map Key	Subdivision Name	County	Location			No. of Lots	ADWR File No.[2]	ADWR Adequacy Determination	Reason(s) for Inadequacy Determination[3]	Date of Determination	Water Provider at the Time of Application
			Township	Range	Section						
1	Greenehaven	Coconino	42 North	8 East	32	770	53-500757	Adequate		12/28/1977	Greenehaven Development Corp.
2	Greenehaven #4	Coconino	42 North	8 East	32	12	53-500758	Adequate		6/3/1988	Greenehaven Water Company
3	Greenehaven Unit #6	Coconino	42 North	8 East	32	83	53-400505	Adequate		3/16/2001	Greenehaven Water Company
4	Greenehaven # 5	Coconino	42 North	8 East	32	86	53-400507	Adequate		7/3/2001	Greenehaven Water Company
5	Greenehaven Mobile Home Estates	Coconino	42 North	8 East	32	151	53-500759	Adequate		7/8/1981	Greenehaven Water Company
6	Greenehaven Unit VII Phase 1	Coconino	42 North	8 East	32	58	53-402001	Adequate		6/22/2006	Greenehaven Water Company
7	Greenehaven Unit VII Phase 1	Coconino	42 North	8 East	32	81	53-402002	Adequate		6/22/2006	Greenehaven Water Company
8	Greenehaven Unit VIII	Coconino	42 North	8 East	32	75	53-402000	Adequate		6/22/2006	Greenehaven Water Company
9	Patio Homes @ Lake Powell View Properties-One	Coconino	42 North	8 East	32	40	53-400698	Adequate		4/2/2002	Greenehaven Water Company

Source: ADWR 2008

Notes:

[1]Each determination of the adequacy of water supplies available to a subdivision is based on the information available to ADWR and the standards of review and policies in effect at the time the determination was made. In some cases, ADWR might make a different determination if a similar application were submitted today, based on the hydrologic data and other information currently available, as well as current rules and policies.

[2] Prior to February 1995, ADWR did not assign file numbers to applications for adequacy. Between 1995-2006 all applications for adequacy were given a file number with a 22 prefix. In 2006 a 53 prefix was assigned to all water adequacy reports and applications regardless of their issue date.

[3] A. Physical/Continuous
1) Insufficient Data (applicant chose not to submit necessary information, and/or available hydrologic data insufficient to make determination)
2) Insufficient Supply (existing water supply unreliable or physically unavailable; for groundwater, depth-to-water exceeds criteria)
3) Insufficient Infrastructure (distribution system is insufficient to meet demands or applicant proposed water hauling)

B. Legal (applicant failed to demonstrate a legal right to use the water or failed to demonstrate the provider's legal authority to serve the subdivision)
C. Water Quality
D. Unable to locate records

NA = Not available to ADWR at this time

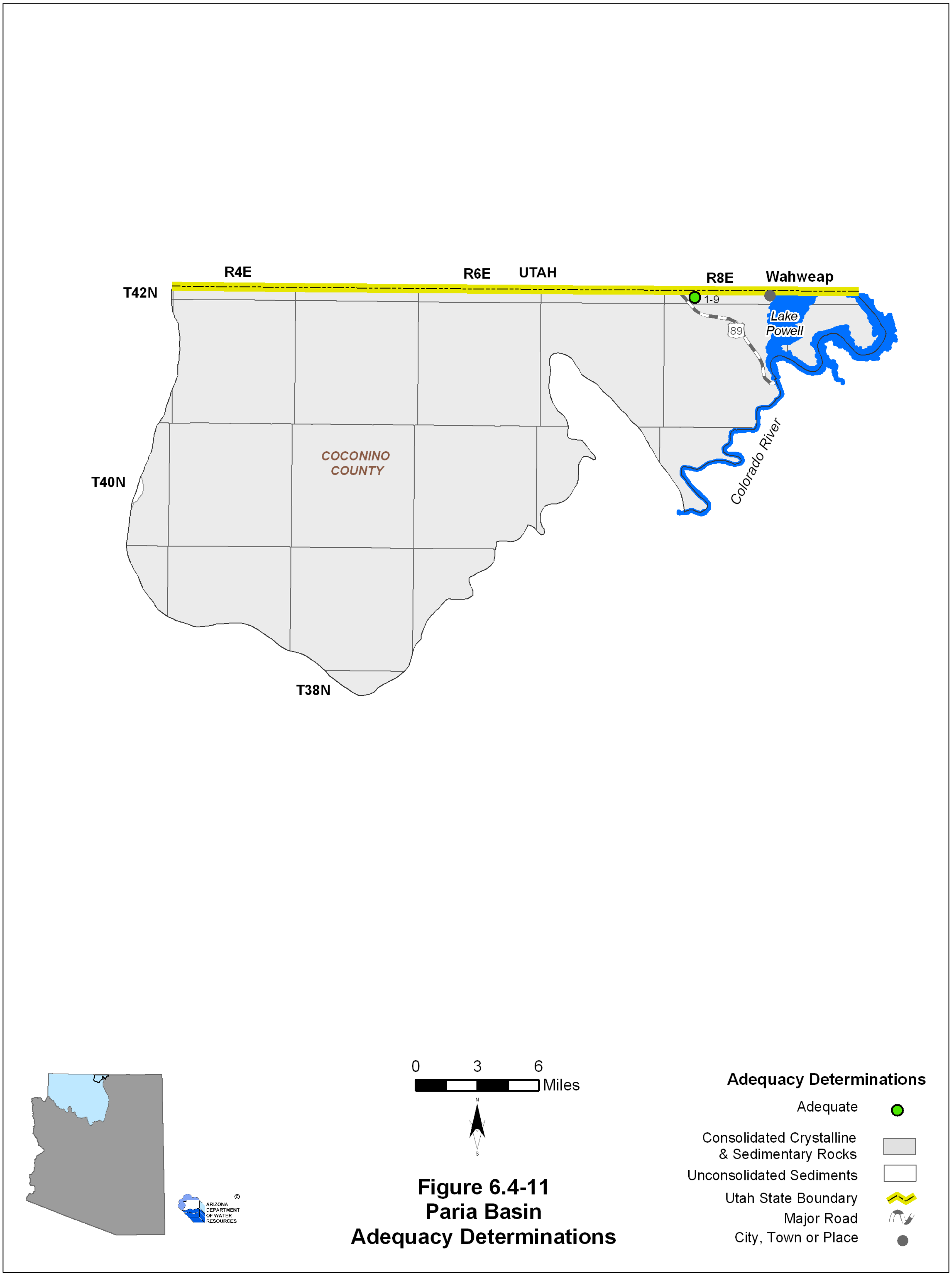


Figure 6.4-11
Paria Basin
Adequacy Determinations

Paria Basin
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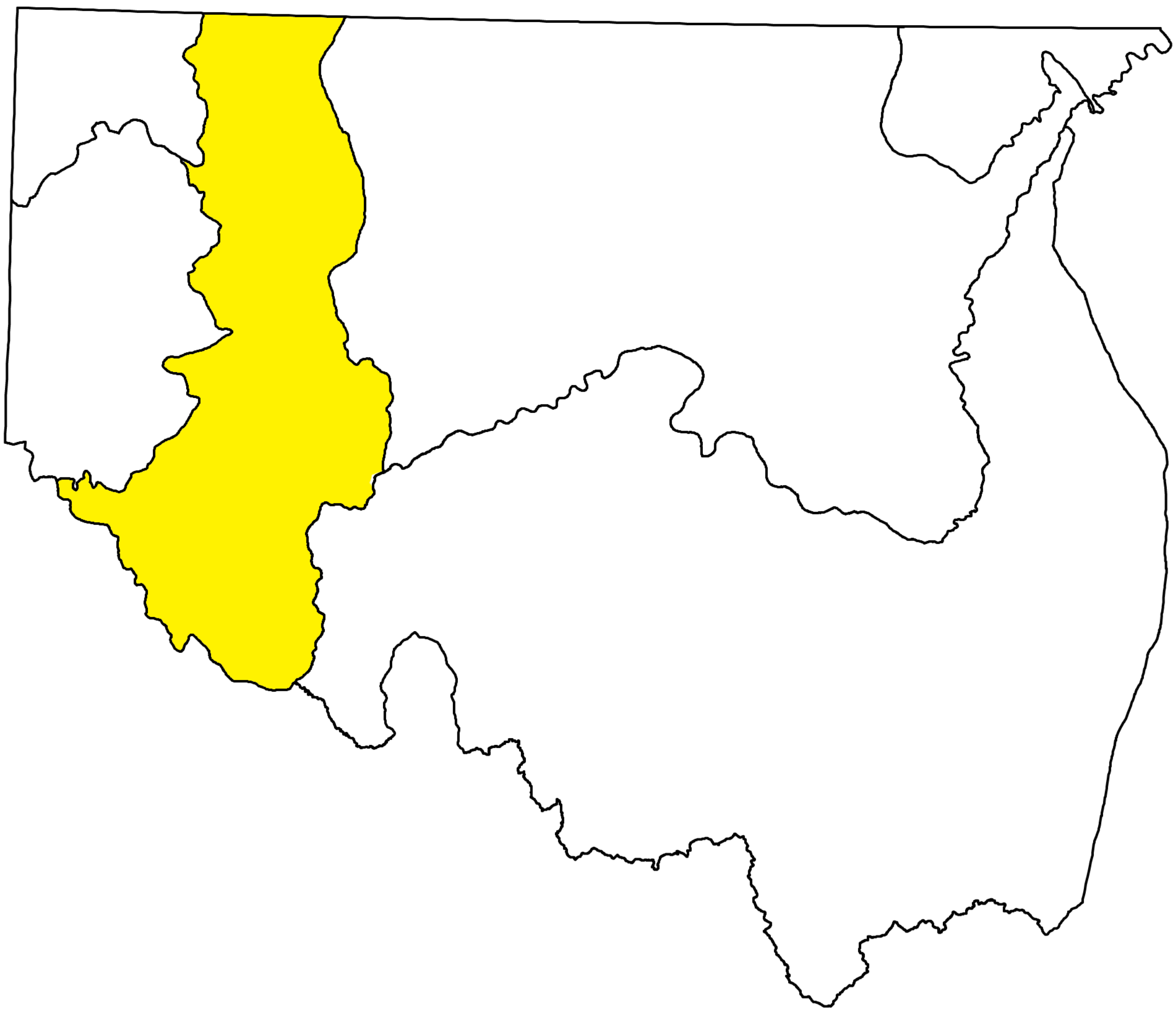
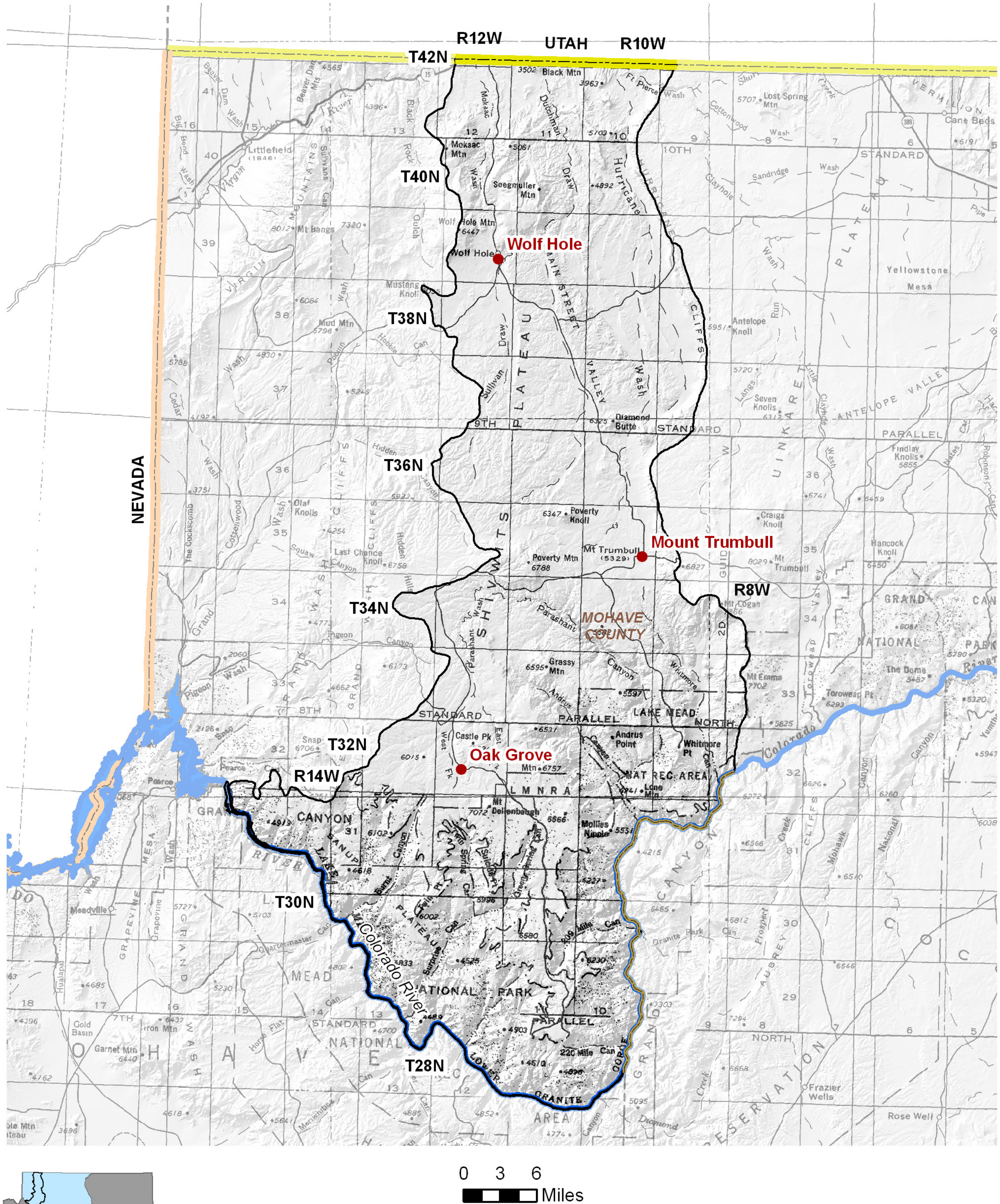
Section 6.5
Shivwits Plateau Basin

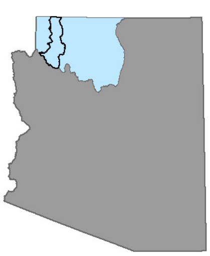


6.5.1 Geography of the Shivwits Plateau Basin

The Shivwits Plateau Basin, located in the western part of the planning area is 1,821 square miles in area. Geographic features and principal communities are shown on Figure 6.5-1. The basin is characterized by plateaus, canyons and cliffs. Vegetation is primarily Great Basin conifer woodland, Great Basin and Mohave desertscrub and Plains and Great Basin grassland with small areas of Rocky Mountain and madrean montane forest and interior chaparral. (See Figure 6.0-11)

- Principal geographic features shown on Figure 6.5-1 are:
  - The Colorado River and Lower Granite Gorge of the Grand Canyon forming the southern basin boundary
  - Shivwits Plateau running north south throughout most of the basin and the Sanup Plateau in the southwest
  - Hurricane Cliffs on the northeastern basin boundary
  - Mt. Dellenbaugh, located south of Oak Grove, the highest point in the basin at 7,072 feet
  - The lowest point at approximately 1,200 feet where the Colorado River exits the basin.





Base Map: USGS 1:500,000, 1981

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Figure 6.5-1
Shivwits Plateau Basin
Geographic Features

Nevada State Boundary
Utah State Boundary
COUNTY
City, Town or Place

6.5.2 Land Ownership in the Shivwits Plateau Basin

Land ownership, including the percentage of ownership by category, for the Shivwits Plateau Basin is shown in Figure 6.5-2. Principal features of land ownership in this basin are the large parcels of land managed by the U.S. Bureau of Land Management (BLM) and National Park Service (NPS). Thirty-four percent of the basin is managed jointly by the BLM and NPS as the Grand Canyon-Parashant National Monument. A description of land ownership data sources and methods is found in Volume 1, Appendix A. More detailed information on protected areas is found in Section 6.0.4. Land ownership categories are discussed below in the order of percentage from largest to smallest in the basin.

U.S. Bureau of Land Management (BLM)

- 53.7% of the land is federally owned and managed by the Arizona Strip Field Office of the Bureau of Land Management.
- BLM land in the basin includes a portion of the Grand Canyon-Parashant National Monument and the 14,650 acre Mt. Logan Wilderness, located south of Mount Trumbull. (see Figure 6.0-14)
- Land use includes grazing, recreation and resource conservation.

National Park Service (NPS)

- 38.1% of the land is federally owned and managed by the National Park Service as the Grand Canyon National Park and the Grand Canyon-Parashant National Monument.
- Land use includes resource conservation and recreation.

State Trust Land

- 4.9% of the land is held in trust for the public schools under the State Trust Land system.
- State land is located throughout most of the basin and is interspersed with BLM and private lands.
- Primary land use is grazing.

Private

- 3.3% of the land is private.
- The majority of the private land is in the vicinity of Mt. Trumbull and north of Oak Grove.
- Land uses include domestic and ranching.

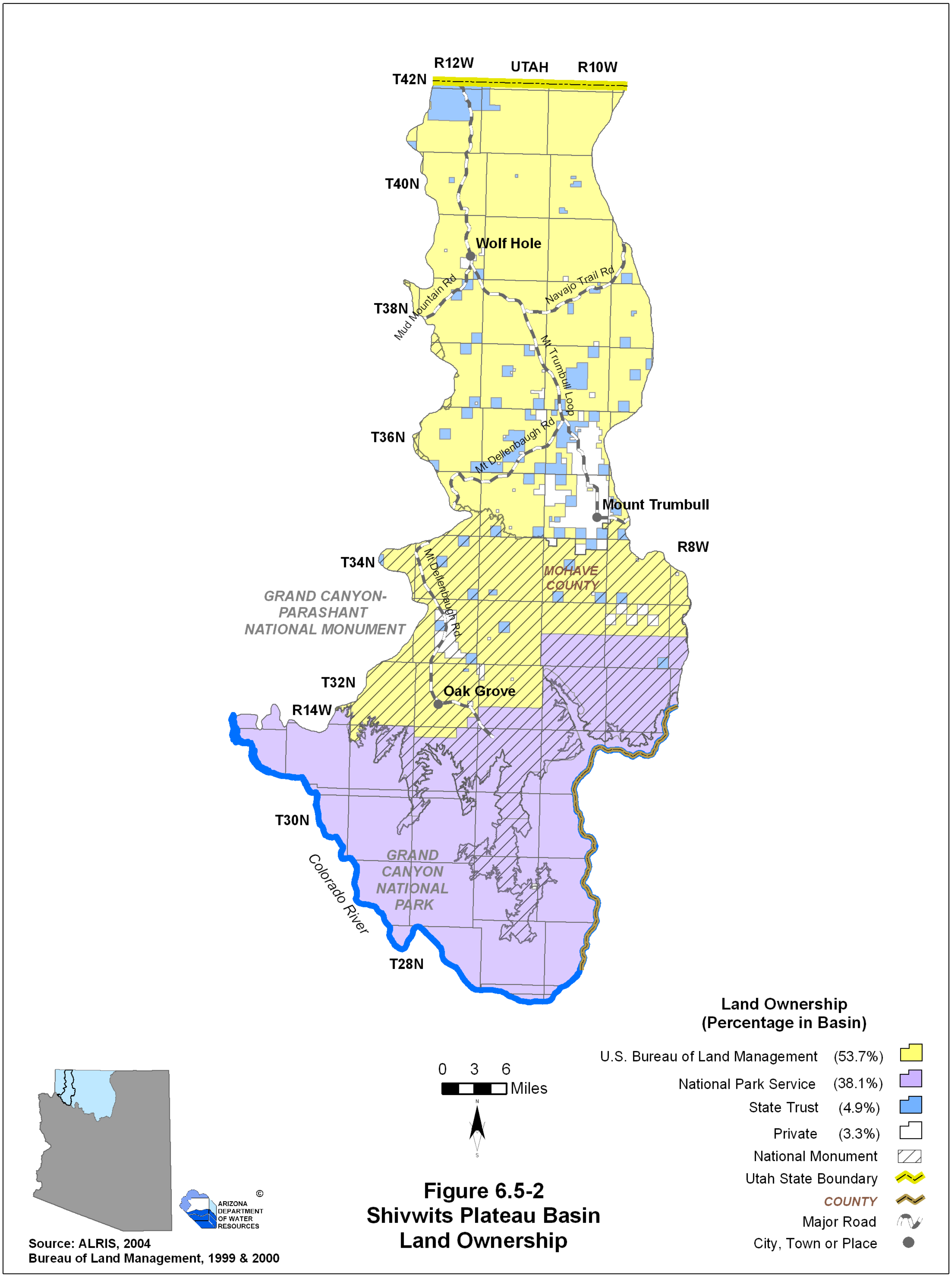


Figure 6.5-2
Shivwits Plateau Basin
Land Ownership

6.5.3 Climate of the Shivwits Plateau Basin

The Shivwits Plateau Basin does not contain NOAA/NWS, Evaporation Pan, AZMET or SNOTEL/Snowcourse stations. Figure 6.5-3 shows precipitation contour data from the Spatial Climate Analysis Service (SCAS) at Oregon State University. More detailed information on climate in the planning area is found in Section 6.0.3. A description of the climate data sources and methods is found in Volume 1, Appendix A.

