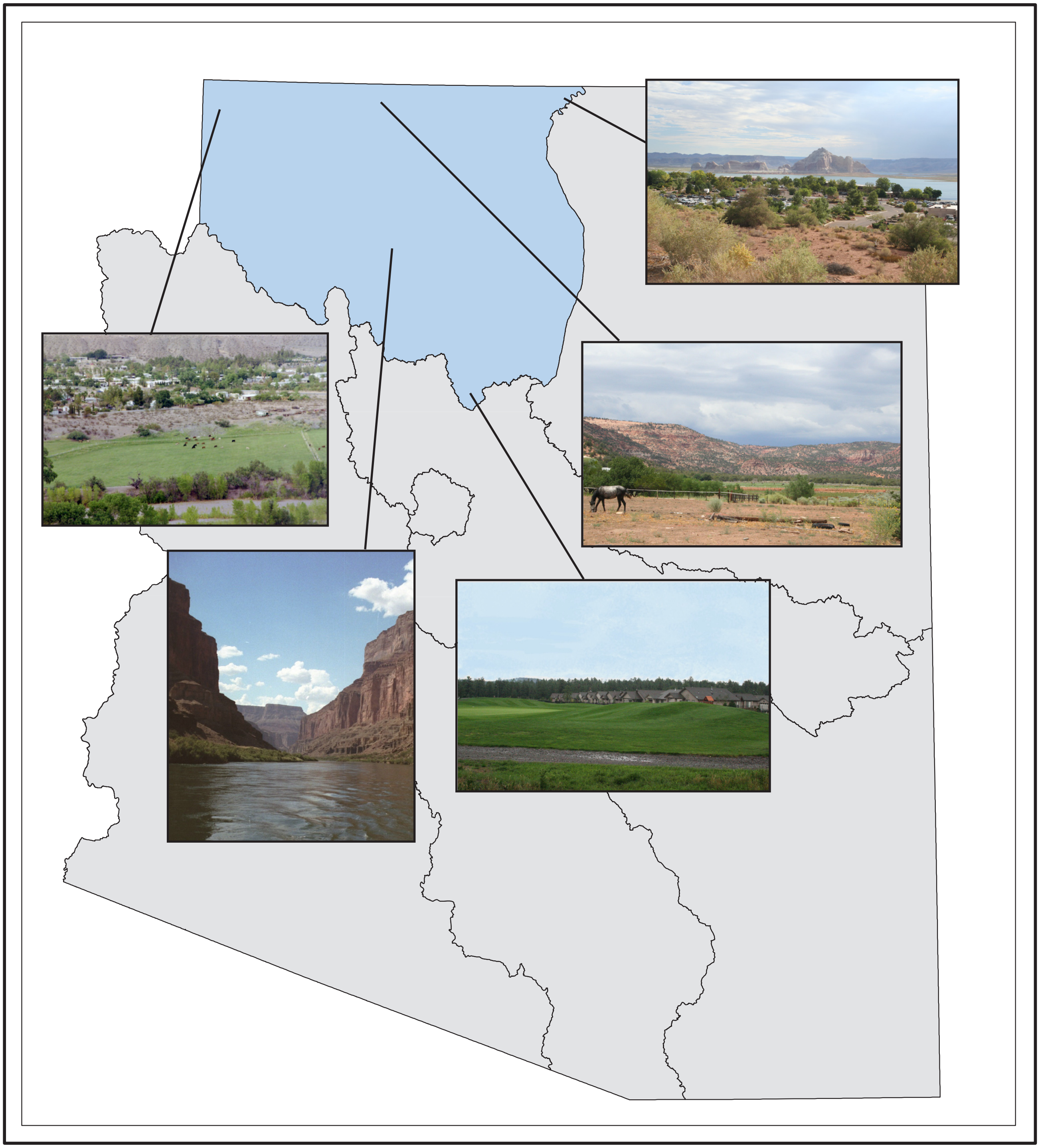
ARIZONA WATER ATLAS
VOLUME 6
WESTERN PLATEAU PLANNING AREA



Arizona Department of Water Resources
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ARIZONA WATER ATLAS
VOLUME 6 - WESTERN PLATEAU PLANNING AREA

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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 divides Arizona into seven planning areas (Figure 6.0-1). There is a separate Atlas volume for each planning area, an introductory volume composed of background information, and an executive summary 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. Elevation ranges from over 12,000 feet on the San Francisco Peaks to about 1,200 feet at Lake Mead. Parts of Coconino County (46% of the county) and Mohave County (38% of the county) are contained within the planning area. There are four Indian reservations including the Havasupai, Hualapai, Kaibab-Paiute and Navajo Indian Reservations located within the planning area.

The planning area is relatively sparsely populated. The 2000 Census planning area population was approximately 17,200 with basin population ranges of just 12 in the Shivwits Plateau Basin to over 9,100 in the Coconino Plateau Basin. Colorado City is the largest community with about 3,334 residents in 2000. Other population centers include Williams, Fredonia, Grand Canyon Village and the Beaver Dam/Littlefield area.

An average of over 8,800 acre-feet of water is used annually in the planning area for agricultural, municipal and industrial uses (cultural water demand). Of this total demand, approximately 5,100 acre-feet is from well pumpage, 3,500 acre-feet is from surface water diversions and almost 300 acre-feet is effluent reuse. The agricultural demand sector is the largest with approximately 4,500 acre-feet of demand a year – 51% of the total demand. The municipal sector demand is about 3,400 acre-feet a year and industrial demand is about 900 acre-feet a year.

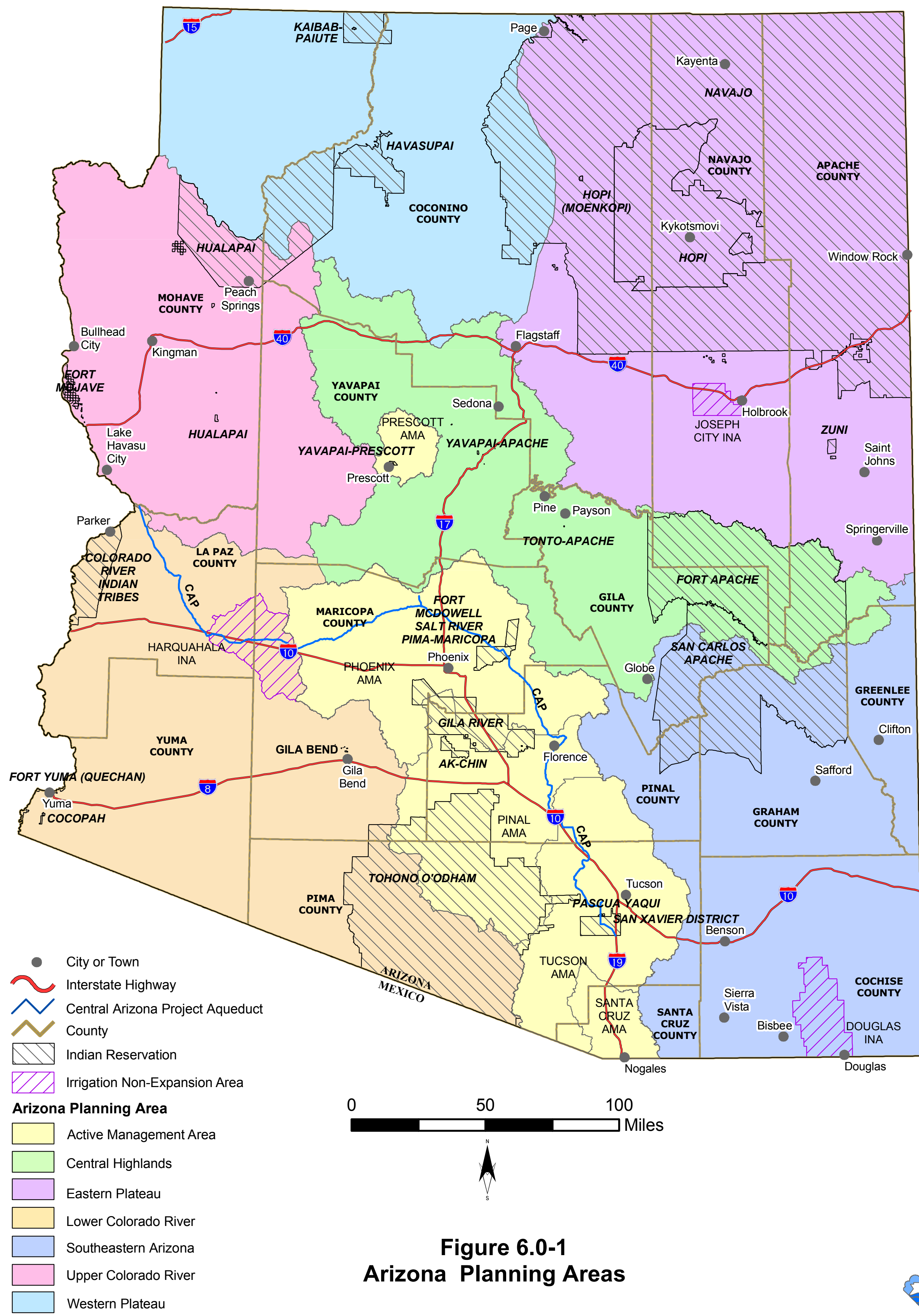


Figure 6.0-1
Arizona Planning Areas

6.0.1 Geography

The Western Plateau Planning Area encompasses 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 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 western portion of the Navajo Indian Reservation (1,177 square miles) and the northeastern portion of the Hualapai Indian Reservation (741 square miles) are located within the planning area (Figure 6.0-1).

Almost all of the planning area is within the Plateau Uplands physiographic province characterized by horizontally stratified sedimentary rocks that have eroded into numerous incised canyons and high desert plateaus (See Volume 1, Figure 1-2). 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 Lowlands physiographic province, which is characterized by northwest-southeast trending mountain ranges separated by broad alluvial valleys. The basin with the largest elevational range in the planning area occurs in the Coconino Plateau Basin with ranges from 1,400 feet where the Colorado River exits the Coconino Plateau Basin in the Grand Canyon to over 12,000 feet in the San Francisco Peaks at the southeastern edge of the basin.

A unique geographic feature of the planning area is the Grand Canyon, primarily 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 entire 277 miles, and 6,000 feet at its deepest point, with an average width of 10 miles. The geologic record at the Grand Canyon is unique in the variety of rocks and their clear exposure in the canyon walls. Nearly half of the earth's 4.6-billion-year history is displayed in the Canyon (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 old found in the inner gorge. 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 and link 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.

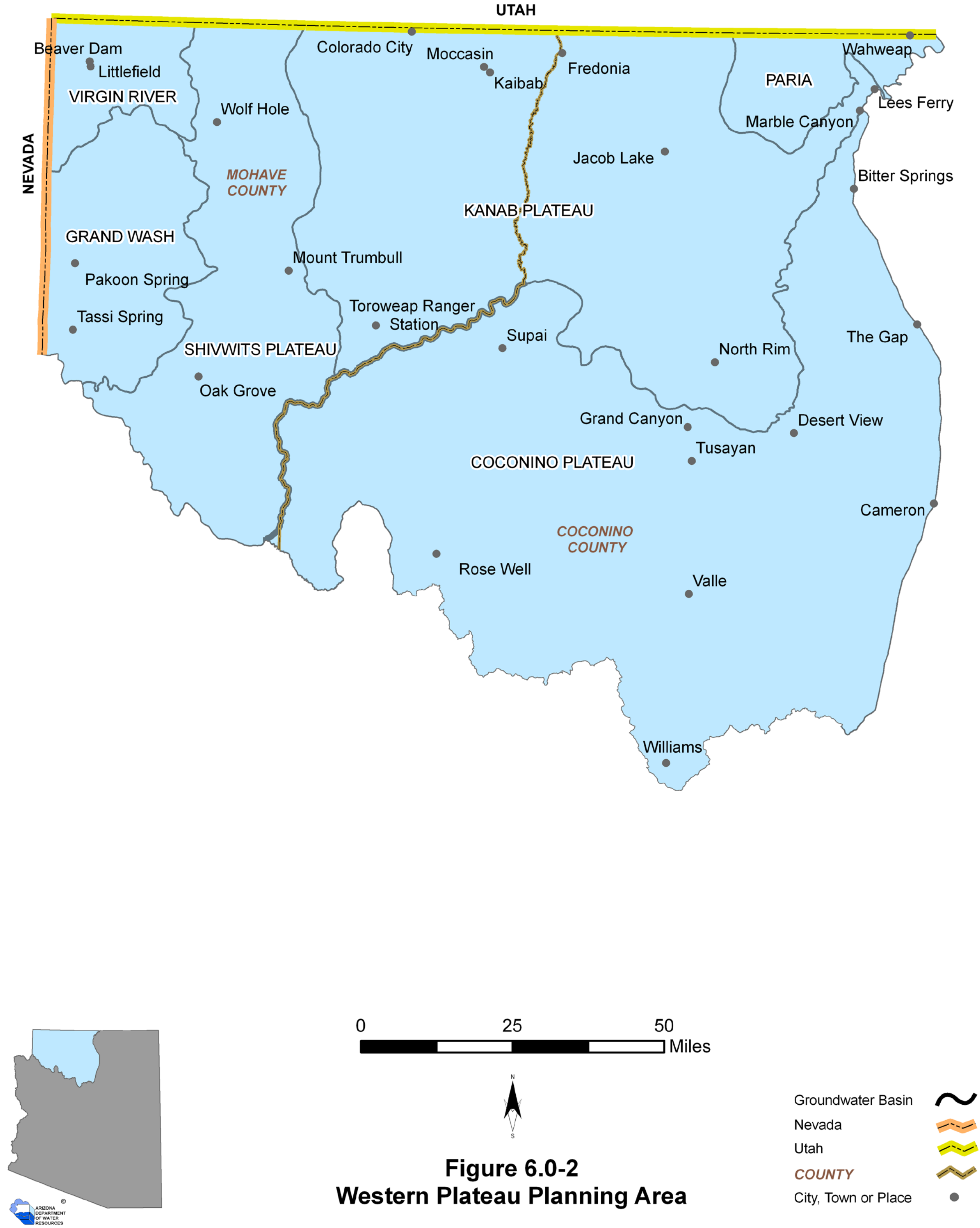


Figure 6.0-2
Western Plateau Planning Area

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. The Coconino Plateau groundwater basin boundary is considered to be north of the Rim. 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 including the south rim of the Grand Canyon (Bills, et al. in press).

