ARIZONA WATER ATLAS
VOLUME 2 –EASTERN PLATEAU PLANNING AREA

PREFACE

Volume 2, the Eastern Plateau Planning Area, is the second in a series of nine volumes that comprise the Arizona Water Atlas. The primary objectives in assembling the Atlas are to present an overview of water supply and demand conditions in Arizona, to provide water resource information for planning and resource development purposes and help to identify the needs of communities. The Atlas also indicates where data are lacking and further investigation may be needed.

The Atlas divides Arizona into seven planning areas (Figure 2.0-1). There is a separate Atlas volume for each planning area, an executive summary volume composed of background information (Volume 1) and a resource sustainability assessment volume (Volume 9). "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 and a summary of water supply and demand data for all planning areas. Appendices in Volume 1 describe data sources and methods of analysis, 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. These data may be obtained by contacting the Arizona Department of Water Resources (Department).

SECTION 2.0 Overview of the Eastern Plateau Planning Area

The Eastern Plateau Planning Area is unique in that it is composed of one groundwater basin, the Little Colorado River Plateau Basin. The planning area is relatively high in elevation and is geographically diverse with the highest peaks in the state as well as deep sandstone canyons and large mesas. Almost two-thirds of the land area is under tribal ownership. Elevations range from over 12,600 feet in the San Francisco Peaks north of Flagstaff to 4,200 feet where the Little Colorado River exits the Basin at Cameron. Parts of three counties are contained within the Eastern Plateau Planning Area: Apache (90% of the county), Coconino (41%) and Navajo (89%) counties. All or parts of three Indian reservations are located within the planning area – the Hopi, Navajo, and Zuni reservations. San Juan Southern Paiute tribal members occupy lands located within the Navajo reservation. The Joseph City Irrigation Non-expansion Area (INA) was designated west of Holbrook in Apache County due to insufficient groundwater to provide a reasonably safe supply for irrigation (A.R.S. § 45-431) (Figure 2.0-2).

Much of the planning area is sparsely populated. Flagstaff is the largest metropolitan area with almost 52,900 residents in 2000 and an estimated population of 64,200 in 2007. Other

Navajo Generating Station. The planning area has a large industrial water use sector due to several electrical generating stations, large coal mining operations and a paper mill.

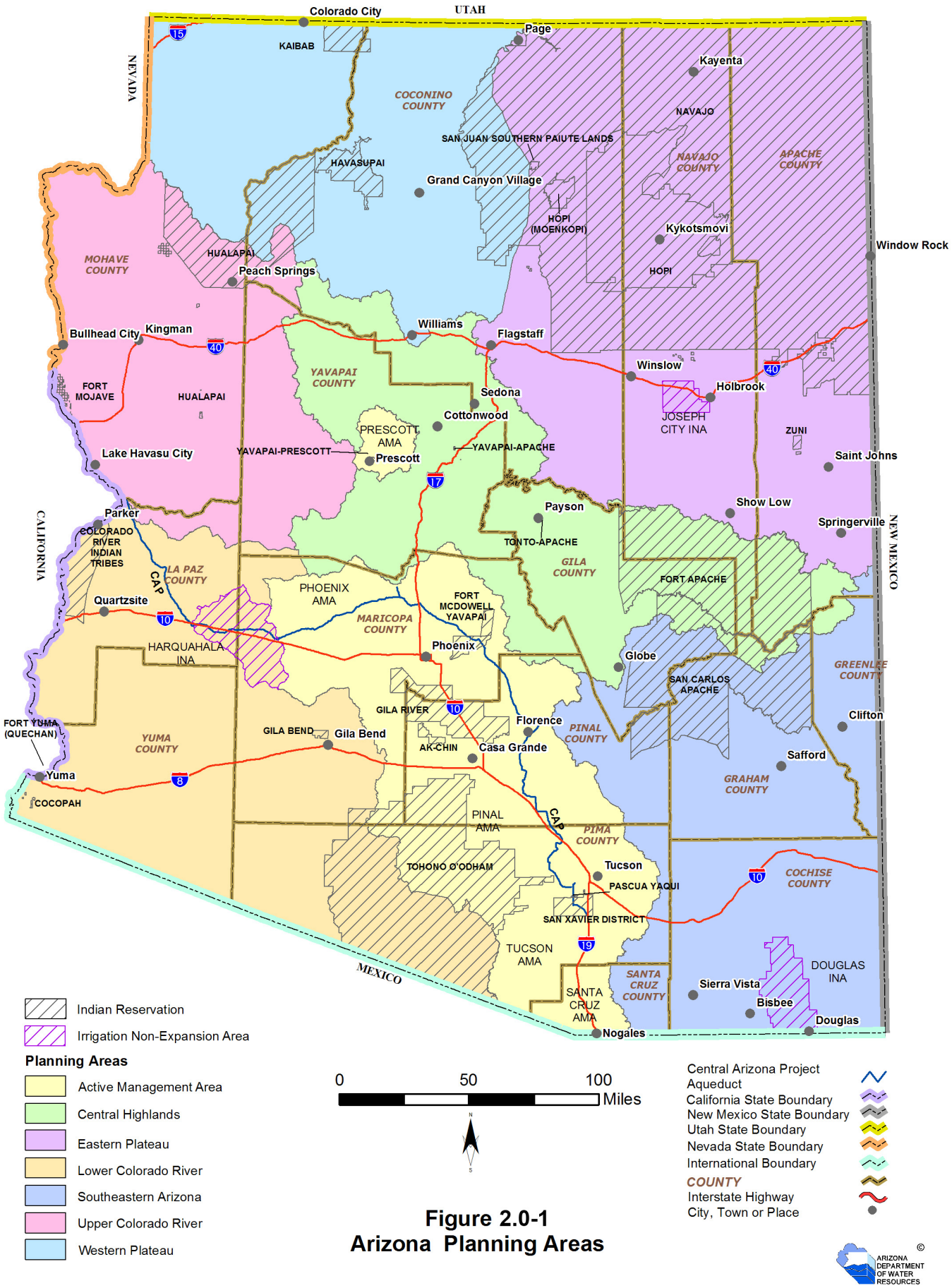
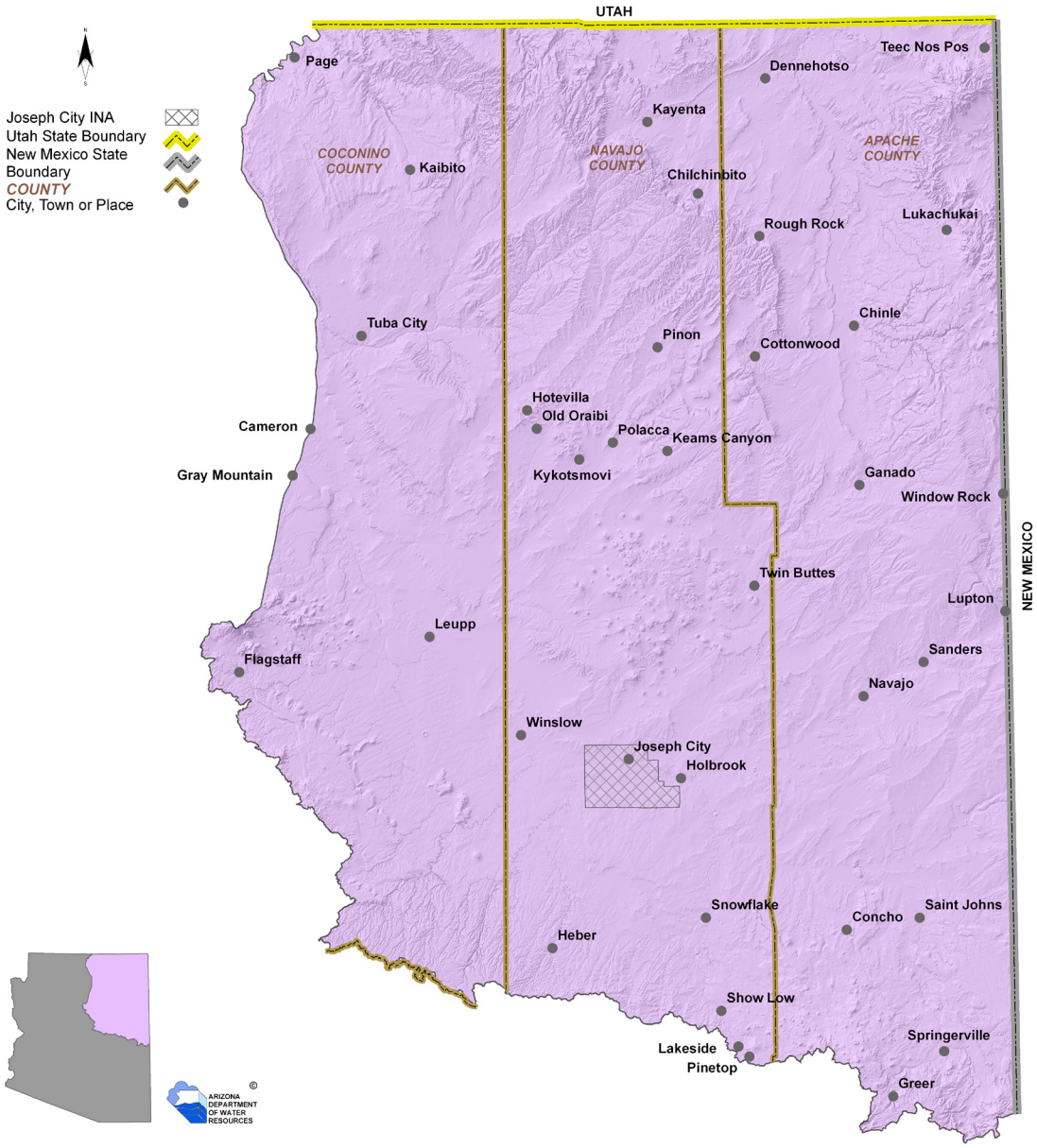


Figure 2.0-1
Arizona Planning Areas

population centers include Show Low/Pinetop/ Lakeside, Winslow/Holbrook, Page, and Tuba City, Window Rock, Chinle and Kayenta on the Navajo Reservation. The 2000 Census planning area population was almost 250,000.

An annual average of about 170,500 acre-feet of water per year was used during the period 2001-2005 in the planning area for agricultural, municipal and industrial uses (cultural water demand). The water supplies utilized to meet these demands include primarily groundwater (104,800 acre-feet), surface water from the Colorado River and other streams (50,800 acre-feet) and effluent (14,900 acre-feet). The planning area has a large industrial water use sector due to the presence of several electrical generating stations, large coal mining operations and a paper mill. Industrial water use is currently about 83,100 acre-feet per year (AFA). Municipal sector average annual demand is approximately 45,000 acre-feet. Agricultural demand is relatively small-scale with an estimated annual demand of 42,400 acre-feet.

Figure 2.0-2 Eastern Plateau Planning Area

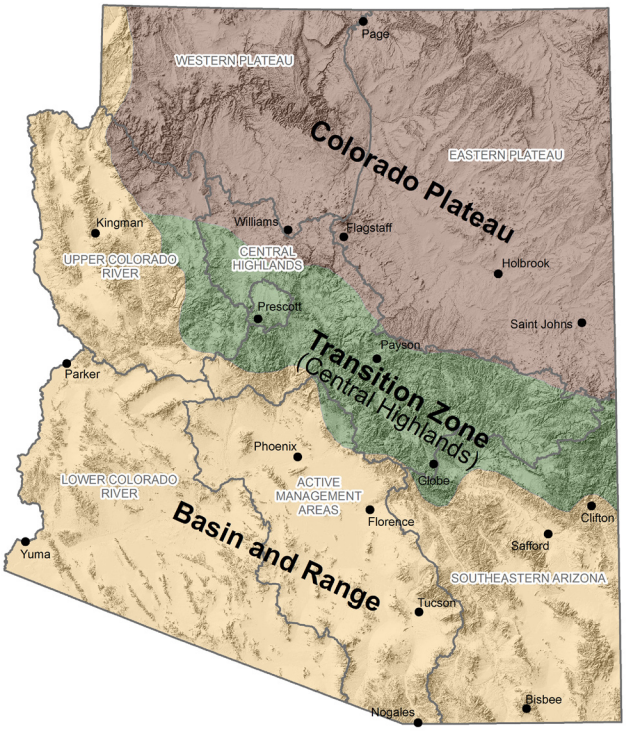


2.0.1. Geography[1]

The Eastern Plateau Planning Area encompasses 26,700 square miles (sq. mi.) in the northeastern portion of the state. The planning area consists of one groundwater basin, the Little Colorado River Plateau Basin. Counties and prominent cities, towns and places are shown in Figure 2.0-2. The planning area is bounded on the north by the Arizona-Utah border, on the east by the Arizona-New Mexico border, on the south by the Mogollon Rim, and on the west by the Coconino Plateau Basin and Paria Basin in the Western Plateau Planning Area, whose boundaries coincide closely with U.S. Highway 89 (Figure 2.0-1). The Mogollon Rim is an escarpment almost 2,000 feet high in some places, extending from central Arizona to the Mogollon Mountains in New Mexico. It forms a hydrologic boundary between the Eastern Plateau Planning Area and the basins of the Central Highlands and Southeastern Arizona planning areas. The Eastern Plateau Planning Area includes parts of four watersheds, which are discussed in Section 2.0-2. All of the Hopi Indian Reservation (2,534 sq. mi.), approximately 56% (14,680 sq. mi.) of the Navajo Indian Reservation, 2% of the Zuni Reservation (16 sq. mi.) and less than 0.2% of the Apache Reservation are located within the planning area. Ninety percent of the Navajo lands in Arizona are located in the Eastern Plateau Planning Area. Many members of the San Juan Southern Paiute Tribe reside in several distinct communities located on the Navajo Reservation. The San Juan Southern Paiute is a relatively small tribe of approximately 265 members. The largest community is located at Willow Springs near Tuba City (ITCA, 2003).

As shown in Figure 2.0-3 the planning area is almost entirely within the Colorado Plateau physiographic province, which covers the northern two-fifths of Arizona. This province is characterized by mostly level, horizontally

Figure 2.0-3 Physiographic Regions of Arizona



Data source: Fenneman and Johnson, 1946

stratified sedimentary rocks that have been eroded into canyons and plateaus, and by some high mountains. Major mountain ranges are the San Francisco Peaks near Flagstaff, the White Mountains in the southeastern portion of the planning area and the Chuska and Lukachukai mountains located along the Arizona-New Mexico border (Figure 2.1-1). The Chuskas reach an elevation of almost 10,000 feet and much of the rain and snow that falls in the Chuskas drains westward into Canyon de Chelly. The Hopi Reservation is characterized by three mesas that rise to an elevation of 7,200 feet. Elevations vary from 12,633 feet at Humphreys Peak near Flagstaff, the state's highest point, to 4,200 feet at Cameron. The average elevation of the planning area is 6,061 feet.

Unique geographic features of the planning area include its relatively high elevation plateaus and mountains, steep cliffs, deeply

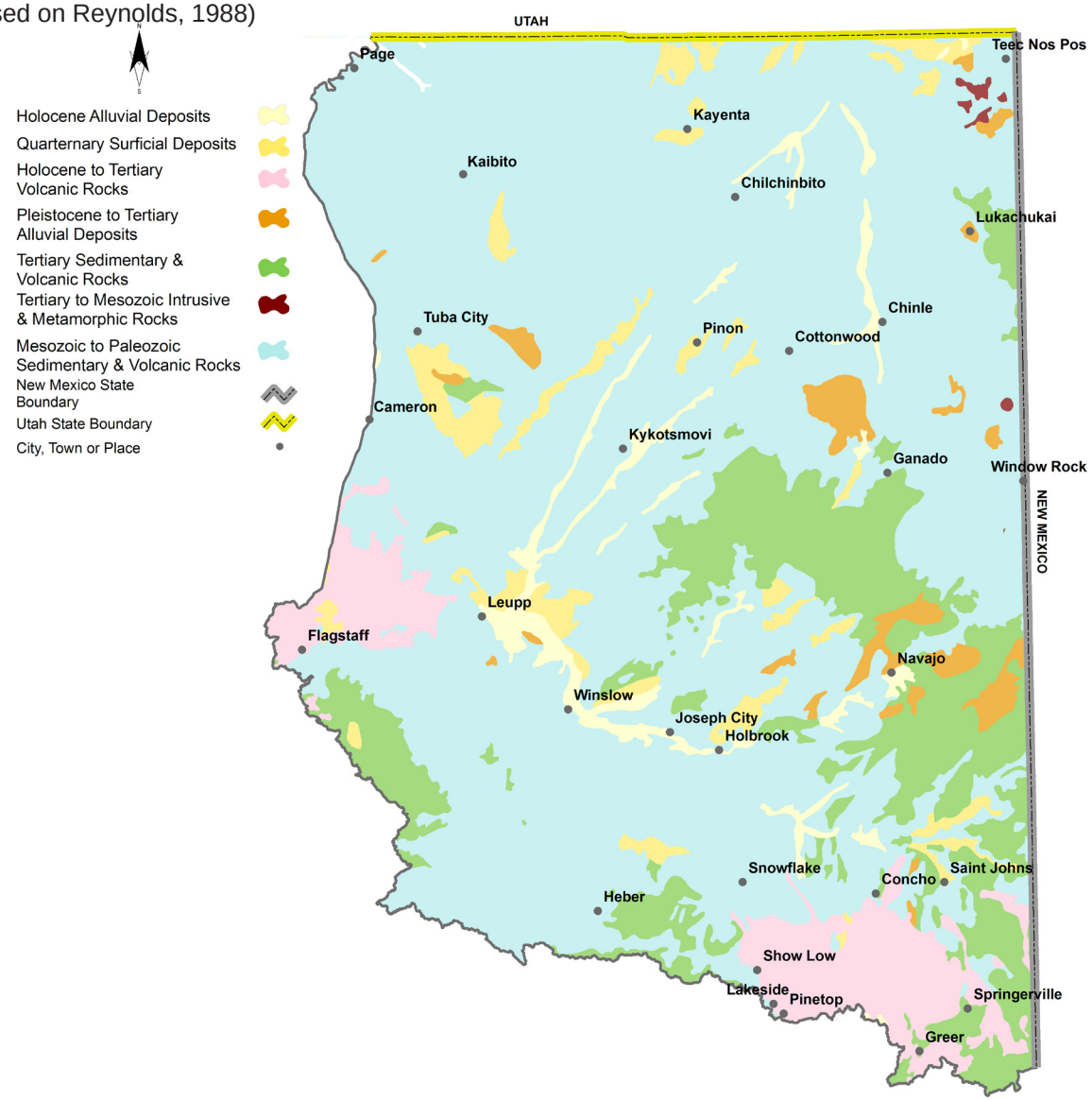
[1] Except as noted, the information in this section is taken from the Arizona Water Resources Assessment, Volume II, ADWR, August 1994.

incised sandstone canyons, and the painted desert consisting of multicolored badland hills and mesas that stretch across much of the mid-section of the planning area. The southern boundary of the planning area marks part of the southern extent of the Colorado Plateau that occupies northern Arizona, northwestern New Mexico, eastern Utah and western Colorado. The Colorado Plateau is at least 500 million years old and has remained "structurally intact" while the surrounding Rocky Mountains and basin and range province were being formed. Huge amounts of sediment were deposited in the region which hardened into sedimentary rock several miles thick. (Grahame and Sisk, 2002)

Another geographic feature of the planning area is the relatively large number of volcanic cinder cones and peaks. Mt. Baldy in the White Mountains and the San Francisco Peaks are volcanic in origin and the San Francisco Peaks are considered potentially active. Sunset Crater northeast of Flagstaff erupted as recently as 1065 AD (Parra and others, 2006). Figure 2.0-4 shows the location of volcanic rocks in the vicinity of Flagstaff and the White Mountains, as well as other geologic information.