SCAS Precipitation Data

- See Figure 6.5-3
- Average annual rainfall is as high as 20 inches along the central eastern basin boundary and as low as four inches at the Colorado River on the basin's western boundary.

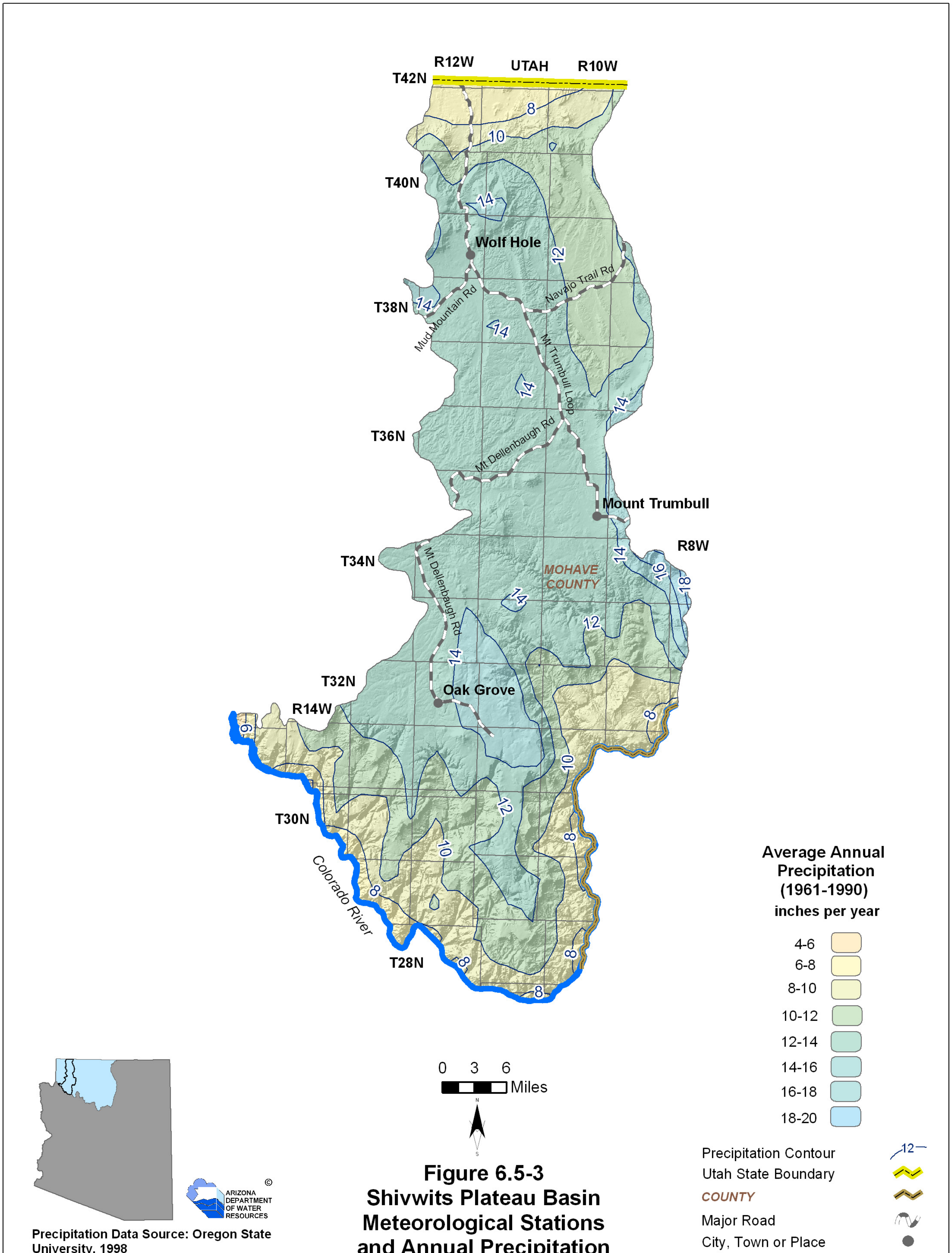


Figure 6.5-3
Shivwits Plateau Basin
Meteorological Stations
and Annual Precipitation

6.5.4 Surface Water Conditions in the Shivwits Plateau Basin

There are no streamflow data or flood ALERT equipment in this basin. Reservoir and stockpond data, including maximum storage or maximum surface area, are shown in Table 6.5-1. The USGS runoff contours and large reservoirs are shown on Figure 6.5-4. Descriptions of stream, reservoir and stockpond data sources and methods are found in Volume 1, Appendix A.

Reservoirs and Stockponds

- Refer to Table 6.5-1.
- The only large reservoir in the basin is Wolf Hole with a maximum surface area of 58 acres. This reservoir is used for fire protection or as a stock or farm pond.
- Surface water is stored or could be stored in two small reservoirs.
- There are 369 registered stockponds in this basin.

Runoff Contour

- Refer to Figure 6.5-4.
- Average annual runoff is highest, 0.5 inches per year or 26.65 acre-feet per square mile, in the northwestern portion of the basin near Mud Mountain Road and decreases to 0.1 inches, or 5.33 acre-feet per square mile, in the southernmost and central portions of the basin.

Table 6.5-1 Reservoirs and Stockponds in the Shivwits Plateau Basin

A. Large Reservoirs (500 acre-feet capacity and greater)

MAP KEY	RESERVOIR/LAKE NAME *(Name of dam, if different)*	OWNER/OPERATOR	MAXIMUM STORAGE (AF)	USE	JURISDICTION
None Identified by ADWR at this time					

B. Other Large Reservoirs (50 acre surface area or greater)[1]

MAP KEY	RESERVOIR/LAKE NAME *(Name of dam, if different)*	OWNER/OPERATOR	MAXIMUM SURFACE AREA (acres)	USE[2]	JURISDICTION
1	Wolf Hole	Private	58	P	NA

Source: Compilation of databases from ADWR & others

C. Small Reservoirs (greater than 15 acre-feet and less than 500 acre-feet capacity)

Total number: 1
Total maximum storage: 20 acre-feet

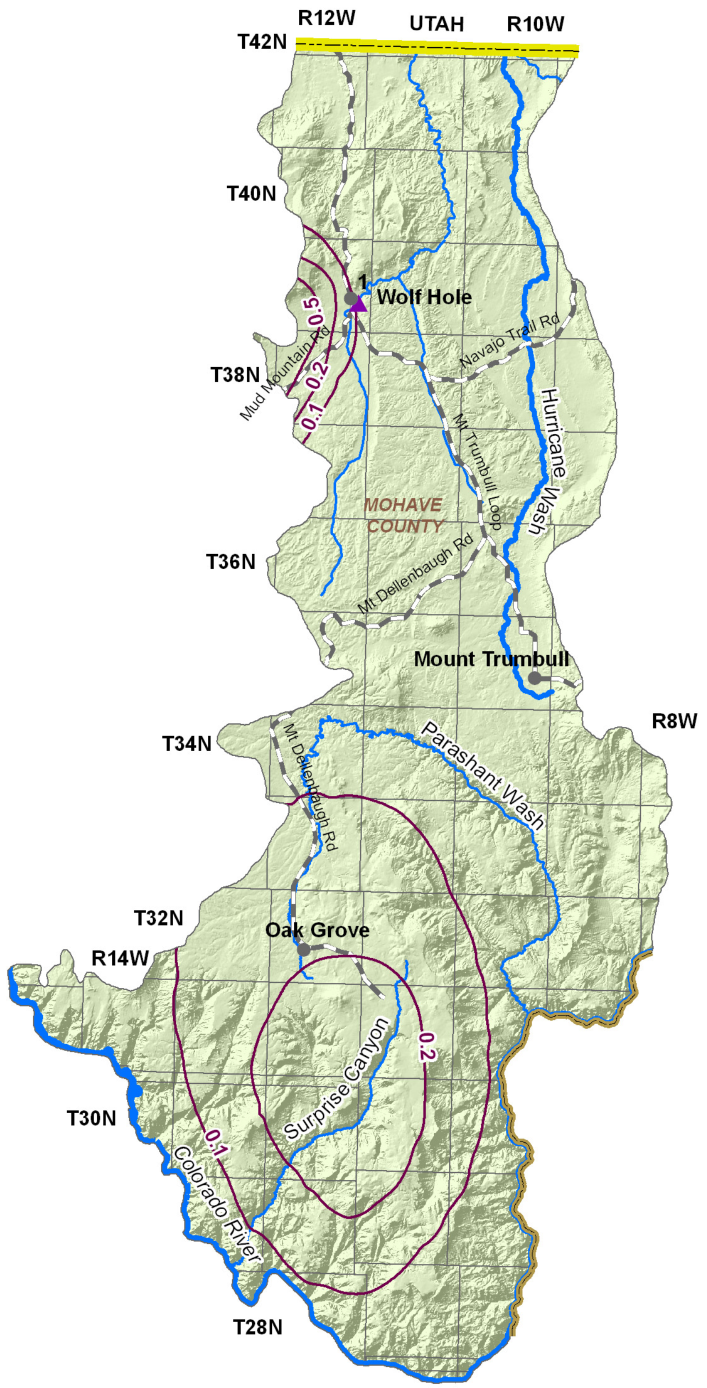
D. Other Small Reservoirs (between 5 and 50 acres surface area)[1]

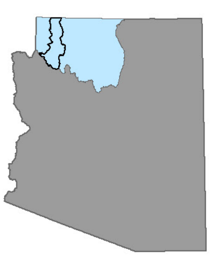
Total number: 1
Total surface area: 10 acres

E. Stockponds (up to 15 acre-feet capacity)

Total number: 369

[1] Capacity data not available to ADWR
[2] P=fire protection, stock or farm pond





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Stream Data Source: ALRIS, 2005

Figure 6.5-4
Shivwits Plateau Basin
Surface Water Conditions

6.5.5 Perennial/Intermittent Streams and Major Springs in the Shivwits Plateau Basin

Major springs with discharge rates and date of measurement and the total number of springs in the basin are shown in Table 6.5-2. The location of a major spring and perennial stream are shown on Figure 6.5-5. Descriptions of data sources and methods for intermittent and perennial reaches and springs are found in Volume 1, Appendix A.

- There are no intermittent streams. Perennial streams include the Colorado River and Boulder Wash.
- There is one major spring in the basin, Spring Canyon located at the Colorado River, with a discharge rate of 331 gallons per minute (gpm).
- Springs with measured discharge of 1 to 10 gpm are not mapped but coordinates are given in Table 6.5-2B. There are five minor springs in this basin.
- The total number of springs, regardless of discharge, identified by the USGS varies from 51 to 56, depending on the database reference.

Table 6.5-2 Springs in the Shivwits Plateau Basin

A. Major Springs (10 gpm or greater):

Map Key	Name	Location		Discharge (in gpm)[1]	Date Discharge Measured
		Latitude	Longitude		
1	Spring Canyon[2]	360107	1132106	331	3/20/2004

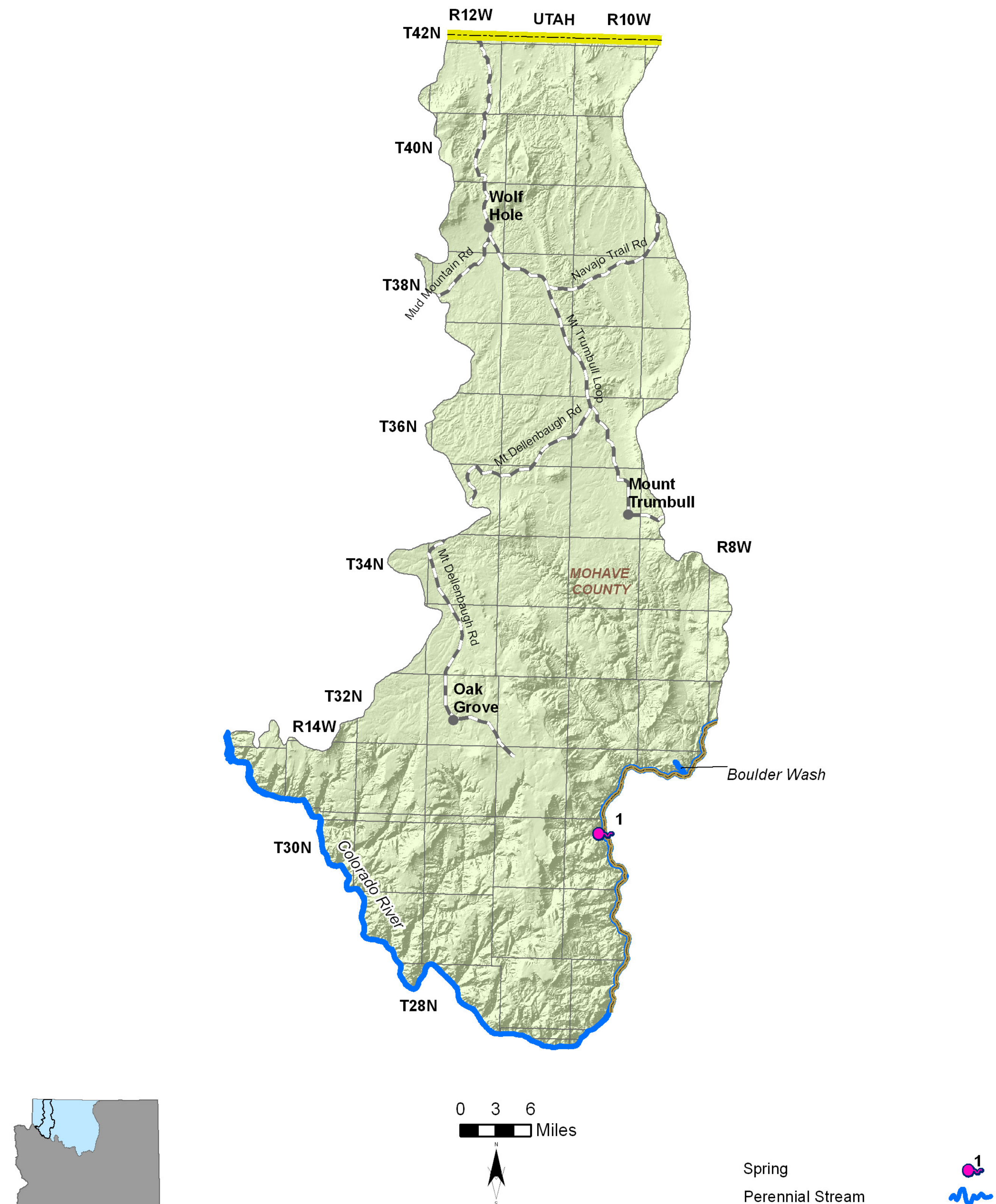
B. Minor Springs (1 to 10 gpm):

Name	Location		Discharge (in gpm)[1]	Date Discharge Measured
	Latitude	Longitude		
Ivanpatch	362340	1132823	3	7/20/1951
Big	362014	1131125	2	8/10/1976
Green	360538	1132825	1	6/18/2000
Poverty	362355	1133251	1	9/8/1976
Russell	363120	1131930	1	7/21/1951

Source: Compilation of databases from ADWR & others

C. Total number of springs, regardless of discharge, identified by USGS (see ALRIS, 2005a and USGS, 2006a): 51 to 56

Notes:
[1] Most recent measurement identified by ADWR
[2] Spring is not displayed on current USGS topo maps



Stream Data Source: AGFD, 1993 & 1997

Figure 6.5-5
Shivwits Plateau Basin
Perennial/Intermittent Streams
and Major (>10 gpm) Springs

6.5.6 Groundwater Conditions of the Shivwits Plateau Basin

Major aquifers, well yields, number of index wells and date of last water-level sweep are shown in Table 6.5-3. Figure 6.5-6 shows water-level change between 1990-1991 and 2003-2004. Figure 6.5-7 contains the hydrograph for the selected well shown on Figure 6.5-6. A description of aquifer data sources and methods as well as well data sources and methods, including water-level changes and well yields are found in Volume 1, Appendix A.

Major Aquifers

- Refer to Table 6.5-3 and Figure 6.5-6.
- The major aquifer in the basin is the recent stream alluvium.
- Almost all of the basin geology consists of consolidated crystalline and sedimentary rock.
- Data on natural recharge, groundwater in storage and groundwater flow direction is not available for this basin.

Well Yields

- Refer to Table 6.5-3
- One source of well yield information, based on 17 reported wells, indicates that the median well yield in this basin is five gallons per minute.

Water Level

- Refer to Figure 6.5-6. Water levels are shown for wells measured in 2003-2004.
- There are no index wells in this basin.
- Water level information is available for one well, with a depth to water of 960 feet. A hydrograph for this well is shown in Figure 6.5-7.