Other significant geographic features are numerous high plateaus, steep cliffs, deeply incised canyons and few surface water features. In the extreme northwest corner of the planning area, the Virgin River cuts through the Beaver Dam Mountains creating the spectacular 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.

6.0.2 Hydrology[1]

Groundwater Hydrology

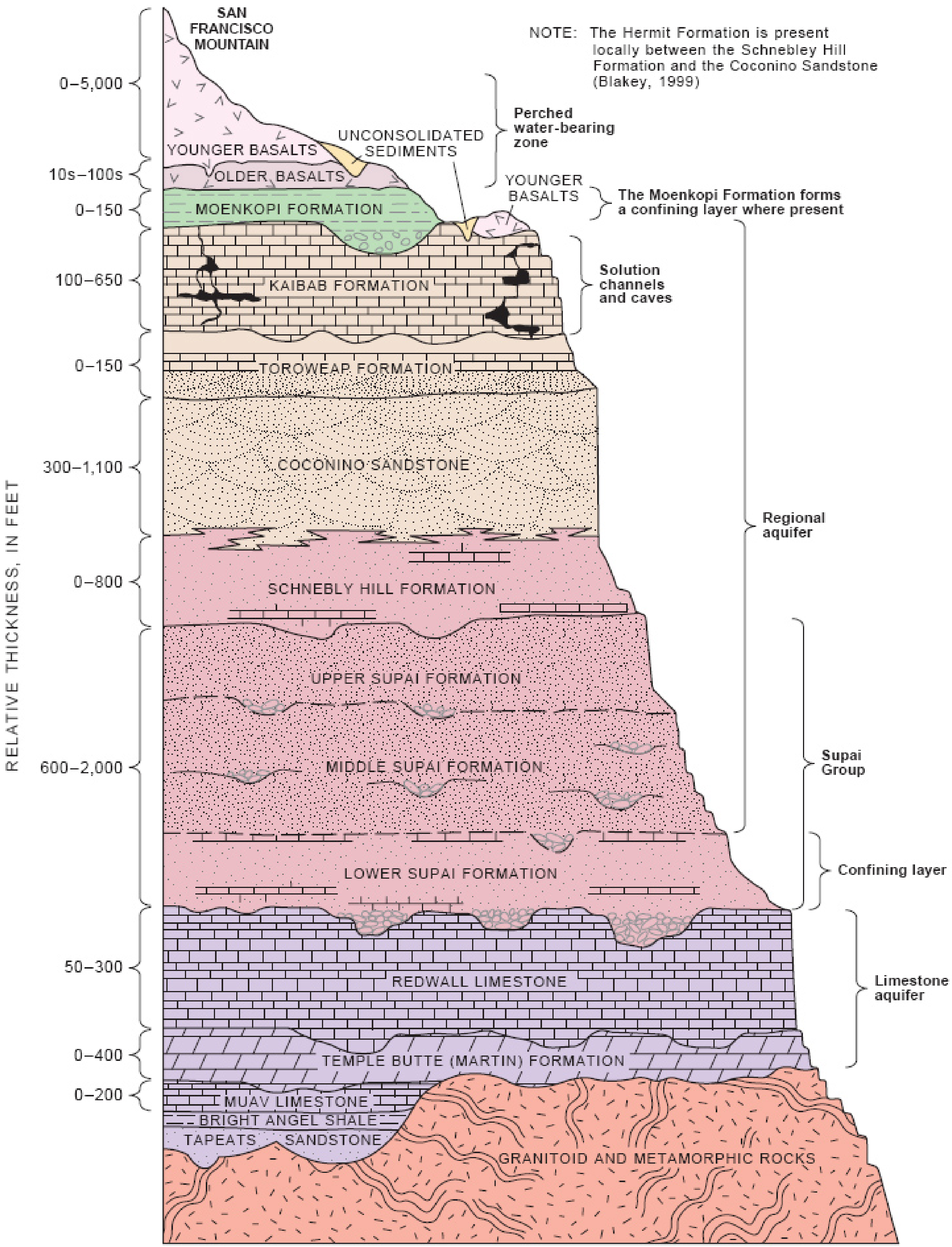
The Western Plateau Planning Area is generally characterized by relatively flat-lying alternating sequences of sandstones, limestones and shales. Faults and monoclines control groundwater movement along the regional gradient. The westernmost basins contain basin-fill sediments composed of silt, sand and gravel. Relatively few hydrologic studies have been conducted in the planning area and general hydrologic characteristics are described below.

Coconino Plateau Basin
The Redwall-Muav (R-aquifer 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 and Chinle formations, volcanic rocks and unconsolidated sediments overlie the C- and R-aquifers and provide locally important sources of water. A stratigraphic section of the Coconino Plateau that illustrates the relationship between these various units is shown on Figure 6.0-3. 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 from precipitation and runoff and may be undependable water supplies. An exception is the “Inner Basin Aquifer” of the San Francisco Peaks where the 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 at a depth of greater than 3,000 feet below land surface in most areas (Bills, et al., in press). Relatively few wells have been completed

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

Figure 6.0-3 Generalized stratigraphic section of the Coconino Plateau, Arizona (Bills and Flynn, 2002)



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. Lateral movement of groundwater occurs through fracture zones and solution cavities and is generally northward toward the Grand Canyon where springs discharge along the Little Colorado and Colorado Rivers and Havasu Creek. Regional structures in the basin, including the Mesa Butte Fault and the Cataract syncline, direct flow to major discharge areas on the lower Little Colorado River and in Cataract Canyon (USBOR, 2006). Water quality is generally good in the basin but poor locally where there is leakage from overlying units or other factors.

Water levels in wells are typically quite deep in the basin and yields in the R-aquifer are relatively low depending on the occurrence of fractures, faults and solution channels. 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 gallons per minute (gpm) (HydroResources, 2007). While water has been found in perched aquifers near Williams at depths less than 950 feet deep, yields from these more shallow wells are generally less than five gallons per minute. At Williams, three of the four water system wells are drilled to depths exceeding 3,500 feet below land surface. Water level depths in these wells are between 2,740 and 2,875 feet. Water in the deepest of the Williams wells is of poor quality with elevated metals concentrations, including arsenic, and high corrosivity (City of Williams, 2007).

Widely-spaced faults and monoclines affect the movement of groundwater in the region. 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).

The C-aquifer, consisting of hydraulically connected sandstones, limestones and shales occurs primarily in the far eastern and southeastern portion of the basin. Although perched zones occur, it is largely drained of water in the rest of the basin, coincident with the northeast-southwest trending Mesa Butte Fault (Bills et al., in press). Infiltration of precipitation through volcanic rocks and the Kaibab Formation is the primary source of recharge to the C-aquifer. Groundwater movement through the water-bearing units of the C-aquifer is likely through faults and fractures (USBOR, 2006). 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. Within the R-aquifer, groundwater moves along the northern part of the Mesa Butte Fault and other faults and discharges at Blue Springs on the Little Colorado River (Montgomery, et al., 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, et al., 2002). Water quality in the upper and middle parts of this aquifer is good, but generally degrades due to salts at increasing depths.

Grand Wash Basin

The Grand Wash Basin, in the western part of the planning area, is located along the boundary of the Plateau Uplands and Basin and Range provinces. 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. Only 12 wells are registered in the basin and two of these have depths that range from about 20 feet to over 500 feet (see Figure 6.2-6).

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. Recharge from precipitation or local surface runoff is small. 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 is a confining unit in the area, preventing 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 Lacy, 1992). Water quality is generally good in the basin although total dissolved solids concentrations equal or exceeds drinking water standards at several springs.

Kanab Plateau Basin

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 formations. 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 et al., 2004). The two basin hydrographs available for the study period (See Figure 6.3-7) are wells completed in the Kayenta Formation at Moccasin, with a recent water level of 87 feet below land surface, and one in "sedimentary rock" south of Fredonia and north of Kanab Creek with a recent water level of 611 feet. These aquifers are generally isolated and not hydraulically connected. Within the aquifers, faults act as conduits for vertical and lateral groundwater movement. Major faults include the Toroweap and Sevier faults. Groundwater also occurs in recent stream alluvium, including the Cane Beds area west of Moccasin. The median well yield from ten large wells in the basin was 70 gpm. Elevated levels of total dissolved solids and lead have been measured at some sites although water quality is generally good for most uses.

Paria Basin

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 in this basin is the N-aquifer composed of Navajo Sandstone and the Kayenta and Moenave Formations. Groundwater development is relatively small with only 12 wells registered in the basin. Well yields vary from 30 to 1,400 gallons per minute, with the largest yields coming from wells completed in sedimentary rocks. Water levels in wells are relatively deep, ranging from about 480 feet to 1,500 feet deep. In some places in the Paria Basin, 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 the Paria River Canyon. However, some groundwater moves south toward the Vermilion Cliffs, which form the southern basin boundary. Arsenic concentrations above the drinking water standard have been measured at a number of wells in the Wahweap area (see Table 6.3-7).

Figure 6.0-4 Geologic cross section of the Shivwits Plateau, Kanab Plateau and Coconino Plateau Basins (modified from Billingsley and Welmeyer, 2003)

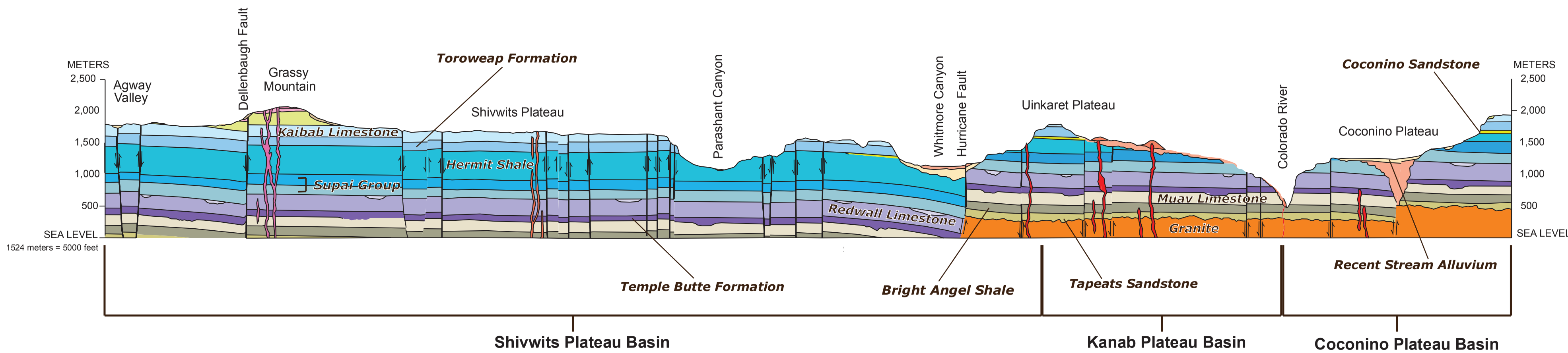


Figure 6.0-4 shows a cross section of the geology in the Shivwits Plateau, Kanab Plateau and the western portion of the Coconino Plateau basins. The cross section begins in the west-central portion of the Shivwits Plateau Basin (T33N, R12W) and proceeds at a southeastern diagonal across the Shivwits 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 is a general indication of the location of the water bearing units and their depth and thickness in this particular area. The diagram also shows the impact of the Hurricane Fault on the depth and occurrence of the geologic units.