Much of the planning area is arid with few perennial or intermittent streams; however a significant number of perennial streams and lakes are found at higher elevations along its

Figure 2.0-4 Surface Geology of the Eastern Plateau Planning Area
(Based on Reynolds, 1988)



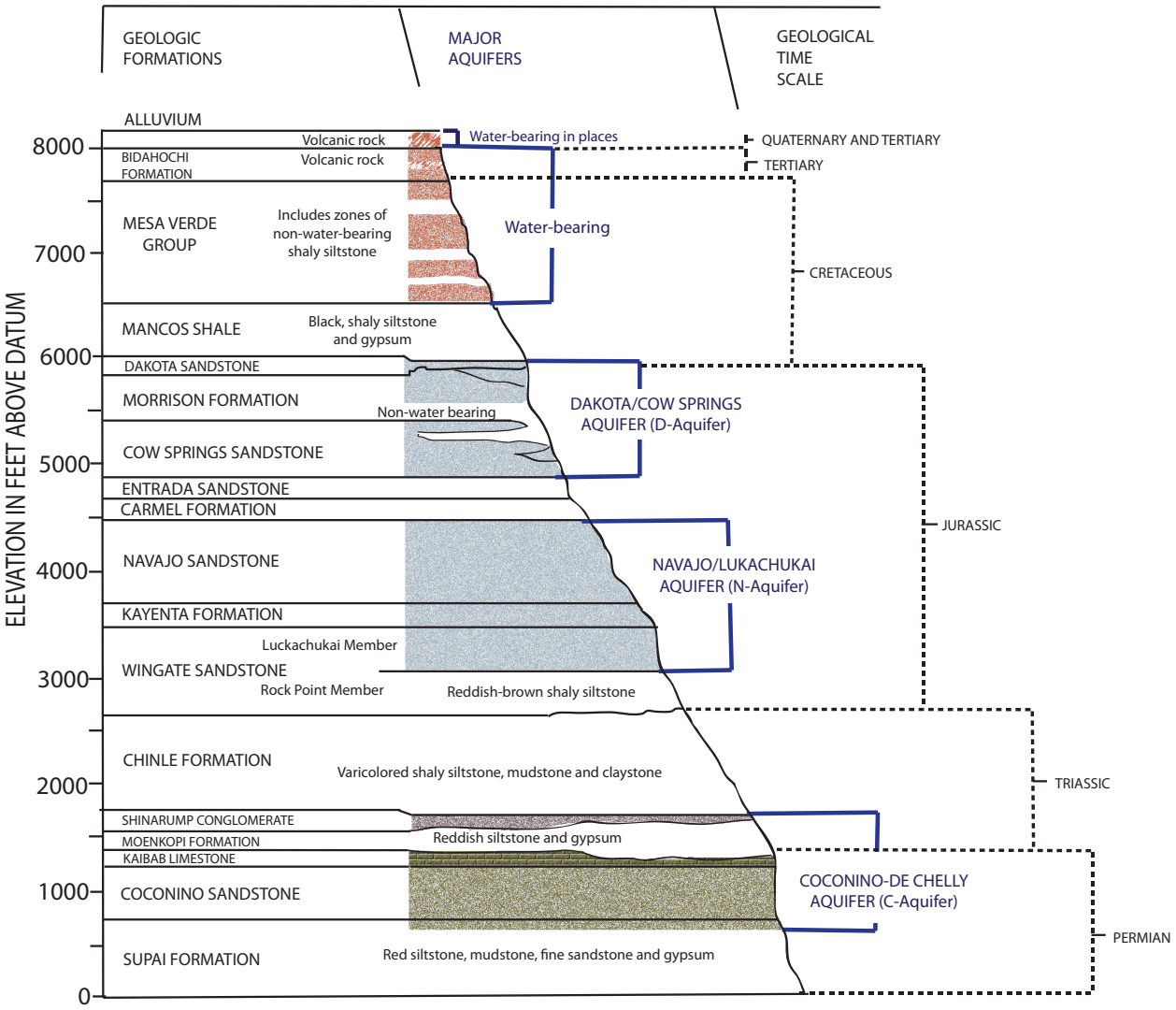
southern boundary, and the Colorado River defines the extreme northwestern boundary of the planning area (Figure 2.1-5).

2.0.2 Hydrology[2]

Groundwater Hydrology

A significant portion of the planning area is underlain by Mesozoic to Paleozoic sedimentary and volcanic rocks (Figure 2.0-4) that form the area's regional aquifers. The sedimentary rocks consist of sandstones and limestones stacked on top of one another that are generally separated by low permeability shales and siltsones. The three largest regional aquifers are the D-, N-, and C-aquifers. Each has a very large areal extent within the basin and except for the D- and N- aquifers, there is little vertical hydrologic connection between them. These water-bearing formations gain thickness towards the center of the basin resulting in artesian conditions. Primary recharge areas are along the southern and eastern periphery of the planning area. It is estimated that there are about 508 million acre-feet (maf) in storage in Little Colorado River Plateau aquifers (ADWR, 1990a). Figure 2.0-5 shows a generalized cross-section of the water-bearing formations of the planning area. In addition to these regional aquifers, several local aquifers are important groundwater sources. One of the most extensive is the Bidahochi aquifer

Figure 2.0-5 Water Bearing Formations of the Little Colorado River Plateau Basin



[2] Ibid

in the east central part of the planning area, composed of tertiary sedimentary and volcanic rocks (See Figure 2.1-7 for the location of large local and regional aquifers).

The C-aquifer is the largest and most productive aquifer in the planning area with an areal extent of 21,655 square miles. It is named for its primary water-bearing unit, the Coconino Sandstone. The C-aquifer extends from the Mogollon Rim in the south to an area west of the Little Colorado River and northeast into New Mexico. Water flow in the aquifer is generally in a west-northwest direction. Recharge to the aquifer is along the Mogollon Rim and on the Defiance Plateau (Hart and others, 2002). The major discharge from the C-aquifer is at Blue Springs along the lower Colorado River. ADWR (1990) estimated there was about 413 maf of C-aquifer water in storage in the planning area.

Water levels measured in selected wells drilled in the C-aquifer varied in depth from 37 feet to almost 2,000 feet below land surface (bls) (Figure 2.1-8). Of the 24 wells measured in 2003-2004, 14 wells showed water level declines since 1990-1991. Most declines were between -1 to -15 feet, however declines of more than 30 feet were measured near Springerville and St. Johns in the vicinity of power plants, and near Flagstaff in the Lake Mary wellfield.

The C-aquifer is utilized as a water supply south of the Little Colorado River and along the southern edge of the basin by Flagstaff, Heber, Overgaard, Show Low, Snowflake and Concho. North of the river the C-aquifer is too deep to be economically useful, or is unsuitable for most uses because of high concentrations of total dissolved solids. In general, the water quality of the C-aquifer degrades with increasing distance from recharge areas and at increasing depths (USBOR, 2006).

The N-aquifer occurs north of the Little Colorado River and has an areal extent of 6,250 square miles. The Navajo and Wingate Sandstones are the main water-bearing units in the N-aquifer. Groundwater flow direction varies as shown in Figure 2.1-7 and is generally south and west or north and west. The aquifer is generally unconfined but there are artesian conditions in the Black Mesa area and near Window Rock and much of the aquifer underlying the Hopi Reservation is unconfined (ADWR, 2008a). Natural recharge to the N-aquifer has recently been estimated at 2,600 to 20,246 AFA (OSM 2008). Water is discharged via springs, baseflow to streams and as underflow to drainages. N-aquifer storage estimates vary from 166 maf to 526 maf (ADWR, 1989; ADWR, 2008a).

Water levels measured in selected wells drilled in the N-aquifer vary in depth from 17 feet to 851 feet bls as shown in Figure 2.1-8. Water level changes between 1990-1991 and 2003-2004 varied in these measured wells (see Figure 2.1-7). Recent adjudication investigation on the Hopi reservation showed median well depths of 745 feet for claimed wells (ADWR, 2008a).

N-aquifer water quality is generally good and is a source of supply for the Navajo and Hopi Reservations. However, there are sites of uranium and heavy metal contamination due to past uranium mining and milling operations. Groundwater remediation activities are underway near Tuba City where a plume of groundwater contamination extends south and southeast of an uranium ore mill operation and 37 extraction wells convey water to an onsite treatment plant (DOE, 2008a)

The N-aquifer is utilized for mining operations at the Black Mesa Coal Mine operation. Until 2005, N-aquifer water was also used for the Black Mesa Coal Mine slurry pipeline that delivered coal to the Mohave Generating Station at Laughlin, Nevada. From the pre-mining period to 2003, the median water level decline was more than 23 feet in 26 wells and declines were approximately 72 feet for 12

wells in the confined part of the aquifer. (Truini, et al., 2005) To relieve impacts on the N-aquifer from pumping at Black Mesa, a proposal to use C-aquifer water withdrawn near Leupp was considered and a study undertaken that was completed in 2005 (Leake, et al., 2005). The Mohave Generating Station suspended operation in 2005, which has significantly reduced the need for N-aquifer withdrawals.

The D-aquifer overlays portions of the N- and C-aquifer in the planning area and is the smallest of the three regional aquifers. It covers about 3,125 square miles under the Navajo and Hopi reservations. The D-aquifer is composed of the Dakota, Cow Springs and Entrada sandstones. Flow direction is toward the southwest in the southern part of the aquifer and toward the northwest in the northern portion (Figure 2.1-7). Annual recharge is estimated at 5,392 acre-feet (GeoTrans and Waterstone, 1999). Recharge probably occurs along the eastern slope of Black Mesa where units of the aquifer outcrop (Lopes and Hoffman, 1997), and also locally along washes. There is some connection between the D-aquifer and the underlying N-aquifer and D-aquifer discharge also occurs via springs, baseflow to streams and as underflow along washes (ADWR, 2008a). ADWR (1989) estimated that there are 15 maf in storage in the D-aquifer.

Little Colorado River near Springerville. Local aquifers include alluvial deposits that occur along washes and stream channels, including along the Little Colorado River and its tributaries.

Water level data from a well collected in 2003-2004 in the D-aquifer showed a depth to water at 271 feet bls and no water level decline since 1990-1991. Median water levels at 48 claimed wells on the Hopi reservation were 268 feet (ADWR, 2008a). Water quality is marginal to unsuitable for domestic use due to high concentrations of dissolved solids. Nevertheless, it is utilized in the north-central parts of the planning area for domestic use.

Local aquifers are important for domestic uses where the regional aquifers are too deep or have unsuitable water quality. Local aquifers include alluvial deposits that occur along washes and stream channels, including along the Little Colorado River and its tributaries, sedimentary and volcanic rocks of the Bidahochi and other formations and some sandstones. The Bidahochi formation forms a local aquifer in the central part of Apache and Navajo counties and south of Sanders. Most recharge to the Bidahochi aquifer probably occurs from direct precipitation. In the southeastern part of Navajo County, saturated basaltic rocks together with underlying sedimentary rocks are locally known as the Lakeside-Pinetop aquifer, which is an important supply for the area. The aquifer covers an area of about 16 square miles and is composed of two distinctive but hydrologically well-connected water-bearing zones (Overby, 2007). Undifferentiated sandstones west of Show Low along the Mogollon Rim and in the Springerville-Eagar area form aquifers that are also locally important supplies.

The City of Flagstaff has become more dependent on groundwater from several distinct aquifers. The aquifer in the vicinity of Flagstaff is complex and composed of sandstones, siltstones and limestones. Groundwater flow in the aquifer is poorly understood because

of its depth and complex geologic structure. Recent geologic mapping indicate structural features such as faults and fractures that have important effects on the occurrence and flow of groundwater in this aquifer. Unconsolidated sediments and volcanic rocks in this area may also be waterbearing, but their areal extent is limited and yields are generally low. The Woody Mountain and Lake Mary well fields extract water from this aquifer. Water levels in these well fields show seasonal fluctuations and long-term declines due to pumping. (Bills and others., 2000) The San Francisco Peaks caldera, known as the Inner Basin, contains an aquifer that historically supplied much of the municipal water for the City of Flagstaff (Grahame and Sisk, 2002). In the Fort Valley area northwest of Flagstaff, a perched aquifer at a depth of a few hundred feet is utilized by individual land owners (Pinkham and Davis, 2002).

As shown in Figure 2.1-9, well yields are typically low (<100 gpm) north of the Little Colorado River, and higher in the south-central and southeast part of the planning area where wells encounter the C-aquifer. D-aquifer well yields are comparatively low, with yields up to 20 to 25 gpm reported (ADWR, 1989).

Groundwater quality data from selected sampling sites are shown in Table 2.1-7 and mapped on Figure 2.1-10. The most frequently exceeded constituents, measured in order of greatest occurrence, were arsenic, radionuclides, thallium, lead and total dissolved solids (TDS). North of Highway 264, thallium and radionuclides were most frequently reported. Between Highway 264 and Interstate 40, the parameter most frequently exceeded at measured sites was arsenic. South of Interstate 40, arsenic and cadmium were the most frequently exceeded constituents.

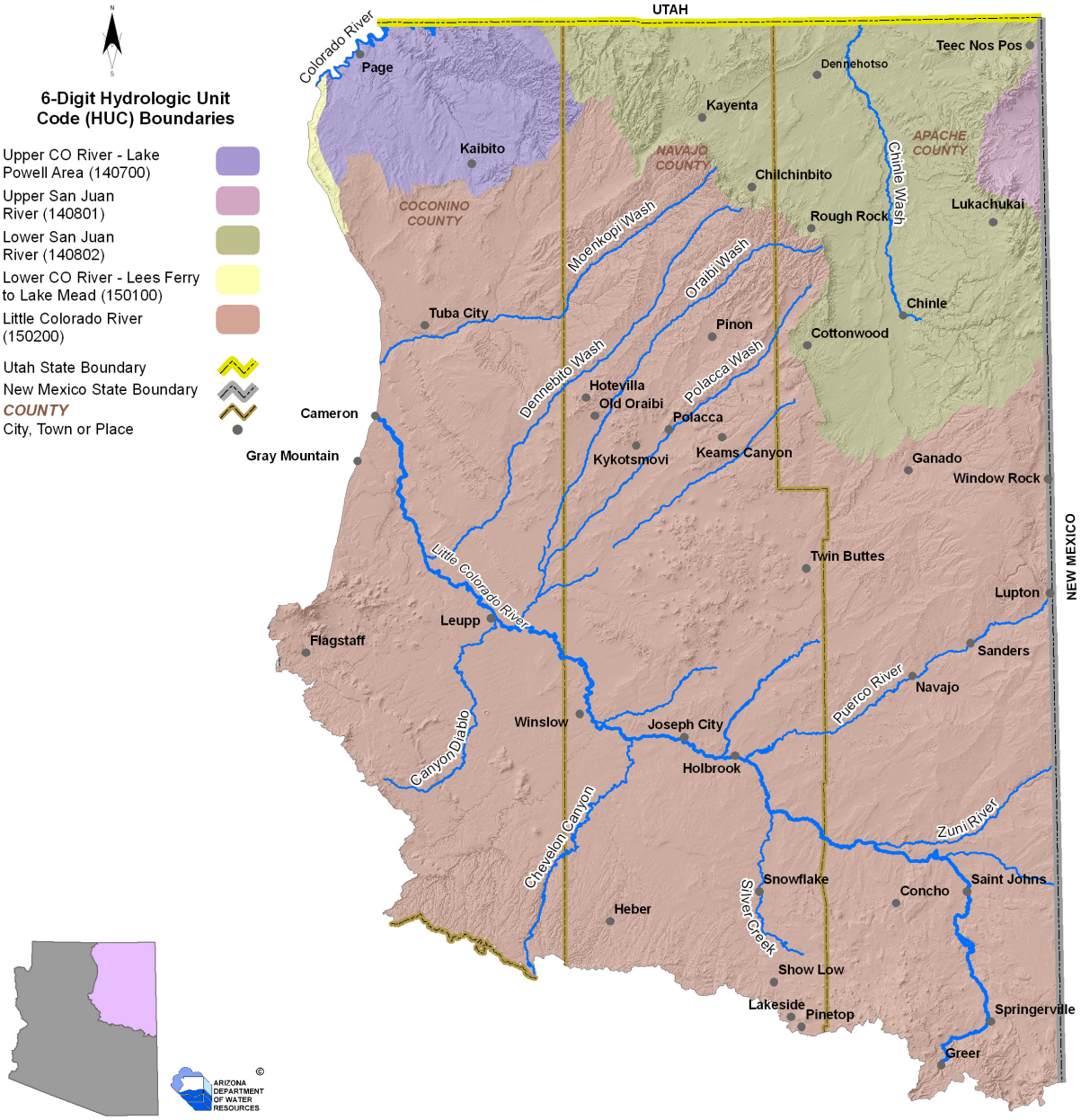
Surface Water Hydrology

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 hydrologic area (Seaber et al., 1987). A 6-unit code corresponds to accounting units, which are used by the USGS for designing and managing the National Water Data Network. There are portions of five watersheds in the planning area at the accounting level: the Little Colorado River, the Lower San Juan River, the Upper Colorado River-Lake Powell Area, the Upper San Juan River and a very small portion of the Lower Colorado River-Lees Ferry to Lake Mead (see Figure 2.0-6). The two largest watersheds, the Little Colorado River and the Lower San Juan River are discussed briefly below.

The Little Colorado River is the main drainage for the planning area, flowing from the White Mountains area and leaving the basin at Cameron. The northeastern part of the planning area drains northward toward the San Juan River as part of the Colorado River Watershed. In this area, Chinle Creek collects the majority of the surface water runoff. The southern two-thirds of the basin are within the Little Colorado

Little Colorado River near Greer. The river was formerly perennial throughout its length but it now flows perennially only in some areas.

Figure 2.0-6 Eastern Plateau Planning Area USGS Watersheds
(Data Source: USGS 2005)



River watershed. Streams and runoff in this area generally flow toward the Little Colorado River.