Table 6.5-3 Groundwater Data for the Shivwits Plateau Basin

Basin Area, in square miles:	1,821	
	Name and/or Geologic Units	
Major Aquifer(s):	Recent Stream Alluvium	
Well Yields, in gpm:	Range 2-35 Median 5 (17 wells reported)	Reported on registration forms for all wells (Wells55)
	Range 0-45	ADWR (1990 and 1994b)
	Range 0-10	Anning and Duet (1994)
Estimated Natural Recharge, in acre-feet/year:	N/A	
Estimated Water Currently in Storage, in acre-feet:	N/A	
Current Number of Index Wells:	0	
Date of Last Water-level Sweep:	1976 (9 wells measured)	

N/A=Not Available

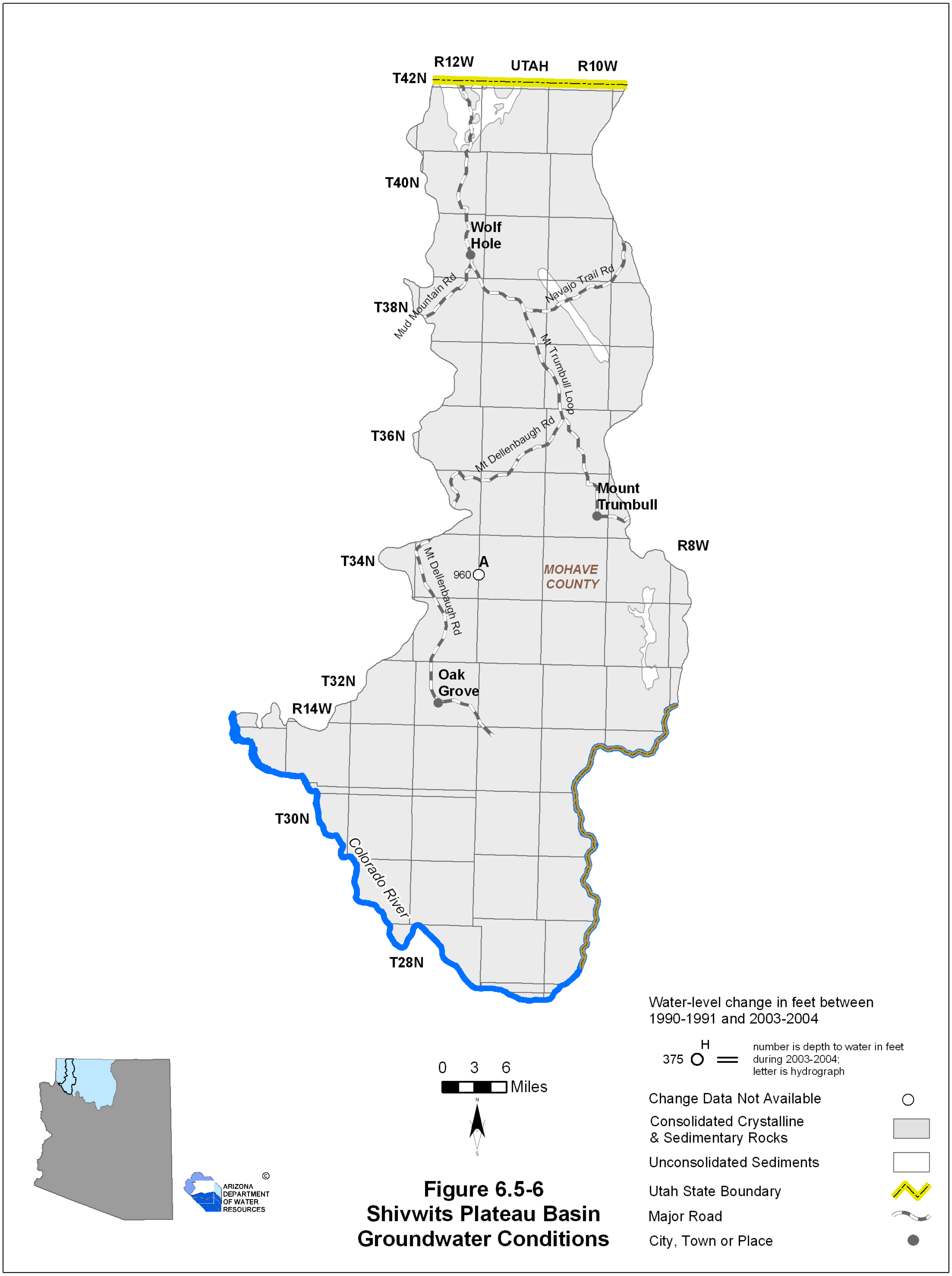
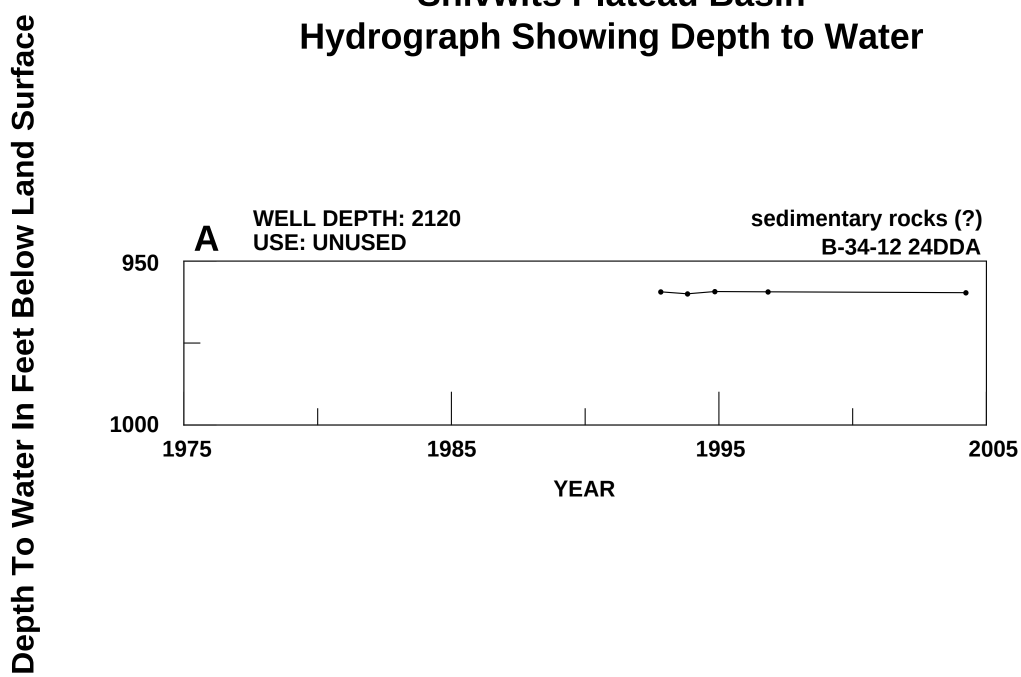


Figure 6.5-6
Shivwits Plateau Basin
Groundwater Conditions

Figure 6.5-7
Shivwits Plateau Basin
Hydrograph Showing Depth to Water



6.5.7 Water Quality of the Shivwits Plateau Basin

Wells, springs and mine sites with parameter concentrations that have equaled or exceeded drinking water standard(s), including location and parameter(s) are shown in Table 6.5-4A. Impaired lakes and streams with site type, name, length of impaired reach, area of impaired lake, designated use standard and parameter(s) exceeded is shown in Table 6.5-4B. Figure 6.5-8 shows the location of water quality occurrences keyed to Table 6.5-4. Not all parameters were measured at all sites; selective sampling for particular constituents is common. A description of water quality data sources and methods is found in Volume 1, Appendix A.

Well, Mine or Spring sites that have equaled or exceeded drinking water standards (DWS)

- Refer to Table 6.5-4A.
- One spring has a parameter concentration that has equaled or exceeded the drinking water standard for arsenic.

Lakes and Streams with impaired waters

- Refer to Table 6.5-4B.
- The water quality standard for suspended sediment concentration was exceeded in one 28-mile stream reach, the Colorado River from Parashant Canyon to Diamond Creek. This impaired reach is located along part of the border with the Coconino Plateau Basin.
- This reach is not part of the ADEQ water quality improvement effort called the Total Maximum Daily Load (TMDL) Program at this time.

Table 6.5-4 Water Quality Exceedences in the Shivwits Plateau Basin[1]

A. Wells, Springs and Mines

Map Key	Site Type	Site Location			Parameter(s) Concentration has Equaled or Exceeded Drinking Water Standard (DWS)[2]
		Township	Range	Section	
1	Spring	30 North	13 West	24	As

Source: Compilation of databases from ADWR & others

B. Lakes and Streams

Map Key	Site Type	Site Name	Length of Impaired Stream Reach (in miles)	Area of Impaired Lake (in acres)	Designated Use Standard[3]	Parameter(s) Exceeding Use Standard[2]
a	Stream	Colorado River (Parashant Canyon to Diamond Creek)	28[4]	NA	A&W	Se, suspended sediment concentration

Source: ADEQ 2005

Notes:

NA = Not Applicable
[1] Water quality samples collected between 1976 and 2001.
[2] As = Arsenic
Se = Selenium
[3] A&W = Aquatic and Wildlife
[4] Total length of the impaired reach. This reach is located along part of the border with the Coconino Plateau Basin.

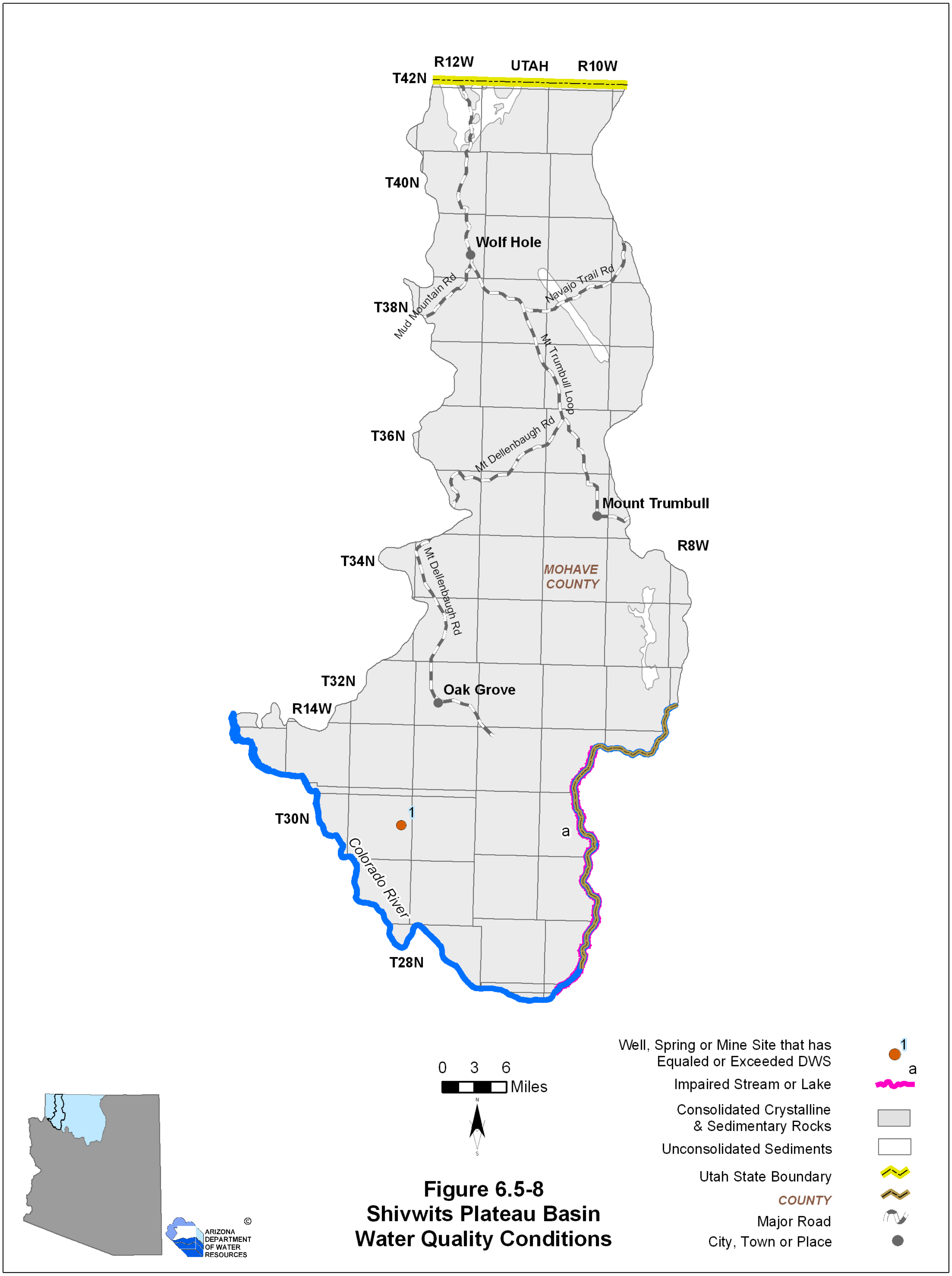


Figure 6.5-8
Shivwits Plateau Basin
Water Quality Conditions

6.5.8 Cultural Water Demand in the Shivwits Plateau Basin

Cultural water demand data including population, number of wells and the average well pumpage and surface water diversions by the municipal, industrial and agricultural sectors are shown in Table 6.5-5. There is no recorded effluent generation in this basin. The USGS National Gap Analysis Program, the primary source of cultural demand map data, showed no demand centers for this basin. A description of cultural water demand data sources and methods is found in Volume 1, Appendix A. More detailed information on cultural water demand is found in Section 6.0.7.

Cultural Water Demand

- Refer to Table 6.5-5
- Population in this basin is very small, with 12 residents in 2000.
- There are no recorded surface water uses in this basin. All groundwater use is for municipal (domestic) demand and has remained relatively constant since 1971.
- As of 2005 there were 17 registered wells with a pumping capacity of less than or equal to 35 gallons per minute (gpm) and two wells with a pumping capacity of more than 35 gpm.

Table 6.5-5 Cultural Water Demand in the Shivwits Plateau Basin[1]

Year	Estimated and Projected Population	Number of Registered Water Supply Wells Drilled: Q ≤ 35 gpm	Number of Registered Water Supply Wells Drilled: Q > 35 gpm	Average Annual Demand (in acre-feet): Well Pumpage: Municipal	Well Pumpage: Industrial	Well Pumpage: Agricultural	Surface-Water Diversions: Municipal	Surface-Water Diversions: Industrial	Surface-Water Diversions: Agricultural	Data Source
1971		14[2]	0[2]	<500			NR			ADWR (1994a)
1972										
1973										
1974										
1975										
1976				<500			NR			
1977										
1978										
1979										
1980	4									
1981	4	0	0	<500			NR			
1982	5									
1983	5									
1984	6									
1985	6									
1986	6	0	0	<500			NR			
1987	7									
1988	7									
1989	8									
1990	8									
1991	8	3	0	<300	NR	NR	NR			USGS (2007)
1992	9									
1993	9									
1994	10									
1995	10									
1996	10	0	0	<300	NR	NR	NR			
1997	11									
1998	11									
1999	12									
2000	12									
2001	12	0	2	<300	NR	NR	NR			
2002	12									
2003	12									
2004	12									
2005	12									
2010	12									
2020	12									
2030	12									
	TOTALS:	**17**	**2**							

[1] Does not include evaporation losses from stockponds and reservoirs.
[2] Includes all wells through 1980.
NR - Not reported

6.5.9 Water Adequacy Determinations in the Shivwits Plateau Basin

There are no water adequacy applications on file with the Department as of December 2008 for the Shivwits Plateau Basin. A description of the Water Adequacy Program is found in Volume 1, Appendix C. Adequacy determination data sources and methods are found in Volume 1, Appendix A.

Shivwits Plateau Basin
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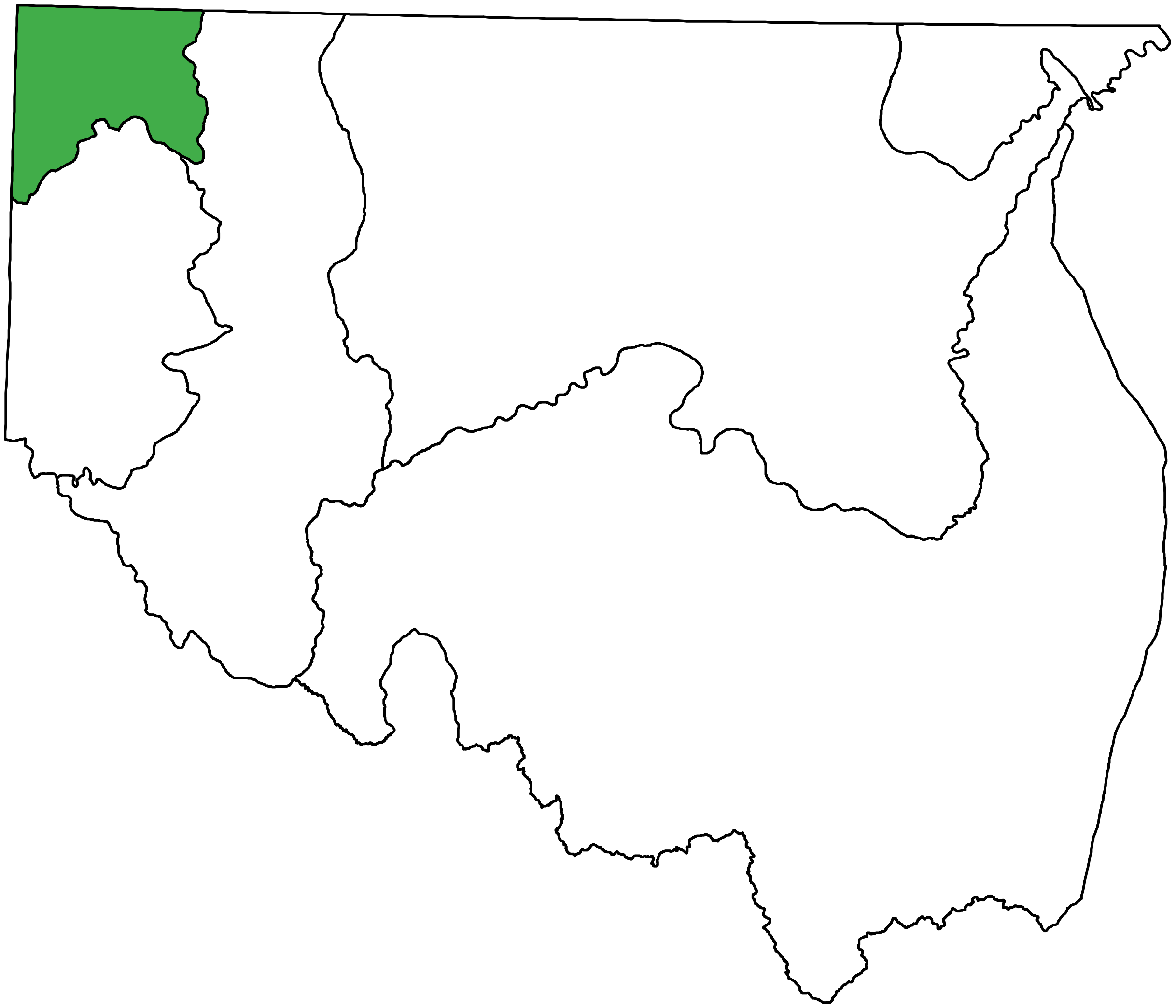
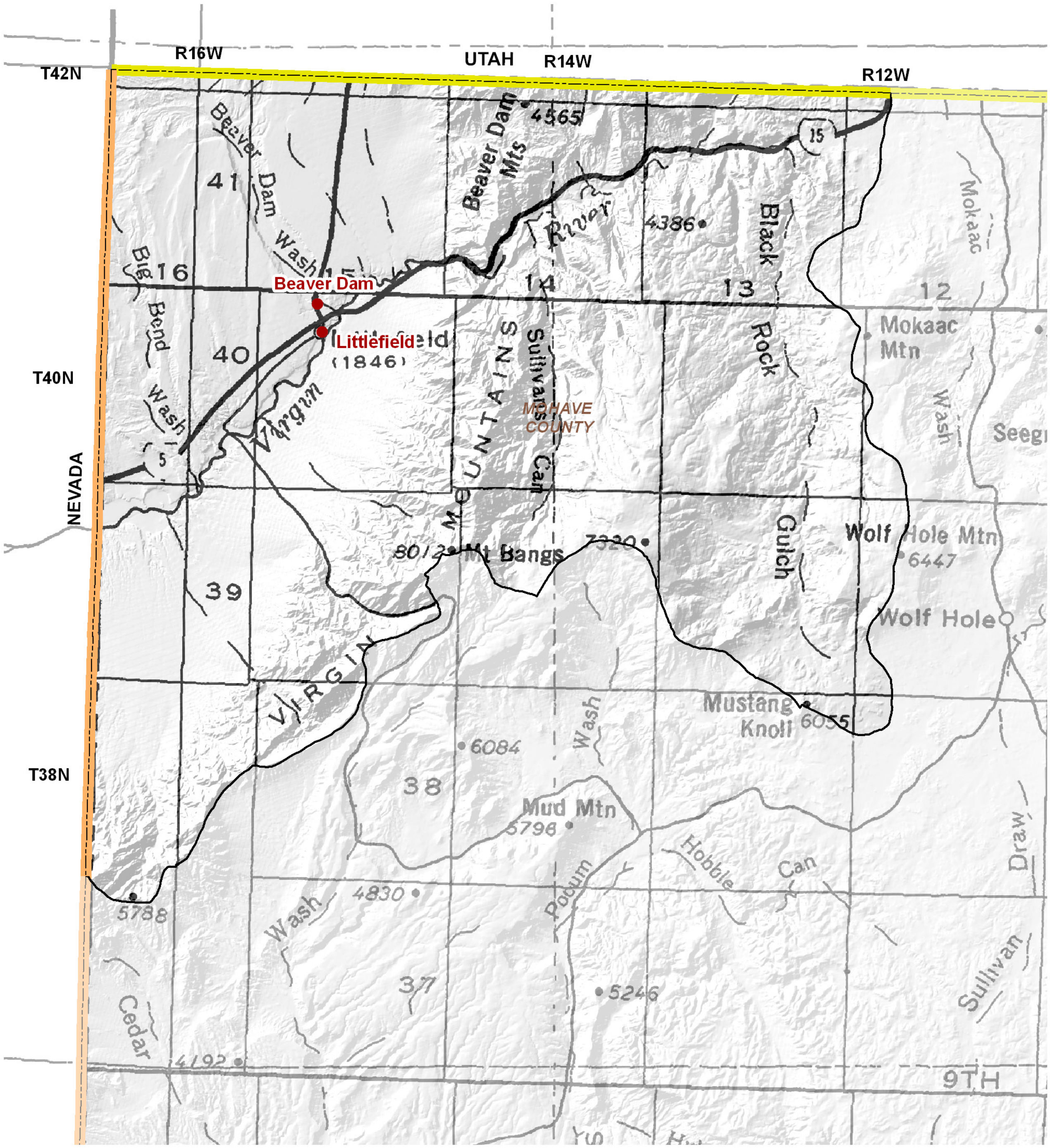
Section 6.6
Virgin River Basin

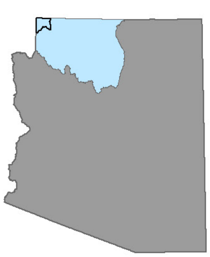


6.6.1 Geography of the Virgin River Basin

The Virgin River Basin, located in the northwestern-most part of the planning area is 434 square miles in area. Geographic features and principal communities are shown on Figure 6.6-1. The basin is characterized by mountains and a broad valley west of the mountains. Vegetation is primarily Mohave desertscrub with smaller areas of Great Basin desertscrub, Great Basin conifer woodland, interior chaparral and a small area of Rocky Mountain and madrean montane conifer forest. (See Figure 6.0-11) Riparian vegetation along the Virgin River is predominantly tamarisk.