Shivwits Plateau Basin

Most of the Shivwits Plateau Basin covers a 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. There are only 18 registered wells in the basin. Recent water levels in wells range from 10 feet to over 960 feet (see Figure 6.5-7). Stream alluvium is the major aquifer in the basin with well yields ranging from 2 to 35 gallons per minute. 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. Water from springs and seeps tends to be of slightly better quality than well water, although arsenic at levels that equal or exceed drinking water standards has been detected in one spring.

Virgin River Basin

Located in the northwestern corner of Arizona, the Virgin River Basin extends into Utah and Nevada. It contains a broad alluvial valley in the western half of the basin and the relatively high elevation Beaver Dam and Virgin Mountains along its southern and eastern boundary. Principal aquifers are basin fill in the Virgin River Valley and Beaver Dam Wash, and the Muddy Creek Formation. The eastern, mountainous part of the basin is composed of 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 the alluvial-fan deposits of 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 unconfined. Groundwater flow is toward the Virgin River Valley.

The Muddy Creek Formation is 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 forms 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 this 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).

Well yields range widely in the basin, as shown 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 yield from 53 large diameter wells completed in the basin is 650 gpm. Water quality ranges from very good to poor due to high concentrations of arsenic, chloride, sulfate and total dissolved solids. Salt concentrations in groundwater increase downstream in the floodplain area along the Virgin River.

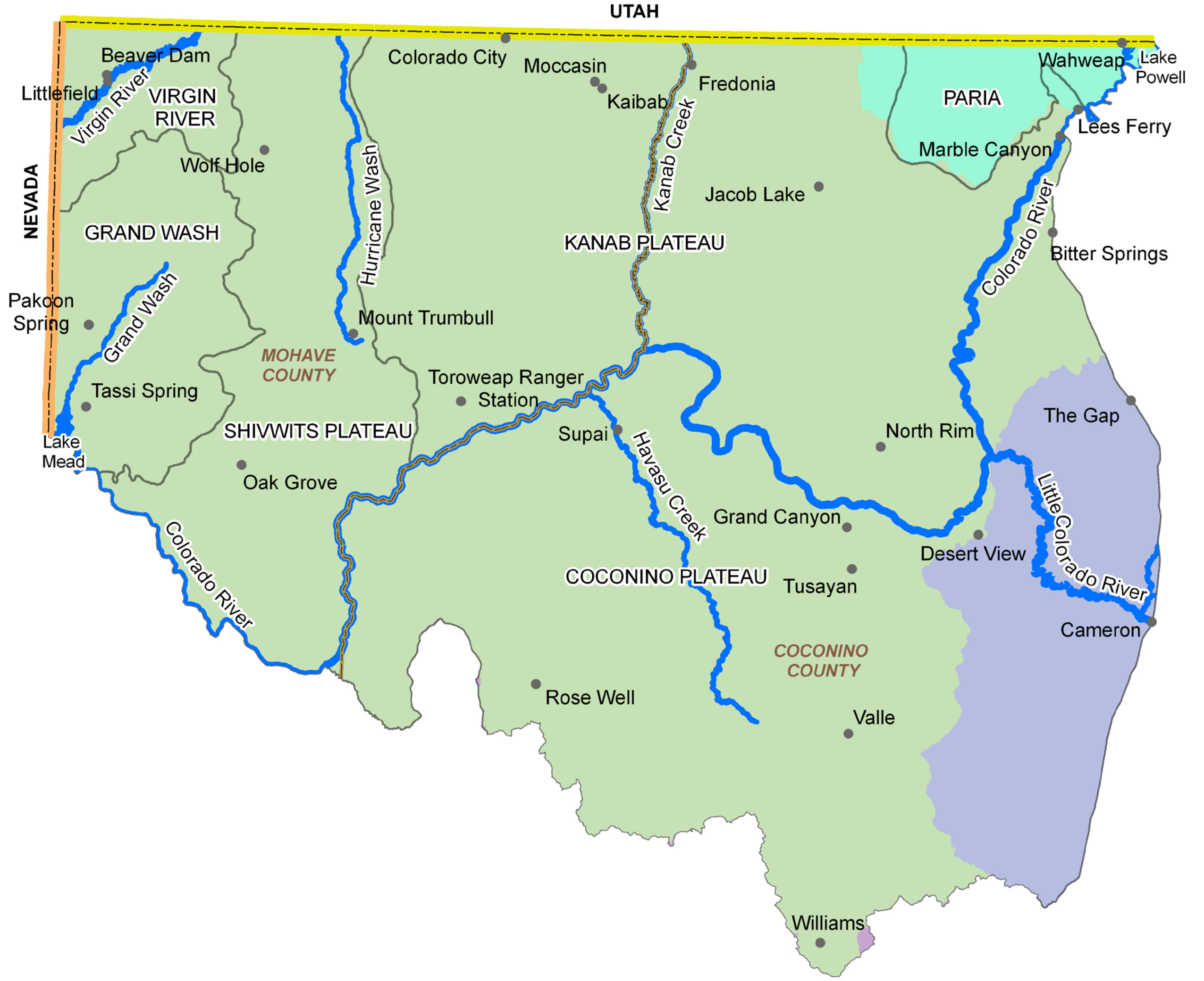
Surface Water Hydrology

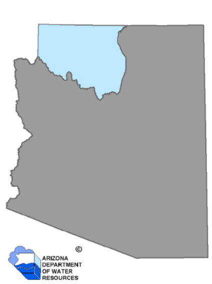
The U.S. Geological Survey (USGS) divides and subdivides the United States into successively smaller hydrologic units based on hydrologic features. These units are classified into four levels. From largest to smallest these are: regions, subregions, accounting units and cataloging units. A hydrologic 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: the Little Colorado River; the Lower Colorado River, Lees Ferry to Lake Mead; and the Upper Colorado River, Lake Powell Area (Figure 6.0-5). (A very small portion of the Verde River Watershed is located east of Williams and is not discussed in this volume).

<u>The Little Colorado River</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 planning area is a 13-mile stretch of the Little Colorado River below Blue Springs, which has a discharge of over 101,000 gpm. Blue Springs is the only large spring in the area.

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).

<u>Upper Colorado River, Lake Powell Area</u>
The boundary of the Upper Colorado River 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 Paria River and the Colorado River are the only perennial streams in this portion of the planning area. The single streamflow gage in the area 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. There are two nearby gages on the west side of the Colorado River in the Eastern Plateau Planning Area. 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 million acre feet (maf) per year. The average annual flow at the gage below Glen Canyon Dam is now 8.4 maf. Downstream, flow records at the gage on the Colorado River at Lees Ferry show 20.3 million acre-feet. This gage has been in operation since 1921.





Data Source: USGS, 2005

Figure 6.0-5
Western Plateau Planning Area
USGS Watersheds

In May 1983, a heavy snowpack in the Upper Basin of the Colorado River 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). By contrast, releases from Glen Canyon Dam in July 2007 were 13,100 cfs on average and, due to prolonged drought, the reservoir was at 53% capacity. Since 1999 inflow to Lake Powell has been below average in every year except one (USBOR, 2007a).

Lake Powell provides water storage to meet flow obligations at Lees Ferry under the terms of the 1922 Colorado River Compact. (See Volume 1, Appendix A) 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 this portion of the planning area although springs reportedly have supported domestic and stock watering uses (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, 2002).

Lower Colorado River, Lees Ferry to Lake Mead

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.

The only other perennial streams in the planning area west of Diamond Creek 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. The Virgin River drains an area of about 6,100 square miles. 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.

Colorado River

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 this reach of the Colorado River in addition to three gages in the Lake Powell area. The three easternmost gages are located on the north side of the river above the Little Colorado River and near Bright Angel Creek (see Figure 6.3-5). The two westernmost gages are located on the south side of the river near Havasu Creek and Diamond Creek (see Figure 6.1-5). The easternmost 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, the only pre-dam gage, has the highest mean flow and a maximum flow of 20.5 maf in 1984. The only currently operating downstream gage has a similar flow regime to the gage above the Little Colorado River.

The preceding statistics and the relative uniformity of seasonal flows reflect the controlled releases of water from Glen Canyon Dam (See Tables 6.1-2 and 6.3-2). Prior to construction of the 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. (USBORb, 2007)

A tree-ring-based reconstruction of over 500 years of Colorado River streamflow found as many as eight droughts similar in severity to the 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 one 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 et al, 2007)

Virgin River and Beaver Dam Wash
Average annual flow in the Virgin River above the Narrows gage is about 92,600 acre-feet. Downstream, the stream gage near Littlefield, with a much longer period of record (72 years), shows an average annual flow of 174,502 acre-feet and a maximum flow of 506,912 acre-feet in 1983. Below the Narrows gage, flow increases downstream to the Littlefield gage and beyond due to springs and groundwater inflow (Dixon and Katzer, 2002). (See Figure 6.6-5 for gage locations)

Older reports indicate that flow in the Virgin River disappeared into the riverbed before the river entered Arizona from Utah and reappeared about five miles above Littlefield due to spring discharge. More recently, the AGFD report that the entire reach within Arizona is perennial (see Figure 6.6-6). Post 1990 gage data and seepage measurements suggest that historical seepage losses to the groundwater system in Utah are no longer occurring. Based on seepage measurements along the Virgin River in Arizona, it appears that between 20 to 30 cfs of Virgin River flow is lost upstream of the Narrows gage in Arizona through infiltration (Cole and Katzer, 2000). Studies estimate that 20 to 50 cfs (14,500 to 36,200 acre-feet per year) reenters the river via springs and groundwater discharge between the Narrows and the Littlefield gage. These springs are collectively referred to as the Littlefield Springs, consisting of eight springs over a distance of seven miles between the two gages (Trudeau, et al., 1983). The springs are difficult to measure 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). Springs support perennial flow in Beaver Dam Wash, which discharges to the Virgin River above the Littlefield gage. These springs collectively discharge over 1,100 gpm.

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. 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 along its course. Calcium carbonate precipitates out of the spring water, forming travertine deposits along the creek bottom/bed. 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, et al., 2004).

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 Lacy, 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.

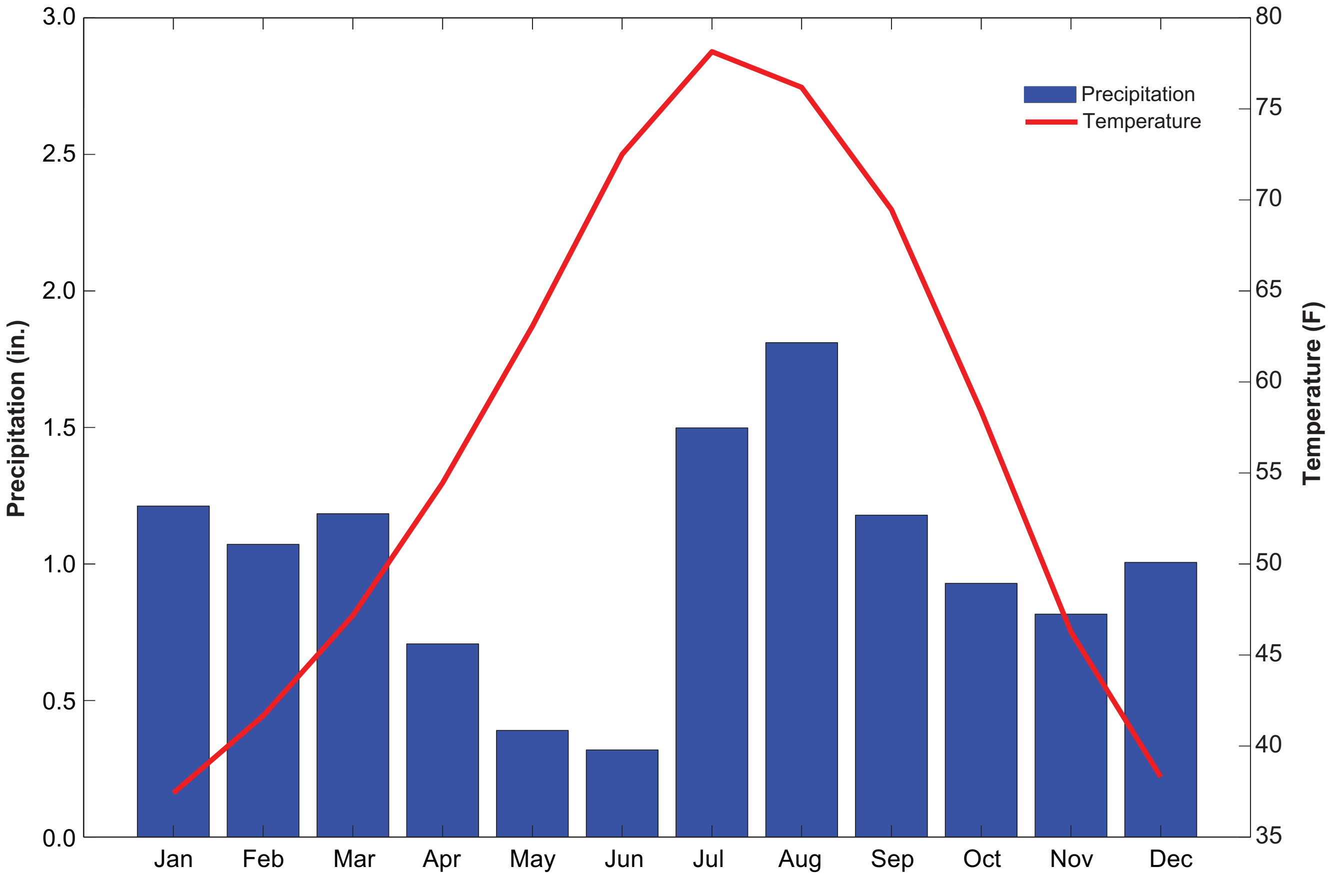
6.0.3 Climate[2]

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 elevation (less than 5000 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 6.0-6); however, the northwestern part

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

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.