Little Colorado River

The Little Colorado River Watershed covers most of the planning area and extends west into the Coconino Plateau Basin where it drains to the Colorado River. The eastern part of the watershed extends into New Mexico. The watershed area is approximately 27,051 square miles and covers about 19% of the state (Parra and others, 2006). The Little Colorado River is the major surface drainage in the watershed, originating in the White Mountains and flowing northwest to the Colorado River. The river was formerly perennial throughout its length but it now flows perennially only from its headwaters to Lyman Lake, north of Springerville (Tellman and others, 1997), below its confluence with Silver Creek and below Blue Springs near its confluence with the Colorado River in the

Western Plateau Planning Area. Elsewhere it is intermittent due primarily to impoundments, diversions and falling groundwater levels (Tellman and others, 1997). A number of perennial and intermittent streams occur at higher elevations in the watershed, including Silver Creek and Chevelon Creek (see Figure 2.1-6). Ninety-six percent of the streams in the watershed are ephemeral or intermittent (Parra and others, 2006).

There are currently 21 active streamgage stations in the watershed. The maximum recorded annual flow in the watershed was 587,869 acre-feet at a discontinued gage on the Little Colorado River at Grand Falls located downstream of Leupp. The median flow at this station was 162,171 acre-feet (see Table 2.1-2)

Most of the 70 major springs in the planning area are located in the Little Colorado River Watershed. Approximately a quarter of the major springs have discharge rates of 100 gpm or more. Discharges from most springs were measured during or prior to 1990 and may not be indicative of current conditions. There are clusters of major springs near Tuba City, in the vicinity of Pinetop-Lakeside and in the Saint Johns-Concho area. The largest spring, with a measured discharge of over 3,600 gpm is Silver Springs (Table 2.1-5). Silver Springs discharges water from the volcanic portion of the Pinetop-Lakeside aquifer and maintains perennial flow in Silver Creek. Historically, Silver Springs provided the majority of the surface water supply for the Silver Creek Irrigation District. White Mountain Lake is the major water storage reservoir for the District (ADWR, 1990b). There are 94 large reservoirs in the planning area. Information on their storage capacity or surface area, type of use and owner/operator are listed in Table 2.1-4.

Within the watershed, reaches of the Little Colorado River and Nutrioso Creek have impaired water quality due to levels of turbidity, lead, copper and silver in excess of use standards. In addition, eight lakes are impaired due primarily to concentrations of mercury exceeding use standards (see Table 2.1-7).

Lower San Juan River

The Lower San Juan River Watershed drains most of the northeastern portion of the planning area. Chinle Creek is the major drainage, collecting most of the surface water runoff in the area that originates primarily in the Chuska Mountains and the Defiance Plateau (Grahame and Sisk, 2002). The watershed drains northward toward Utah and the San Juan River which in turn is tributary to the Colorado River. Chinle Creek is perennial for approximately six miles near the Utah border (ADWR, 1994a).

Only one of the four streamgages shown on Figure 2.1-5 is currently active; a real-time gage at Chinle Creek near Mexican Water close to the Utah border. The others were discontinued during 2005-2006. The maximum recorded flow in the watershed was measured at this remaining active gage with a flow of almost 67,700 acre-feet in 1982. Median flow at this gage is about 15,500 AFA (see Table 2.1-2).

There are seven major springs identified in the watershed. The largest is an unnamed spring west of Kayenta with a discharge rate of 30 gpm. There are seven large reservoirs in the watershed including the fourth largest in the planning area, Many Farms Lake. The dam was constructed in 1937 for irrigation purposes at the community of Many Farms north of Chinle.

2.0.3 Climate[3]

The Eastern Plateau Planning Area is a semi-arid, relatively high elevation region with cooler average temperatures than in other parts of Arizona. Average annual maximum temperatures in the planning area range from

[3] Information in this section was provided by Institute for the Study of Planet Earth, Climate Assessment for the Southwest (CLIMAS), May, 2006

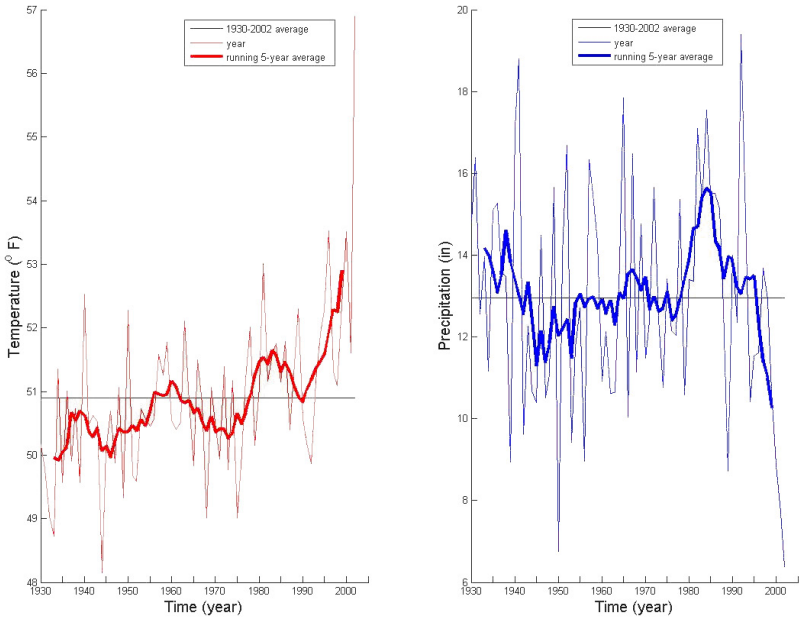
61˚F at Greer to 82˚F at Cameron. Annual average temperature is 50.8°F, compared to the state-wide average of 59.9°F. Eastern Plateau temperatures display a long-term warming trend (Figure 2.0-7), as in other parts of Arizona.

Parts of the Eastern Plateau Planning Area downwind of high elevation mountains along its southern boundary receive diminished precipitation due to the "rain shadow effect." As moisture-laden air flows over topographic features such as mountain ranges, the air is lifted and cooled, resulting in greater precipitation on the windward side of the mountain. In contrast, the leeward side of mountain ranges receive much less precipitation as the air sinks, warms, and dries, creating a "rain shadow."

Precipitation in the Eastern Plateau Planning Area is characterized by a multi-peaked distribution similar to much of Arizona (Figure 2.0-8). Precipitation is highest during July and August when the area receives over 43% of yearly precipitation, while the driest months on average are April, May and June. Average annual precipitation ranges from about four inches at Monument Valley in the far northeastern part of the planning area to 36 inches in the White Mountains, Mogollon Rim and San Francisco Peak areas. Most of the Navajo and Hopi Reservation lands receive less than 10 inches of rainfall a year. The highest precipitation on the Navajo Reservation is in the Chuska Mountains with an average annual precipitation of 25 inches (Navajo Nation, 2001).

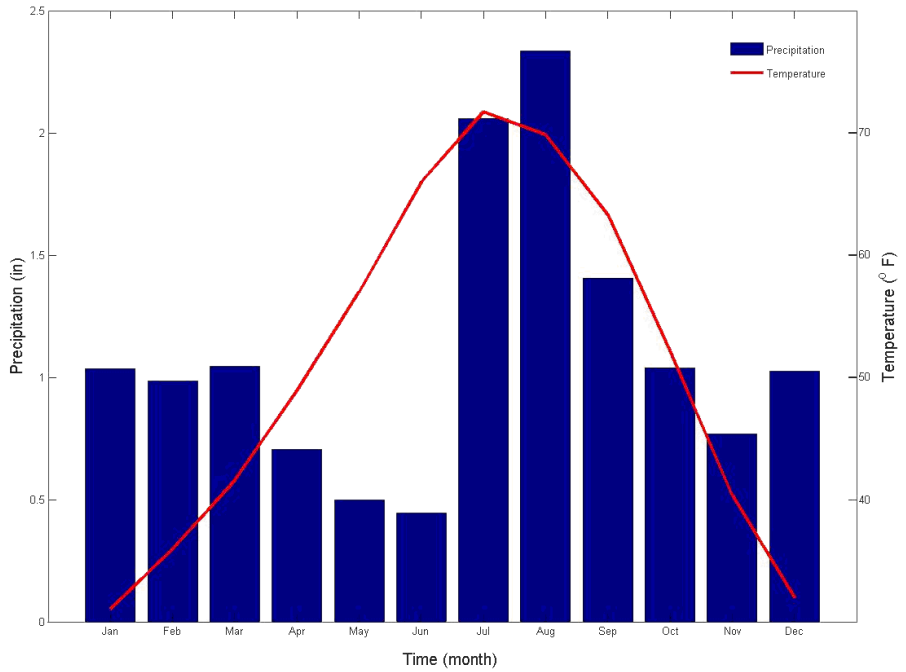
Much of the state's snowfall occurs along the Mogollon Rim and White Mountains in the Eastern Plateau and Central Highlands Planning Areas. Snowfall is an important water source and is often defined in terms of snow-water equivalent (SWE). SWE is dependent on snow density and describes the amount of liquid water present in a melted sample of

Figure 2.0-7 Average Temperature and Total Precipitation in the Eastern Plateau Planning Area From 1930-2002.



Horizontal lines are average temperature (50.8 °F) and precipitation (13.0 inches), respectively. Light lines are yearly values and highlighted lines are 5-year moving average values. Data are from selected Western Regional Climate Center cooperative weather observation stations located south of the Little Colorado River. (http://www.wrcc.dri.edu/summary/climsmaz.html). Figure author: CLIMAS

Figure 2.0-8 Average Monthly Precipitation and Temperature in the Eastern Plateau Planning Area, 1930-2002.



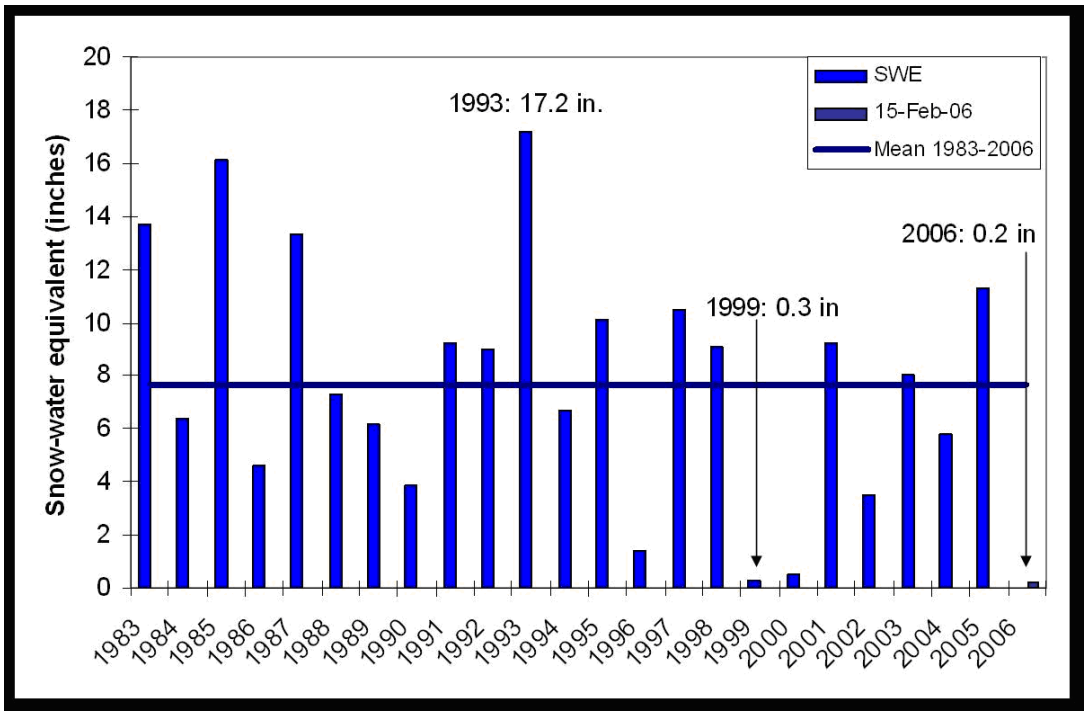
Data are from selected Western Regional Climate Center cooperative weather observation stations located south of the Little Colorado River. (http://www.wrcc.dri.edu/summary/climsmaz.html). Figure author: Ben Crawford, CLIMAS.

snow; light, powdery snow yields less water than dense wet snow. Observations recorded March 1st from 1983 to 2006 at Mt. Baldy in the southeastern portion of the planning area show SWE variations from 1983 to the present (Figure 2.0-9). The Mt. Baldy record shows relatively high snow pack during the 1980s and early-to-mid 1990s, followed by substantially lower snow pack since 1999.

Two important features of precipitation in this region are variability between individual years, and shifts between wetter and drier than average periods on longer, 10-20 year (decadal) time scales (Figure 2.0-7 and Figure 2.0-10). Winter precipitation records dating from 1000 A.D., estimated from tree ring reconstructions for Arizona climate divisions, show extended periods of above and below average precipitation in every century. A climate division is a region within a state that is generally climatically homogeneous. Arizona has been divided into seven climate divisions. Climate Division 2 (Coconino, Navajo and Apache Counties) includes the entire Eastern Plateau Planning Area and extends west and south.

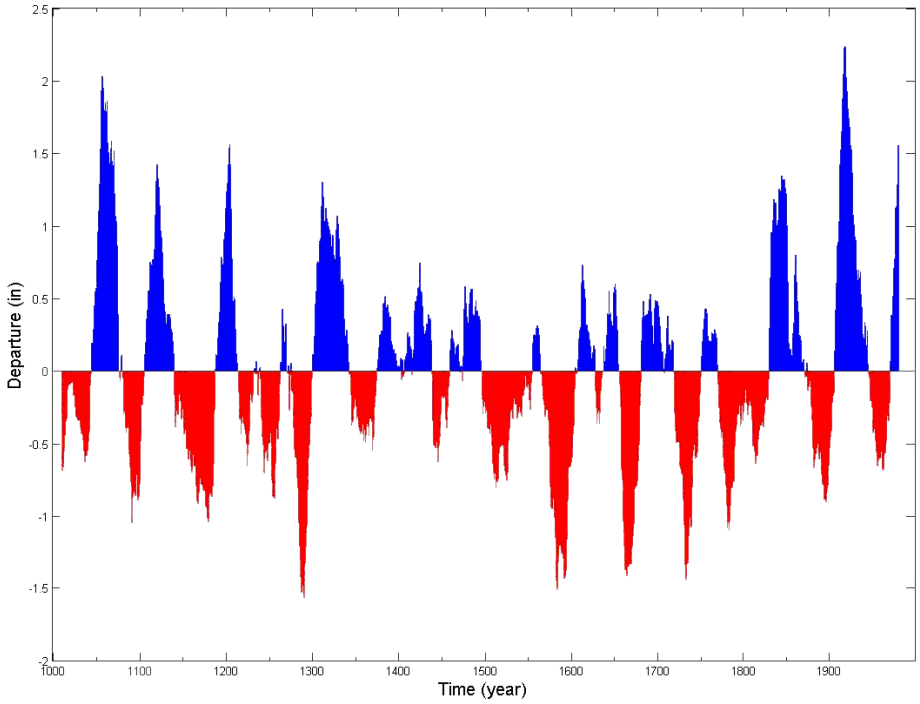
There have been multiple extended periods of above and below-average winter precipitation in the planning area during every century since 1000 A.D. (Figure 2.0-10). The 1200s, 1500s, and 1700s were notably dry; in contrast, the mid-1000s, early 1300s and early 1900s that were notably wet. More recently, the 1950s were relatively dry, whereas the 1980s received above-average precipitation (Figure 2.0-7). These decadal shifts are related to circulation changes in the Pacific Ocean. On time scales of 2-7 years, the El Niño-Southern Oscillation (ENSO) in the Pacific Ocean, with its phases of El Niño and La Niña, is associated with precipitation variations in the region, most notably during winter months (November-April). During El Niño episodes, there is a

Figure 2.0-9 Mt. Baldy Snow-Water Equivalent (SWE) for 1983-2006.



Observations were recorded March 1st for each year except 2006, where February 15 was used. The horizontal, bold line is average SWE from 1983-2006 and highest SWE years (1993) and lowest SWE years (1999 and 2006) are highlighted. Figure author: CLIMAS

Figure 2.0-10 Winter (November-April) Precipitation Departures From Average, 1000-1988, Reconstructed From Tree Rings - Arizona NOAA Climate Division 2



Arizona NOAA Climate Division 2 (Northeastern Arizona) includes Coconino, Navajo and Apache counties. Data are presented as a 20-year moving average to show variability on decadal time scales. The average winter precipitation for 1000-1988 is 6.1 inches. Data: Fenbiao Ni, University of Arizona Laboratory of Tree-Ring Research and CLIMAS. Figure author: CLIMAS.

greater likelihood of increased precipitation; nevertheless El Niño winters can produce below-average precipitation. Generally, La Niña conditions are associated with drought in the region.

2.0.4 Environmental Conditions

Environmental conditions reflect the impacts of geography, climate and cultural activities 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 and wilderness and unique waters.

Vegetation

Information on ecoregions and biotic (vegetative) communities in the planning area are shown on Figure 2.0-11. Most of the Eastern Plateau Planning Area is located in the Colorado Plateau Shrublands ecoregion while higher elevation areas are located in the Arizona Mountains Forests ecoregion. Biotic communities range from Great Basin desertscrub at lower elevations to areas of subalpine grassland. Plains and Great Basin grasslands are the predominant biotic community in the planning area. Due to grazing and fire suppression efforts, pre-settlement environmental conditions have been permanently altered in the region. Woodland communities have expanded considerably and the increase in ponderosa pine density has led to both an increase in the severity and size of wildfires, and to a decrease in stream and spring flows due to less soil absorption of precipitation (Grahame and Sisk, 2002).

In Arizona, alpine tundra is found only at the highest elevations on the San Francisco Peaks, generally over 12,000 feet. (This small area is not distinguishable on Figure 2.0-11). Only specially adapted species can survive the harsh climate including small, ground-hugging mosses, lichens and herbs. An area of the San Francisco Peaks has been closed to travel to protect an endemic groundsel (*Senecio franciscanus*), a threatened species. Areas of subalpine grassland are found at high elevations in the White Mountains, in the Chuska Mountains and on the San Francisco Peaks. (Grahame and Sisk, 2002).

High-elevation subalpine conifer forests are limited to relatively small isolated mountaintop stands on the San Francisco Peaks, White Mountains and Chuska Mountains 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

Aspen forest on Escudilla Mountain in the White Mountains. High elevation subalpine conifer forests are limited to relatively small isolated mountaintop stands on the San Francisco Peaks, White Mountains and Chuska Mountains at elevations of 8,500 to almost 12,000 feet with annual precipitation from 30 to 40 inches a year.