- Principal geographic features shown on Figure 6.6-1 are:
  - The Virgin River running from the northeast to southwest and the lowest point at 1,600 feet where the river exits the basin
  - Virgin and Beaver Dam Mountains in the center of the basin
  - Mt. Bangs on the southern basin boundary, the highest point in the basin at 8,012 feet





Base Map: USGS 1:500,000, 1981

Figure 6.6-1
Virgin River Basin
Geographic Features

Nevada State Boundary
Utah State Boundary
City, Town or Place

6.6.2 Land Ownership in the Virgin River Basin

Land ownership, including the percentage of ownership by category, for the Virgin River Basin is shown in Figure 6.6-2. The principal feature of land ownership in this basin is the large portion of land managed by the U.S. Bureau of Land Management. A description of land ownership data sources and methods is found in Volume 1, Appendix A. More detailed information on protected areas is found in Section 6.0.4. Land ownership categories are discussed below in the order from largest to smallest percentage in the basin.

U.S. Bureau of Land Management (BLM)

- 91.7% of the land is federally owned and managed by the Arizona Strip Field Office of the Bureau of Land Management.
- A small portion of BLM land is managed as the Grand Canyon-Parashant National Monument. The basin includes the 19,600 acre Beaver Dam Mountains Wilderness and a portion of the 87,900 acre Paiute Wilderness, located in the eastern portion of the basin. (see Figure 6.0-14)
- Primary land use is recreation, resource conservation and grazing.

Private

- 5.0% of the land is private.
- The majority of the private land is in the vicinity of Beaver Dam/Littlefield and west of Elbow Canyon Road in an area known as "Scenic."
- Land uses include domestic, commercial and agriculture.

State Trust Land

- 3.3% of the land is held in trust for the public schools under the State Trust Land system.
- State land is located throughout the basin and is interspersed with BLM and private lands.
- Primary land use is grazing.

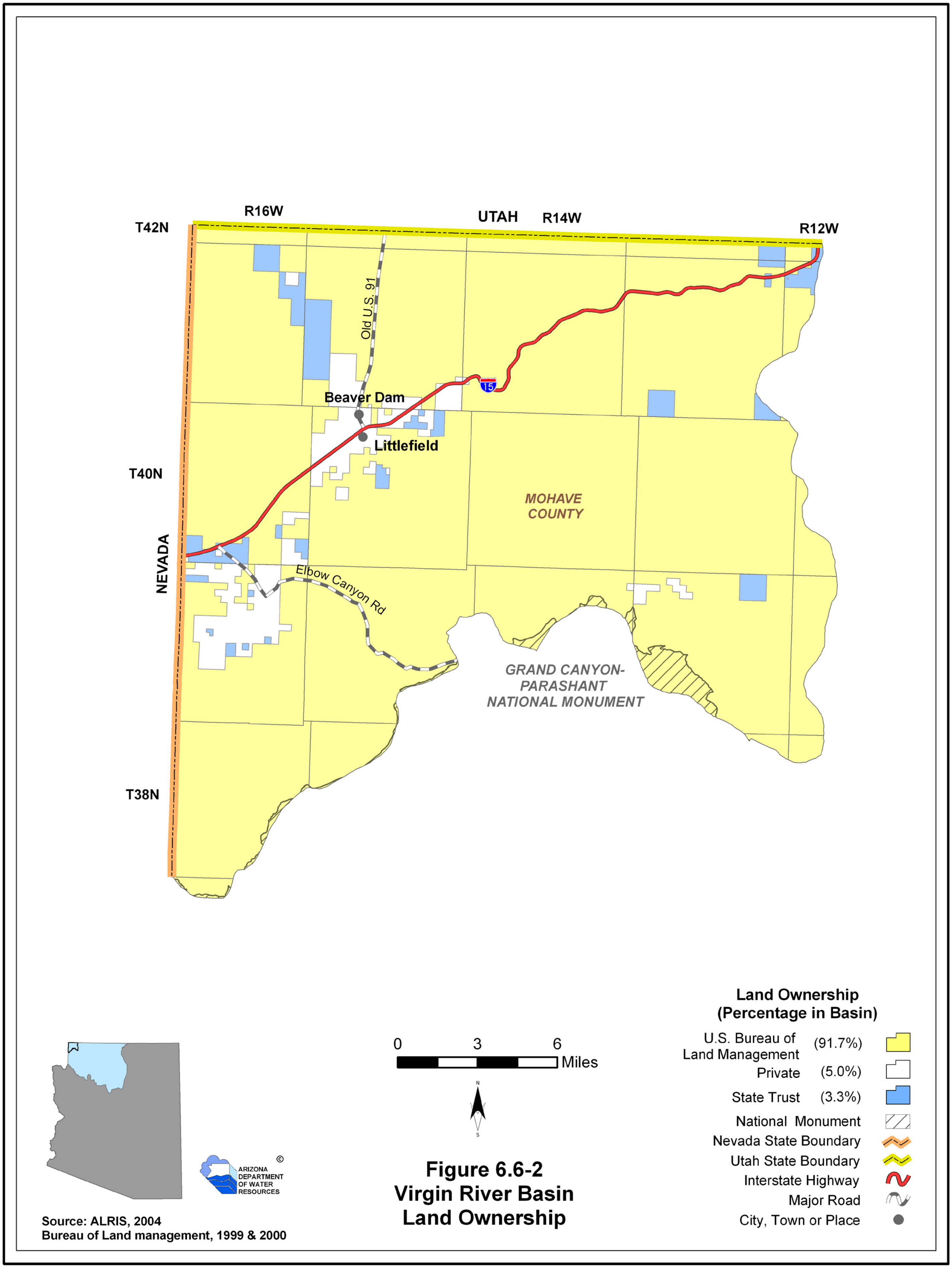


Figure 6.6-2
Virgin River Basin
Land Ownership

6.6.3 Climate of the Virgin River Basin

Climate data from NOAA/NWS Co-op Network stations are complied in Table 6.6-1 and the locations are shown on Figure 6.6-3. Figure 6.6-3 also shows precipitation contour data from the Spatial Climate Analysis Service (SCAS) at Oregon State University. The Virgin River Basin does not contain Evaporation Pan, AZMET or SNOTEL/Snowcourse stations. More detailed information on climate in the planning area is found in Section 6.0.3. A description of the climate data sources and methods is found in Volume 1, Appendix A.

NOAA/NWS Co-op Network

- Refer to Table 6.6-1A
- Temperatures at the one NOAA/NWS Co-op Network station range from an average annual high of 89.5°F in July to an average annual low of 45.5°F in January.
- The highest average seasonal rainfall occurs in the winter season (January-March) when 40% of the annual rainfall occurs. Average annual rainfall is 7.59 inches.

SCAS Precipitation Data

- See Figure 6.6-3
- Additional precipitation data shows average annual rainfall as high as 16 inches in the southeastern portion of the basin and as low as four inches in the western portion of the basin.

Table 6.6-1 Climate Data for the Virgin River Basin

A. NOAA/NWS Co-op Network:

Station Name	Elevation (in feet)	Period of Record Used for Averages	Average Temperature Range (in F)		Average Precipitation (in inches)				
			Max/Month	Min/Month	Winter	Spring	Summer	Fall	Annual
Beaver Dam	1,880	1971-2000	89.5/Jul	45.5/Jan	3.05	0.89	1.68	1.97	7.59

Source: WRCC, 2005

B. Evaporation Pan:

Station Name	Elevation (in feet)	Period of Record Used for Averages	Avg. Annual Evap (in inches)
None			

Source: WRCC, 2005

C. AZMET:

Station Name	Elevation (in feet)	Period of Record	Average Annual Reference Evaportranspiration, in inches (*Number of years to calculate averages*)
None			

D. SNOTEL/Snowcourse:

Station Name	Elevation (in feet)	Period of Record	Average Snowpack, at Beginning of the Month, as Inches Snow Water Content *(Number of measurements to calculate average)*					
			Jan.	Feb.	March	April	May	June
None								

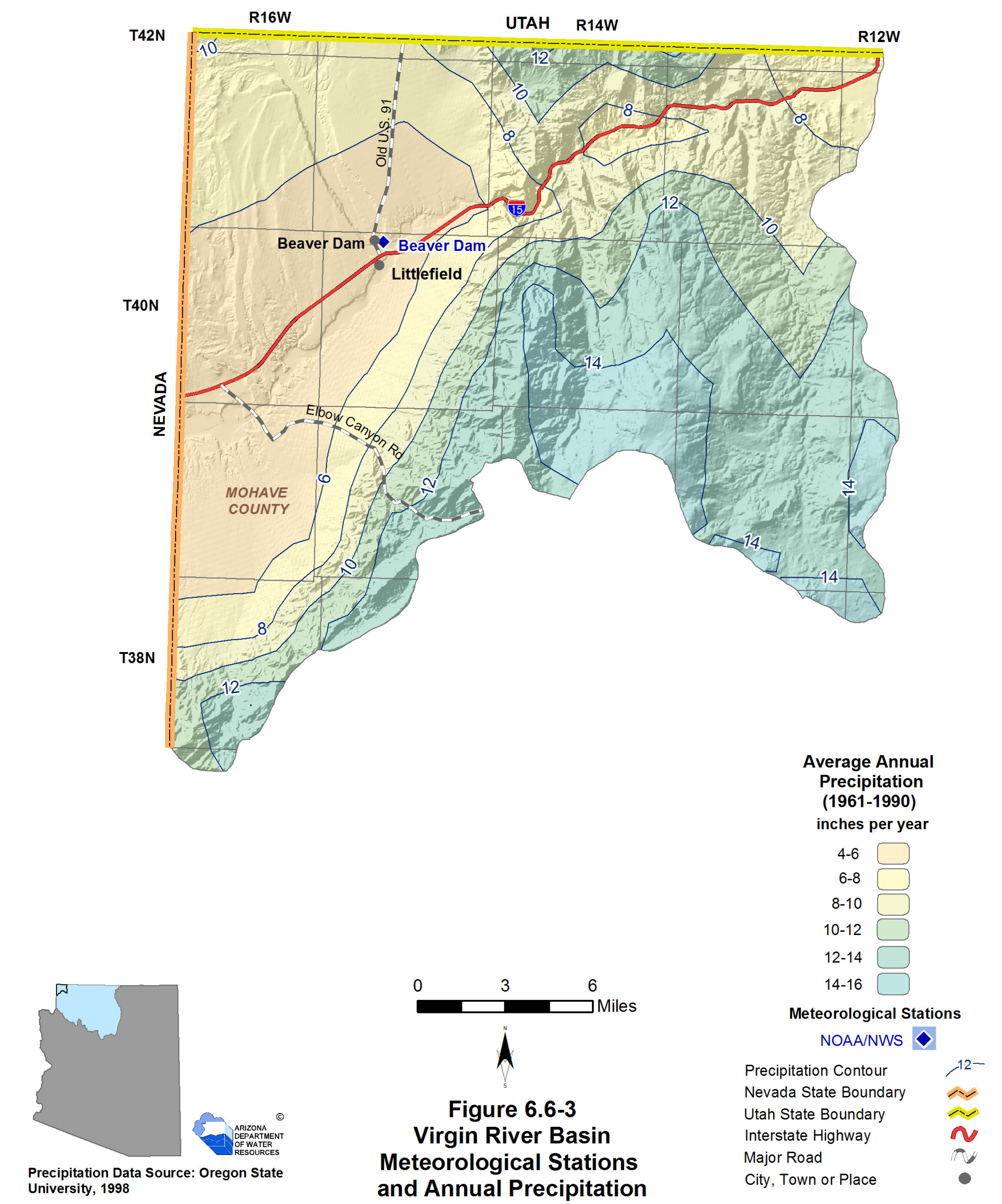


Figure 6.6-3
Virgin River Basin
Meteorological Stations
and Annual Precipitation

6.6.4 Surface Water Conditions in the Virgin River Basin

Streamflow data, including average seasonal flow, average annual flow and other information are shown in Table 6.6-2. Flood ALERT equipment in the basin is shown in Table 6.6-3. Reservoir and stockpond data, including maximum storage or maximum surface area, are shown in Table 6.6-4. The location of streamflow gages identified by USGS number, flood ALERT equipment, USGS runoff contours and large reservoirs are shown on Figure 6.6-5. Descriptions of stream, reservoir and stockpond data sources and methods are found in Volume 1, Appendix A.

Streamflow Data

- Refer to Table 6.6-2.
- Data from three real-time stations located at two watercourses are shown in the table and on Figure 6.6-5.
- In general, average seasonal flow is highest in the winter (January-March).
- The maximum annual flow was 597,522 acre-feet in 2005 at the Virgin River at Littlefield station with a contributing drainage area of 5,090 square miles. This annual flow is not shown on Table 6.6-2 because the statistics are current as of December 2004.
- Figure 6.6-4 shows the periodic flood events in the Virgin River recorded at the Littlefield gage from 1930-2006.

Flood ALERT Equipment

- Refer to Table 6.6-3.
- As of October 2005 there was one station in the basin.

Reservoirs and Stockponds

- Refer to Table 6.6-4.
- There are no large reservoirs and one small reservoir with a total surface area of six acres.
- There are 45 registered stockponds in the basin.

Runoff Contour

- Refer to Figure 6.6-5.
- Average annual runoff is highest, 0.5 inches per year or 26.65 acre-feet per square mile, at the southeastern tip of the basin and decreases to 0.1 inches, or 5.33 acre-feet per square mile, to the north and west.

Figure 6.6-4 Annual Flows (acre-feet) Virgin River at Littlefield, Arizona, water years 1930-2006 (Station # 9415000)

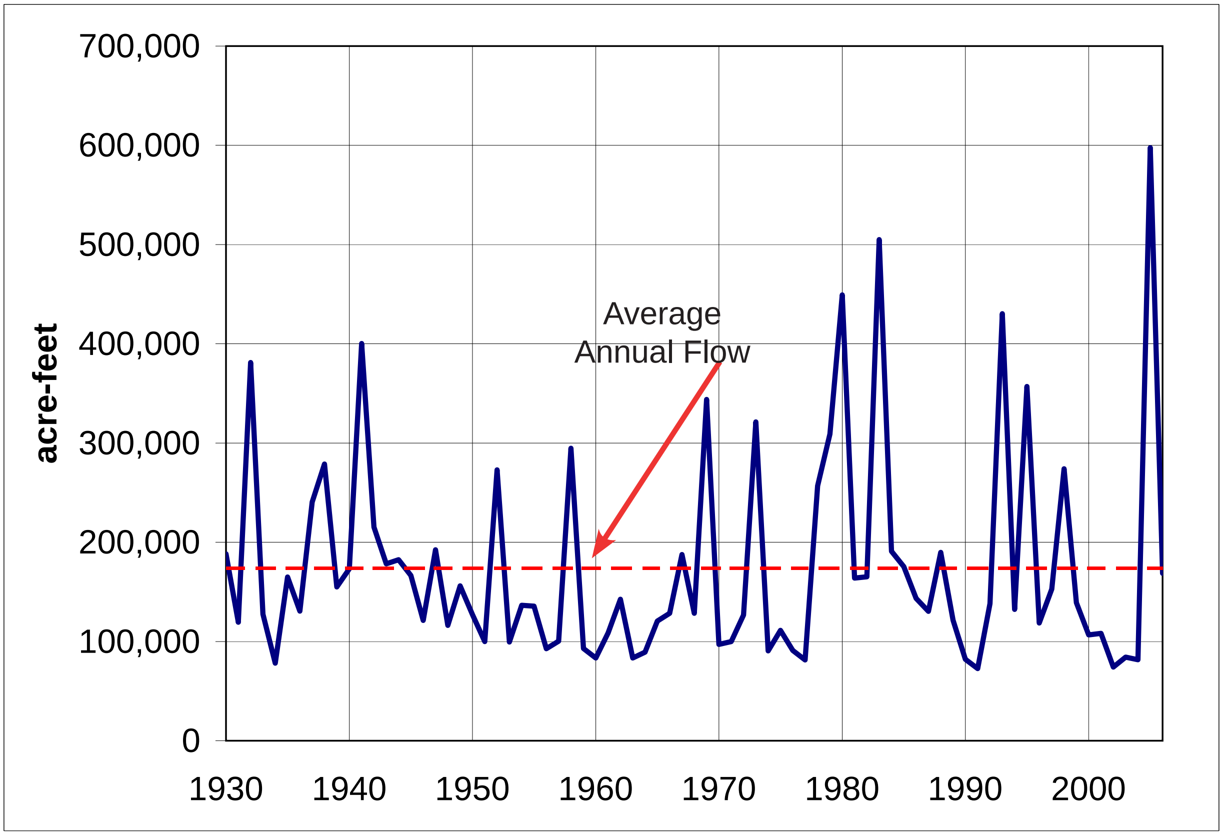


Table 6.6-2 Streamflow Data for the Virgin River Basin

Station Number	USGS Station Name	Drainage Area (in mi^2)	Gage Elevation (in feet)	Period of Record	Average Seasonal Flow (% of annual flow)				Annual Flow (in acre-feet/year)				Years of Annual Flow Record
					Winter	Spring	Summer	Fall	Minimum	Median	Mean	Maximum	
9413700	Virgin River above the Narrows near Littlefield	4,415	2,000	6/1998-current (real time)	31	21	19	29	68,506 (2000)	71,764	92,644	137,663 (2001)	3
9414900	Beaver Dam Wash at Beaver Dam	575	1,850	2/1993-current (real time)	42	21	17	20	1,151 (2002)	1,709	1,572	1,947 (1996)	5
9415000	Virgin River at Littlefield	5,090	1,764	10/1929-current (real time)	32	33	15	20	73,140 (1977)	141,935	174,502	506,912 (1983)	72

Source: USGS (NWIS) 2005 & 2008

Notes:
NA = Not available
Statistics based on Calendar Year
Annual Flow statistics based on monthly values
Summation of Average Annual Flows may not equal 100 due to rounding
Period of record may not equal Year of Record used for annual Flow/Year statistics due to only using years with a 12 month record
In Period of Record, current equals November 2008
Seasonal and annual flow data used for statisitics current through 12/2004

Table 6.6-3 Flood ALERT Equipment in the Virgin River Basin

Station ID	Station Name	Station Type	Install Date	Responsibility
7570	Beaver Dam	Weather Station	NA	Mohave County FCD

Source: ADWR 2005c

Notes:
FCD = Flood Control District
NA = Not available at this time

Table 6.6-4 Reservoirs and Stockponds in the Virgin River Basin

A. Large Reservoirs (500 acre-feet capacity and greater)

MAP KEY	RESERVOIR/LAKE NAME *(Name of dam, if different)*	OWNER/OPERATOR	MAXIMUM STORAGE (AF)	USE	JURISDICTION
None identified by ADWR at this time					