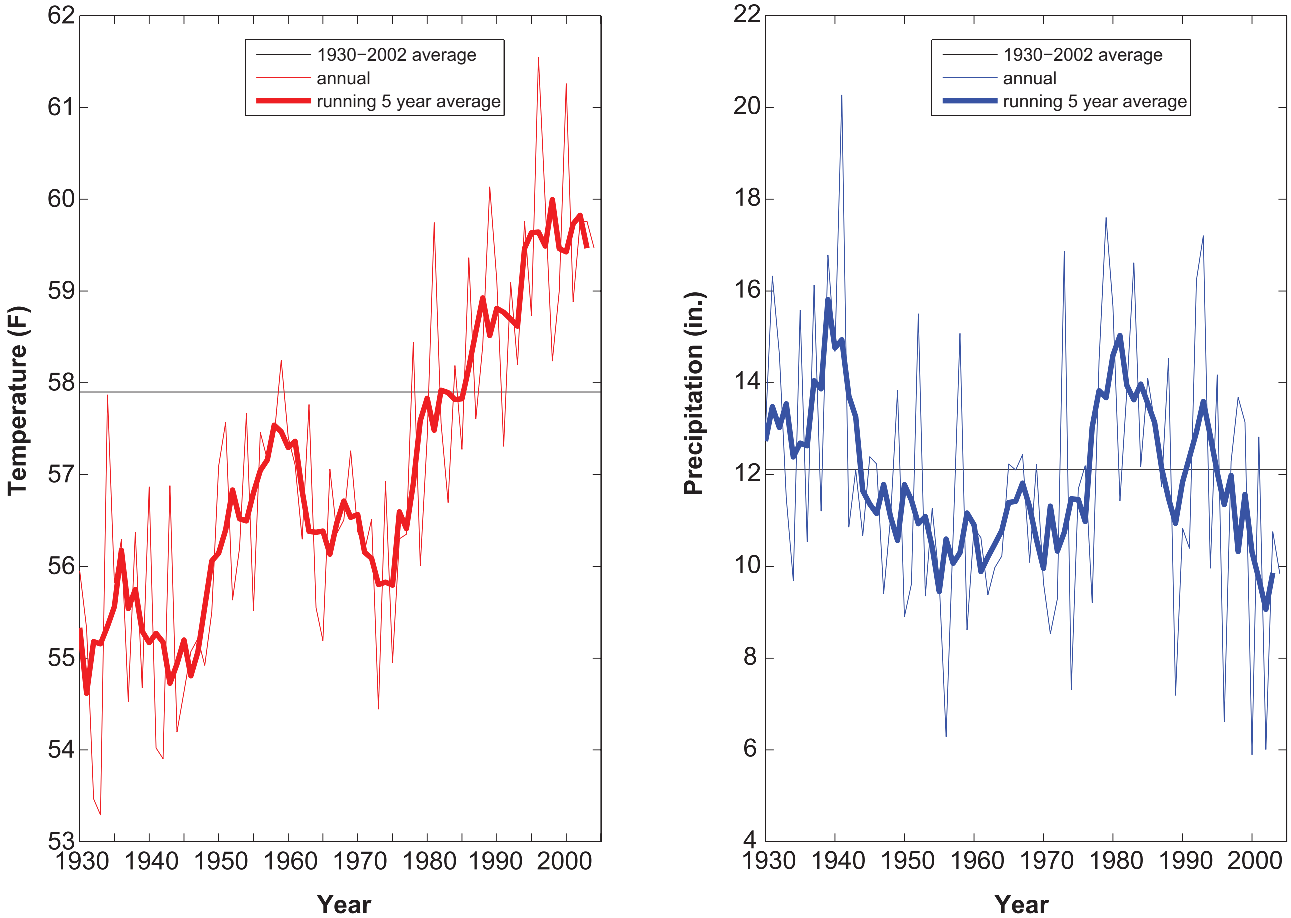
Figure 6.0-6 Average monthly precipitation and temperature from 1930-2002



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

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.

Figure 6.0-7 Average annual temperature and total annual precipitation for the Western Plateau Planning Area from 1930-2002

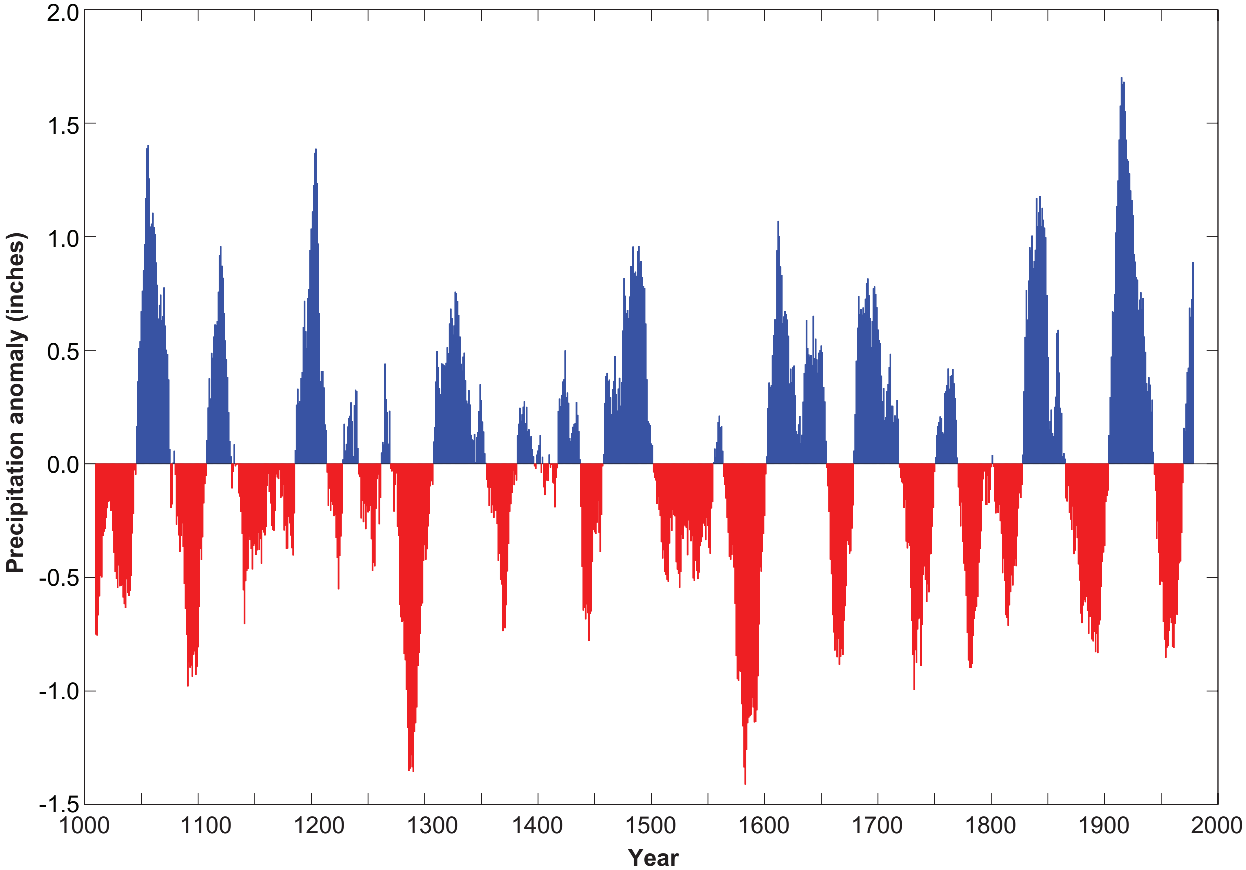


Horizontal lines are average temperature (57.9 °F) and precipitation (12.1 inches), respectively. Light lines are yearly values and highlighted lines are 5-year moving average values. Data are from the Western Regional Climate Center. Figure author: Gregg Garfin, CLIMAS.

Average annual temperatures in the Western Plateau Planning Area have been increasing since the 1930s, and especially rapidly since the mid-1970s (see Figure 6.0-7). 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.

Winter precipitation records dating to 1000 A.D., estimated from tree-ring reconstructions for Arizona climate divisions, show extended periods of above and below average precipitation in every century (Figure 6.0-8**)**. A climate division is a region within a state that is generally climatically homogeneous. Arizona has been divided into seven climate divisions. Notably dry periods in the Western Plateau Planning Area 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.

Figure 6.0-8 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: Gregg Garfin, CLIMAS.

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[3]

Information on ecoregions and biotic (vegetative) communities in the planning area are shown on Figure 6.0-9. 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 at lower elevations to a small area of alpine tundra above 12,000 feet on the

[3] Except as noted, information in this section is from AZGF, 2004.

San Francisco Peaks in the Coconino Plateau Basin. Much of the planning area is covered by Great Basin conifer woodland and plains grassland.

Alpine tundra communities are found only at the highest elevations on the San Francisco Peaks, generally over 12,000 feet. 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. The Peaks are the southernmost climatic alpine area in the United States. 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).

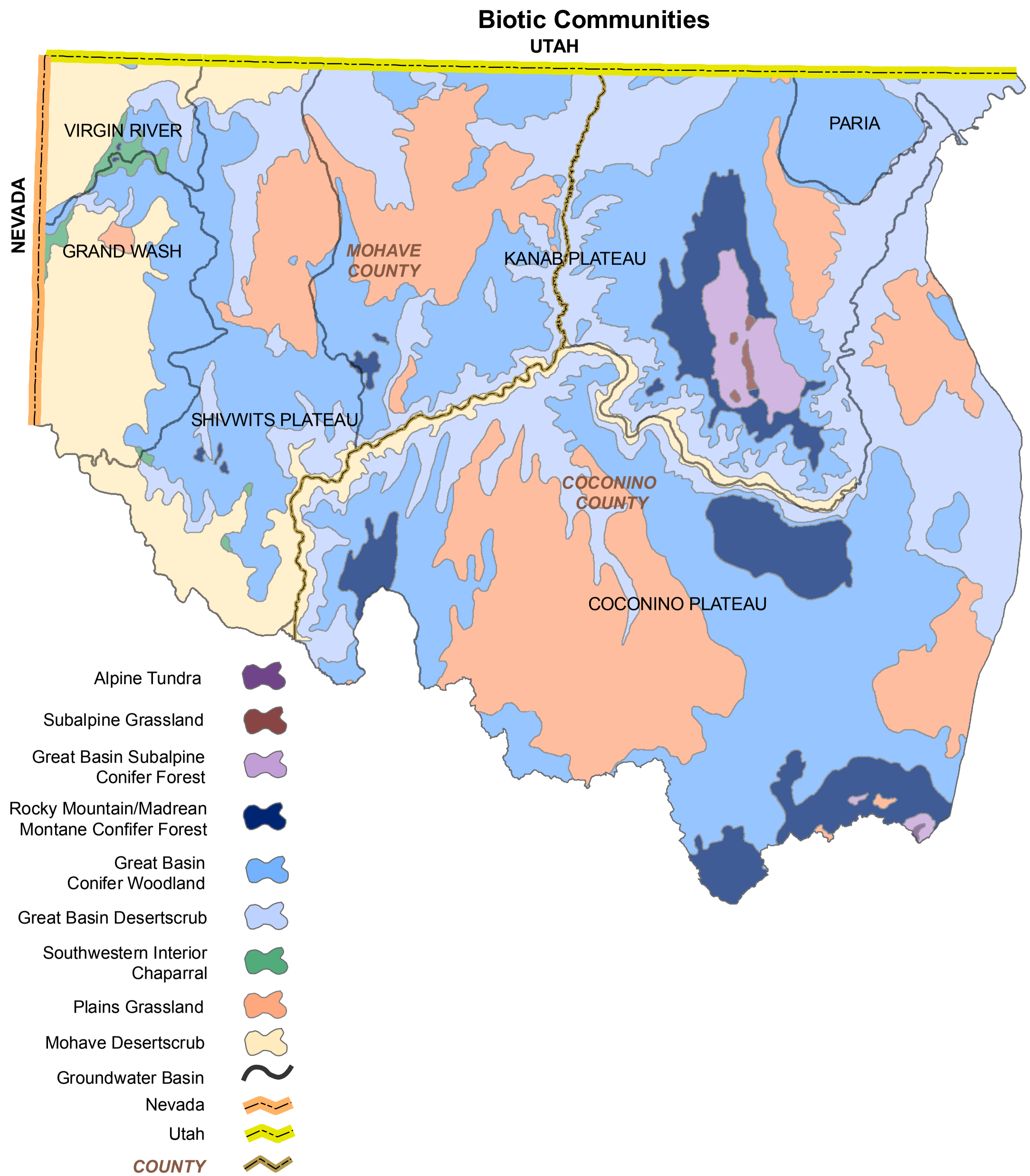
High elevation subalpine conifer forests are limited to relatively small isolated mountaintop stands on the Kaibab Plateau and the San Francisco Peaks area at elevations of 8,500 to almost 12,000 feet with annual precipitation from 30 to 40 inches a year. These forests consist of dense stands of fir, 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).