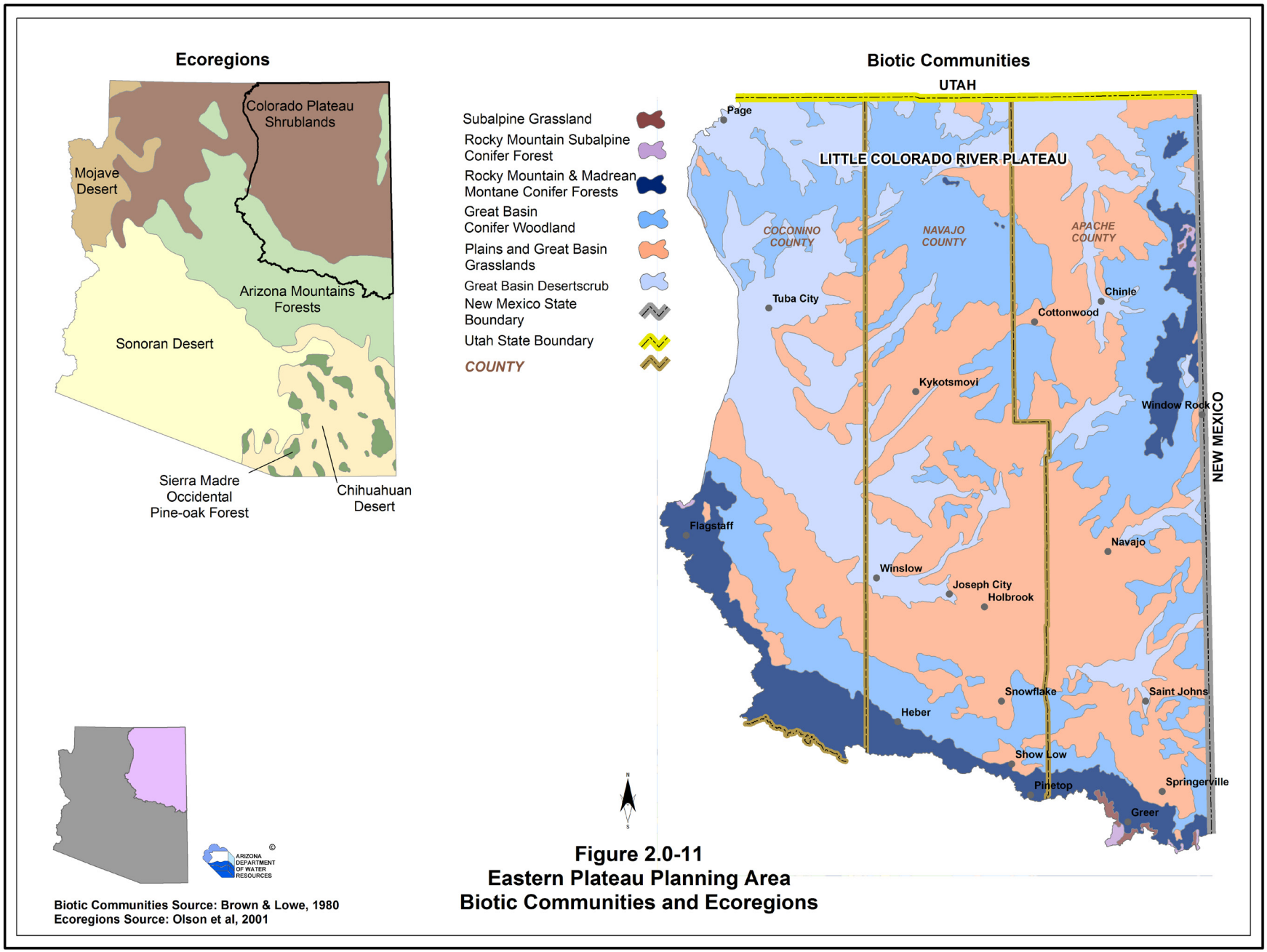


Figure 2.0-11
Eastern Plateau Planning Area
Biotic Communities and Ecoregions

and aspen trees. Much of the precipitation is snow, but summer rainfall 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 (Graham and Sisk, 2002). Recent surveys of aspen sites show that low-elevation dry sites on the Coconino National Forest (<7,500 feet) experienced 95% mortality since 2000. Sites surveyed on the Apache-Sitgreaves National Forest above 7,500 feet showed 40% mortality in both mid- and high-elevation sites. Researchers found that while insects and disease were associated with the mortality, they appeared to be secondary agents on already drought-stressed trees. (USDA, 2008)

Rocky Mountain (Petran) and Madrean Montane conifer forests commonly occur between about 7,200 to 8,700 feet. Above 8,000 feet, in areas that receive from 25 to 30 inches of annual rainfall, the forest contains a mix of conifers that may include Douglas-fir, white fir, limber pine, blue spruce, and white pine, with ponderosa pine on warmer slopes. Aspen and Gambel oak are prominent in these forests following disturbances. Below 8,000 feet, in areas that receive about 18 to 26 inches of annual precipitation, the mix of species give way to almost pure stands of ponderosa pine. The forest stretching from near Flagstaff along the Mogollon Rim to the White Mountains region is the largest ponderosa pine forest on the continent (Grahame and Sisk, 2002). 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). In the planning area these forests extend across the entire southern boundary and are also found along the northeastern boundary in the Chuska and Lukachukai Mountains and the Defiance Plateau.

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 2.0-11. Bark beetle infestations have affected large areas of piñon pine and juniper on the Navajo reservation and in the White Mountains in recent years although activity decreased in most areas in 2007 (USDA, 2008).

Plains and great basin 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 grasslands extend almost unbroken through the entire length and width of the planning area. Native bunchgrasses have been largely replaced by Eurasian annual species such as cheatgrass and shrubs have invaded the grasslands due to grazing and fire-suppression practices (Grahame and Sisk, 2002).

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 throughout the planning

Great Basin desertscrub near the base of the Lukachukai Mountains.

area but primarily in the western portion. 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).

Riparian vegetation has been mapped along East Clear Creek, Chevelon Creek, the Little Colorado River, Chinle Creek and at a number of other locations in the planning area (see Figure 2.0-13). Using Arizona Game & Fish Department data, Parra and others (2006), identified approximately 5,226 acres of riparian vegetation and ten different riparian types in the Little Colorado River watershed. Wet meadow, conifer oak and tamarisk groups comprised the largest amount of riparian vegetation. The Little Colorado River headwaters area had the greatest amount of wetland vegetation. Less abundant were mixed broadleaf, mountain scrub and mesquite (Parra and others, 2006). In the other planning area watersheds Russian olive and tamarisk are widely found. At higher elevations and along streams draining the Chuska Mountains and Defiance Plateau, conifer oak, wet meadow and mixed broadleaf occur (AZGF, 1997 & 1993).

Webb and others (2007) studied changes in riparian vegetation along a number of watercourses in the Southwestern United States. Watercourses studied in the Eastern Plateau Planning Area include the Little Colorado River and Moenkopi Wash. They noted that reaches of the Little Colorado River historically supported groves of cottonwood trees although the spatial distribution was not known. A series of floods and downcutting, and drainage of the alluvial aquifer, resulted in removal of most of this riparian vegetation. Woody riparian vegetation, primarily tamarisk but some native species, now populate terraces and parts of the channel.

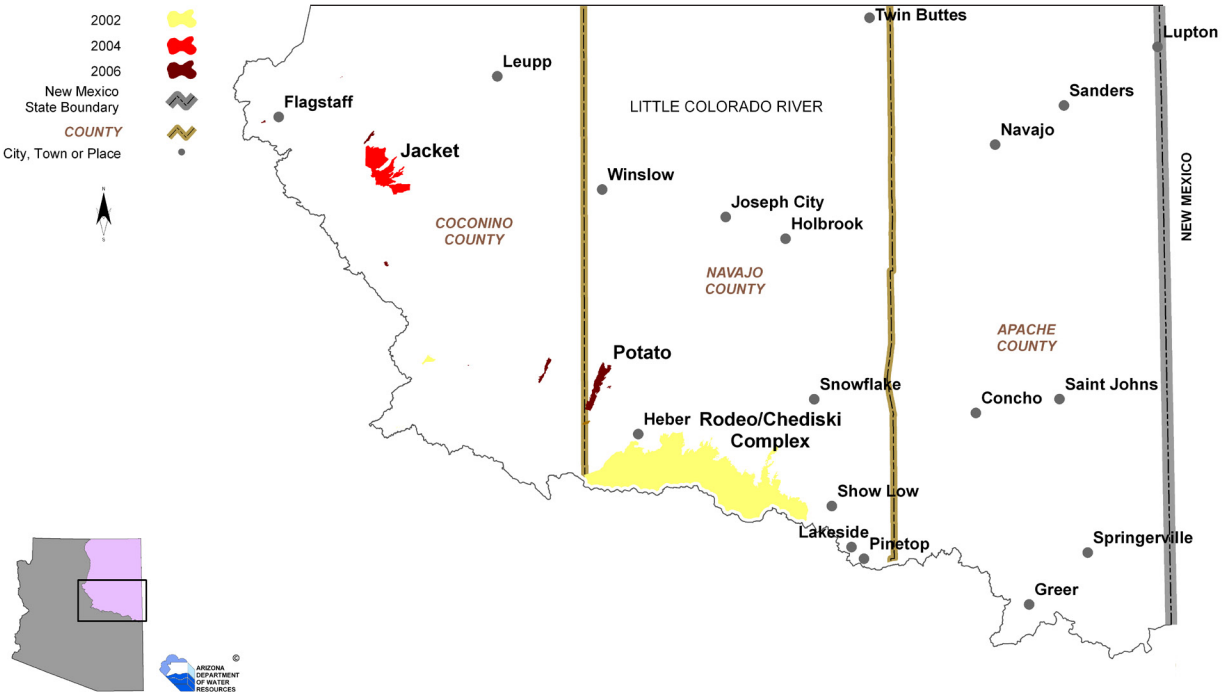
Tamarisk on Chevlon Creek.

Moenkopi Wash was a wide, barren channel in the early 1930s but development of a low floodplain during the 1940s has allowed establishment of tamarisk and scattered cottonwood groves.

Several major wildfires occurred in the Eastern Plateau Planning Area during the severe drought years between 2002 and 2006 (see Figure 2.0-12). The Rodeo-Chedeski fire in 2002, Arizona's largest-ever, consumed about 462,600 acres in the Eastern Plateau and Central Highlands planning areas. The Jacket Fire, southeast of Flagstaff and the largest recorded fire in the Coconino National Forest, burned over 17,200 acres in 2006.

In the Southwest, fire can be among the most significant watershed disturbance agents, particularly to peak stream flows. In areas severely burned by the Rodeo-Chedeski Fire, peak flows were as much as 2,350 times greater than previously measured peak flows, the highest known post-fire peak flow in the Southwest. Increased peak flows can degrade stream channels and make them unstable, increase sediment production and cause flood damage. (Neary and others, 2003) Drought, wildfire and long-term climate change involving warmer temperatures with earlier Spring season and less snow cover could result in vegetative changes in the planning area with implications on runoff, infiltration and water supplies.

Figure 2.0-12 Eastern Plateau Planning Area Location of Major Wildfires, 2002-2006 (Source: USFS 2007a)



Extended drought combined with high tree densities resulted in the largest outbreak of pine bark beetle populations ever recorded in Arizona during 2002 – 2004 with massive mortality, particularly in the Kaibab National Forest in the Western Plateau Planning Area (USDA, 2006). By 2007, bark beetle activity in Arizona had decreased substantially with the exception of the Apache-Sitgreaves National Forest, much of which is located in the Eastern Plateau Planning Area. Also noted in 2007 were large outbreaks of pine sawflies in several locations. This outbreak defoliated ponderosa pines in an area between Pinedale and Overgaard where many trees had been previously damaged in the 2002 Rodeo-Chediski fire, and on Navajo tribal lands. Study plots were established in Arizona in 2003-2004 to monitor the impacts from bark beetle infestations on fuel loading and fire behavior. Preliminary analysis shows that mortality plots have significantly higher fuel loads than areas with no mortality (USDA, 2008).

Fire damage from Rodeo-Chedeski fire near Show Low. Photo taken in 2009.

Arizona Water Protection Fund Programs

The objective of the Arizona Water Protection Fund Program (AWPF) is to provide funds for protection and restoration of Arizona's rivers and streams and associated riparian habitats. Thirty-two projects were funded in the planning area through 2008. Many of these were for the purpose of fencing and for stream and watershed restoration. A list of projects and types of

projects funded in the Eastern Plateau Planning Area through FY 2008 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 Volume 1 and on the Department's website.

Nutrioso Creek at EC Bar Ranch. One of the AWPF projects in the Eastern Plateau Planning Area.

Instream Flow Claims

An instream flow water right is a non-diversionary appropriation of surface water for recreation and wildlife use. Four applications for instream flow claims have been filed in the Eastern Plateau Planning Area, listed in Table 2.0-1. All applications are currently pending. As shown in Figure 2.0-13, the length of the instream flow claims for Chevelon Creek and East Clear Creek/Clear Creek are extensive. All claims are located in creeks south of the Little Colorado River.

Threatened and Endangered Species

A number of listed threatened and endangered species are present in the Eastern Plateau Planning Area. Those listed by the U.S. Fish and Wildlife Service (USFWS) as of 2008 are shown in Table 2.0-2.[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.

Table 2.0-1 Instream flow claims in the Eastern Plateau Planning Area

Map Key	Stream	Applicant	Application No.	Permit No.	Certificate No.	Filing Date
1	Billy Creek	Cartier, David N.	33-94853.0	Pending	Pending	9/14/1989
2	Billy Creek	Walker, F. Duane	33-94847.0	Pending	Pending	9/14/1989
3	Chevelon Creek	Apache-Sitgreaves National Forest	33-96707.0	Pending	Pending	2/13/2002
4	Clear Creek/East Clear Creek	Coconino National Forest	33-90107.0	Pending	Pending	7/29/1985

[4] An "endangered species" is defined by 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 forseeable future throughout all or a significant portion of its range

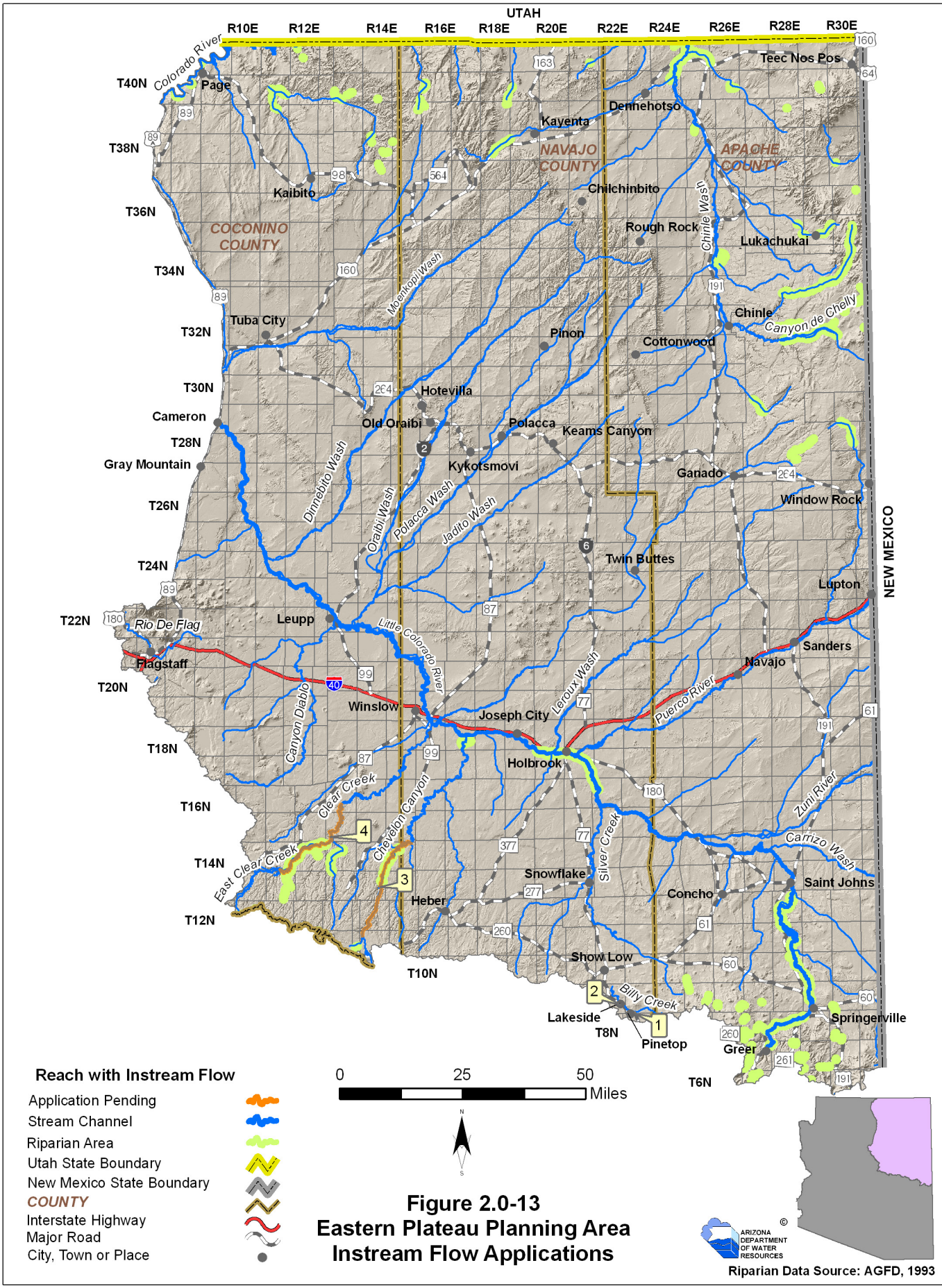


Figure 2.0-13
Eastern Plateau Planning Area
Instream Flow Applications

Table 2.0-2 Threatened and endangered species in the Eastern Plateau Planning Area

Common Name	Threatened	Endangered	Elevation/Habitat
Apache Trout	X		>5000 ft./cold mountain streams
Bald Eagle	X		Varies/large trees or cliffs near water
Black-footed ferret		X	<10,500 ft./grassland plains
California Brown Pelican		X	Varies/lakes and rivers
California Condor		X	Varies/high desert canyonlands and plateaus
Chiricahua Leopard Frog	X		3,300-8,900 ft./streams, rivers, backwaters, ponds, stock tanks
Little Colorado Spinedace	X		4,000-8,000 ft./moderate to small streams in pools & riffles
Loach Minnow	X		<8,000 ft./benthic species of small to large perennial streams
Mexican Gray Wolf		X	4,000-12,000 ft. /chapparal, woodland, forests
Mexican Spotted Owl	X		4,100-9,000 ft./canyons, dense forests with multi-layered foliage structure
Navajo Sedge	X		5,700-6,000 ft./silty soils at shady seeps and springs
Peebles Navajo Cactus		X	5,400-5,600 ft/gravely soils of the Shinarump conglomerate
San Francisco Peaks Groundsel	X		10,900 ft+/Alpine tundra
Southwestern Willow Flycatcher		X	<8,500 ft./cottonwood-willow and tamarisk along rivers and streams
Zuni Fleabane	X		7,300-8,000 ft./selenium-rich red or gray detrital clay soils derived from the Chinle and Baca formations