B. Other Large Reservoirs (50 acre surface area or greater)

MAP KEY	RESERVOIR/LAKE NAME *(Name of dam, if different)*	OWNER/OPERATOR	MAXIMUM SURFACE AREA (acres)	USE	JURISDICTION
None identified by ADWR at this time					

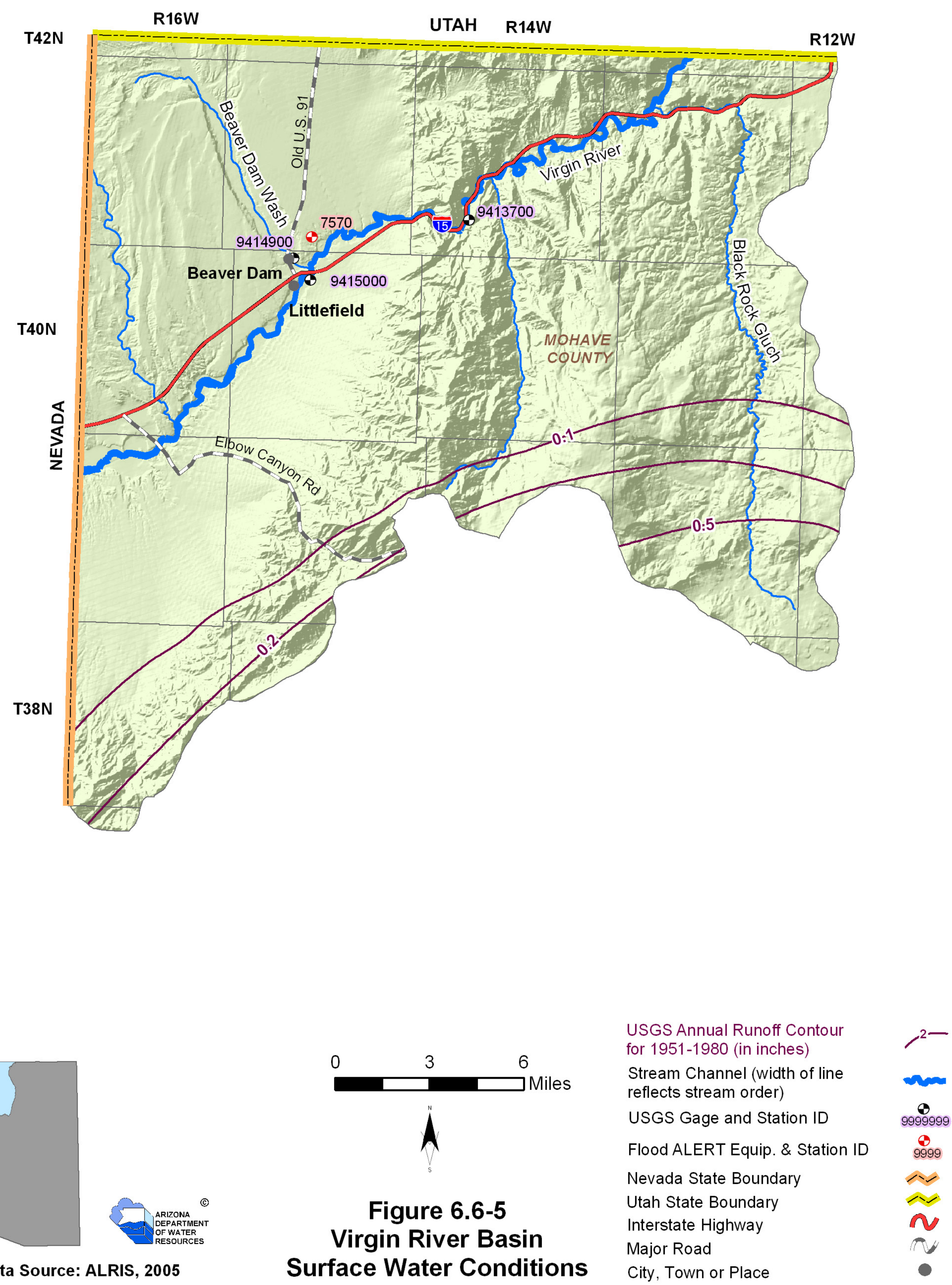
Source: Compilation of databases from ADWR & others

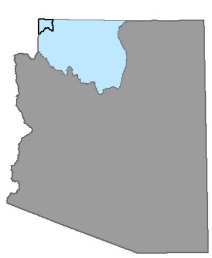
C. Small Reservoirs (greater than 15 acre-feet and less than 500 acre-feet capacity)
Total number: 0
Total maximum storage: 0 acre-feet

D. Other Small Reservoirs (between 5 and 50 acres surface area)[1]
Total number: 1
Total surface area: 6 acres

E. Stockponds (up to 15 acre-feet capacity)
Total number: 45

[1] Capacity data not available to ADWR





Stream Data Source: ALRIS, 2005

Figure 6.6-5
Virgin River Basin
Surface Water Conditions

6.6.5 Perennial/Intermittent Streams and Major Springs in the Virgin River Basin

Major springs with discharge rates and date of measurement and the total number of springs in the basin are shown in Table 6.6-5. The locations of major springs and perennial streams are shown on Figure 6.6-6. Descriptions of data sources and methods for intermittent and perennial reaches and springs are found in Volume 1, Appendix A.

- There are no intermittent streams. Perennial streams are the Virgin River and a short reach of Beaver Dam Wash.
- There are eight springs along a seven mile reach of the Virgin River near the Narrows. The total discharge for these springsis between 8,980 gpm and 22,400 gpm.
- The total number of springs, regardless of discharge, identified by the USGS varies from 23 to 25, depending on the database reference.

Table 6.6-5 Springs in the Virgin River Basin

A. Major Springs (10 gpm or greater):

Map Key	Name	Location		Discharge (in gpm)[1]	Date Discharge Measured
		Latitude	Longitude		
1	Littlefield (multiple)	365539	1134950	8,980 - 22,400[2]	During or prior to 2000
2	Beaver Dam Wash (multiple)	365411	1135615	1,120[3]	During or prior to 1997

B. Minor Springs (1 to 10 gpm):

Name	Location		Discharge (in gpm)	Date Discharge Measured
	Latitude	Longitude		
None identified by ADWR at this time				

Source: Compilation of databases from ADWR & others

C. Total number of springs, regardless of discharge, identified by USGS (see ALRIS, 2005a and USGS, 2006): 23 to 25

Notes:

[1] Most recent measurement identified by ADWR
[2] Discharge of 8 springs in a 7 mile reach from the Narrows to the Littlefield gage
[3] Estimation of discharge along Beaver Dam Wash above Littlefield gage

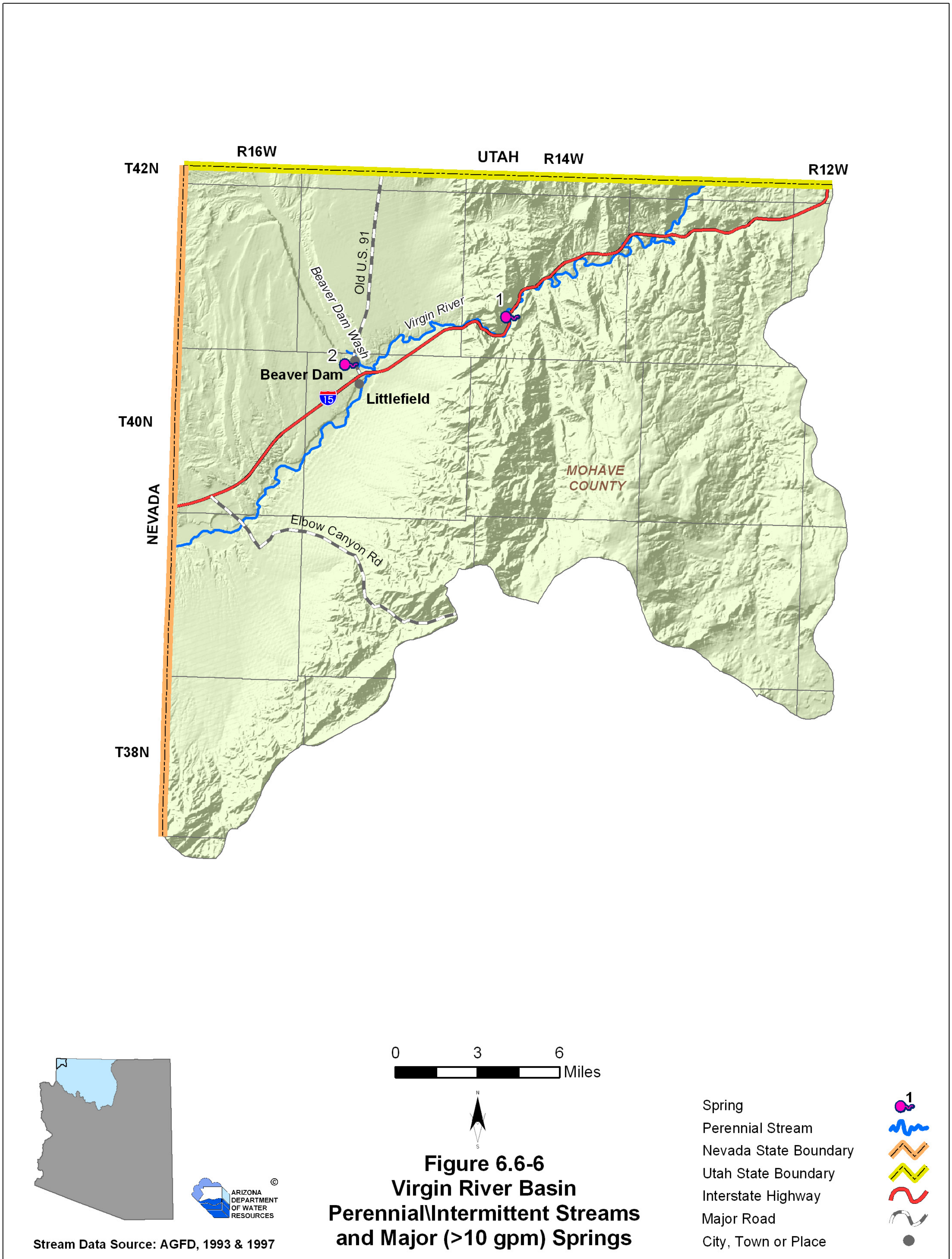


Figure 6.6-6
Virgin River Basin
Perennial\Intermittent Streams and Major (>10 gpm) Springs

6.6.6 Groundwater Conditions of the Virgin River Basin

Major aquifers, well yields, estimated natural recharge, estimated water in storage, number of index wells and date of last water-level sweep are shown in Table 6.6-6. Figure 6.6-7 shows aquifer flow direction and water-level change between 1990-1991 and 2003-2004. Figure 6.6-8 contains hydrographs for selected wells shown on Figure 6.6-7. Figure 6.6-9 shows well yields in five yield categories. A description of aquifer data sources and methods as well as well data sources and methods, including water-level changes and well yields are found in Volume 1, Appendix A.

Major Aquifers

- Refer to Table 6.6-6 and Figure 6.6-7.
- Major aquifers in the basin include basin fill and sedimentary rock (Muddy Creek Formation).
- Flow direction is generally toward the west following Beaver Dam Wash and the Virgin River drainages.

Well Yields

- Refer to Table 6.6-6 and Figure 6.6-9.
- As shown on Figure 6.6-9, well yields in this basin range from less than 100 gallons per minute (gpm) to greater than 2,000 gpm.
- One source of well yield information, based on 53 reported wells, indicates that the median well yield in this basin is 650 gpm.

Natural Recharge

- Refer to Table 6.6-6.
- The natural recharge estimate for this basin is greater than 30,000 acre-feet per year (AFA).

Water in Storage

- Refer to Table 6.6-6.
- The storage estimate for this basin is is 1.7 million acre-feet (maf) of water in storage to a depth of 1,200 feet.

Water Level

- Refer to Figure 6.6-7. Water levels are shown for wells measured in 2003-2004.
- The Department annually measures six index wells in this basin. Hydrographs for four of these wells and one other well are shown in Figure 6.6-8. Index well hydrographs are: A, B, D and E.
- There is one ADWR automated groundwater level monitoring device located near Littlefield.
- The deepest recorded water level in the basin is 380 feet in the northern portion of the basin and the shallowest is 57 feet north of Beaver Dam.

Table 6.6-6 Groundwater Data for the Virgin River Basin

Basin Area, in square miles:	434	
Major Aquifer(s):	**Name and/or Geologic Units**	
	Basin Fill	
	Sedimentary Rock (Muddy Creek Formation)	
Well Yields, in gal/min:	Range 3-5,500 Median 650 (53 wells reported)	Reported on registration forms for large (>10-inch) diameter wells (Wells55)
	Range 0-2,000	ADWR (1990 and 1994b)
	Range 0-2,500	Anning and Duet (1994)
Estimated Natural Recharge, in acre-feet/year:	>30,000	Virgin Valley Water District (2005)
Estimated Water Currently in Storage, in acre-feet:	1,700,000 (to 1,200 ft)	ADWR (1994b)
Current Number of Index Wells:	6	
Date of Last Water-level Sweep:	1991 (65 wells measured)	

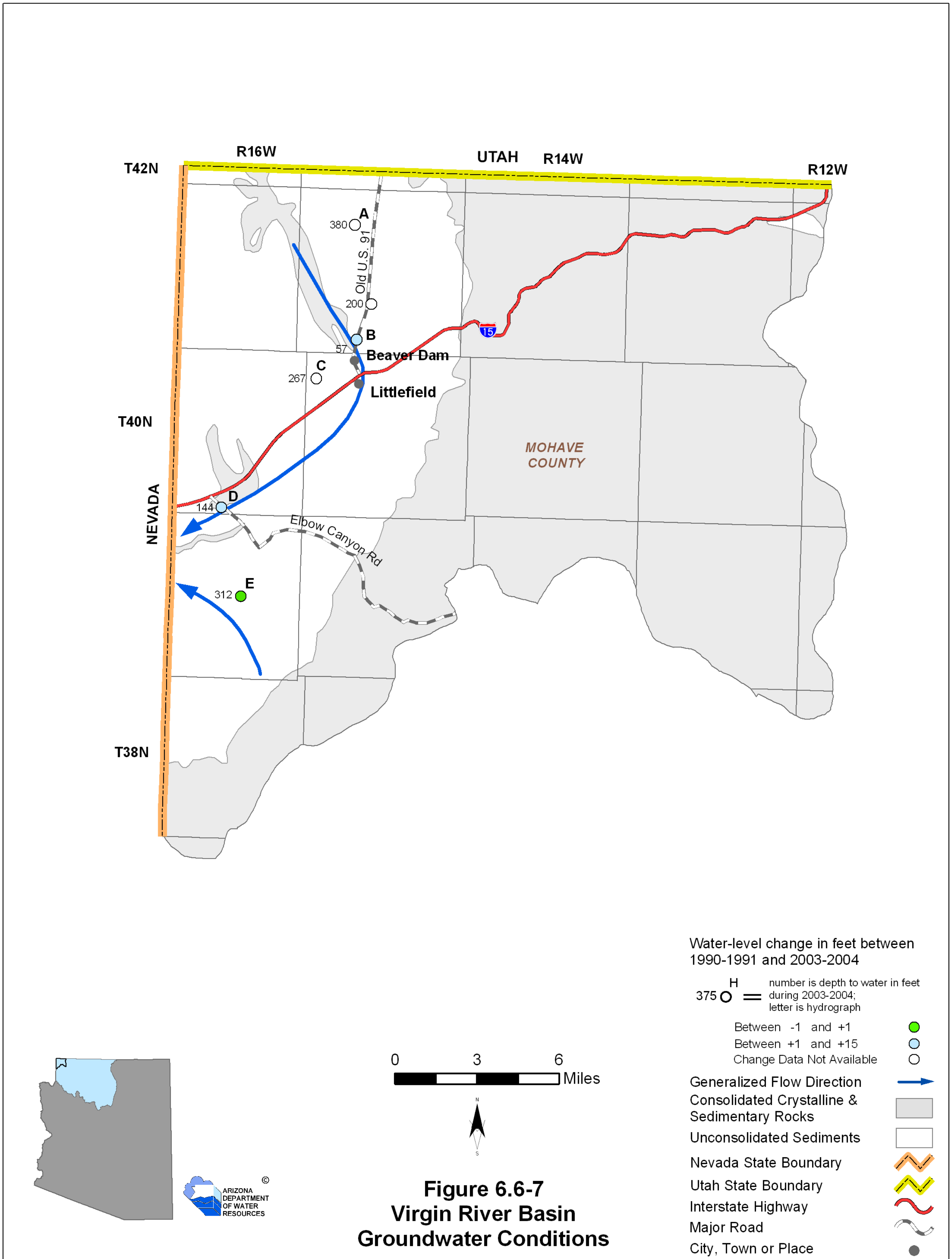
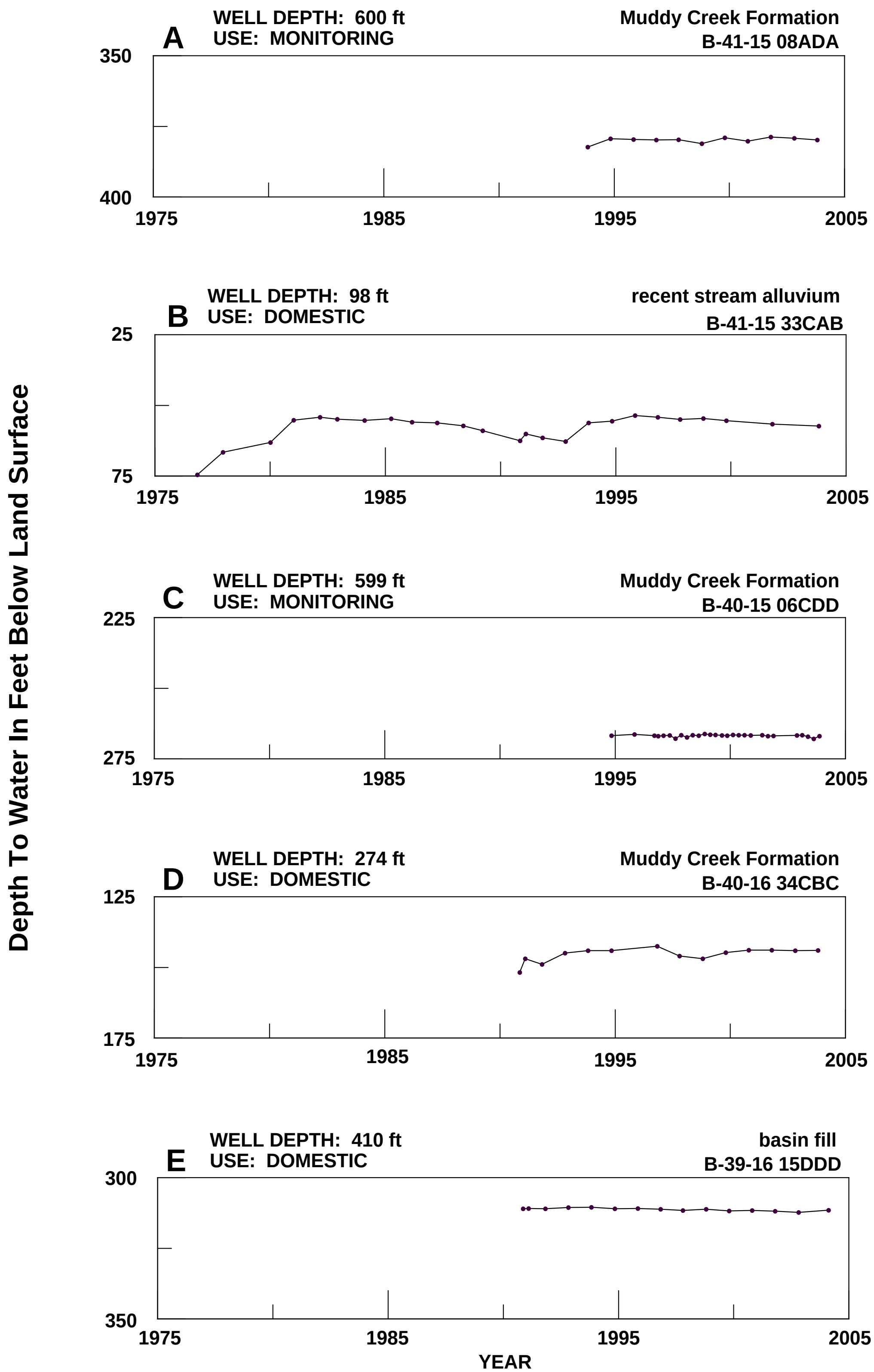