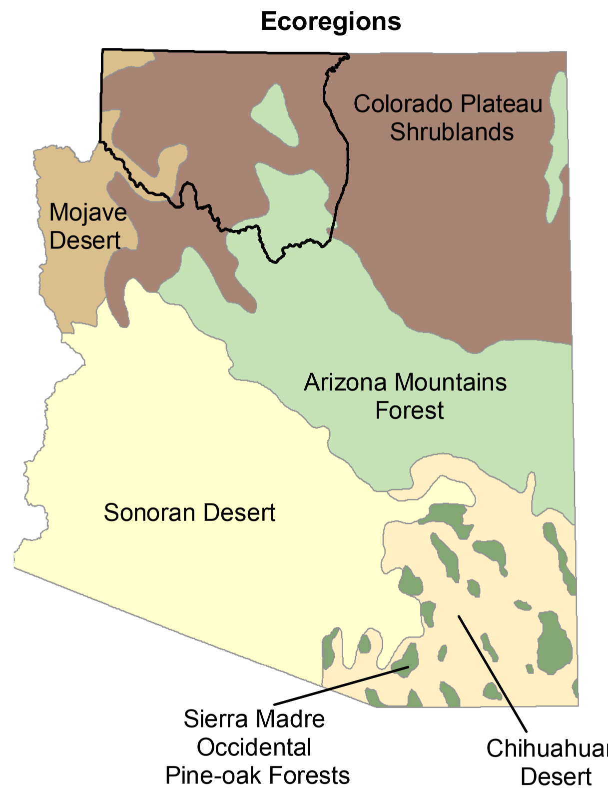
Rocky Mountain (Petran) and Madrean Montane conifer forests commonly occur between about 7,200 to 8,700 feet. Above 8,000 feet in areas that receive from 25 to 30 inches of annual rainfall, the forest contains a mix of conifers that may include Douglas-fir, white fir, limber pine, blue spruce, and white pine, with ponderosa pine joining the mix 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).

Several years of drought combined with high tree densities resulted in the largest outbreak of pine bark beetle populations ever recorded in Arizona during 2002 – 2004. While drought conditions improved in 2004 and 2005, by 2006, Ponderosa pine mortality due to Ips beetles increased, 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). 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.

Great Basin Conifer (piñon-juniper) woodlands cover large areas below the ponderosa pine forest at elevations between about 5,000 and 7,500 feet that receive about 10 to 20 inches of annual precipitation. Extensive stands exist throughout the planning area as shown on Figure 6.0-9. Piñon

Figure 6.0-9
Western Plateau Planning Area
Biotic Communities and Ecoregions





Biotic Communities Source: AGFD, 1993
Ecoregions Source: World Wildlife Fund, 2004

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 few watercourses in the planning area including Kanab Creek, the Paria River and the Colorado River. However, these areas are not well mapped. Tamarisk and strand communities exist along the Virgin River. 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.

Arizona Water Protection Fund Programs

The objective of the Arizona Water Protection Fund Program (AWPF) program is to provide funds for protection and restoration of Arizona's rivers and streams and associated riparian habitats. Eight restoration projects in the Western Plateau Planning Area have been funded by the AWPF through 2005. Five projects were funded in the Coconino Plateau Basin and primarily involve research. Three Kanab Plateau Basin projects funded research, exotic species control, revegetation and watershed enhancement. A list of projects and project types funded in the Western Plateau Planning Area through 2005 is found in Appendix A of this volume. A description of the program, a complete listing of all projects funded, and a reference map is found in Appendix C of Volume 1.

Instream Flow Claims

An instream flow water right is a non-diversionary appropriation of surface water for recreation and wildlife use. Seven applications for instream flow claims were filed by the Bureau of Land Management in the Virgin River Basin. 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. Applications are listed in Table 6.0-1 and shown on Figure 6.0-10.

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

ADWR 2005a

Threatened and Endangered Species

A number of listed threatened and endangered species may be present in the Western Plateau Planning Area. Those listed by the U.S. Fish and Wildlife Service (USFWS) as of May 2006 are shown in Table 6.0-2.[4] Presence of a listed species may be a critical consideration in water resource management and supply development in a particular area. The USFWS should be contacted for details regarding the Endangered Species Act (ESA), designated critical habitat and current listings.

[4] 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."

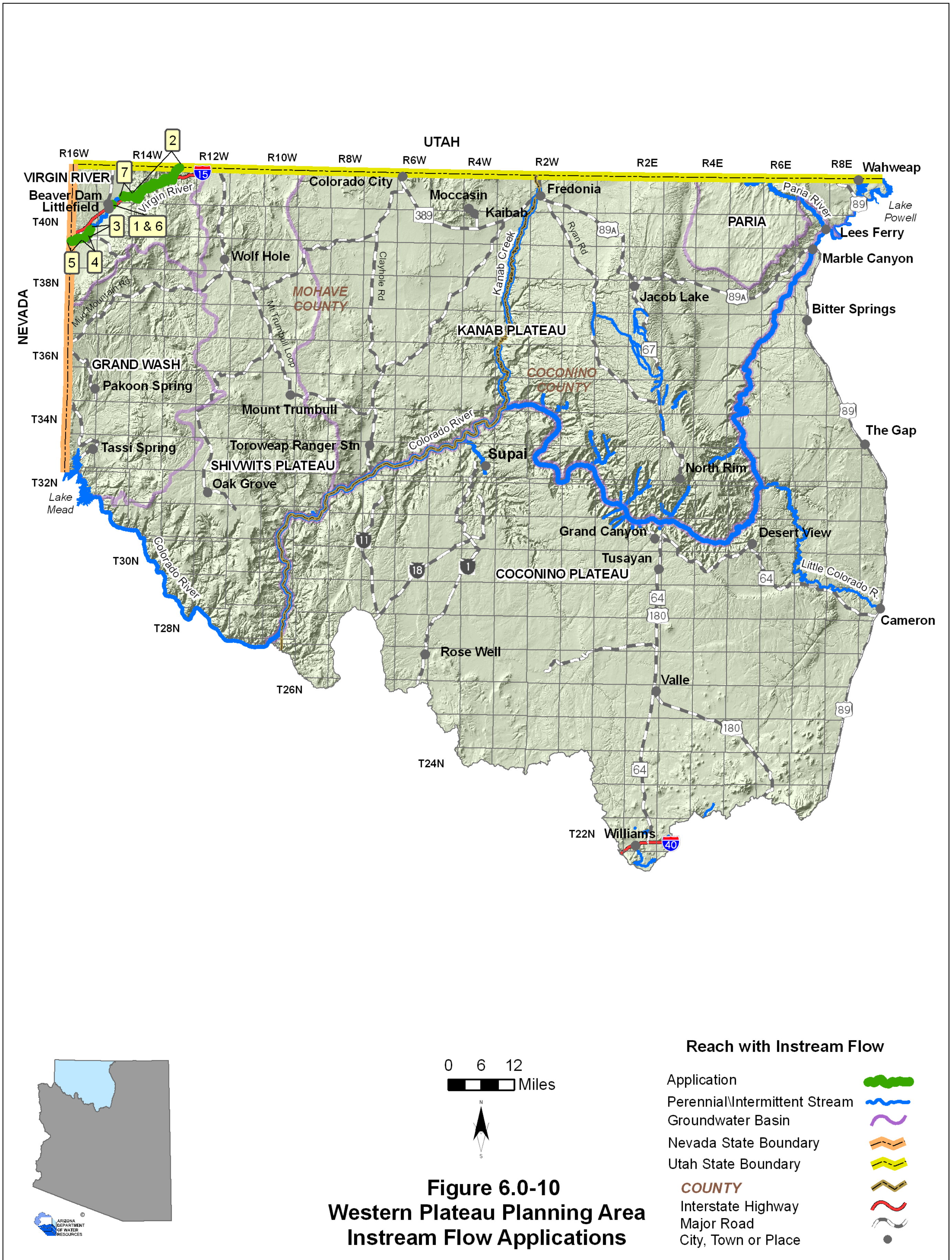


Figure 6.0-10
Western Plateau Planning Area
Instream Flow Applications

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 and 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. There are now over 60 condors in Arizona. In Arizona, reintroduction of the condor 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 number 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 2 million combined acres.

Ten wilderness areas are entirely within the planning area as well as part of another. 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 the Virgin River and Paria basins, stretching from the confluence of the Little Colorado and Colorado Rivers west to Lake Mead (see landownership 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 contains a diversity of biotic communities ranging from Mohave Desertscrub to Subalpine Conifer Forest. It 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).

Table 6.0-2 Listed threatened and 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 areas 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 2006, USDOI 2007

Table 6.0-3 Wilderness areas in the Western Plateau 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. Humphrey's 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-Vermillion Cliffs*	112,500	Kanab Plateau, Paria (part)	Paria Canyon and Vermillion 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.

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

Construction and operation of Glen Canyon Dam has significantly altered Colorado River flows and the sediment, 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.

In March 2007, the Arizona Strip Proposed Plan/Final Environmental Impact Statement (FEIS) was released. The Proposed Plan/FEIS serves multiple functions. It is a revised Resource Management Plan for the Arizona Strip Field Office, 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, management of areas having wilderness characteristics, protection of natural and cultural resources, management of livestock grazing, and recreation. There will be three final management plans that result from this effort with four records of decision signed by the BLM and NPS later in 2007 (BLM, 2007). Over 8,500 comments were received during the public scoping process conducted in preparation of the draft EIS. Most comments were related to concerns about vehicular access and wilderness and resource protection. Both monuments are withdrawn from mineral entry. Grazing is allowed with adjustments to meet management objectives and adjustments will be made to routes as necessary. 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, et al., 2004).

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 in the area. Since designation of the Grand Canyon-Parashant N.M., 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, et al. 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, 2007c)

In 1997, then 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, 2007c). Before release of the EIS, the Secretary authorized an artificial flood in the Grand Canyon that would mimic historic spring flows, 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,2007c).

Another activity that will impact how releases are managed from Glen Canyon Dam is the development of guidelines for the operation of the reservoir under shortage conditions. 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 Basin States (Arizona, California, Nevada). Regulations and operations criteria have never been established for shortage conditions. 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. These guidelines will provide more predictability regarding expected annual water deliveries. An EIS is being completed for this effort, expected to be finalized in September 2007 (USBOR, 2007d).

The preferred alternative 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 Basin States from Lake Mead below 7.5 maf/year; adoption of guidelines for the coordinated operation of Lake Mead and Lake Powell to improve operations under low reservoir conditions; and adoption of guidelines to allow storage and delivery of conserved water in Lake Mead to increase the flexibility of meeting water needs under drought and low storage conditions. The final EIS will include a determination of the environmental impact of the preferred alternative (USBOR, 2007e).

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 but is not federally managed or protected.