Sources: AZGF 2008, USFWS 2008

National Parks, Monuments and Wilderness Areas

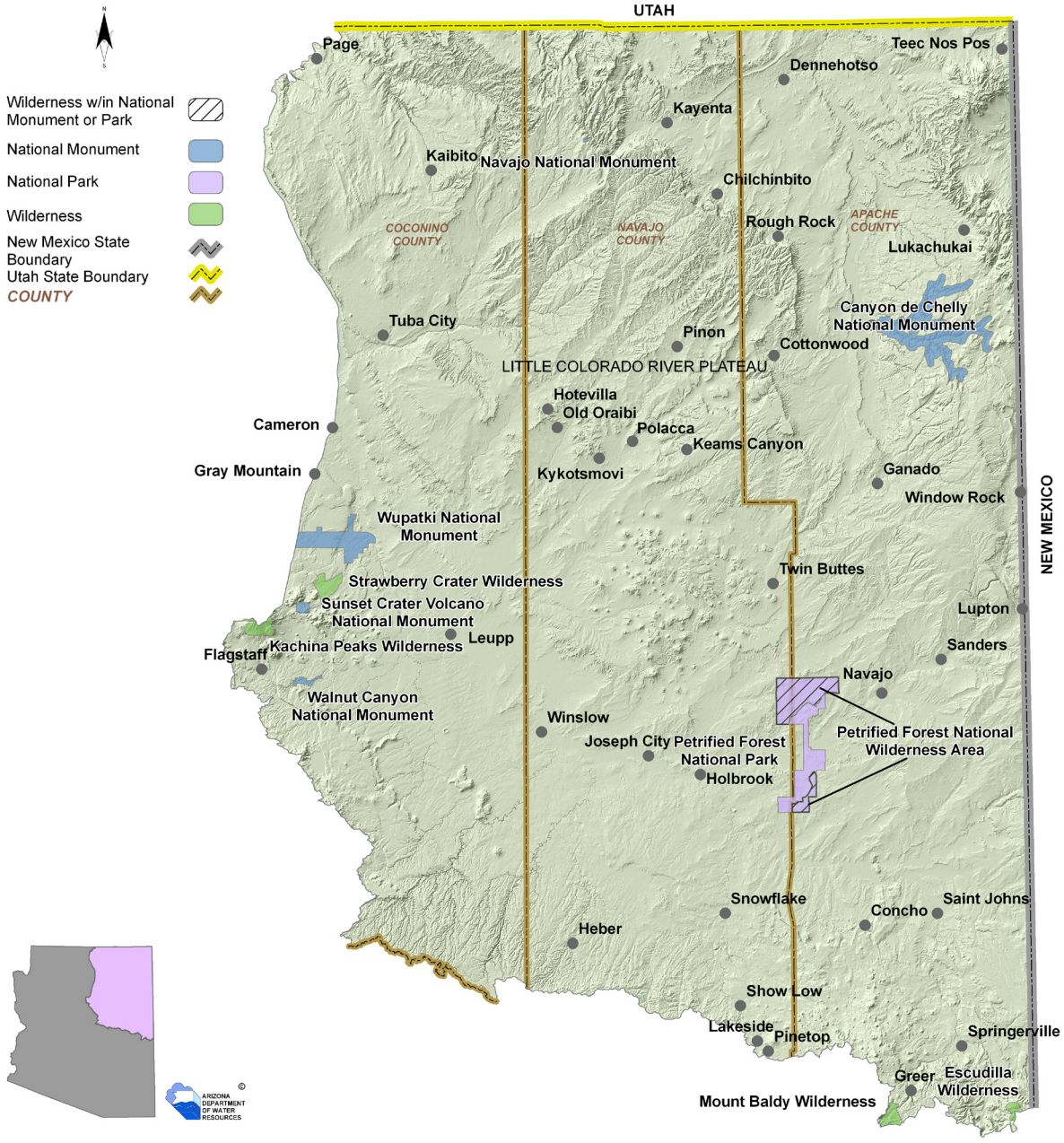
The Eastern Plateau Planning Area contains relatively few federally protected areas considering its large size. (see Figure 2.0-14) It contains one national park, five national monuments and five wilderness areas. In total there are approximately 436,600 acres of protected federal lands, accounting for 2.5% of the land area.

Petrified Forest National Park encompasses approximately 218,533 acres. Originally established in 1906 as a national monument to protect fossilized wood deposits, the addition of mostly Painted Desert land in 1932 helped

to upgrade the national monument to national park status in 1962. In 1970, over 50,000 acres of the park were designated as wilderness. In 2004, an additional 125,000 acres of land were added to the park, more than doubling its size. Over 250 fossil plant, invertebrate and vertebrate sites have been identified in the park (NPS, 2008a).

Several national monuments exist near Flagstaff including Sunset Crater Volcano, Wupatki and Walnut Canyon National Monuments. The 3,040 acre Sunset Crater Volcano National Monument was established in 1930 to protect its volcanic formations. Nearby, Wupatki National Monument was established in 1924 to preserve Citadel and Wupatki pueblos. Monument boundaries have been expanded several times to include additional pueblos and other archeological resources to a total of 35,422 acres. East of Flagstaff, Walnut Canyon National Monument was established in

Figure 2.0-14 Eastern Plateau Planning Area Protected Areas (Wilderness Data Source: National Atlas of the United States 2005, Land Ownership Data Source: ALRIS 2005)



Painted Desert, Petrified Forest National Park. The Eastern Plateau Planning Area contains relatively few federally protected areas considering its large size; one national park, five national monuments and five wilderness areas.

1915 to preserve ancient cliff dwellings. The monument contains a variety of archeological and natural resources on approximately 3,600 acres.

Canyon de Chelly and Navajo National Monuments are located within the Navajo Reservation. Canyon de Chelly, located east of Chinle, was initially established in 1931 to protect the canyon's archeological resources. At approximately 83,840 acres in size, it is unique among National Park Service (NPS) units as it is comprised entirely of Navajo Tribal Trust Land that remains home to the canyon community. The NPS works in partnership with the Navajo Nation to manage park resources and sustain the Navajo community living within the monument (NPS, 2008b). Navajo National Monument, located west of Kayenta, was created in 1909 to protect 13th century cliff dwellings and other archeological resources. Currently monument boundaries include 600 acres encompassing three distinct and non-contiguous sections, Betatakin, Keet Seel and Inscription House. Monument lands are inholdings within the reservation. Local Navajo are integral in supporting the park and participating in its activities and the monument is an important socio-cultural and economic component of the region (Rothman, 1991).

All or portions of five wilderness areas, encompassing 91,568 acres, are located within the Eastern Plateau Planning Area. Wilderness areas are designated under the 1964 Wilderness Act to preserve and protect the designated area in its natural condition. Designated areas, their size and a brief description of the area are listed in Table 2.0-3. The Eastern Plateau Planning Area contains the smallest number of wilderness acres, by far, compared with any of the state's planning areas.

Table 2.0-3 Wilderness areas in the Eastern Plateau Planning Area

Wilderness Area	Acres	Description
Escudilla	5,200 (Partial)	Mountain meadows and Escudilla Mountain (10,912 ft)
Kachina Peaks	18,615 (Partial)	Mt. Humphrey's (11,500 ft) and only arctic-alpine vegetation in the state
Mount Baldy	7,079 (Partial)	Mixed conifers and ponderosa pine to fir and spruce.
Petrified Forest*	50,260	Shortgrass prairie, colorful mesas, buttes and badlands
Strawberrry Crater	10,414	Volcanic cinder cone and lava flow formations

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

Unique Waters

Two "unique waters" occur in the planning area, designated by the Arizona Department of Environmental Quality (ADEQ) pursuant to A.C.C. R18-11-112, as having exceptional recreational or ecological significance and/or providing habitat for threatened or endangered species. Surface water must be of good water quality, free flowing and perennial to be classified as a unique water. In the planning area, a portion of the West Fork of the Little Colorado River above Government Springs (located in the Salt River Basin), and Lee Valley Creek from its headwaters to Lee Valley Reservoir have been classified as unique waters.

2.0.5 Population

Census data for 2000 show a total of almost 250,000 residents in the Eastern Plateau Planning Area. Arizona Department of Commerce population projections forecast a population of more than 378,000 by 2030. The 2000 Census populations for the planning area and Indian reservations are shown in Table 2.0-4. In 2000 about 55% of the planning area population resided in the non-reservation portion. The Navajo Reservation population comprises approximately 42% of the planning area population.

Shown in Table 2.0-5 are incorporated and unincorporated communities in the planning area with 2000 Census populations greater than 1,000 and growth rates for two time periods. Communities are listed from highest to lowest population in 2000. Flagstaff is by far the largest community in the planning area with 38% of the non-tribal population. There are a number of rapidly growing larger communities including Flagstaff, Show Low, Pinetop-Lakeside and Taylor. Some communities grew more rapidly between 2000 and 2006 than during the previous ten year period. There are also rapidly growing communities on the Navajo Reservation, with high growth rates in a number communities including Kaibito, Lukachukai and Pinon.

Table 2.0-4 2000 Census population of the Eastern Plateau and Indian Reservations

Basin/*Reservation*	2000 Census Population
Little Colorado River	249,545
Navajo	*104,565*
Hopi	*6,946*
San Juan Southern Paiute	*265*
Zuni	*NA*

Source: U.S. Census Bureau 2006

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. In 2000, none of the counties in the planning area had populations greater than 125,000 residents. The Act also requires that twenty-three communities outside AMAs include a water resources element in their general plans. In the Eastern Plateau Planning Area this requirement applies to the communities of Flagstaff, Pinetop-Lakeside, Show Low, Snowflake and Taylor, which have all completed plans. Plans must consider water demand and water resource availability in conjunction with growth, land use and infrastructure. Completed plans are listed in basin references in this volume and may contain useful information for water resources planning.

Beginning in 2007, all community water systems in the state were required to submit Annual Water Use Reports and System Water Plans. The reports and plans are intended to reduce community water systems' vulnerability to

Table 2.0-5 Communities in the Eastern Plateau Planning Area with a 2000 Census population greater than 1,000.

Communities	1990 Census Pop.	2000 Census Pop.	Percent Change 1990-2000	2006 Pop. Estimate[1]	Percent Change 2000-2006	Projected 2030 Pop.
Flagstaff	45,857	52,894	15.3%	62,030	17.3%	83,746
Winslow	9,279	9,520	2.6%	9,945	4.5%	11,706
Tuba City	7,323	8,225	12.3%	8,899	8.2%	10,572
Show Low	5,020	7,695	53.3%	10,555	37.2%	19,625
Window Rock/ Fort Defiance	7,795	7,120	-8.6%	7,120	0.0%	7,120
Page	6,598	6,809	3.2%	7,230	6.2%	8,027
Chinle	5,059	5,366	6.1%	5,524	2.9%	6,086
Kayenta	4,372	4,922	12.6%	5,186	5.4%	6,701
Holbrook	4,686	4,917	4.9%	5,455	10.9%	7,684
Snowflake	3,679	4,460	21.2%	5,180	16.1%	7,048
Eager	4,025	4,033	0.2%	4,530	12.3%	6,252
Pinetop-Lakeside	2,422	3,582	47.9%	4,540	26.7%	6,758
Taylor	2,418	3,176	31.3%	4,270	34.4%	8,210
St. Johns	3,294	3,269	-0.8%	3,925	20.1%	6,559
Heber-Overgaard	1,581	2,722	72.2%	3,596	32.1%	6,642
Springerville	1,802	1,972	9.4%	2,125	7.8%	2,485
Kaibito	641	1,607	150.7%	2,337	45.4%	4,149
LeChee	NA	1,606	--	2,725	69.7%	5,504
Lukachukai	113	1,565	1284.9%	1,669	6.7%	2,041
Many Farms	1,294	1,548	19.6%	1,678	8.4%	2,143
Ganado	1,257	1,505	19.7%	1,633	8.5%	2,087
St. Michaels	1,119	1,295	15.7%	1,386	7.0%	1,708
First Mesa/Polacca	1,108	1,124	1.4%	1,124	0.0%	1,124
Dilkon	NA	1,265	--	1,541	21.8%	2,501
Pinon	468	1,190	154.3%	1,543	29.6%	2,772
Tsaile	1,043	1,078	3.3%	1,096	1.7%	1,161
Total > 1000	**122,253**	**144,465**	**18.2%**	**166,841**	**13.4%**	**230,411**
Remainder of Planning Area	**87,201**	**105,080**	**20.5%**	**112,513**	**7.1%**	**147,981**
Total Planning Area	**209,454**	**249,545**	**19.1%**	**279,354**	**11.9%**	**378,392**

[1] 2006 population shown is the 2006 estimate for incorporated areas and the 2006 projection for unicorporated areas.
Source: Department of Commerce 2006, U.S. Census Bureau 2006

drought, and to promote water resource planning to ensure that water providers are prepared to respond to water shortage conditions. In addition, the information will allow the State to provide regional planning assistance to help communities prepare for, mitigate and respond to drought. An Annual Water Use Report must be submitted each year by the systems that includes information on water pumped, diverted and received, water delivered to customers and effluent used or received. The System Water Plan must be updated and submitted every five years and consist of three components, a Water Supply Plan, a Drought Preparedness Plan and a Water Conservation Plan. By January 1, 2008, all systems were required to submit plans. By the end of 2008, plans have been submitted by 61 community water systems in the planning area. Almost all of the larger systems submitted plans and these plans were used to prepare this document. Annual water report information and a list of water plans is found in Appendix B.

The Department's Water Adequacy Program also connects 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 the county does not adopt the provision, the legislation allows a city or town to adopt a local ordinance that requires a demonstration of adequacy. By the end of 2008, none of the counties or jurisdictions in the planning area had adopted the new provision.

Subdivision adequacy determinations (Water Adequacy Reports), including the reason for the inadequate determination, are provided in Table 2.1-10 and their location is shown on Figure 2.1-12. Also shown are approved applications for an Analysis of Adequate Water Supply (AAWS). This application is typically associated with large, master planned communities. As of December 2008, two AAWS applications had been approved in the planning area with a total of 1,936 lots.

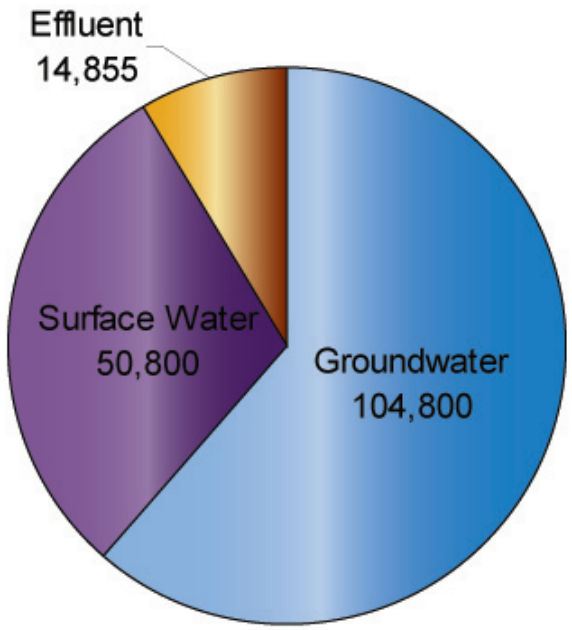
The service areas of 14 water providers in the planning area have been designated as having an adequate water supply. Designation information and the general location of the service area are also shown in Table 2.1-10 and on Figure 2.1-12. If a subdivision is served by one of these designated water providers, a separate adequacy determination is not required. As of December 2008 these included:

- Apache County
    - Town of Springerville
    - City of Saint Johns
- Coconino County
    - City of Flagstaff
    - City of Page
- Navajo County
    - City of Holbrook
    - City of Show Low
    - Town of Taylor
    - City of Winslow
    - Arizona Water Company, Lakeside and Pinetop
    - Town of Snowflake
    - Fools Hollow Water Company (Show Low)
    - Park Valley Water Company (Show Low)
    - Pineview Water Company (Show Low)
    - Voyager at White Mountain Lakes Water Co. (Show Low)

2.0.6 Water Supply

Surface water, groundwater and effluent are important water supplies for municipal, industrial and agricultural uses in the Eastern Plateau Planning Area. As shown in Figure 2.0-15, groundwater is the principal water supply utilized, meeting 61% of the demand on average in 2001-2005. Due to recent drought conditions, some communities that historically used significant amounts of surface water, such as Flagstaff, have turned to more reliable groundwater supplies. Population growth, supply reliability and the desire for economic development is spurring interest in exploring long-term water supply augmentation options such as securing Colorado River water, constructing water conveyance pipelines and acquiring lands with groundwater supplies. Effluent is also utilized by several communities for golf course, landscape irrigation and for industrial and agricultural purposes.

Figure 2.0-15 Water Supply Utilized in the Eastern Plateau Planning Area, 2001-2005 (in acre-feet)



Surface Water

Surface water is a significant water supply in some areas but is geographically limited. On the Navajo reservation, two-thirds of the average annual surface water originates in the Chuska Mountains and the Defiance Plateau and is locally available for agricultural and domestic use. Surface water at higher elevations in the southeastern part of the planning area is used primarily for agricultural use, although the Town of Eagar uses a small amount of surface water from Coon Springs (Town of Eagar, 2008). Colorado River water is the water supply for Page and neighboring LeChee. When there is sufficient rain and snow, surface water is stored in lakes near Flagstaff and used for municipal purposes.

Surface water from the Lake Mary reservoir system is an important municipal supply for the City of Flagstaff. The 30-year median inflow to the system from January to May was 5,000 acre-feet, but due to evaporation and seepage losses, the average availability is approximately 2,250 acre-feet (USBOR, 2006). Because surface water is drought sensitive, it can be unreliable, which has stimulated interest in additional well drilling and development of groundwater supplies in the Flagstaff area. In wet years, Lake Mary has provided 70% of the City's water supply (Pinkham and Davis, 2002); however in 1990, 2000 and 2002, there was very little inflow into Lake Mary. Recently, groundwater use has increased and supplies about 70% of the annual demand (Reed, 2005).

The Salt River Project acquired the rights to the surface water in the C.C. Cragin Reservoir, formerly the Blue Ridge Reservoir, from the Phelps Dodge Corporation in February 2005 as part of the Gila River Indian Water Rights Settlement Act. In addition to satisfying obligations to the Gila River Indian Community, the reservoir will be used to supplement Salt River Project shareholders' water supply and as a water supply for northern Gila County (SRP, 2006). Located near the southwestern boundary of the Eastern Plateau Planning Area on East Clear Creek, this supply is not available to users in the planning area.

The domestic water supply for the City of Page and the neighboring Navajo Nation Chapter of LeChee is obtained from Lake Powell through pumping and conveyance facilities first constructed in 1957. This water is available pursuant to a Colorado River Upper Basin allocation of 2,740 acre-feet of consumptive use.[5] The existing raw water supply facilities marginally meet the current peak demands of the two communities during summer months. A new lake intake to increase capacity, a new pipeline to LeChee and groundwater well development are being considered to provide a more reliable supply (TETRA TECH RMC, 2003). In addition, the City of Page has

[5] Consumption of water brought about by human endeavors….along with the associated losses incidental to these uses." USBOR, 2004, Colorado River System Consumptive Uses and Losses Report 1996-2000.

Lake Powell. The domestic water supply for the City of Page and the neighboring Navajo Nation Chapter of LeChee is obtained from Lake Powell through pumping and conveyance facilities first constructed in 1957.

requested an additional allocation of Colorado River water.