Figure 6.6-7
Virgin River Basin
Groundwater Conditions

Figure 6.6-8
Virgin River Basin
Hydrographs Showing Depth to Water in Selected Wells



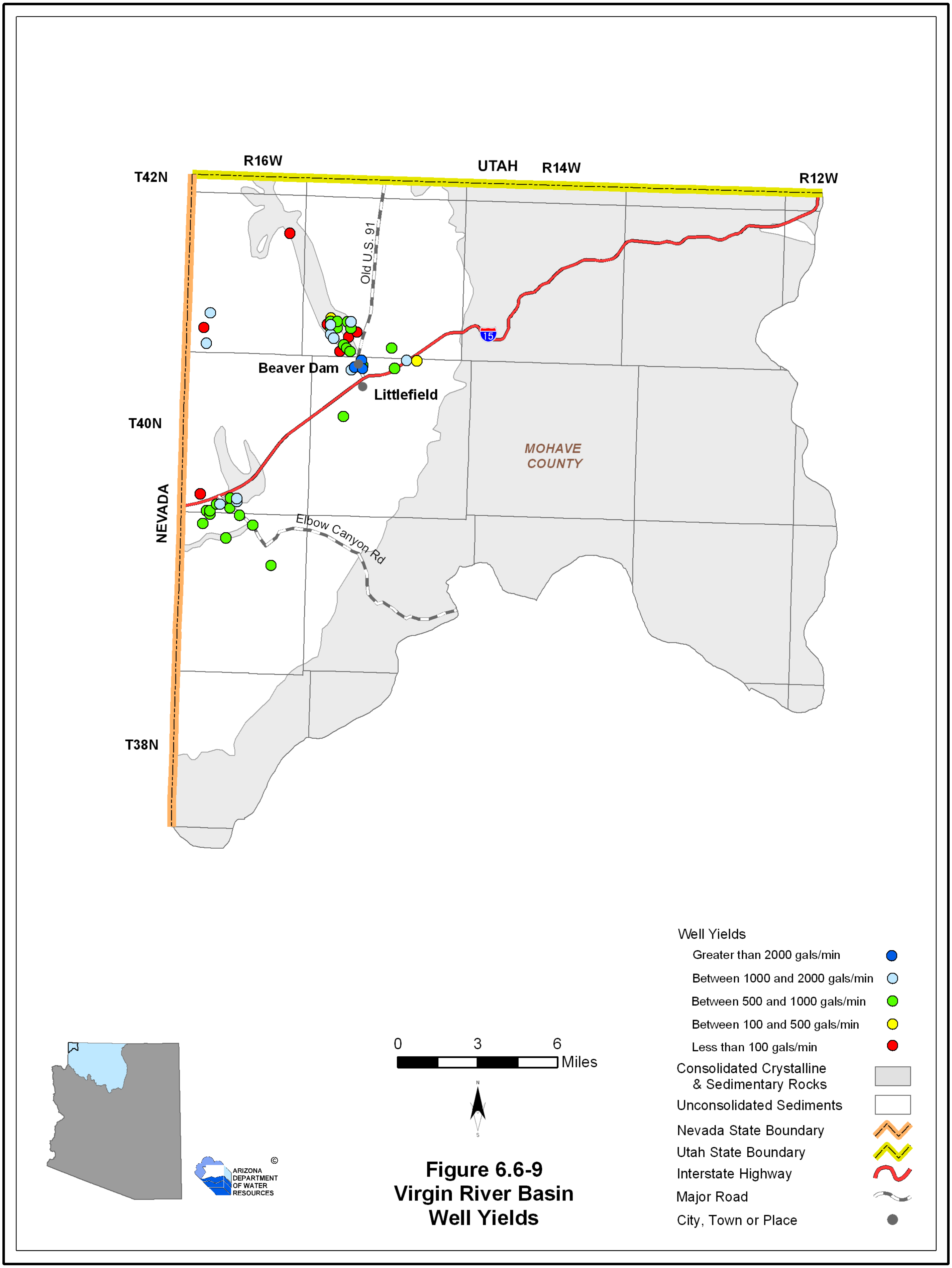


Figure 6.6-9
Virgin River Basin
Well Yields

6.6.7 Water Quality of the Virgin River Basin

Wells, springs and mine sites with parameter concentrations that have equaled or exceeded drinking water standard(s), including location and parameter(s) are shown in Table 6.6-7A. Impaired lakes and streams with site type, name, length of impaired reach, area of impaired lake, designated use standard and parameter(s) exceeded is shown in Table 6.6-7B. Figure 6.6-10 shows the location of water quality occurrences keyed to Table 6.6-7. All community water systems are regulated under the Safe Drinking Water Act and treat water supplies to meet drinking water standards. Not all parameters were measured at all sites; selective sampling for particular constituents is common. A description of water quality data sources and methods is found in Volume 1, Appendix A.

Well, Mine or Spring sites that have equaled or exceeded drinking water standards (DWS)

- Refer to Table 6.6-7A.
- Thirteen wells have parameter concentrations that have equaled or exceeded drinking water standards.
- The most common standard equaled or exceeded was arsenic. Other standards equaled or exceeded were radionuclides, nitrates and lead.

Lakes and Streams with impaired waters

- Refer to Table 6.6-7B.
- Water quality standards for suspended sediment concentration and selenium were exceeded in one 10-mile stream reach, the Virgin River from Beaver Dam Wash to Big Bend Wash.
- This reach is not part of the ADEQ water quality improvement effort called the Total Maximum Daily Load (TMDL) Program at this time.

Table 6.6-7 Water Quality Exceedences in the Virgin River Basin[1]

A. Wells, Springs and Mines

Map Key	Site Type	Site Location			Parameter(s) Concentration has Equaled or Exceeded Drinking Water Standard (DWS)[2]
		Township	Range	Section	
1	Well	41 North	15 West	32	As
2	Well	41 North	15 West	32	As
3	Well	40 North	15 West	3	As, Rad
4	Well	40 North	15 West	3	As
5	Well	40 North	15 West	3	As
6	Well	40 North	15 West	4	As
7	Well	40 North	15 West	5	As
8	Well	40 North	15 West	5	As
9	Well	40 North	16 West	33	NO3
10	Well	39 North	16 West	3	Pb
11	Well	39 North	16 West	11	As
12	Well	39 North	16 West	11	As
13	Well	39 North	16 West	15	As

Source: Compilation of databases from ADWR & others

B. Lakes and Streams

Map Key	Site Type	Site Name	Length of Impaired Stream Reach (in miles)	Area of Impaired Lake (in acres)	Designated Use Standard[3]	Parameter(s) Exceeding Use Standard[2]
a	Stream	Virgin River (Beaver Dam Wash to Big Bend Wash)	10	NA	A&W	Se, Suspended sediment concentration

Source: ADEQ 2005d

Notes:

NA = Not Applicable
[1] Water quality samples collected between 1997 and 2002.
[2] As = Arsenic
NO3 = Nitrate
Rad = One or more of the following radionuclides - Gross Alpha, Gross Beta, Radium, and Uranium
Se = Selenium
[3] A&W = Aquatic and Wildlife

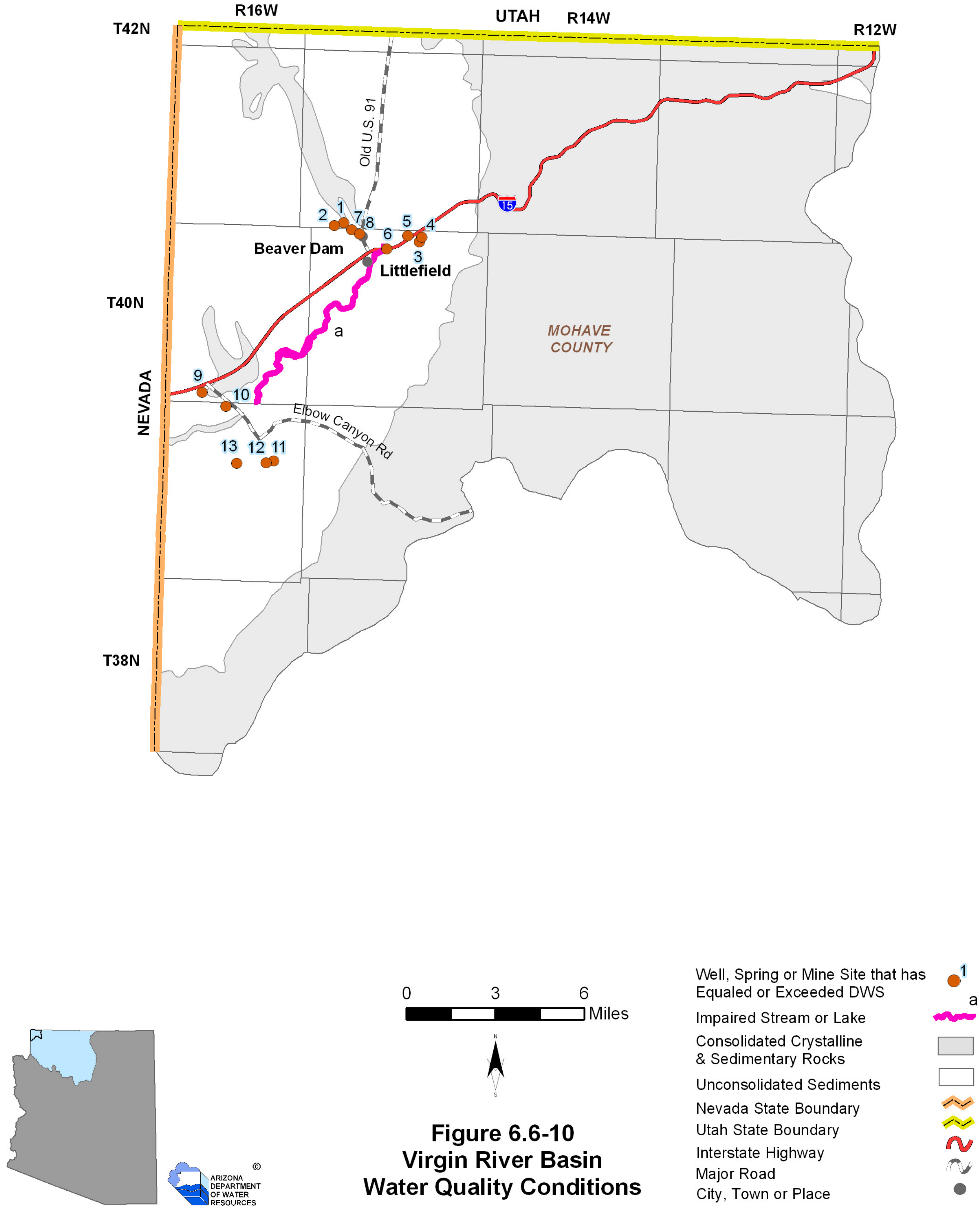


Figure 6.6-10
Virgin River Basin
Water Quality Conditions

6.6.8 Cultural Water Demand in the Virgin River Basin

Cultural water demand data including population, number of wells and the average well pumpage and surface water diversions by the municipal, industrial and agricultural sectors are shown in Table 6.6-8. Effluent generation including facility ownership, location, population served and not served, volume treated, disposal method and treatment level is shown in Table 6.6-9. Figure 6.6-11 shows the location of demand centers. A description of cultural water demand data sources and methods is found in Volume 1, Appendix A. More detailed information on cultural water demand is found in Section 6.0.7.

Cultural Water Demand

- Refer to Table 6.6-8 and Figure 6.6-11.
- Population in this basin increased from 99 in 1980 to 1,532 in 2000 and is projected to reach 3,267 by 2030.
- Groundwater demand increased from 5,000 AFA on average in 1971-1975 to approximately 9,150 AFA on average from 1996-2000. In 2001-2005 groundwater demand was 2,950 AFA on average.
- Surface water demand was 3,000 AFA on average from 1971-1990 and increased to approximately 6,350 acre-feet in 1996-2000. In 2001-2005 surface water use was approximately 1,650 AFA on average due to declining agricultural demand.
- Most basin demand for both surface water and groundwater is for irrigation. Agricultural demand centers are found in the vicinity of Beaver Dam/Littlefield and Elbow Canyon Road. Flooding in January 2005 destroyed some of the agricultural fields in this basin.
- All recorded industrial demand in the basin is for two golf courses.
- There are two sand and gravel operations in the vicinity of Scenic and Beaver Dam, their water demand was not available.
- As of 2005 there were 248 registered wells with a pumping capacity of less than or equal to 35 gallons per minute (gpm) and 136 wells with a pumping capacity of more than 35 gpm.

Effluent Generation

- Refer to Table 6.6-9.
- There are four wastewater treatment facilities in this basin, but information on population served, effluent generation and disposal method is available only for the Beaver Dam Sewer Company Wastewater Treatment Plant. This plant serves 119 people, generates 6.2 acre-feet of effluent and discharges to a watercourse.

Table 6.6-8 Cultural Water Demand in the Virgin River Basin[1]

<table>
<tr><th rowspan="3">Year</th><th rowspan="3">Estimated and Projected Population</th><th colspan="2" rowspan="2">Number of Registered Water Supply Wells Drilled</th><th colspan="6">Average Annual Demand (in acre-feet)</th><th rowspan="3">Data Source</th></tr>
<tr><th colspan="3">Well Pumpage</th><th colspan="3">Surface-Water Diversions</th></tr>
<tr><th>Q ≤ 35 gpm</th><th>Q > 35 gpm</th><th>Municipal</th><th>Industrial</th><th>Agricultural</th><th>Municipal</th><th>Industrial</th><th>Agricultural</th></tr>
<tr><td>**1971**</td><td></td><td rowspan="10">21[2]</td><td rowspan="10">37[2]</td><td colspan="3" rowspan="5">5,000</td><td colspan="3" rowspan="5">3,000</td><td rowspan="20">ADWR (1994a)</td></tr>
<tr><td>**1972**</td><td></td></tr>
<tr><td>**1973**</td><td></td></tr>
<tr><td>**1974**</td><td></td></tr>
<tr><td>**1975**</td><td></td></tr>
<tr><td>**1976**</td><td></td><td colspan="3" rowspan="5">6,000</td><td colspan="3" rowspan="5">3,000</td></tr>
<tr><td>**1977**</td><td></td></tr>
<tr><td>**1978**</td><td></td></tr>
<tr><td>**1979**</td><td></td></tr>
<tr><td>**1980**</td><td>99</td></tr>
<tr><td>**1981**</td><td>109</td><td rowspan="5">11</td><td rowspan="5">16</td><td colspan="3" rowspan="5">6,000</td><td colspan="3" rowspan="5">3,000</td></tr>
<tr><td>**1982**</td><td>119</td></tr>
<tr><td>**1983**</td><td>129</td></tr>
<tr><td>**1984**</td><td>139</td></tr>
<tr><td>**1985**</td><td>150</td></tr>
<tr><td>**1986**</td><td>160</td><td rowspan="5">43</td><td rowspan="5">32</td><td colspan="3" rowspan="5">7,000</td><td colspan="3" rowspan="5">3,000</td></tr>
<tr><td>**1987**</td><td>170</td></tr>
<tr><td>**1988**</td><td>180</td></tr>
<tr><td>**1989**</td><td>190</td></tr>
<tr><td>**1990**</td><td>200</td></tr>
<tr><td>**1991**</td><td>333</td><td rowspan="5">71</td><td rowspan="5">22</td><td rowspan="5"><300</td><td rowspan="5">700</td><td rowspan="5">7,800</td><td rowspan="5">NR</td><td rowspan="5"><300</td><td rowspan="5">5,800</td><td rowspan="15">USGS (2007) ADWR (2008b) ADWR (2005a)</td></tr>
<tr><td>**1992**</td><td>466</td></tr>
<tr><td>**1993**</td><td>600</td></tr>
<tr><td>**1994**</td><td>733</td></tr>
<tr><td>**1995**</td><td>866</td></tr>
<tr><td>**1996**</td><td>999</td><td rowspan="5">37</td><td rowspan="5">15</td><td rowspan="5"><300</td><td rowspan="5">700</td><td rowspan="5">8,300</td><td rowspan="5">NR</td><td rowspan="5"><300</td><td rowspan="5">6,200</td></tr>
<tr><td>**1997**</td><td>1,133</td></tr>
<tr><td>**1998**</td><td>1,266</td></tr>
<tr><td>**1999**</td><td>1,399</td></tr>
<tr><td>**2000**</td><td>1,532</td></tr>
<tr><td>**2001**</td><td>1,598</td><td rowspan="5">65</td><td rowspan="5">14</td><td rowspan="5"><300</td><td rowspan="5">700</td><td rowspan="5">2,100</td><td rowspan="5">NR</td><td rowspan="5"><300</td><td rowspan="5">1,500</td></tr>
<tr><td>**2002**</td><td>1,664</td></tr>
<tr><td>**2003**</td><td>1,729</td></tr>
<tr><td>**2004**</td><td>1,795</td></tr>
<tr><td>**2005**</td><td>1,860</td></tr>
<tr><td>**2010**</td><td>2,188</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>**2020**</td><td>2,783</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>**2030**</td><td>3,267</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td>***WELL TOTALS:***</td><td>**268**</td><td>**136**</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

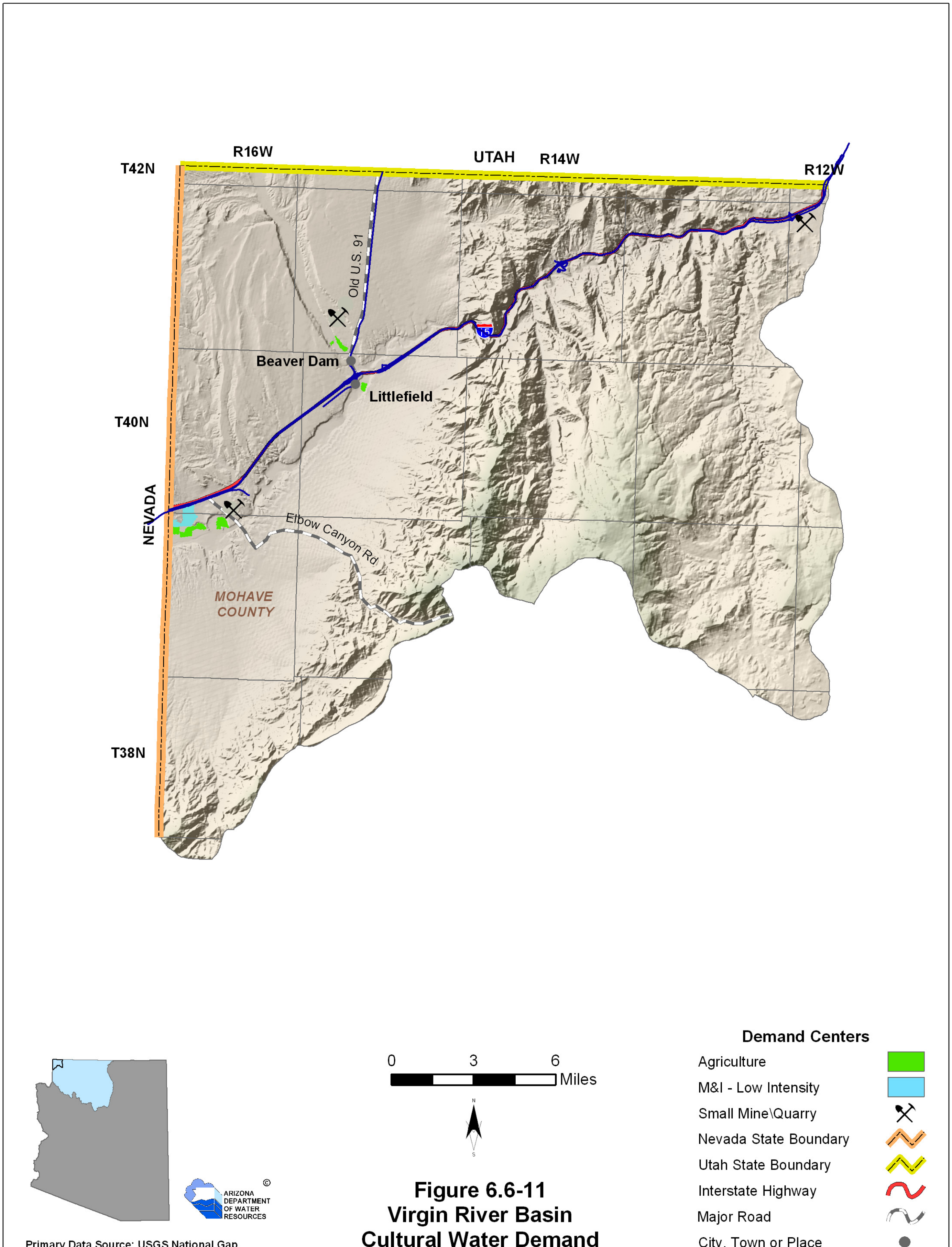
[1] Does not include effluent of evaporation losses from stockponds and reservoirs.
[2] Includes all wells through 1980.
NR - Not reported