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 about 17,200 residents in the planning area. Arizona Department of Economic Security (DES) population projections suggest that the planning area population will more than double by 2050, 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 most populous basin is the Coconino Plateau with about 9,500 residents in 2000. The Shivwits Plateau and Grand Wash basins have very low populations with 12 and 15 residents, respectively. The 2000 Census populations for each basin and Indian reservation, listed from highest to lowest, are shown in Table 6.0-4.

Table 6.0-4 2000 Census population of basins and Indian reservations in the Western Plateau Planning Area

Basin/Reservation	2000 Census Population
Coconino Plateau	9,164
Havasupai	*650*
Navajo	*3,068*
Kanab Plateau	5,930
Kaibab-Paiute	*196*
Virgin River	1,532
Paria	555
Grand Wash	15
Shivwits Plateau	12

Shown in Table 6.0-5 are 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 25% between 1990 and 2000. There are only two incorporated communities within the planning area, Colorado City and Williams. Rapid growth is occurring in several areas including Beaver Dam/Littlefield, Colorado City, Valle and recently, Williams. The unincorporated areas of Beaver Dam/Littlefield and nearby Scenic, Arizona, are growing rapidly in large part due to growth in Mesquite, Nevada, the state's fastest growing community. Mesquite experienced an annual growth rate of almost 9% between 2000 and 2005, 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 are related primarily to that part of the County south of the Colorado River.

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 are 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 will be submitted each year by the systems, beginning June 1, 2007, and include information on water pumped or diverted, water received, water delivered to customers, and effluent used or received. The System Water Plan will be updated and submitted every five years and will consist of three components, a Water Supply Plan, a Drought Preparedness Plan and a Water Conservation Plan. Systems serving populations greater than 1,850 were required to submit plans by January 1, 2007. Systems that serve populations less than 1,850 are required to submit plans by January 1, 2008. Plans have been submitted by the large systems of City of Williams and Colorado City, and by the small systems of Grand Canyon National Park and HydroResources-Tusayan. These plans were used to prepare this document.

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	2005 Pop. Estimate	Percent Change 2000-2005	Projected 2050 Pop.
Colorado City*	Kanab Plateau	2,426	3,334	37%	4,080	22%	8,887
City of Williams*	Coconino Plateau	2,532	2,842	12%	3,145	11%	4,587
Grand Canyon Village	Coconino Plateau	1,499	1,460	-3%	NA	NA	2,693
Town of Cameron	Coconino Plateau	1,011	1,231	22%	NA	NA	4,157
Beaver Dam/Littlefield	Virgin River	762	1,053	38%	NA	NA	NA
Town of Fredonia	Kanab Plateau	1,207	1,036	-14%	1,110	7%	1,462
Town of Tusayan	Coconino Plateau	NA	562	NA	NA	NA	774
Town of Valle	Coconino Plateau	123	534	334%	NA	NA	1,010
Total >500		9,560	12,052	21%	NA	NA	NA
Other		3,382	5,156	34%	NA	NA	NA
Total		**12,942**	**17,208**	25%	NA	NA	**35,266**

Source: DES 2005: www.workforce.az.gov, U.S. Census Bureau 2006, BOR 2006
Notes: 2005 population estimates not available for unincorporated communities
NA = not available
* = incorporated communities

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.

Subdivision adequacy determinations (Water Adequacy Reports), including the reason for the inadequate determination, are provided in the basin sections of this volume and are summarized for each basin in Table 6.0-6. As shown, there were a limited number of subdivisions with a water adequacy determination in the planning area. 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. Since 2005, additional applications have been filed in the Virgin River Basin. The largest is a pending application for Beaver Dam Ranch, a 1,840-acre development with a projected demand of 5,300 acre-feet per year at build out.

Table 6.0-6 Water Adequacy Determinations in the Western Plateau Planning Area as of 2005

Basin	Number of Subdivisions	Number of Lots[1]	Lots w/ Adequate Determ.	Lots w/ Inadequate Determ.	Approx. Percent of Lots w/ Percent Inadequate Determ.
Coconino Plateau	27	>1194	0	>1194	100%
Grand Wash	none	none	none	none	none
Kanab Plateau	9	360	201	159	44%
Paria	6	991	991	0	0%
Shivwits Plateau	none	none	none	none	none
Virgin River	10	>627	>601	26	4%

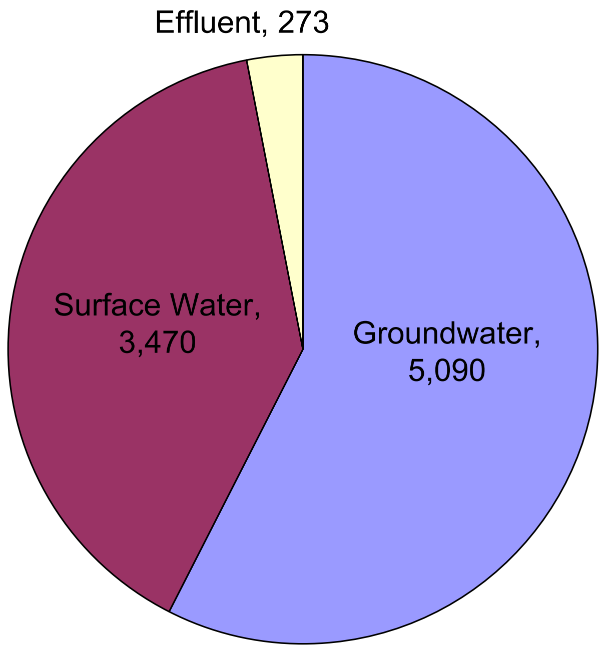
Source: ADWR 2006
Notes:
[1] Data on number of lots are missing for some subdivisions; actual number is larger

No water providers in the planning area are designated as having an adequate water supply for their entire service area. 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 6.0-11, groundwater is the primary water supply, accounting for about 58% 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 39% of the total water demand is met with surface water. Effluent is utilized for golf course irrigation and for landscape irrigation 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 accounted for as groundwater. This is reflected in the cultural water demand tables in each basin section.

Figure 6.0-11 Water supplies utilized in the Western Plateau Planning Area in acre-feet (average annual use 2001-2003)



Surface Water

About 3,500 acre-feet per year of surface water diverted from streams or springs is used on average in the planning area. Surface water is used primarily for agricultural irrigation but also as a municipal and industrial water supply.

<u>Municipal and Industrial Supply</u>
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).

Havasu Creek, which flows from springs emanating from the Redwall-Muav Formations, is a water supply for the Havasupai Tribe at Supai. Surface water is used as both a municipal and agricultural supply on the reservation.

In the Kanab Plateau Basin, about half of Fredonia's municipal water supply is surface water from springs, the rest is water delivered from Utah. Jacob Lake Lodge uses about seven acre-feet of spring water a year from Warm Spring. Surface water from springs is also a supply for Twin City Water (Colorado City) and Badger Creek Water in the small community of Vermilion Cliffs. Marble Canyon Co. has a Colorado River contract for 70 acre-feet per year.

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, 2004).

In the Virgin River Basin, a small amount of surface water is diverted from Beaver Dam Wash for golf course irrigation.

<u>Agricultural Supply</u>

In the Kanab Plateau Basin, 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, diverted between the Kanab Dam and the Fredonia Dam (ADWR, 1998). It is not known precisely how many acres are currently actively irrigated but based on a cursory observation of the area in August 2007 and recent aerial photos, there appears to be far less irrigated land and surface water use now than in the past. The Arizona Strip Partnership (now inactive) identified the lack of sufficient surface water supplies for agriculture as an issue in Fredonia.

In 2000, about 1,700 acres in the Littlefield area in the Virgin River Basin were in cultivation. However, due to recent flood damage and conversion to domestic uses, agricultural acreage is presently about 500-600 acres. It is estimated that about 225 of these acres are irrigated with approximately 1,500 acre-feet of surface water diverted from the Virgin River.

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 in the planning area where it is pumped from relatively shallow local aquifers or from deep regional aquifers. Groundwater pumpage averaged about 5,100 acre-feet during the period 2001 to 2003. Groundwater is a supply for municipal, industrial and agricultural users in the planning area. 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 below land surface 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 yield of 16 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.

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 both aquifer recharge and storage are only available for the Virgin River Basin and estimates of groundwater in storage are only available for the Coconino Plateau and Paria basins.

In order to better understand the water supply situation in areas of the state where data are lacking, the Department has established automated groundwater monitoring sites that record water levels in wells. This information is available through an interactive map on the Department's website to allow access to local information for planning, drought mitigation and other purposes (www.azwater.gov/dwr/). These devices were 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.

Figure 1-18 of Volume 1 of the Atlas shows the location of automatic water-level recording sites as of 2005. At that time there were four sites in the planning area, three of which were USGS sites. There is currently one automated Department-operated site in the planning area located west of Littlefield in the Virgin River Basin.

Index well hydrographs, which display historic water level behavior in 14 index wells in the planning area (primarily in the Virgin River Basin) are also available at the same web location through an interactive map. 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 sections 6.1-6.6.

Municipal and Industrial Supply

With the exception of Fredonia, which utilizes surface water to meet about half of its demand and Grand Canyon Village, all other 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 currently 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 below land surface, 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 an industrial supply for two golf courses in the Virgin River Basin.

Agricultural Supply

Groundwater is an agricultural water supply primarily in the Littlefield and Beaver Dam area in the Virgin River Basin. It is also used to a lesser degree for agricultural irrigation in the Kanab Plateau Basin at Colorado City, Moccasin/Kaibab and Cane Beds areas. In general, use of groundwater for irrigation is declining in the planning area.

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 is met by effluent. Effluent is used for golf course irrigation and municipal uses totaling about 270 acre-feet annually. Effluent supplies about half of the water requirements of the Elephant Rock Golf Course at Williams. Effluent generated at Tusayan is reused for toilet flushing in hotels and businesses and for landscape irrigation. Wastewater at the South Rim of the Grand Canyon is reused for toilet flushing, landscape irrigation and other uses. At Valle, effluent is used for landscape irrigation and fire protection.

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 in the planning area. Table 6.0-7 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 6.0-12.

Table 6.0-7 Active contamination sites 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 2002, ADEQ 2006a, ADEQ 2006b

There are 27 active LUST sites in the planning area. There are 11 sites at Fredonia, six at Jacob Lake, five at Williams, three at Tusayan, and one each at Cameron and Wahweap. 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).

6.0.7 Cultural Water Demand

Several recent studies provide detailed information on cultural water uses in the Coconino Plateau Basin. These studies are primarily related to developing additional water supplies to meet future water demands and include the North Central Arizona Water Supply Study (USBOR, 2006), 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).

Total cultural water demand in the Western Plateau Planning Area averaged approximately 8,800 acre-feet per year during the period from 2001-2003. As shown in Figure 6.0-13, the agricultural demand sector is the largest use sector with approximately 4,500 acre-feet of demand, 51% of the total. With the exception of small pastures, agricultural demand occurs only in the Kanab Plateau and Virgin River basins. About 44% of this agricultural demand is met by surface water diverted