Springs are an important water supply for habitat, wildlife, domestic and cultural/religious purposes in parts of the planning area. On tribal lands, the communities of Tuba City, Moenkopi and Ganado rely on springs for domestic and agricultural uses.

Legal availability of a surface water supply is also an important consideration. As described in detail in Appendix C, the legal framework and process under which surface water right applications and claims are administered and determined is complex. Rights to surface water are subject to the doctrine of prior appropriation which is based on the tenet "first in time, first in right". This means that the person who first put the water to a beneficial use acquires a right that is superior to all other surface water rights with a later priority date. Under the Public Water Code, beneficial use is the basis, measure and limit to the use of water. Each type of surface water right filing is assigned a unique number as explained in Appendix C and shown in Table 2.0-6. The act of filing a statement of claim of rights to use public waters (36) does not in itself create a water right. A Certificate of Water Right (CWR) may be issued if the terms of the permit to appropriate water (3R, 4A, or 33, and in certain cases 38) are met. CWRs retain the original permit application number.

Surface water rights may also be determined through judicial action in state or federal court in which the court process establishes or confirms the validity of the rights and claims and ranks them according to priority. Court decreed rights are considered the most certain surface water right. Major court determinations in the planning area are the Norviel and Concho decrees. The Norviel Decree is comprised of four judicial actions (between 1914 and 1923) determining rights of landowners to divert surface water in and around Saint Johns to the headwaters of the Little Colorado River. The Concho Decree (1927) determined the relative rights to use surface water from Concho Springs and Concho Creek in Apache County.

Arizona has two general stream adjudications in progress to determine the nature, extent and priority of water rights across the entire river systems of the Gila River and the Little Colorado River. Pertinent to the Eastern Plateau Planning Area, the Little Colorado River (LCR) Adjudication is being conducted in the Superior Court of Arizona in Apache County. The LCR Adjudication was initiated by a petition filed by Phelps Dodge Corporation in 1978. It now covers 27,000 square miles and includes three watersheds (Lower Little Colorado River, Upper Little Colorado River and Silver Creek), 5 Indian reservations (Hopi, Navajo, Zuni, Fort Apache and San Juan Southern Paiute) and over 3,000 parties. All parties who claim to have a water right within the river system are required to file a statement of claimant (SOC) (39) or risk loss of their right. This includes reserved water rights for public lands and Indian reservations which for the most part, have not been quantified or prioritized. Results from the Department's investigation of surface water right and adjudication filings are presented in

Hydrographic Survey Reports (HSRs). Within the Eastern Plateau Planning Area, HSRs have been published for the Silver Creek Watershed (1990), Indian Lands in the Little Colorado River System (1994) and the Hopi Indian Reservation (2008).

Table 2.0-6 summarizes the number of surface water right and adjudication filings in the planning area. The methodology used to query the Department's surface water right and SOC registries is described in Appendix C. Of the 19,529 filings that specify surface water diversion points and places of use in the planning area, 797 CWRs have been issued to date. Figure 2.0-16 shows the general location of surface water diversion points listed in the Department's surface water rights registry. The numerous points reflect the large number of stockponds and reservoirs that have been constructed in the planning area as well as diversions from streams and springs. Locations of registered wells, many of which are referenced as the basis of claim in SOCs are also shown in Figure 2.0-16.

Groundwater

Groundwater is withdrawn from both large regional aquifers and from local and perched aquifers. The location of registered exempt and non-exempt wells is shown in Figure 2.0-16.[6] Flagstaff pumps groundwater from perched water bearing zones within the upper 500 feet or in the deeper C-aquifer (Woody Mountain and Lake Mary wellfields and inner city wells) and from shallow volcanic aquifers in the Inner Basin. Depth to water in C-aquifer wells ranges from approximately 1,200 to 1,600 feet bls. In 2005, Flagstaff purchased the Red Gap Ranch east of the city as a potential source of groundwater supplies. The USBOR (2006) reported sustainable or safe yield volumes from the city's various groundwater supplies as follows: Woody Mountain wellfield, 3,500 AFA; Lake Mary wellfield, 2,500 AFA; inner city wells, 1,300 to 2,800 AFA; and inner basin wells, 542 AFA.

Table 2.0-6 Count of surface water right and adjudication filings in the Eastern Plateau Planning Area[1]

Basin	Type of Filing							Total
	BB[2]	3R[3]	4A[3]	33[3]	36[4]	38[5]	39[6]	
Little Colorado River Plateau	134	163	196	373	3,289	3,275	12,099	**19,529**

Notes:

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

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

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

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

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

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

[6] The term "exempt-well" is used to describe any well having a pump with a maxiumum pumpiing capacity of 35 gallons per minute or less. The term "non-exempt well" refers to a well having a pump with a capacity of more than 35 gallons per minute.

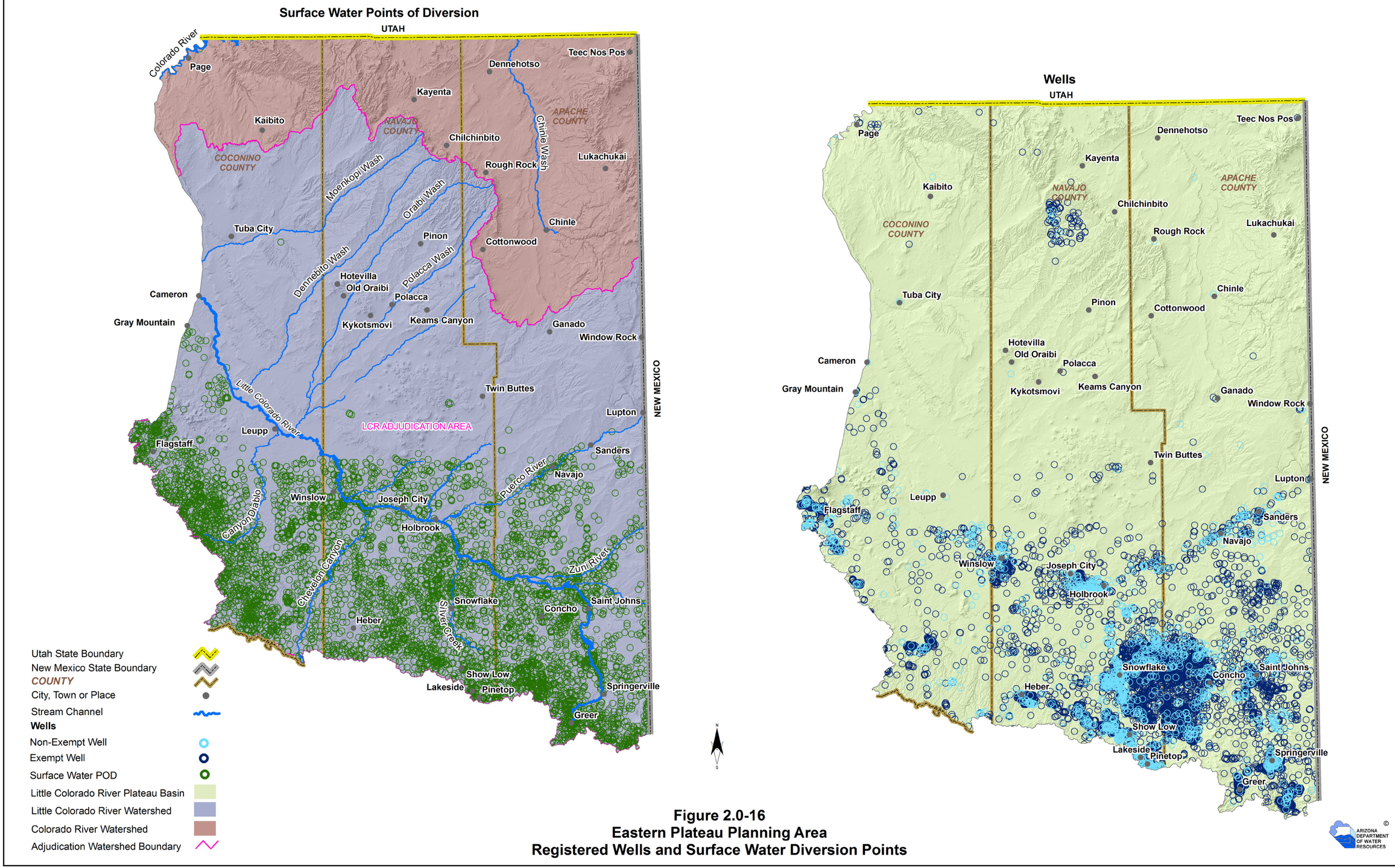


Figure 2.0-16
Eastern Plateau Planning Area
Registered Wells and Surface Water Diversion Points

The cities of Holbrook and Winslow rely entirely on groundwater pumped from the C-aquifer. Groundwater from the C-aquifer and from local aquifers (Bidahochi, Lakeside-Pinetop and White Mountain aquifers) is the principal water supply for municipal use in the Mogollon Rim region, including the communities of Heber, Pinetop-Lakeside, Show Low, Snowflake, Springerville, Eagar, Saint Johns and Greer.

North of the Little Colorado River, including on the Navajo and Hopi reservations, the N-aquifer, which is of good quality, is the primary water supply. In this area the C-aquifer is generally too deep and saline to be used. The D-aquifer underlies much of the Hopi and Navajo reservations and is utilized in some areas; however water quality is marginal due to elevated concentrations of dissolved solids. The community of Cameron pumps highly saline groundwater from wells near the Little Colorado River and treats it for use.

The Department's Groundwater Site Inventory (GWSI) database, the main repository for statewide groundwater well data, is available on the Department's website (www.azwater.gov/). The GWSI database consists of over 42,000 records of wells and over 210,000 groundwater level records statewide. GWSI contains spatial and geographical data, owner information, well construction and well log data and historic groundwater data including water level, water quality, well lift and pumpage records. Included are hydrographs for statewide index wells and automated groundwater monitoring sites, which can be searched and downloaded to access local information for planning, drought mitigation and other purposes. Approximately 1,700 wells are designated as index wells statewide out of over 43,700 GWSI sites. (GWSI sites are primarily well sites but include other types of sites such as springs and drains). Typically, index wells are visited once each year by the Department's field staff to obtain a long-term record of groundwater level fluctuations. Approximately 200 of the GWSI sites are designated as automated wells. These systems measure water levels four times daily and store the data electronically. Automated groundwater monitoring sites are established to better understand the water supply situation in areas of the state where data are lacking. These devices are located based on areas of growth, subsidence, type of land use, proximity to river/stream channels, proximity to water contamination sites or areas affected by drought.

Volume 1 of the Atlas shows the location of index wells and automatic water-level recording sites as of January 2009. At that time there were a total of 94 index wells and four ADWR automatic water-level sites in the Eastern Plateau Planning Area. The automated sites are located at Flagstaff, Joseph City, east of Holbrook and south of Saint Johns. The most updated maps may be viewed at the Department's website.

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 in Section 2.1.6.

Effluent

More than 36,500 acre-feet of effluent is estimated to be generated annually in the planning area (Table 2.1-9). The communities of Flagstaff, Flagstaff Ranch, Holbrook and Page use effluent for golf course and landscape irrigation. In 2006 and 2007 over 2,300 acre-feet of effluent was used in the Flagstaff area. Reclaimed water is produced by both of the city's wastewater treatment plants. A total of 10 schools, eight parks, two cemeteries, three golf courses and a playing field at Northern Arizona University receive treated effluent. In addition, a large industrial user, SCA Tissues, which had been Flagstaff's second largest potable water user, converted to 100% reclaimed water use

in 2005, resulting in a potable water savings of more than 300 AFA (SCA, 2007). Flagstaff also has a reclaimed water hauling program that makes Class A+ and Class B reclaimed water available for non-potable uses at four sites located throughout the city (City of Flagstaff, 2008). A proposal to use Flagstaff effluent to make snow at the Snowbowl ski area has resulted in a multi-year court battle between a coalition of tribes and environmentalists and the owners of Snowbowl and the Forest Service that remains unresolved.

Other communities in the planning area discharge effluent to fields for agricultural irrigation or to support wetlands (see Table 2.1-9). The Town of Eagar provides treated wastewater at no cost to local hay farmers (Town of Eagar, 2005) and all Snowflake's effluent is applied to a local rancher's hay field.

Approximately 11,900 AFA of industrial wastewater is generated by the Catalyst Paper Mill (formerly Abitibi) near Heber and discharged to a dry lake where it is used to irrigate pasture. Effluent generation location, volumes and disposal method are shown in Table 2.1-9.

View of Northern Arizona University, Flagstaff, Arizona. In 2006 and 2007 over 2,300 acre-feet of effluent was used in the Flagstaff area.

Contamination Sites

Environmental contamination sites 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 (state designated WQARF sites), Voluntary Remediation Program (VRP), Uranium Mill Tailings Remedial Action (UMTRA) and Leaking Underground Storage Tank (LUST) sites was conducted for the planning area. Of these various contamination sites, VRP, UMTRA and LUST sites are found in the planning area. Table 2.0-7 lists the contaminant and affected media at UMTRA and VRP sites. The location of all contamination sites in the planning area is shown on Figure 2.0-17.

There are three active VRP sites with soil and groundwater contamination. PCE, TCE and fuel oil are found in groundwater at the Arizona Public Service (APS) Cholla Power Plant site. At Winslow, soil contamination is found at the La Posada Hotel site, located adjacent to a railroad station and equipment yard. The Georgia-Pacific Corporation site in Flagstaff is also a railroad site; the particular contaminants at this site are not known. 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).

Two UMTRA sites are located on the Navajo Reservation at Tuba City and Monument Valley. The former Monument Valley mill and tailings site covers approximately 83 acres. Surface remediation was completed in 1994. A nitrate

Table 2.0-7 Contamination sites in the Eastern Plateau Planning Area

SITE NAME	MEDIA AFFECTED AND CONTAMINANT
Uranium Mill Tailings Remedial Action (UMTRA) Sites	
Tuba City Disposal Site	Groundwater - Molybdenum, Nitrate, Selenium, Uranium and Sulfate
Monument Valley Processing Site	Groundwater - Uranium, Ammonium, Nitrate and Sulfate
Voluntary Remediation Program (VRP) Sites	
APS Cholla Power Plant	Groundwater - Tetrachloroethylene (PCE), Trichloroethylene (TCE) and Fuel oil Soil - Fuel Oil
La Posada Hotel	Soil - Diesel fuel and Total petroleum hydrocarbons (TPH)
Georgia-Pacific Corp. Flagstaff Facility	Soil and Groundwater - Unknown

Sources: ADEQ 2002, ADEQ 2006a, ADEQ 2006b

plume with concentrations ranging from 44 to 1,030 mg/L extends approximately 4,500 feet north of the site. Uranium concentrations exceed the UMTRA standard of 0.044 mg/L at a site in the alluvial aquifer and in a well completed in the De Chelly formation that was contaminated from the overlying alluvium. Approximately 540 million gallons of groundwater in the alluvial aquifer are contaminated. The Department of Energy (DOE) will conduct pilot studies and continue with remediation, monitoring and enforcement strategies until contaminant concentrations have been reduced to acceptable levels. (DOE, 2007)

The Tuba City site, located five miles east of Tuba City is a former uranium mill that created radioactive mill tailings that were conveyed to evaporation ponds at the site. Surface remediation was completed in 1990. Seepage from the evaporation ponds contaminated groundwater in the N-aquifer. The original volume of contaminated groundwater was between 1.5 and 3 billion gallons. Contaminants include molybdenum, nitrate, selenium, uranium and sulfate. Active groundwater remediation is underway at the site using extraction wells and removal of contaminants (DOE, 2008b).

Widespread mining and milling of uranium ore on the Navajo Reservation beginning in the 1940s also resulted in a large number of abandoned uranium mines (AUMs) and dispersion of radiation and heavy metal contamination in soil and water. In 1993, the Navajo Nation brought concerns about health risks associated with these mining activities to the EPA, DOE and Bureau of Indian Affairs (BIA). In response, EPA initiated a study through the Superfund Program to assess human exposure to radiation and heavy metals from each known AUM on the Navajo Nation. By August 2007, EPA completed a study identifying 520 AUMs. In June 2008, the EPA, in partnership with DOE, BIA, the Indian Health Service and the Nuclear Regulatory Commission, finalized a five-year plan for cleaning up the abandoned uranium mining sites on the Navajo Nation. (EPA, 2008)

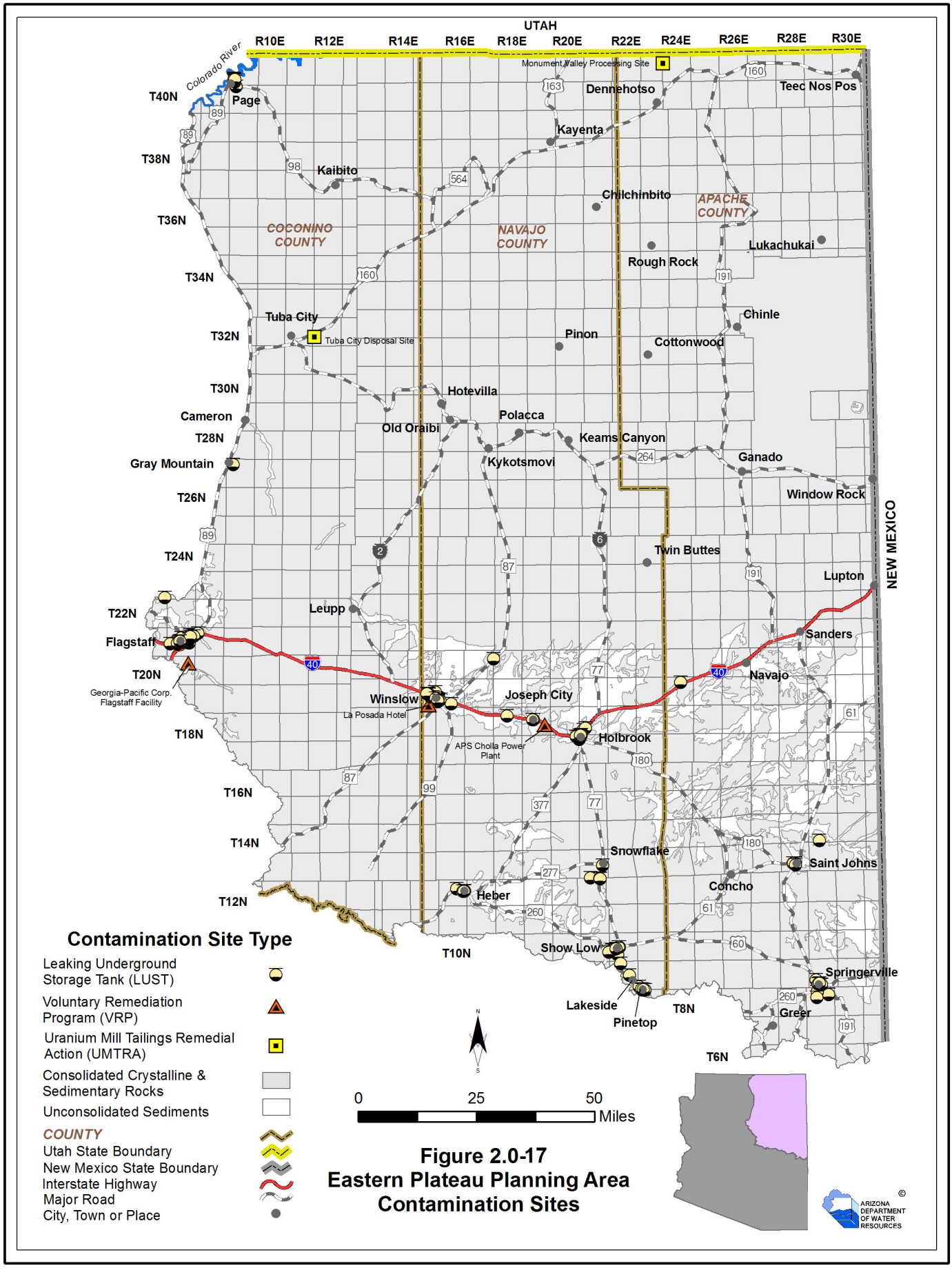


Figure 2.0-17
Eastern Plateau Planning Area
Contamination Sites

There are 260 active LUST sites in the planning area. Fifty-seven sites are located at Flagstaff, 53 at Winslow, 37 at Holbrook, 29 at Show Low/ Pinetop/Lakeside, 28 at Springerville/Eagar, 18 at Page, 11 at Heber and eight at Snowflake.