Table 6.6-9 Effluent Generation in the Virgin River Basin

Facility Name	Ownership	City/Location Served	Population Served	Volume Treated/Generated (acre-feet/year)	Disposal Method									Current Treatment Level	Population Not Served	Year of Record
					Water-course	Evaporation Pond	Irrigation	Golf Course/Turf/ Landscape	Municipal Reuse	Wildlife Area	Discharged to Another Facility	Infiltration Basins	Other			
Beaver Dam Sewer Co. WWTP	Virgin River ID	Beaver Dam	119	6.2	X									Secondary	NA	2002
Biasi WWTP	Private	Beaver Dam	NA													
Shadow Ridge WWTP	NA	Littlefield	NA													
Virgin Acres WWTP	NA	Beaver Dam	NA													

Source: Compilation of databases from ADWR & others

Notes:
Year of Record is for the volume of effluent treated/generated
NA:Data not currently available to ADWR
WWTP: Waste Water Treatment Plant
ID: Improvement District



Primary Data Source: USGS National Gap Analysis Program, 2004; ADWR, 2007

Figure 6.6-11
Virgin River Basin
Cultural Water Demand

6.6.9 Water Adequacy Determinations in the Virgin River Basin

Water adequacy determination information including the subdivision name, location, number of lots, adequacy determination, reason for the inadequacy determination, date of determination and subdivision water provider are shown in Table 6.6-10A and B for water reports and analysis of adequate water supply. Figure 6.6-12 shows the locations of subdivisions keyed to the Table. A description of the Water Adequacy Program is found in Volume 1, Appendix C. Adequacy determination data sources and methods are found in Volume 1, Appendix A.

- All subdivisions receiving an adequacy determination are in Mohave County. Fifteen water adequacy determinations for 1,643 lots have been made in this basin through December, 2008. One thousand six hundred and seventeen lots in 14 subdivisions, or 99% of lots, were determined to be adequate.
- The one determination of inadequacy was because the applicant chose not to submit the necessary information, and/or the available hydrologic data was insufficient to make a determination.
- There are two Analysis of Adequate Water Supply applications for a total of 27,700 lots.

Table 6.6-10. Adequacy Determinations in the Virgin River Basin[1]

A. Water Adequacy Reports

Map Key	Subdivision Name	County	Location			No. of Lots	ADWR File No.[2]	ADWR Adequacy Determination	Reason(s) for Inadequacy Determination[3]	Date of Determination	Water Provider at the Time of Application
			Township	Range	Section						
1	Beaver Dam Estates	Mohave	41 North	15 West	5	48	53-500309	Adequate		5/6/1992	Beaver Dam East Domestic W.I.D.
2	Beaver Dam Oasis	Mohave	41 North	15 West	33	9	53-500310	Adequate		1/23/1992	Dry Lot Subdivision
4	Beaver Dam Resort, Inc.	Mohave	40 North	15 West	4, 5	191	53-500311	Adequate		10/1/1987	Beaver Dam Water Company
5	Beaver Dam Virgin Acres #1	Mohave	41 North	15 West	32	51	53-300115	Adequate		7/10/1996	Beaver Dam Water Company
6	Desert Springs Ranchos	Mohave	40 North	15 West	3	21	53-500585	Adequate		1/13/1994	Dry Lot Subdivision
7	Fairview Mobile Home Estates	Mohave	40 North	16 West	32	26	53-500629	Inadequate	A1	11/30/1987	Beaver Dam Water Company
9	Shadow Ridge	Mohave	39 North	16 West	17, 21	478	53-700568	Adequate		12/4/2008	Beaver Dam Water Company
10	Shadow Ridge, Phase 1	Mohave	39 North	16 West	21	67	53-402211	Adequate		12/6/2006	Beaver Dam Water Company
11	Terra Vista Skies	Mohave	40 North	16 West	32	30	53-400852	Adequate		7/21/2006	Beaver Dam Water Company
12	Virgin Acres - B	Mohave	41 North	15 West	32	40	53-300568	Adequate		12/4/1998	Beaver Dam Water Company
13	Virgin Acres	Mohave	41 North	15 West	29, 32	320	53-501641	Adequate		9/25/1995	Biasi Water Company, Inc.
14	Virgin Acres	Mohave	41 North	15 West	32	65	53-300485	Adequate		7/24/1998	Beaver Dam Water Company
15	Virgin Acres, aka Biasi Ranch Estates	Mohave	41 North	15 West	29	19	53-401814	Adequate		9/8/2005	Biasi Water Company, Inc.
16	Virgin Village I & II	Mohave	41 North	15 West	32	93	53-300507	Adequate		10/7/1998	Biasi Water Company, Inc.
17	Vista Verde	Mohave	40 North	16 West	33	185	53-500057	Adequate		3/10/2008	Beaver Dam Water Company

B. Analysis of Adequate Water Supply

Map Key	Subdivision Name	County	Location			No. of Lots	ADWR File No.[2]	Date of Determination	Water Provider at the Time of Application
			Township	Range	Section				
3	Beaver Dam Ranch	Mohave	40 North	15 West	5, 6, 7, 8, 17, 18	23,420	43-500093	7/9/2008	Beaver Dam Water Company
8	Michael T. Black Properties	Mohave	39 North	16 West	11, 14	4,280	43-700506	7/9/2008	Virgin Mountain Utilities

Source: ADWR 2008a

Notes:

[1]Each determination of the adequacy of water supplies available to a subdivision is based on the information available to ADWR and the standards of review and policies in effect at the time the determination was made. In some cases, ADWR might make a different determination if a similar application were submitted today, based on the hydrologic data and other information currently available, as well as current rules and policies.

[2] Prior to February 1995, ADWR did not assign file numbers to applications for adequacy. Between 1995-2006 all applications for adequacy were given a file number with a 22 prefix. In 2006 a 53 prefix was assigned to all water adequacy reports and applications regardless of their issue date.

[3] A. Physical/Continuous
1) Insufficient Data (applicant chose not to submit necessary information, and/or available hydrologic data insufficient to make determination)
2) Insufficient Supply (existing water supply unreliable or physically unavailable; for groundwater, depth-to-water exceeds criteria)
3) Insufficient Infrastructure (distribution system is insufficient to meet demands or applicant proposed water hauling)

B. Legal (applicant failed to demonstrate a legal right to use the water or failed to demonstrate the provider's legal authority to serve the subdivision)
C. Water Quality
D. Unable to locate records

NA = Not available to ADWR at this time

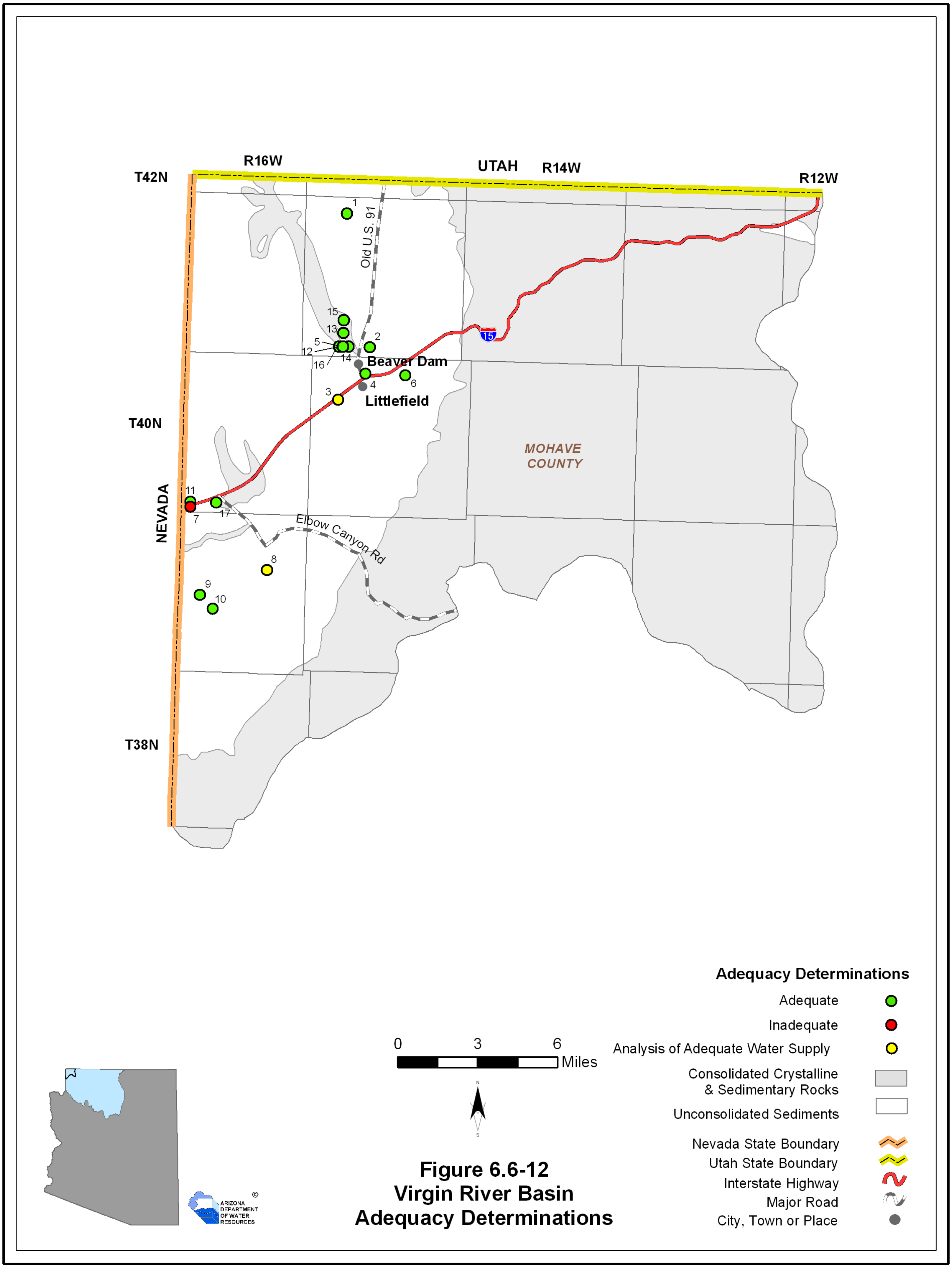


Figure 6.6-12
Virgin River Basin
Adequacy Determinations

Virgin River Basin
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ACRONYMS AND ABBREVIATIONS

AAWS	Analysis of Adequate Water Supply
ADMMR	Arizona Department of Mines and Mineral Resources
ADWR	Arizona Department of Water Resources
ADEQ	Arizona Department of Environmental Quality
AFA	Acre-feet per annum (year)
ALERT	Automated Local Evaluation in Real Time
ALRIS	Arizona Land Resource Information System
AMA	Active Management Area
AMP	Adaptive Management Program
AMWG	Glen Canyon Adaptive Management Work Group
ASLD	Arizona State Land Department
AWPF	Arizona Water Protection Fund
AZGF	Arizona Game and Fish Department
AZGS	Arizona Geological Survey
AZMET	Arizona Meteorological Network
BLM	United States Bureau of Land Management
bls	Below land surface
C-Aquifer	Coconino Aquifer
cfs	cubic feet per second
CLIMAS	Climate Assessment for the Southwest
CWR	Certificate of water right
DES	Arizona Department of Economic Security
DOD	United States Department of Defense
DWID	Domestic water improvement district
EIS	Environmental Impact Statement
ESA	Endangered Species Act
FEIS	Final Environmental Impact Statement
GIS	Geographic Information System
GCNP	Grand Canyon National Park
gpm	Gallons per minute
GWSI	Groundwater Site Inventory System
HSR	Hydrographic Survey Report
HUC	Hydrologic Unit Code
ITCA	Intertribal Council of Arizona
LCR	Little Colorado River
LDIG	Local Drought Impact Group
LUST	Leaking Underground Storage Tank
maf	Million acre-feet
NHD	National Hydrography Dataset
NOAA	National Oceanic and Atmospheric Administration
NPS	United States National Park Service
NRCS	Natural Resources Conservation Service
NWIS	National Water Information System

Appendix A

Appendix A
Arizona Water Protection Fund Projects in the Western Plateau Planning Area through 2008[1]

WESTERN PLATEAU PLANNING AREA			
Groundwater Basin	**AWPF Grant #**	**Project Title**	**Project Category**
Coconino Plateau	96-0019	Response of Bebb Willow to Riparian Restoration	Stream Restoration
Coconino Plateau	99-071	Protection of Spring and Seep Resources of the South Rim, Grand Canyon National Park by Measuring Water Quality, Flow, and Associated Biota	Research
Coconino Plateau	99-074	Proposal to Inventory, Assess, and Recommend Recovery Priorities for Arizona Strip Springs, Seeps, and Natural Ponds	Research
Coconino Plateau	99-093	Coconino Plateau Regional Water Study	Research
Coconino Plateau	05-131	Management & Control of Tamarisk and Other Invasive Vegetation at Backcountry Seeps, Springs, and Tributaries in Grand Canyon National Park	Exotic Species Control
Coconino Plateau	06-138	Management and Control of Tamarisk and Other Invasive Vegetation at back County Seeps, Springs, and Tributaries in Grand Canyon National Park – Second Year Phase II	Habitat Restoration
Grand Wash	06-137	Pakoon springs Restoration Design and Implementation Project	Habitat Restoration
Kanab Plateau	96-0004	Hydrologic Investigation & Conservation Planning: Pipe Springs	Research
Kanab Plateau	98-061	Watershed Enhancement on the Antelope Allotment	Upland Water Developments
Kanab Plateau	99-075	Glen and Grand Canyon Riparian Restoration Project	Exotic Species Control & Revegetation
Paria	08-157	Paria River Exotic Removal Project	Habitat Restoration

[1] A map with all Arizona Water Protection Fund grant locations can be found in Volume 1

Appendix B

APPENDIX B: Community Water System Annual Reports and Submitted Plans

PCC	FACILITY	Basin	2006 Withdrawn	2006 Diverted	2006 Received	2006 Total Demand	2006 Delivered	2006 Delivered to	2007 Withdrawn	2007 Diverted	2007 Received	2007 Total Demand	2007 Delivered	2007 Delivered to
91-000088	ADOT GRAND CANYON AIRPORT	Coconino Plateau			5	5	10	CUSTOMER			6	6		
91-000107	BELLEMONT TRUCK CENTER	Coconino Plateau	69			69	69	CUSTOMER	80			80	78	CUSTOMER
91-000085	CAMERON TRADING POST	Coconino Plateau		40		40	40	CUSTOMER	NR					
91-000115	GRAND CANYON NP	Coconino Plateau		883	176	1059	432/3/177	CUSTOMER/ SYSTEM/ OTHER					522	CUSTOMER
91-000109	HYDRO RESOURCES-TUSAYAN	Coconino Plateau	153			153	126/25	CUSTOMER/ SYSTEM	114			114	88 26	CUSTOMER/ SYSTEM
91-000114	USFS-KNF-TUSAYAN ADMIN	Coconino Plateau			3	3	3	CUSTOMER			3	3	3	CUSTOMER
91-000105	VALLE AIRPORT GRAND CANYON	Coconino Plateau	35			35	35	CUSTOMER	37			37	38	CUSTOMER
91-000097	WILLIAMS, CITY OF	Coconino Plateau	389		153	542	489/153	CUSTOMER/ OTHER	512	85		597	428	CUSTOMER
91-000346	CENTENNIAL PARK DWID	Kanab Plateau	NR						NR					
91-000087	FREDONIA, TOWN OF	Kanab Plateau	NR						NR					
91-000311	HILDALE/COLORADO CITY	Kanab Plateau			1480	1480	1291	CUSTOMER			1494	1494	1426	CUSTOMER
91-000116	GLEN CANYON NRA-WAHWEAP	Paria	NR						8			8	8	CUSTOMER
91-000348	BEAVER DAM EAST DWID	Virgin River	13			13	13	CUSTOMER	12			12	12	CUSTOMER
91-000310	BEAVER DAM WC #2	Virgin River	296			296	296	CUSTOMER	161			161	160	CUSTOMER
91-000352	BIASI WATER COMPANY	Virgin River	33			33	33	CUSTOMER	48			48	48	CUSTOMER
91-000345	CHIEF SLEEP EASY TP	Virgin River	NR						3			3	3	CUSTOMER
91-000340	DS WATER COMPANY	Virgin River	NR						NR					
91-000356	VIRGIN MOUNTAIN UTILITIES	Virgin River	4			4	4	CUSTOMER	2			2	2	CUSTOMER
91-000353	VIRGIN MT ESTATES MHP	Virgin River	10			10	10	CUSTOMER	10			10	10	CUSTOMER

PCC = Program Certificate Conveyance (used as the community water system ID number)

Community Water Systems that have submitted a System Water Plan to the Department as of 12/2008

PCC	NAME	Basin
91-000085	CAMERON TRADING POST	Coconino Plateau
91-000088	ADOT GRAND CANYON AIRPORT	Coconino Plateau
91-000097	WILLIAMS, CITY OF	Coconino Plateau
91-000105	VALLE AIRPORT GRAND CANYON	Coconino Plateau
91-000107	BELLEMONT TRUCK CENTER	Coconino Plateau
91-000109	HYDRO RESOURCES-TUSAYAN	Coconino Plateau
91-000114	USFS-KNF-TUSAYAN ADMIN	Coconino Plateau
91-000115	GRAND CANYON NP	Coconino Plateau
91-000087	FREDONIA, TOWN OF	Kanab Plateau
91-000311	HILDALE/COLORADO CITY	Kanab Plateau
91-000346	CENTENNIAL PARK DWID	Kanab Plateau
91-000116	GLEN CANYON NRA-WAHWEAP	Paria
91-000310	BEAVER DAM WC #2	Virgin River
91-000345	CHIEF SLEEP EASY TP	Virgin River
91-000348	BEAVER DAM EAST DWID	Virgin River
91-000352	BIASI WATER COMPANY	Virgin River
91-000353	VIRGIN MT ESTATES MHP	Virgin River
91-000356	VIRGIN MOUNTAIN UTILITIES	Virgin River

PCC = Program Certificate Conveyance (used as the community water system ID number)

Appendix C

APPENDIX C
SURFACE WATER RIGHT AND ADJUDICATION FILINGS

Surface water is defined in Arizona as "waters of all sources, flowing in streams, canyons, ravines or other natural channels, or in definite underground channels, whether perennial or intermittent, floodwaters, wastewaters, or surplus water, and of lakes, ponds and springs on the surface" (A.R.S. § 45-101).