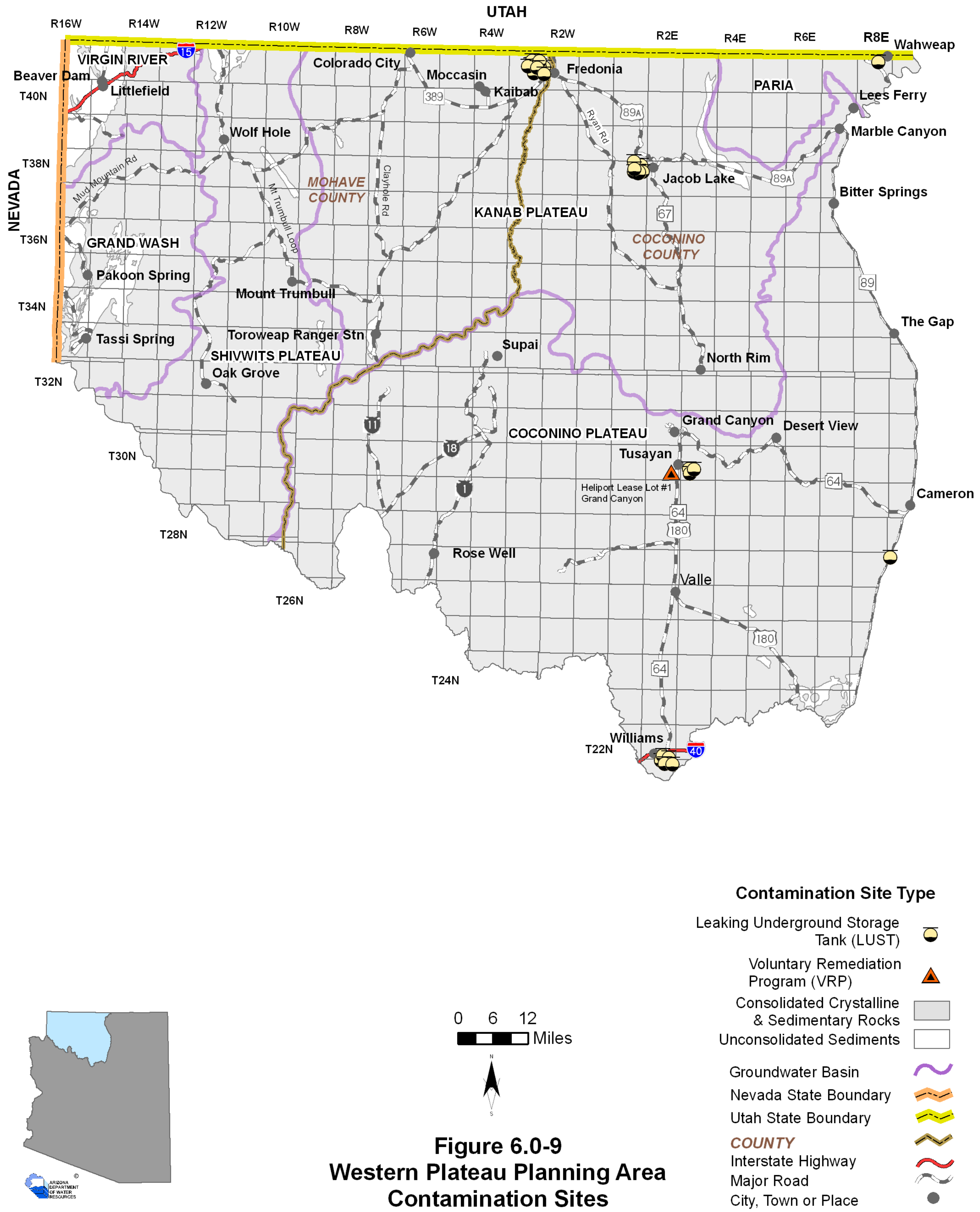
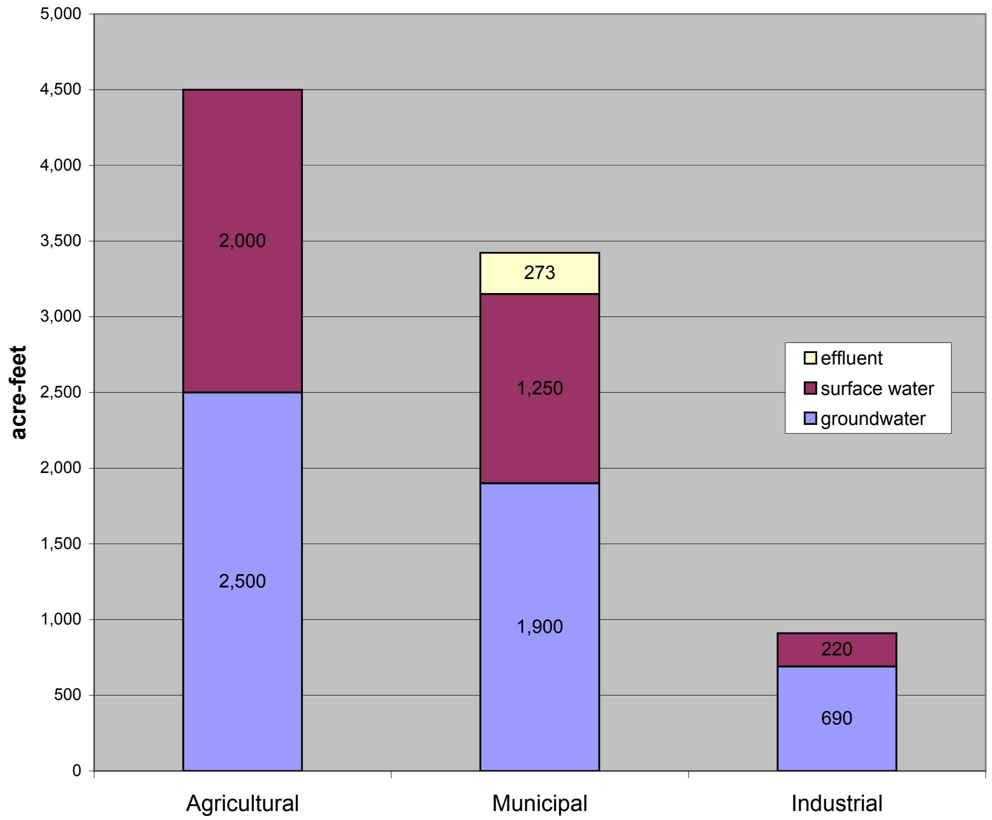


Figure 6.0-9
Western Plateau Planning Area Contamination Sites

from the Virgin River and Kanab Creek. Municipal demand represents about 39% of the total planning area demand with an average of 3,400 acre-feet during the period 2001-2003. Municipal demand is primarily met by groundwater and the municipal sector is the only sector that utilizes effluent. Industrial demand, primarily related to golf course irrigation, accounted for 900 acre-feet, 10% of the total demand during this period. Tribal water demand is included in these totals.

Figure 6.0-13 Western Plateau Planning Area Average Cultural Water Demand by Sector, 2001-2003

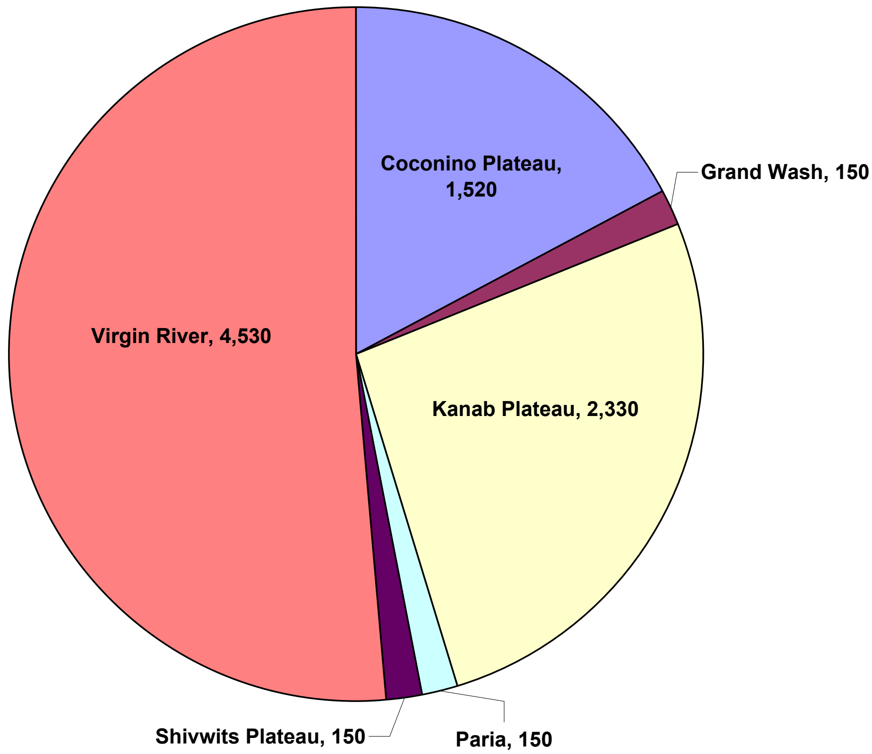


Cultural demand volumes vary substantially between planning area basins and ranges from 150 acre-feet a year in several basins to over 4,500 acre-feet a year in the Virgin River Basin (see Figure 6.0-14).

Tribal Water Demand

The largest Indian reservation in the planning area is the western portion of the Navajo Reservation, the largest reservation in terms of size in Arizona. All of the Havasupai 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 is estimated to be less than 450 acre-feet per year.

Figure 6.0-14 Average total basin water demand per year in acre-feet, 2001-2003



Water demand on the portion of the Navajo Reservation within the Western Plateau Planning Area is associated with domestic and tourism-related uses at several communities including Cameron, Gray Mountain, Cedar Ridge and Bodeway (The Gap). Stockwatering is also a likely use. Approximately 250 acre-feet is used annually in this area (USBOR, 2006).

The Kaibab-Paiute Reservation contains five villages, the largest of which is Kaibab. The 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). Demand is estimated at less than 100 acre-feet per year. 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 from wells 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 is likely less than 100 acre-feet per year on the reservation.

Municipal Demand

Municipal demand is summarized by groundwater basin and water supply in Table 6.0-8. Average annual demand during 2001-2003 was over 3,400 acre-feet. Fifty-five percent of the municipal demand is met by groundwater. Surface water is used in the Coconino Plateau Basin by Williams and Grand Canyon National Park-South Rim, and in the Kanab Plateau Basin by Fredonia, 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 irrigation and fire protection at Valle.

Table 6.0-8 Average annual municipal water demand in the Western Plateau Planning Area (2001-2003) in acre-feet

Basin	Groundwater	Surface Water[1]	Effluent[2]	Total
Coconino Plateau	300	950	273	1,523
Grand Wash	<300			<300
Kanab Plateau	1,000	300		1,300
Paria	<300			<300
Shivwits Plateau	<300			<300
Virgin River	<300			<300
Total Municipal	1,900	1,250	273	3,423

Sources: USGS 2005b, ADWR 2005c

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

[1] Shown on Table 6.0-8 is 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] Effluent figures are for golf course, turf irrigation and municipal reuse in Tusayan, Grand Canyon Village and Williams in 2006

Primary municipal demand centers are Colorado City, Fredonia, Grand Canyon National Park, Tusayan and Williams. It is estimated that about 65% of the planning area population is served by a water provider. Six water providers in the planning area served 100 acre-feet or more of water in 2003. These providers and their demand in 1991, 2000 and 2003 are shown in Table 6.0-9. In 2003, 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.

<u>City of Williams</u>

The City of Williams was until recently completely reliant on surface water. Due to drought conditions which 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 the water treatment process. In 2003, Williams used about 590 acre-feet of water- 336 acre-feet of surface water and 254 acre-feet of groundwater. Annual water demand and the supply used fluctuates from year to year. In 2005, Williams used a total of just 386 acre-feet of which only 29 acre-feet was groundwater (City of Williams, 2007).

Table 6.0-9 Water providers serving 100 acre-feet or more water per year in 2003, excluding effluent, in the Western Plateau Planning Area

Basin/Water Provider	1992 (acre-feet)	2000 (acre-feet)	2003 (acre-feet)
Coconino Plateau Basin			
City of Williams	450	620	590
Grand Canyon National Park Water Utility - South Rim	528	528	528
HydroResources-Town of Tusayan	135	125	129
Kanab Plateau Basin			
Centennial Park DWID - Colorado City	NA	NA	613
Fredonia Water Department	NA	417	440
Twin City Water Company - Colorado City	NA	NA	960

Sources: ADWR 2005c, ADWR 2004, City of Williams 2006, Coconino County 1997, Town of Colorado City 2006

NA = Not Available

Notes: Williams began using groundwater in 2000. Grand Canyon National Park receives its water from Roaring Springs in the Kanab Plateau Basin, about 88% of the total demand for the Park is used at the South Rim. In 1992 water in Tusayan was provided by the Canyon Squire Inn well (64 af), water hauled from Williams and Bellemont (40 af) and Grand Canyon National Park (30 af). Estimate of water served by Centennial Park DWID includes some water use for agriculture. Fredonia served 440 af in 2003, however, 220 af is water from Utah. Twin City Water Company water use is from 2006 and includes water from wells in Utah.

Municipal uses include residential, commercial and the only municipal golf course in the planning area. The Elephant Rock Golf course uses approximately half surface water and half effluent for irrigation. 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 to commercial haulers is restricted during drought (Pinkham and Davis, 2002). While growth in Williams has been relatively slow, it has approved water allocations to more than 1,000 future lots. Expansion of both its water treatment plant and wastewater treatment plant 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 with about 600 acre-feet of surface water used in 2003. The South Rim receives most of the Park's visitors and uses 90% of the water. 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. 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 South Rim, Desert View, North Rim, Roaring Springs, Phantom Ranch and Indian Gardens and provides hauled water to four sites on the South Rim that are not connected to the distribution system (NPS, 2006).

Some of the treated wastewater from the South Rim is 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, one-site plumbing is incomplete. It is estimated that about 130 acre-feet of effluent is used annually at the South Rim.

Tusayan

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 560. Tusayan's economy is based on tourism including hotels, restaurants, an airport and visitor service establishments (Pinkham and Davis, 2002).