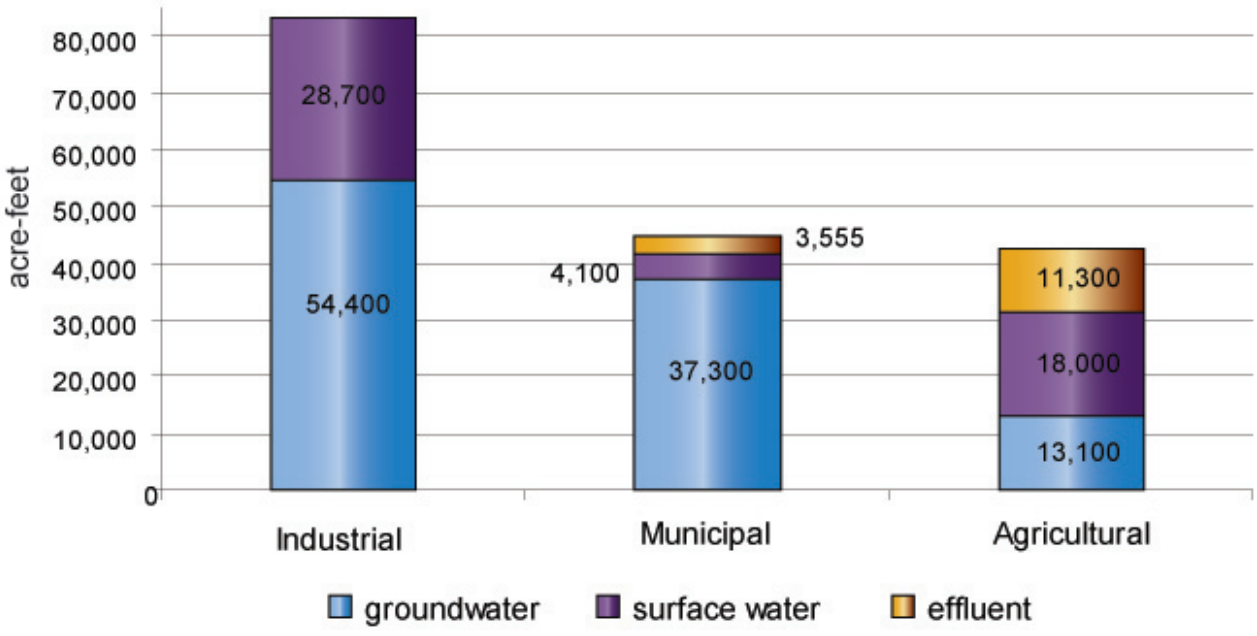
2.0.7 Cultural Water Demand

Cultural water demand in the Eastern Plateau Planning Area averaged approximately 170,400 AFA during the period from 2001 to 2005. Water demand by each sector and water source is shown in Figure 2.0-18. The industrial demand sector is the largest user with 83,100 AFA of water demand, 49% of the total. About two-thirds of the industrial demand is met by groundwater. The municipal sector accounts for about 26% of the cultural demand with almost 45,000 AFA. Most of the municipal demand is met with groundwater. Agricultural demand is approximately 42,400 AFA, 25% of the total. The agricultural sector utilizes comparable volumes of groundwater, surface water and effluent. Most of the agricultural effluent use is at one location and source, the Catalyst Paper Mill northeast of Heber. Surface water is the largest component of agricultural supply, meeting about 42% of the agricultural demand. Tribal water demand is included in these totals.

Tribal Water Demand

Tribal water demand is about a tenth of the overall cultural water demand in the planning area (not including the pumpage by Peabody Western Coal Company at Black Mesa). The Navajo Reservation is the largest and most populated with an estimated annual demand of 11,700 acre-feet and an Arizona population of about 105,000 in 2000. Demand on the Hopi Reservation is approximately 1,000 AFA. With a 2004 on-reservation population of about 8,000, Hopi people have continually occupied the area since 500 A.D. The community of Old Oraibi, established as early as 1100, is considered the oldest continuously inhabited settlement in the United States (ADOC, 2008).

Figure 2.0-18 Cultural Water Demand by Sector in the Eastern Plateau Planning Area, 2001-2005 (in acre-feet)



Navajo Nation

Major municipal demand centers on the Navajo Nation include Chinle, Kayenta, Tuba City and Window Rock/Fort Defiance. Specific amounts used in each community are not known. According to a 2002 Navajo Department of Water Resources (NDWR) report, approximately 40% of the population routinely hauls water for domestic and stock uses. According to the report, the Navajo Nation has the highest percentage of its population lacking potable water systems compared to any other region in the United States. Most municipal water supplies are groundwater (NDWR, USBOR & USIHS, 2002).

The Navajo Tribal Utility Authority (NTUA) is the largest public water provider for the Nation, which extends into New Mexico and Utah. The NTUA operates more than 90 public water systems with approximately 24,000 connections throughout the entire reservation, supplying more than 12,000 acre-feet of residential and 3,300 acre-feet of commercial water per year. It is estimated that smaller operators (NDWR and BIA) serve about 10,000 people and convey about 1,500 acre-feet of water annually. The USGS estimates that approximately 10,500 acre-feet of water was used for municipal purposes in the Arizona portion of the Navajo Reservation in 2006 (USGS, 2008). About 500 acre-feet of wastewater is used for dust abatement and construction. Other major uses are associated with coal mining on Black Mesa and electrical generation (NDWR, USBOR & USIHS, 2002).

Field in Canyon del Muerto, Navajo Reservation. Navajo reservation irrigation consists of Ak Chin (dryland farming) and small irrigation projects.

Navajo reservation irrigation consists of Ak Chin (dryland farming) and small irrigation projects. Between 1910 and the late 1950's the U.S. Government built and expanded dozens of small irrigation projects amounting to about 46,200 acres reservation-wide. Because of inadequate management and funding for operation and maintenance, these small systems have deteriorated and by 1986, a Soil Conservation Service survey found only 16,670 acres still were farmed, a decrease of 64% (NDWR, 2002b).

A field examination by Department staff and Navajo Nation representatives in the Upper Colorado River Basin portion of the planning area found approximately 400 acres of active surface water irrigation in 2005. The total water requirement for the crops grown on these acres was estimated at approximately 600 acre-feet (USBOR, 2007). The report did not include an irrigation efficiency estimate. The survey also found another 500 acres in the Upper Basin that were dryland farmed.

The extent of recent irrigation activity elsewhere on the Arizona portion of the reservation (Little Colorado River) is not well known but appears to be limited. The Hydrographic Survey Report for Indian Lands in the Little Colorado River System (ADWR, 1994b), reported approximately 3,000 irrigated acres in that portion of the reservation. An analysis of recent aerial images show approximately 200 acres irrigated in this area, resulting in total reservation acreage of roughly 600 acres, or 1,200 AFA on the Navajo Reservation (ADWR, 2008b).

An additional 4,400 acre-feet of groundwater was withdrawn annually from tribal lands for the

Black Mesa and Kayenta coal mines and slurry pipeline. With closure of the Mohave Generating Station at Laughlin, Nevada in 2005, the slurry pipeline that deliverd coal from the Black Mesa mine is not operating. As a result withdrawals dropped to 1,500 acre-feet in 2006.

Hopi Tribe

Major municipal demand centers on the Hopi Reservation include Polacca, Kykotsmovi, Shungopavi, Hotevilla and Moenkopi. The N-aquifer is the only aquifer of sufficient quality and accessibility to supply reliable drinking water to the Hopi villages on the three mesas (Hopi Tribe, 2005). The village of Moenkopi uses approximately 160 acre-feet of water from N-aquifer springs.

The Department completed the Preliminary Hydrographic Survey Report for the Hopi Indian Reservation (Hopi HSR) in December 2008, which contains detailed water demand information. The report found that public water systems delivered 445 acre-feet of groundwater in 2006 (ADWR, 2008a). The USGS estimates that an additional 100 acre-feet of groundwater is annually used for domestic purposes (USGS, 2008).

Agriculture on the Hopi Reservation consists primarily of traditional farming activities on small plots of land. The predominant crop grown is corn, with smaller percentages of orchards, beans, melons and squash. The Hopi HSR identified approximately 5,000 traditionally irrigated acres scattered throughout the reservation. These areas are irrigated through a combination of dryland farming, rainwater harvesting or surface water diversions during rainfall events. The survey also found approximately 180 acres of non-traditionally irrigated lands at Pasture Canyon near Moenkopi, 155 acres of which were irrigated in 2005. These acres are irrigated using non-traditional ("modern") irrigation methods at an estimated rate of 2.0 acre-feet per acre or about 310 AFA (ADWR, 2008a).

Dry land farming of corn on the Hopi Reservation.

Zuni Heaven Reservation

The Zuni Heaven Reservation was established by Congress in 1984 through Public Law 98-498 and expanded in 1990 through Public Law 101-486 to further the religious and cultural needs of the Zuni Tribe. Zuni Heaven is a religious pilgrimage site from the main reservation in New Mexico and was a lush riparian habitat with springs, streams and a sacred lake (Hadin Kyaya) as late as the 1930s. Surface water depletions, dams, groundwater pumping and incisement of the Little Colorado River through the Zuni lands resulted in loss of the springs, lake and riparian habitat. The Zuni Indian Tribe Water Rights Settlement Agreement of 2002 provides sufficient water for the reservation including reestablishment and maintenance of the wetland environment. A minimum wetland restoration volume of 5,500 AFA from various sources was identified, including unappropriated surface water flows reaching the reservation, water from Zuni Lands upstream of the reservation, acquired surface water rights and underground water. The agreement allows pumping of up to 1,500 AFA from the Zuni Pumping Lands for restoration of the wetlands and to provide water to the sacred lake. In 2008, the Tribe withdrew approximately 157 acre-feet of water from wells on the Zuni Pumping Lands.

Municipal Demand

The primary municipal water demand centers in the planning area are located at Flagstaff, Winslow/Holbrook, Page and in the White Mountain/Mogollon Rim communities of Eagar, Pinetop-Lakeside, Heber-Overgaard, Show Low, Snowflake, Springerville, Saint Johns and Taylor. Demand centers are discussed briefly below. Estimated water demand served by public and private water providers is shown in Table 2.0-8 for each water demand center. Reported water withdrawals and deliveries for all community water systems in the planning area in 2006 and 2007 are found in Appendix B. Effluent is used for municipal purposes by Flagstaff, Page and Holbrook for golf course, urban irrigation and for industrial purposes.

An estimate of water demand associated with domestic/self-supplied wells is also listed in Table 2.0-8. This demand is difficult to estimate. A population-based estimate rather than an estimate based on the number of domestic wells was used due to uncertainties regarding whether wells drilled are currently functioning. Water hauling is also common in unincorporated areas around Flagstaff and on the Navajo Reservation.

Municipal water demand is primarily residential and commercial. Demand varies seasonally in some communities due to tourism and summer-only landscape watering. Because of the higher elevation, shorter growing season, higher rainfall and rural nature of many parts of the planning area, outdoor landscape watering is typically lower than that in the lower elevation, drier parts of the state. There have been significant conservation efforts in the Flagstaff area. Some of these programs target outdoor water use and landscape design, e.g., rebates for replacement of high water use landscaping. Estimated per capita usage in Flagstaff is 116 gallons per capita per day (GPCD), which is lower than many cities in Arizona (City of Flagstaff, 2009). Public municipal systems serve the majority of water demand in the planning area. Non-Indian large utility systems that served more than 500 acre-feet of water in 2006 are listed in Table 2.0-9.

Estimated demand and water supply for all golf courses in the planning area is shown in Table

Table 2.0-8 Municipal demand in the Eastern Plateau Planning Area in 2006 (in acre-feet)

	Groundwater	Surface Water	Effluent	Total
Municipal Demand Served by a Water Provider				
Flagstaff Area	7,700	1,600	2,300	11,600
Heber-Overgaard/Forest Lakes	900	0	0	900
Page	0	2,250	770	3,020
Saint Johns/Concho	800	0	0	800
Show Low/Pinetop-Lakeside	4,200	0	0	4,200
Snowflake-Taylor	2,400	0	300	2,700
Springerville/Eagar	900	100	0	1,000
Winslow/Holbrook	2,600	0	185	2,785
Total Water Provider	**19,500**	**3,950**	**3,555**	**27,005**
Domestic/Self-supplied	**7,000**	**0**	**0**	**7,000**
Hopi Reservation	**540**	**160**	**0**	**700**
Navajo Nation	**10,500**	**NR**	**0**	**10,500**
Total Municipal	**37,540**	**4,110**	**3,555**	**45,205**

Source: ADWR Community Water Systems 2006 Annual Reports, USGS 2008

Table 2.0-9 Water providers serving 500 acre-feet or more of water per year, excluding effluent, in the Eastern Plateau Planning Area

Water Provider	1991 (AF)	2000 (AF)	2006 (AF)
Arizona Water Company-Lakeside	597	897	792
Arizona Water Company-Overgaard	183	337	503
Doney Park Water	455	737	781
Eager Municipal Water	680	781	700
Flagstaff, City of	8,172	9,927	8,485
Holbrook, City of	1,166	956	790
Page Municipal	2,740	2,740	2,250
Show Low Municipal	830	1,205	1,485
Saint Johns Municipal	558	757	662
Snowflake, Town of	872	1,323	1,416
Taylor, Town of	445	721	871
Winslow Municipal	2,000	1,863	1,744

Source: Community Water System 2006 Annual Reports, USGS 2007

2.0-10. Golf course demand is estimated to be approximately 4,500 acre-feet a year, of which approximately 2,700 acre-feet of groundwater, surface water and effluent is served from the Flagstaff municipal system comprising approximately 6% of the total municipal demand. Four golf courses, Aspen Valley, Continental and Pine Canyon in Flagstaff, and Hidden Cove Country Club in Holbrook use 100% effluent from a municipal source. The remaining 1,800 acre-feet of golf course demand is served from a facility well or surface water diversion and is considered an industrial demand in the Atlas.

Flagstaff Area

A number of water systems serve the Flagstaff area including the City of Flagstaff, Doney Park Water and Flagstaff Ranch. The nearby

Table 2.0-10 Golf course demand in the Eastern Plateau Planning Area (c.2006)

Facility	# of Holes	Demand (acre-feet)	Water Supply
Aspen Valley and Continental Golf Courses (Flagstaff)	36	1078	Effluent
Bison Golf Course - Show Low 1&2*	18	150	Groundwater
Concho Valley Country Club*	18	88/87	Groundwater/Surface Water
Flagstaff Ranch	18	88/22	Groundwater/Effluent
Greer Lakes Golf Resort*	18	150	Groundwater
Hidden Cove (Holbrook)	9	75	Effluent
Juniper Ridge RV Resort* (Show Low)	9	75	Groundwater
Lake Powell National Golf Club (Page)	18	719/46	Effluent/Surface Water
Pine Canyon (Flagstaff)	18	330	Effluent
Pine Meadows Country Club (Overgaard)	9	75	Groundwater
Pinetop Country Club*	18	150	Groundwater
Pinetop Lakes Golf & Country Club*	18	125	Groundwater
River Run Golf Course* (Eagar)	18	150	Groundwater
Silver Creek Golf Club* (Show Low)	18	441	Groundwater
Snowflake Municipal	27	225	Groundwater
Torreon Golf Club* (Show Low)	36	300	Groundwater
White Mountain Country Club* (Pinetop)	18	150	Groundwater

Source: ADWR, 2008c

communities of Kachina Village, Mountainaire, and Forest Highlands are located in the Verde River Basin. The City of Flagstaff is by far the largest provider in the entire planning area, with a potable demand of 8,500 acre-feet in 2006. It also delivered another 2,300 acre-feet of effluent for irrigation and industrial use.

As mentioned previously, the water supply for Flagstaff has become more diversified, with recent investment in additional groundwater development. It also continues to expand its reclaimed water system and recruit new reclaimed water customers. The city offers reduced water rates for reclaimed water use, rebates for the cost of a connection to the reclaimed system and provides reclaimed water hauling locations to users in several areas. Northern Arizona University is the largest water customer in Flagstaff, comprising about 8-10 percent of the annual demand (Pinkham and Davis, 2002).

The other large provider in the Flagstaff area is Doney Park Water, which serves groundwater to unincorporated communities known as Doney Park, Timberline and Fernwood located primarily east of Highway 89, and Cosnino and Winona located southeast of Doney Park along the Townsend-Winona Road. Doney Park Water also provides standpipe services. The Doney Park Water service area is not expected to expand significantly. Water users in the area are not connected to a centralized wastewater system and use on-site wastewater treatment such as septic systems (Pinkham and Davis, 2002). In 2006, Doney Park Water served almost 800 acre-feet of groundwater pumped from six wells to primarily single family residences (97% of deliveries).

Flagstaff Ranch is a growing, 850-acre development west of Flagstaff that includes a residential community, golf course and a business park. Flagstaff Ranch Water Company serves the residential development and provides standpipe services. In 2006 it withdrew about 50 acre-feet of groundwater. Separate wells provide irrigation water to the golf course, which is supplemented with effluent. (Pinkham and Davis, 2002)

Heber-Overgaard/Forest Lakes

The adjacent, unincorporated communities of Heber and Overgaard, with a combined population of approximately 3,600, are located in southern Navajo County along Highway 260. In 2007 Arizona Water Company withdrew about 500 acre-feet of groundwater from five wells to serve Overgaard. In 2007 Heber Domestic Water District withdrew about 140 acre-feet of water from three wells to serve Heber. Neither community has a centralized wastewater treatment system. The Bison Ranch master planned community east of Overgaard is served by a private wastewater treatment plant.