In 1864, the first territorial legislature of Arizona adopted the doctrine of prior appropriation to govern the use of surface water. The doctrine is based on the tenet of "first in time, first in right" which means that the person who first puts the water to beneficial use acquires a right that is superior to later appropriators of the water. Since the population and water use were both relatively small at that time, no method was initially specified by the legislature for filing surface water right claims or granting rights. By the late 1800s, rapid development of irrigated agriculture combined with drought years had resulted in severe water shortages along the Salt and Gila Rivers. The territorial legislature responded in 1893 with a requirement that new water appropriations be posted at the point of diversion. However, until 1919, a person could acquire a surface water right simply by applying the water to beneficial use and recording a notice of appropriation at the state and country recorder's office. There still was not a mechanism for granting surface water rights (ADWR, 1992).

On June 12, 1919, the state legislature enacted a surface water code. Now known as the Public Water Code, the law generally requires that a person apply for and obtain a permit in order to appropriate surface water. There is an exception for water use from the mainstem of the Colorado River, which requires a contract with the Secretary of the Interior. In addition, most persons claiming surface water rights prior to the code have been required to file a statement of claim under the Water Rights Registration Act of 1974, although the act did not provide a process for determining the validity of these claims. The legislature also enacted the Stockpond Registration Act in 1977 to recognize certain "unpermitted" stockponds constructed after 1919 that had not gone through the application process.

The Public Water Code provides that beneficial use shall be the basis, measure and limit to the use of water within the state. Beneficial uses are domestic (which includes the watering of gardens and lawns not exceeding one-half acre), municipal, irrigation, stockwatering, water power, recreation, wildlife including fish, nonrecoverable water storage, and mining uses (A.R.S. § 45-151(A)). The quantity of water that is reasonable for a particular beneficial use depends on a number of factors, including the location of the use.

The Department maintains a registry of surface water right applications and claims filed in Arizona since the Public Water Code was enacted. Each filing is assigned a unique number with one of the following prefixes

- "3R" – application to construct a reservoir filed before 1972;
- "4A" – application to appropriate surface water filed before 1972;
- "33" – application for permit to appropriate public water or construct a reservoir filed after

1972. In addition to surface water diversions and reservoirs, instream flow maintenance can applied for and is defined as a surface water right that remains in-situ or "in-stream", is not physically diverted or consumptively used, and is for maintaining the flow of water necessary to preserve wildlife, including fish, and/or recreation;

- "36" – statement of claim of rights to use public waters of the state. To make this claim, an applicant or predecessor-in-interest must have initiated a water use based on state law before March 17, 1995;
- "38" – claim of water right for a stockpond and application for certification filed for stockponds constructed after June 12, 1919 and before August 27, 1977. To file this claim and application, the stockpond should have been used exclusively for watering of livestock and/or wildlife, have a maximum capacity of 15 acre-feet, and not be subject to water rights litigation or protests prior to August 27, 1977;
- "39" – statement of claimant filed in *The General Adjudication of the Gila River System and Source* (Gila Adjudication) and *The General Adjudication of the Little Colorado River System and Source* (LCR Adjudication). As explained further below, the department maintains a separate registry of these filings on behalf of the Superior Court of Arizona; and,
- "BB" – decreed water rights determined through judicial action in state or federal court.

These filings specify the source of water, its point of diversion (POD) and place of use (POU), the type and quantity of water use, and date of first use or priority.

If, after moving through a number of administrative steps, an application to appropriate surface water or construct a reservoir (3R, 4A, or 33) is determined to be for beneficial use and not conflict with vested rights or be a menace to public safety or against the interests and welfare of the public, it may be approved and the applicant issued a permit to appropriate. The permit allows the permit holder to construct diversion works, as needed, and put the water to beneficial use. If the terms of the permit are met, the applicant can submit proof of appropriation through an application of certification and may be issued a Certificate of Water Right (CWR). The CWR has a priority date that relates back to the date of application and is evidence of a perfected surface water right that is superior to all other surface water rights with a later priority date, but junior to all rights with an earlier (older) priority date. The CWR also specifies the extent and purpose of the right and may be subject to abandonment and forfeiture if not beneficially used. There are currently approximately 850 applications to appropriate pending with ADWR, and approximately 420 permits and over 7,000 certificates have been issued by ADWR or its predecessors.

A CWR may also be issued based on a stockpond claim (38) if it is found that the facts stated in the claim are true and entitle the claimant to a water right for the stockpond. The priority date depends on the date that the owner of the stockpond filed the claim. If filed prior to March 17, 1996, the priority date is the date of construction. Otherwise, the priority date is the date of filing the claim. Regardless of the date, the CWR for a stockpond claim is junior to (a) Colorado River and other court decreed rights; (b) other rights acquired prior to June 12, 1919 and registered as a statement of claim; and (c) any other CWR issued pursuant to an application filed before August 27, 1977. To date, nearly 20,000 stockpond claims have been filed of which over 3,000 stockpond certificates have been issued by ADWR or its predecessors.

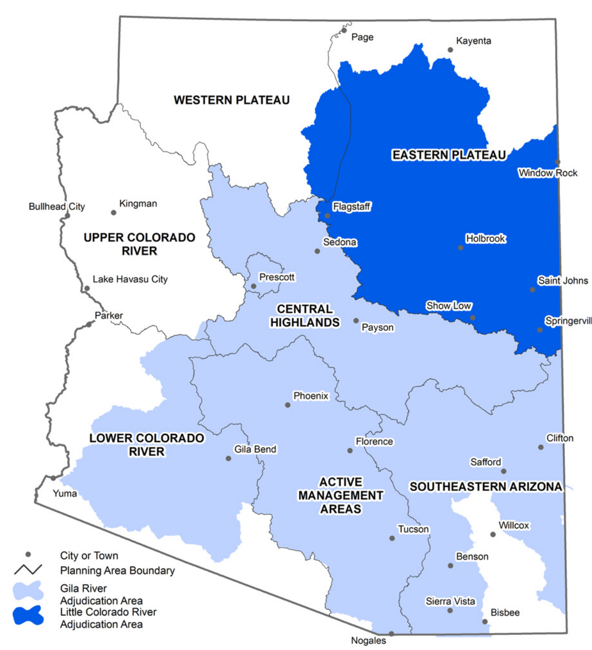
Unlike a CWR, the act of filing a statement of claim (36) does not in itself create a water right, nor does it constitute a judicial determination of the claim. Statements of claim are subject to challenge, but can be admitted “in evidence as a rebuttal presumption of the truth and accuracy of the information contained in the claim” (A.R.S. § 45-185). To date, nearly 30,000 statements of claim have been filed in Arizona.

In addition to the applications and claims described above, ADWR’s registry of surface water right filings includes several rights determined through judicial action in state or federal court. These ‘adjudications’, in which a water right is determined by court action, may be initiated when one or more water users seek to know how their rights compare to the rights of other water users and/or seek judicial relief from alleged interference with their rights by other water users. The court process establishes or confirms the validity of surface water rights and claims, determines whether these have been properly maintained over the years, and ranks them according to their priority. The result is a decree that may, in addition to establishing and confirming rights, specifies terms under which the decreed rights may be exercised if water shortages occur. Court decreed rights are considered the most valued or certain surface water rights because in the absence of abandonment or forfeiture, they are normally accepted as to their validity. More than 1,000 court-decreed rights are listed in ADWR’s registry and given the prefix “BB”.

Although several surface water uses have been decreed, many claims and rights established before and after statehood have still not been examined to see if they remain valid. In addition, many water rights established under federal law and claimed by Indian tribes and the United States have not been quantified or prioritized. To better manage water resources in the state, these diverse rights and claims have been jointed into large, comprehensive determinations.

Arizona currently has two general stream adjudications – the Gila Adjudication and the LCR Adjudication. The purpose of these judicial proceedings is to determine the nature, extent, and priority of water rights across the entire river systems. In addition to confirming existing state-based surface water rights, the adjudications will quantify and prioritize reserved water rights for Indian and non-Indian federal lands. The latter include military bases, national parks and monuments, and national forests. The adjudications will also determine which wells are pumping appropriable underground water (subflow) and therefore are subject to the jurisdiction of the court. The Gila and LCR Adjudications are being conducted in the Superior Court of Arizona in Maricopa and Apache Counties, respectively. ADWR provides technical, legal and administrative support to the adjudication court, as described in A.R.S. § 45-256.

Figure C-1 General Stream Adjudications in Arizona



The Gila Adjudication was initiated in 1974 when SRP filed a petition to determine the water rights in the Salt River Watershed above the Granite Reef Diversion. Since that time, the adjudication area has grown and now covers over 53,000 square miles. It is divided into 7 watersheds and includes 12 Indian reservations and over 24,000 parties. The LCR Adjudication was initiated by a petition filed by Phelps Dodge in 1978. This adjudication now covers 27,000 square miles and includes 3 watersheds, 5 Indian reservations, and over 3,000 parties. A party is a person or entity that has filed one or more statement of claimant (SOC) in the adjudication.

All parties who claim to have a water right within the river systems are required to file an SOC or risk the loss of their right. Well owners are also encouraged to file an SOC since the adjudication process may include water use from a well depending on the well's location relative to streams and other factors. However, a person does not obtain a right to use water by filing an SOC nor is an SOC a legal permit to use water. Rights to use water must be acquired in accordance with state or federal law.

Each year, ADWR sends summons to new surface water appropriators and well owners in the adjudication areas that direct them to file an SOC. In response, the number of SOCs filed in the adjudications continues to increase as new water uses are initiated. To date, nearly 81,000 SOCs have been filed in the Gila Adjudication and over 14,000 SOCs have been filed in the LCR Adjudication. ADWR maintains a separate registry of these adjudication filings on behalf of the Superior Court and assigns each a unique number with the prefix "39".

Table C-1 summarizes the number of surface water right and adjudication filings for each planning area. The table was generated by querying ADWR's surface water right and SOC registries in February 2009. Files are only counted in the table if they include sufficient locational information (Township, Range, and Section) to allow a POD and/or POU to be mapped within the planning area. If a file lists more than one POD or POU in a planning area, it is only counted once in the table for that planning area. However, no attempt was made to avoid counting multiple filings for the same POD/POU which can result if a landowner or lessee has two or more filings or if different applicants each have at least one filing. Since many SOCs list surface water right filings as their basis of claim, multiple filings are common and account, in part, for the large number of filings. Sorting through multiple filings is one of the challenges facing the Department and the adjudication courts. Results from the Department's investigation of surface water right and adjudication filings are presented in Hydrographic Survey Reports (HSRs).

Figure C-2 shows the location of surface water diversion points listed in the Department's surface water rights registry. The numerous points mapped reflect the relatively large number of stockponds and reservoirs that have been constructed across the state as well as diversions from streams and springs. Locations for registered wells, many of which are referenced as the basis of claim in SOCs, are also shown in Figure C-2. Instream flow filings are not shown as these filings do not have points of diversion.

Table C-1 Count of Surface Water Right and Adjudication Filings by Planning Area[1]

PLANNING AREA	TYPE OF FILING							TOTAL
	BB[2]	3R[3]	4A[3]	33[3]	36[4]	38[5]	39[6]	
Eastern Plateau	134	163	196	373	3,289	3,275	12,099	**19,529**
Southeastern	483	395	716	898	8,288	6,415	19,288	**36,483**
Upper Colorado River	0	224	329	469	2,858	2,084	0	**5,964**
Central Highlands	1	287	625	897	8,517	3,928	25,443	**39,698**
Western Plateau	0	415	207	554	1,177	1,270	324	**3,947**
Lower Colorado River	0	26	48	86	355	304	2,323	**3,142**
Active Management Areas	1	269	341	687	4,072	2,913	27,134	**35,417**
Total	**619**	**1,779**	**2,462**	**3,964**	**28,556**	**20,189**	**86,611**	**144,180**

Notes:

[1] Based on a query of ADWR's surface water right and adjudication registries in February 2009. A file is only counted in this table if it provides sufficient information to allow a Point of Diversion (POD) and/or Place of Use (POU) to be mapped within the planning area. If a file lists more than one POD or POU in a given planning area, it is only counted once in the table for that planning area. Several surface water right and adjudication filings are not counted here due to unsufficient locational information. However, multiple filings for the same POD/POU are counted.

[2] Court decreed rights; not all of these rights have been identified and/or entered into ADWR's surface water rights registry.

[3] Application to construct a reservoir, filed before 1972 (3R); application to appropriate surface water, filed before 1972 (4A); and application for permit to appropriate public water or construct a reservoir, filed after 1972 (33).

[4] Statement of claimant of rights to use public waters of the state, filed pursuant to the Water Rights Registration Act of 1974.

[5] Claim of water right for a stockpond and application for certification, filed pursuant to the Stockpond Registration Act of 1977.

[6] Statement of claimant, filed in the Gila or LCR General Stream Adjudications.

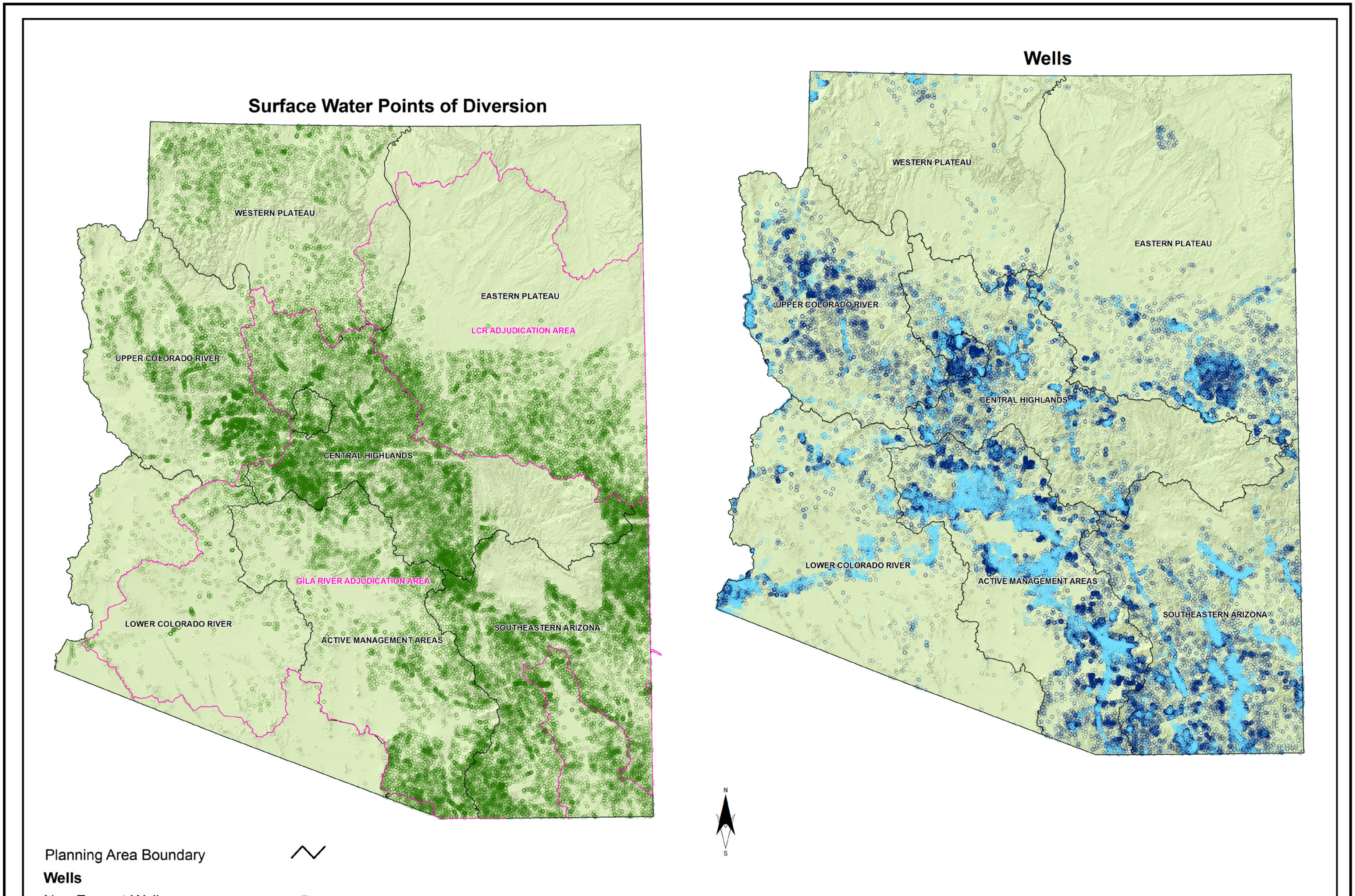


Figure C-2
Registered Wells and Surface Water Diversion Points in Arizona

Appendix D

APPENDIX D
Rural Watershed Partnerships in the Western Plateau Planning Area (2008)

MULTI-PLANNING AREA - Eastern Plateau, Western Plateau and Central Highlands			
Watershed Partnership	**Primary Participants**	**Projects & Accomplishments**	**Issues**
Coconino Plateau Water Advisory Council	Flagstaff, Coconino County, Williams, Sedona, Page, Tusayan, TNC, Grand Canyon Trust, Navajo Nation, Hopi Tribe, Havasupai Tribe, Hualapai Tribe, ADWR, ADEQ, State Land, NRCD, NAU, USGS, USBoR, USFS, National Parks, US Fish and Wildlife, Grand Canyon National Park, AZ Game and Fish, Doney Park Water Co.	• 4 categories of potential water augmentation projects have been identified along with their associated costs. • Groundwater study and conceptual model completed • Phase I Water Demand Study for Coconino Plateau • Growth Impacts Study • Western Navajo Pipeline Study • Development of study for importing C aquifer groundwater east of Flagstaff has been completed. • Flagstaff, Hopi and Navajo are exploring cooperative opportunities for developing C aquifer groundwater. • Flagstaff purchased Red Gap Ranch for possible future development of groundwater. • Hopi HSR initiated. • Water Supply Appraisal Study Completed, which identifies current & future demands and alternatives for meeting projected demands. • Numeric Groundwater Model completed • Strategic Plan has been completed to address water conservation and management on the Plateau	• Continued growth throughout entire plateau region • Limited and deep groundwater supplies. • Drought sensitive surface water supplies of Williams, Flagstaff and others • Groundwater salinity issues in northeastern part of plateau • Numerous water haulers with few hauling stations that are sometimes cutoff during drought • Unable to get adequate water supply designation under current definition • Growth in Page with no current means of additional supply • ESA issues with groundwater usage and impacts on perennial streams • Potential limitation of groundwater usage resulting from reserved groundwater rights of Indians • Uncertainty of Indian water right settlements (LCR & Colorado River) • Proposed San Juan Paiute reservation west of Flagstaff • Potential impacts on springs in Grand Canyon and also on supplies to Havasupai and Hualapai reservations • Access to water development on public lands • Limited groundwater data for entire region • Minor Arsenic issues in Woody Mtn. Well field (9-14 ppb) • Unregulated lot splits • Limited funding resources for planning, projects, infrastructure and studies

MULTI-PLANNING AREA - Eastern Plateau, Western Plateau and Central Highlands			
Watershed Partnership	**Primary Participants**	**Projects & Accomplishments**	**Issues**
		• Attempting to obtain Congressional Authority to complete a Feasibility Study of the water alternatives identified	• Extremely high cost of water augmentation projects • Competition from Phoenix/Tucson for CAP reallocation water and other Colorado River supplies • Congressional Support for completion of a Feasibility Study • Modifications to the current definition of an adequate water supply resulting from the passage of SB1575
Northern Arizona Municipal Water Users Association (NAMWUA)	Prescott Flagstaff Cottonwood Sedona Chino Valley Prescott Valley Williams Clarkdale Payson	• Projected water demands through 2040 have been identified • A request for 70,000 acre-feet of CAP reallocation water has been submitted to ADWR for consideration. • Completed Colorado River Supply Study	• Limited supplies to meet projected demands • ESA issues impacting potential ground and surface water supplies • Limited funding resources for planning, projects, infrastructure and studies • Competition from Phoenix/Tucson for CAP reallocation water and other Colorado River supplies • Funding for Colorado River infrastructure • Water quality issues in Verde Valley and Flagstaff • Upper Basin/Lower Basin issues with Colorado River affect potential for use • Modifications to the current definition of an adequate water supply resulting from the passage of SB1575