HydroResources-Tusayan serves about seventy-five percent of the water demand at Tusayan utilizing two 3,000 foot deep wells that produce 65 to 80 gallons per minute. It delivers about 130 acre-feet of groundwater annually. Other water systems are ADOT, which serves the Grand Canyon Airport, and Anasazi Water (HydroResources, 2007). Anasazi Water has one well, receives some water from HydroResources and uses 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 the event of an emergency. The water systems relied heavily on hauled water prior to 1995 when wells and reclaimed water began to be used (Pinkham and Davis, 2002).

All water used indoors in Tusayan is treated at the South Grand Canyon Sanitary District wastewater treatment plant. Water is treated to ADEQ A+ standards and is used extensively for toilet flushing and irrigation. In 2001, almost 70 acre-feet of effluent was reused. It is estimated that reclaimed water use accounts for 30-50 percent of the total water use at some of the hotels (Pinkham and Davis, 2002).

The Grand Canyon Airport demand is about 10 acre-feet per year. A rainwater collection system, consisting of 5 acres of Hypalon plastic, provides potable water to the terminal, office, hangar facilities and a dozen homes. The airport also uses reclaimed water for irrigation (Pinkham and Davis, 2002). The airport has a connection to the HydroResources water system but rarely needs additional water. However, in 2004, HydroResources sold about 6 acre-feet of groundwater to the airport (HydroResources, 2007).

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 group of religious fundamentalists 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 over 1,600 acre-feet of annual demand served by two systems and a population of more than 3,300.

Most of Colorado City is served water pumped from wells owned by Twin City Water Works, which also serves Hildale Utah. Some of the Twin City Water Works wells are located in Arizona. The City buys water wholesale from Twin City Water Works, treats it to drinking water standards, and delivers it to customers through its water delivery infrastructure. The southeastern part of Colorado City is served by Centennial Park Domestic Water Improvement District, which also provides water for agricultural irrigation. Municipal water uses include residential, commercial and light manufacturing. The wastewater treatment plant in Colorado City was closed in 2002 and wastewater is now treated at a plant in Hildale.

Fredonia

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. Its sawmill closed in 1995 and tourism, government activities and agriculture are the current economic drivers. The population of Fredonia declined between 1990 and 2000 by about 14% but is now slowly increasing. In 2003, about 440 acre-feet of water was served by the municipal utility. About half of the Town's water supply is from springs in Arizona and the remainder is water transported by pipeline from Utah. Approximately 160 acre-feet of effluent is produced at Fredonia but not reused.

Other Communities

The communities of Beaver Dam, Littlefield, Scenic and the surrounding area in the Virgin River Basin are experiencing development pressure due primarily to the rapidly growing community of Mesquite, Nevada. These communities provide housing for much of Mesquite's workforce and for retirees (USDOI, 2007). Currently, the area is served by private water systems or domestic wells. There are several pending applications for water adequacy determinations in the area, the largest of which is an Analysis of Adequate Water Supply for the Beaver Dam Ranch Development totaling 5,300 acre-feet per year. This and other planned developments will result in substantial increases in municipal water demand in the Virgin River Basin from the current demand of less than 300 acre-feet a year. In anticipation of development, some agricultural lands north of Beaver Dam Wash and near Littlefield have gone out of production.

Valle, located between Williams and Tusayan, is a small but rapidly growing community 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. The other system, HydroResources-Valle serves the Grand Canyon Valle Airport, a mobile home park and operates two standpipes for water haulers. 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 is significant subdivision activity in the area (Pinkham and Davis, 2002). The community grew by 334% between 1990 and 2000.

Agricultural Demand

Agricultural demand in the planning area is about 4,500 acre-feet a year, primarily for pasture irrigation (Table 6.0-10). Aside from small domestic pastures and gardens, agricultural irrigation is found only in the Kanab Plateau and Virgin River basins. It should be noted that the data source for the cultural demand maps in the groundwater basin sections is from satellite imagery collected between 1999-2001 and may not accurately represent agricultural demands in the planning area.

Table 6.0-10 Agricultural demand in the Western Plateau Planning Area

	1991-1995 (acre-feet)	1996-2000 (acre-feet)	2001-2003 (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	2,000
Surface Water	5,800	6,200	1,500
Total	13,600	14,500	3,500

Source: USGS 2005c, ADWR 2005d
Notes: Volume <1,000 acre-feet assumed to be 500 acre-feet for computational purposes

There is considerable uncertainty about the amount of acreage currently in production in the Kanab Plateau Basin. Observations in the Colorado City, Cane Beds (east of Colorado City) and Fredonia areas suggest that in the summer of 2007 there was considerably less land irrigated than historic levels. It is estimated that current agricultural demand in the basin is about 1,000 acre-feet a year. About half the agricultural demand occurs in the Fredonia area, 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 primarily east of Kanab Creek south of the town. Historically, the district delivered surface water diverted from Kanab Creek and it is assumed that this is still the source of water (ADWR, 1998). Irrigation in the Colorado City and Cane Beds area is assumed to be less than 1,000 acre-feet of groundwater a year. Large fallow areas, previously irrigated with center pivot systems were observed in the Colorado City area in summer 2007. There is a small amount of agricultural activity, including a 1,300 tree fruit orchard, on the Kaibab-Paiute Indian Reservation and in nearby Moccasin. Estimated groundwater demand is about 50 acre-feet a year.

In the Virgin River Basin, irrigation demand has declined from an annual average of 14,500 acre-feet during the period 1996-2000 to an annual average of 3,500 acre-feet during 2001-2003. This decline has occurred due to recent flood damage along the Virgin River and Beaver Dam Wash and to urbanization. It is estimated that about 525 acres are still in production in the Littlefield/Beaver Dam area (Kyle Spencer, NRCS, personal communication 3/25/05). With the exception of a small nursery operation at Beaver Dam, most of the irrigated land in the area is pasture.

Industrial Demand

Industrial demand in the planning area is relatively small, averaging about 900 acre-feet annually during the period 2001-2003. As shown in Table 6.0-11, quantified industrial demand in the planning area consists of two golf courses served by facility water systems and a small dairy. Both industrial golf courses are in the Virgin River Basin and use both surface water and groundwater. The Meadowayne Dairy, located on the north side of Colorado City in the Kanab Plateau Basin has an annual demand of about 30 acre-feet.

Table 6.0-11 Industrial demand in selected years in the Western Plateau Planning Area

	1991	2000	2003
Type	**Water Use (acre-feet)**		
Golf Course Total	**880**	**880**	**880**
Virgin River			
Groundwater	660	660	660
Surface Water	220	220	220
Dairy/Feedlot Total	**30**	**30**	**30**
Kanab Plateau			
Groundwater	30	30	30

Source: ADEQ 2005, ADWR 2005e, USGS 2005b

Golf courses in the planning area are shown in Table 6.0-12. Hamilton Ranch Golf Course is located in the community of Beaver Dam. Flooding in 2006 washed out all but 8 holes. Irrigation of the course uses about 220 acre-feet/year 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 acre-feet/year 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 met by a combination of effluent and untreated surface water.

Table 6.0-12 Golf course demand in the Western Plateau Planning Area

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

Source: ADWR 2005e
Notes:
* These golf courses are served by their own wells and, therefore, considered to be industrial users

There is additional industrial demand in the planning area not reflected in the table, 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.

The three small mines shown on the Kanab Plateau Basin cultural demand map are uranium mines (Figure 6.3-11). Not all uranium mines are shown. Denison Mines owns the Arizona One mine with plans to begin mining in 2008 as well as two other mines, Canyon and Pinenut, which could be operated in the future. At least eleven mining companies are currently exploring the Arizona Strip and placing claims on breccia pipes for the purpose of uranium mining. The highest grade uranium deposits in the United States occur in breccia-pipe environments in northwest Arizona. 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) 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)

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 the distribution of surveys, and from other sources. Issues and planning, conservation and research activities are discussed in this section.

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 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 is to secure funding to conduct a feasibility study to evaluate water supply alternatives.

On the Arizona Strip, the EIS for the Grand Canyon-Parashant and Vermilion Cliffs national monuments and for other BLM lands (BLM, 2007) is a comprehensive study of much of the area north of the Colorado River. While the focus 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 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. There is a significant amount of interplay between resource development and environmental needs in the planning area given the significant 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, which supplies most of its potable supply, 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.

As mentioned in the population section, by January 2007, all large (>1,850 customers) community water systems in the state are required to submit System Water Plans. Small systems have until January 2008 to submit their plans. 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 the City of Williams and Colorado City, and by two small systems, Grand Canyon National Park and HydroResources-Tusayan. By July 1, 2007, all systems were required to submit an annual water use report with data on water pumped, diverted, received and delivered to customers.

Local Drought Impact Groups (LDIGs) are being formed in all counties across Arizona. 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 Community Water Planning Program.

To support the efforts of the LDIGs, professionals and residents are asked to provide monthly feedback on drought conditions throughout their county. Citizens may also participate with the LDIG by assisting with education and outreach efforts and recommending actions for drought mitigation and response. More information on LDIGs may be found at http://www.azwater.gov/dwr/drought/LDIG.html.

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 had formed in the Fredonia area, (the Arizona Strip Partnership), but is no longer active. A list of participants, activities and issues of all watershed groups in the planning area is found in Appendix B.

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 regional 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 or large water companies. However, as discussed below, a local group has formed to oppose an application to transport groundwater from the basin into Nevada, fearing the transportation will negatively impact local water supplies.

In March 2005, the Department received an application from Wind River Resources, L.L.C. to transport water from Beaver Dam Wash to Mesquite Nevada, pursuant to A.R.S. § 45-291 *et seq*. The statute allows for transportation of groundwater out of state, conditional on seven criteria that will be evaluated before the application can be approved or denied. The proposal calls for construction of three wells in the Mormon Wells area along Beaver Dam Wash to initially withdraw 800 acre-feet/year and up to 14,000 acre-feet per year by 2045, and transport it to the Virgin Valley Water District in Mesquite. The application proposes to use the water from Arizona to mix with the District's water, which has concentrations of arsenic in excess of the drinking water standard. The Office of Administrative Hearings held a three-day hearing in early March 2007 in Beaver Dam and took testimony and received briefs on the application. The record will remain open until October 10, 2007 for the filing of post-hearing briefs. The Administrative Law Judge has 20 days after the record closes to issue his recommended decision and the director of the Department has 30 days thereafter to issue his decision.

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
- Need access to water development on public lands
- Limited groundwater data

Limited supplies to meet projected demands
Limited water resources to meet current 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
Proposed San Juan Paiute Indian Reservation (northeast portion of Coconino Plateau Basin)

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 groundwater and surface water supplies

Environmental:

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

Other:

Unsafe dam issues (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.

With regard to a question of groundwater level trends in their service area, most respondents reported stable water levels as shown by basin with the corresponding number of respondents in Table 6.0-13. One respondent in the Kanab Plateau Basin reported falling water levels and one in the Virgin River Basin reported rising water levels.

Table 6.0-13 Groundwater level trends reported by 2004 survey respondents by groundwater basin (10 respondents)

Basin	Rising	Stable	Falling	Variable	Don't Know
Coconino Plateau		1			1
Kanab Plateau		2	1		
Virgin River	1	4			

Source: ADWR 2005c

Water providers were asked in the 2004 survey to rank 7 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 shown in Table 6.0-14 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.

Table 6.0-14 Water resource issues ranked by 2004 survey respondents in the Western Plateau Planning Area (7 water providers)

Issue	Moderate concern	Major concern	Total	Percent of respondents reporting issue was a major or moderate concern
Inadequate storage capacity to meet peak demand	0	3	3	43%
Inadequate well capacity to meet peak demand	0	1	1	14%
Inadequate supplies to meet current demand	2	1	3	43%
Inadequate supplies to meet future demand	1	2	3	43%
Infrastructure in need of replacement	1	1	2	29%
Inadequate capital to pay for infrastructure improvements	0	5	5	71%
Drought related water supply problems	0	2	2	29%

Source: ADWR 2005c

6.0.9 Groundwater Basin Water Resource Characteristics

Sections 6.1 through 6.6 present data and maps on water resource characteristics of the groundwater basins in the Western Plateau Planning Area. A description of the data sources and methods used to derive this information is found in Section 1.3 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 educational purposes. Other legislation authorized additional state trust lands for specified purposes, which are identified for each basin (ASLD, 2006).

Climate

Climate data including temperature, rainfall, evaporation rates and snow are critical components of water resource planning and management. Averages and 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.

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.

<u>Groundwater Conditions</u>
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.

<u>Water Quality</u>
Water quality conditions impact the availability of water supplies. Water quality data was compiled from a variety of sources as described in Volume 1 Section 1.3. 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.

<u>Cultural Water Demand</u>
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 Appendix A, Volume 1 for more information about the Adequacy Program).

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