Forest Lakes is a primarily summer/vacation home community located west of Heber-Overgaard. In 2006 the Forest Lakes Water Improvement District pumped 235 acre-feet of water to serve over 800 single-family residences and a small number of commercial customers.

Page

The City of Page began as a housing camp in 1957 for the construction of Lake Powell. Incorporated in 1975, its population is now over 9,000. The city provides all water services to Page and to the adjacent community of

City of Page and the Lake Powell National Golf Course. In 2006, 719 acre-feet of effluent was delivered to this golf course.

LeChee on the Navajo Nation. All water used is from Lake Powell through a contract with the USBOR. Considering return flow credits to the Lake, Page is entitled to about 3,300 AFA. Water is withdrawn via intakes on the dam and pumped 1,200 feet uphill to the city's treatment plant. Some untreated water goes directly to the 27-hole municipal golf course. Page plans to increase its water storage capacity and is looking to improve system reliability since it relies on a single pipeline from the Lake Powell intakes. It is also considering well development to provide backup to the surface water system. Most of Page is served by a centralized wastewater treatment system (Pinkham and Davis, 2002). In 2006, the City of Page received 2,250 acre-feet from the USBOR and delivered 1,898 acre-feet to Page and 97 acre-feet to LeChee. In addition, 719 acre-feet of effluent was delivered to the Lake Powell National Golf Course.

Saint Johns/Concho

Saint Johns is the Apache County seat and home to over 3,800 residents. It is served by the Saint Johns Municipal water system, which withdrew about 660 acre-feet of water from two wells in 2006, and by the Saint Johns WWTP. The nearby Coronado Generating Station, a coal fired power plant operated by the Salt River Project, is a major employer. The unincorporated community of Concho is located about 18 miles west of Saint Johns. It consists of the original town of "Old Concho" and the master planned community of Concho Valley, which includes the Concho Valley Golf Course and Concho Lake. Livco Water and Sewer Company provides water and sewer service in Concho Valley. In 2006 it delivered about 100 acre-feet of groundwater to Concho Valley and 12 acre-feet to Old Concho Water Users, which serves Old Concho.

Show Low/Pinetop-Lakeside

The second largest demand center in the planning area with an annual demand of 6,500 acre-feet, the Show Low/Pinetop-Lakeside area had a combined population of about 15,100 residents in 2006. The area is a popular tourism and recreation destination. The primary water providers in Show Low are the City of Show Low, Pineview Water Company and Fools Hollow-Park Valley Water Company. The City of Show Low water utility serves about 80% of the city's approximately 11,000 residents. It withdraws water from the C-aquifer at depths of between 540 to over 600 feet bls (City of Show Low, 2007). In 2006 it withdrew almost 1,500 acre-feet of groundwater from eight wells and delivered three acre-feet to Pineview Water Company. About 900 acre-feet of effluent was treated at the Show Low Wastewater Treatment Plant and delivered to a series of created wetlands including Pintail Lake, Redhead Marsh and Telephone Lake. In 2006, Pineview Water Compnay withdrew about 335 acre-feet of water from four wells for single family and commercial uses. Fools Hollow-Park Valley Water Company withdrew about 185 acre-feet from two wells to serve primarily single-family customers. It also serves Fools Hollow State Park.

The communities of Pinetop and Lakeside incorporated as one in 1984. The town of about 4,600 residents (2006) is primarily served by four water providers; Arizona Water Company-Lakeside, Ponderosa Domestic Water Improvement District (DWID), Pinetop Water Community Facilities District (CFD) and Arizona Water Company-Pinetop Lakes, that together served almost 2,000 acre-feet of groundwater in 2006. Arizona Water Company-Lakeside withdrew 792 acre-feet from five wells to serve primarily residential customers. The next largest provider, Ponderosa DWID withdrew 484 acre-feet of water from seven wells to serve primarily single family customers and turf. Turf deliveries were 86 acre-feet in 2006 and 176 acre-feet in 2007. Pinetop CFD serves almost equal volumes of water to residential and commercial users. In 2006 it withdrew 468 acre-feet of groundwater from five wells. Arizona Water Company-Pinetop

Lakes serves residential customers from two wells. In 2006 it withdrew 208 acre-feet of water. The communities are also served by a number of small water providers. Area wells tap both the deep Coconino aquifer and the shallower Pinetop-Lakeside aquifer. New water provider wells are generally developed in the Coconino aquifer while the shallower aquifer is a substantial source of domestic water (Pinetop-Lakeside, 2004).

Snowflake/Taylor

Snowflake and Taylor are adjacent, incorporated towns located along Silver Creek in southeastern Navajo County. Each is served by municipal water and sewer systems. The largest industry in the area is the Catalyst Paper Mill located about 15 miles west of Snowflake/Taylor. Other local industries include a large hog feedlot operation, a 20-acre hydroponic tomato greenhouse, cattle grazing and farming. The population of Snowflake was about 5,180 in 2006 when the city utility served 1,416 acre-feet of water from four wells to about 1,640 connections. Wells are located in the C-aquifer with water levels generally between 100-400 ft bls. Reportedly, expansion of both the water and wastewater systems is needed. Treated effluent from the Snowflake WWTP is stored in a pond for irrigating agricultural fields. In 2006 about 300 acre-feet of effluent was delivered to a hay field (Town of Snowflake, 2007). Taylor, with a 2006 population of 4,270, withdrew 871 acre-feet from two active wells. Of this total, 222 acre-feet was delivered to turf and "other" including parks and streetscapes.

Springerville-Eagar

The incorporated communities of Springerville and Eagar are located in Round Valley at the edge of the White Mountains in southern Apache County. They have a combined population of over 6,600 with 4,530 residents in Eagar and 2,125 residents in Springerville in 2006. Both communities are served by municipal water and wastewater utilities. The nearby Tucson

Round Valley, Arizona. In 2006 Springerville served 291 acre-feet of groundwater and Eagar withdrew 595 acre-feet of groundwater and diverted 105 acre-feet of surface water.

Electric Power Springerville Generating Station is a major area employer. Springerville served 291 acre-feet of groundwater to residential and commercial customers from seven wells in 2006. Eagar's water supply comes from seven wells and a spring. Water use averages 150,000 gallons per day in the winter to one mgd in the summer. Peak demand exceeds well pump capacity and the town is planning construction of two new wells. Approximately 60% of the town is connected to a centralized sewer system. Wastewater from the Eagar WWTP is provided for crop irrigation (Town of Eagar, 2002). In 2006, Eagar withdrew 595 acre-feet of groundwater from six wells and diverted 105 acre-feet of surface water. It delivered 98 acre-feet of effluent for agricultural use.

Winslow-Holbrook

These two relatively large communities are located in the Little Colorado River Valley in Navajo County. Holbrook, with a 2006 population of about 5,600, is the county seat. Both communities are served by municipal water systems. The Arizona Public Service Cholla Power Plant is located near Holbrook and is a major area employer. Holbrook withdraws water from the C-aquifer from six wells. In 2006 it withdrew 790 acre-feet of groundwater. Holbrook's sewer system serves

customers in and around the city. The Painted Mesa WWTP treats an average of 0.5 mgd and effluent is reused for agricultural irrigation and for irrigation of the Hidden Cove Golf Course. Located west of Holbrook, Winslow is larger, with a 2006 population of over 10,100. Municipal groundwater is pumped from six wells located southwest of the city. In 2006 it withdrew 1,744 acre-feet of groundwater and diverted 2,000 acre-feet from Clear Creek. Diversions from Clear Creek are for non-municipal uses, primarily recreation. Another approximately 1,000 acre-feet of effluent from the Winslow WWTP was delivered for agricultural irrigation of a farm leased by the city for non-dairy forage crops.

Agricultural Demand

Agricultural demand on non-tribal lands has significantly declined from historic levels. Cessation of some agricultural irrigation has occurred recently in the Hunt Valley area and near Saint Johns due to purchase by the Zuni Tribe to preserve tribal water resources at Zuni Heaven, a historically riparian area sacred to the Zuni.

Areas of greatest non-Indian agricultural irrigation are near the communities of Saint Johns, Springerville, Snowflake/Taylor, Joseph City and Holbrook. In some areas, particularly Snowflake/Taylor, the proportions of surface water and groundwater used varies significantly from year to year with fluctuations in precipitation. Agriculture on the Navajo and Hopi reservations is served primarily by surface water and land is also dryland farmed ("traditional" farming). As mentioned above, "non-traditional" Indian agricultural demand is estimated to be about 1,550 acre-feet. Dryland farming utilizes water harvesting techniques to catch and direct runoff to crops. Because there is no supplemental irrigation, both spring soil moisture and late summer precipitation are needed for success. It is estimated that approximately 8,800 acres in the planning area are actively irrigated with a combination of 42,950 acre-feet of surface water, groundwater and effluent. Agricultural demand is summarized in Table 2.0-11.

Described below is historic agricultural irrigation information from investigations conducted by the Department in 1990 and 1994. In the summer of 2008, staff from the USGS conducted a survey of agricultural lands in the planning area. Preliminary information from this survey is also discussed below and summarized in Table 2.0-12. The survey found approximately 8,000 active (not fallow) acres irrigated during the 2008 growing season on non-tribal lands in the planning area.

Silver Creek Watershed-Pinetop-Lakeside, Show Low, Snowflake, Taylor

Several irrigation companies historically supplied agricultural irrigation water in the Show Low/ Pinetop-Lakeside area. These included the Show Low, Pinetop-Woodlands, Woodlands and Lakeside Irrigation Companies. The irrigation season is limited and irrigated lands were used for pasture, orchards and gardens. The Silver Creek Irrigation District operates in the communities of Shumway, Taylor and Snowflake. Historically, Silver Springs provided the majority

Table 2.0-11 Agricultural demand in the Eastern Plateau Planning Area

	1991-1995 (acre-feet)	1996-2000 (acre-feet)	2001-2005 (acre-feet)
Non-Indian Total	**51,200**	**37,700**	**41,400**
Surface Water	14,700	15,400	17,000
Groundwater	36,500	22,300	13,100
Effluent	UNK	UNK	11,300
Indian Total	**1,550**	**1,550**	**1,550**
Navajo [1]			
Surface Water	1,200	1,200	1,200
Hopi			
Surface Water	350	350	350
TOTAL	**52,750**	**39,250**	**42,950**

Source: ADWR 2008b, USGS 2007

[1] Navajo irrigated acreage estimated based on 2005 aerial data
UNK= Unknown

Table 2.0-12 Active agricultural acres in the Eastern Plateau Planning Area

Area	Source	Acres	Crop Type	Irrigation System
Heber	REUSED WATER (CATALYST CORP)	1,691	ALFALFA	FLOODED
		272	SORGHUM	
		75	TREES	
		60	CORN	
		54	BARLEY	
Subtotal		***2,152***		
Holbrook	GROUNDWATER	41	RYE GRASS	FLOODED
		13	CORN/GRASS MIX	
	HOLBROOK RECLAIM WATER	62	ALFALFA	FLOODED
Subtotal		***115***		
Joseph City INA	GROUNDWATER	153	ALFALFA	FLOODED
		47		SPRINKLER
		22		CENTER PIVOT
		23	CORN	FLOODED
		88	RYE GRASS	FLOODED
		17		SPRINKLER
		32		CENTER PIVOT
		1	VEGETABLES	FLOODED
Subtotal		***383***		
Show Low	SURFACE WATER (SHOW LOW CREEK)	4	CORN	FLOODED
		259	GRASS	FLOODED
Subtotal		***263***		
Snowflake	GROUNDWATER	44	BARLEY	FLOODED
		35	SOD	SPRINKLER
		4		CENTER PIVOT
		289	ALFALFA	FLOODED
	GROUND WATER / SURFACE WATER (SILVER CREEK LAKE)	95	BERMUDA GRASS	FLOODED
		203	CORN	
		45	GREENHOUSE	
		41	OATS	
		1,526	RYE GRASS	
Subtotal		***2,281***		
Springerville/Eager	SURFACE WATER (OTHER)	119	RYE GRASS	FLOODED
		2	VEGETABLES	
	SURFACE WATER FROM GREER RESERVOIR	29	ALFALFA	FLOODED
		1,101	RYE GRASS	
		2	VEGETABLES	
Subtotal		***1,253***		
Saint Johns	GROUNDWATER	101	SOD	SPRINKLER
		94		CENTER PIVOT
		32	OATS	FLOODED
		19	ALFALFA	
		17	RYE GRASS	
	SURFACE WATER (LYMAN LAKE)	257	ALFALFA	FLOODED
		580	RYE GRASS	
		87	SUDAN GRASS	
Subtotal		***1,187***		
Woodruff	GROUNDWATER	243	ALFALFA	FLOODED
	SURFACE AND GROUNDWATER	162	RYE GRASS	FLOODED
Subtotal		***405***		
TOTAL		***8,041***		

Source: USGS 2009

of the surface water supply for the District. White Mountain Lake is the major water storage reservoir for the District. The area is within the Silver Creek Watershed for which a Hydrographic Survey Report was filed with the Adjudication court in 1990. At that time, almost 6,300 acres were irrigated with surface water and groundwater, using a total of almost 29,000 acre-feet per year (ADWR, 1990).

In 2008, the USGS observed 263 acres of primarily grass irrigation with water diverted from Show Low Creek in the Show Low area. In the Snowflake, Taylor, Shumway area, approximately 2,281 acres were irrigated with surface water from White Mountain Reservoir and with groundwater. The primary crop was rye grass.

Joseph City Irrigation Non-Expansion Area (INA)

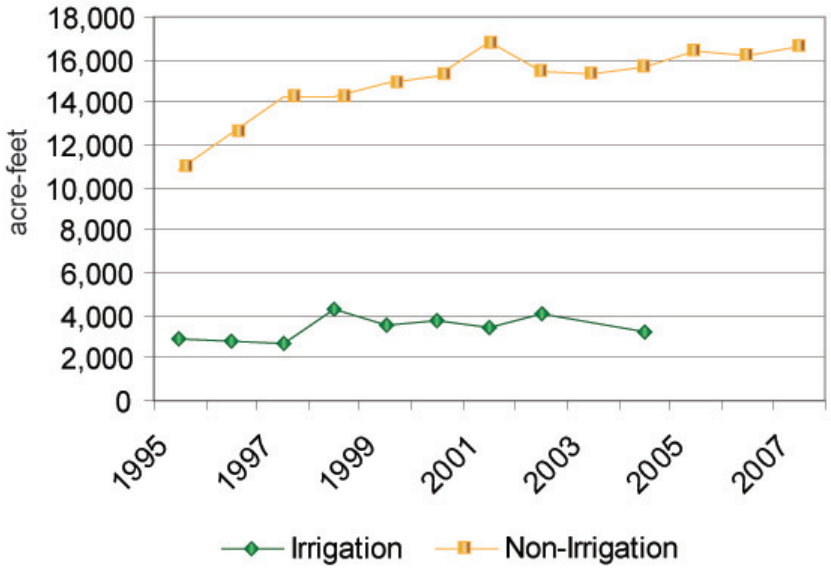
The Joseph City INA was established in 1980 by the Arizona Groundwater Management Act. The area had previously been designated as a Critical Groundwater Area in 1974. Designation of an area as an INA recognizes that there is "insufficient groundwater to provide a reasonably safe supply for the irrigation of the cultivated lands at the current rate of withdrawal" A.R.S. § 45-402(22). Within an INA, irrigation with groundwater is restricted to lands that were irrigated prior to establishment of the area. Groundwater withdrawals by irrigation and large non-irrigation users, such as cities or golf-courses, must be reported annually to the Department. Irrigation and non-irrigation uses (primarily the Cholla Generating Station), are shown in Figure 2.0-19. Irrigation use in the INA had generally been between 2,000 and 4,000 acre-feet a year, served by the Joseph City Irrigation Company. Irrigation use was not reported for 2006 and 2007.

In 2008, the USGS observed about 383 acres of active irrigation, primarily alfalfa, in the Joseph City INA.

Upper Little Colorado River-Springerville, Eagar, Nutrioso, Greer, Vernon, Saint Johns, Concho, Woodruff

The Department conducted an inventory of irrigation use in the Upper Little Colorado River watershed and published a report in 1994 (ADWR, 1994c). The inventory divided the area into ten regions: Nutrioso; Greer; Round Valley, including the Round Valley Water Users Association (Eagar) and Springerville Water Rights and Ditch Company; Vernon; Saint Johns including Lyman Water Company and the Saint Johns Irrigation Company; Concho, including Concho Water Company; Hunt; Hay Hollow; Woodruff, including the Woodruff Irrigation Company and Sanders. At that time, 18,980 acres were irrigated with a total surface water and groundwater use of almost 35,000 acre-feet. The biggest volumes of water use were in the Saint Johns area (6,600 acre-feet) and in the Hunt Valley area, located west of Saint Johns (3,800 acre-feet). The cropped acres were

Figure 2.0-19 Irrigation and Non-irrigation Water Demand in the Joseph City INA



primarily pasture. No use was reported in the Sanders region. As mentioned previously, the Zuni tribe has recently purchased and retired agricultural lands in the Hunt Valley area and near Saint Johns.

By the summer of 2008, the USGS observed irrigation of approximately 2,271 acres in the area. In the Springerville/Eager area 1,252 acres of primarily rye grass was irrigated with surface water. Irrigation water used at Eagar is conveyed via pipeline from the Greer Lakes. That summer, 1,187 acres of primarily rye grass and alfalfa was irrigated in the Saint Johns area with a combination of groundwater and surface water from Lyman Lake. Southeast of Holbrook at Woodruff, another 405 acres of alfalfa and rye grass was observed irrigated with groundwater and surface water.

Lower Little Colorado River-Winslow, Holbrook, Heber, Flagstaff

The Department conducted an inventory of irrigation use in the Lower Little Colorado River watershed and published a report in 1994 (ADWR, 1994d). Similar to the Upper Little Colorado River watershed inventory, the area was divided into four regions: Winslow, Holbrook, Heber and Flagstaff. At the time of the inventory, (excluding the Joseph City Irrigation Company located in the Joseph City INA), about 3,700 acres were actively irrigated with a combination of 10,600 acre-feet of surface water and groundwater. Use was reported in three of the regions: 4,380 AFA at Winslow; 3,300 AFA at Heber; and 2,900 AFA at Holbrook. Pasture and alfalfa were the primary crops grown. No irrigation was reported in the Flagstaff region.

By the summer of 2008, the USGS found that irrigation had ceased at Winslow, although in 2007 the City of Winslow reported that 1,000 acre-feet of effluent was applied to forage crops at a farm leased by the city. At Heber, 1,691 acres of alfalfa, 272 acres of sorghum and 189 acres of trees, corn and barley were irrigated with water discharged from the Catalyst Paper Mill. Irrigation had diminished in the Holbrook area with about 115 acres of rye grass, corn and alfalfa irrigated with a mix of groundwater (53 acres) and effluent (62 acres).

Industrial Demand

Industrial water demand in the planning area includes mining, electrical power generation, paper production, dairies and feedlots and golf course irrigation served by a facility water system. This demand is summarized in Table 2.0-13 for selected time periods. Industrial demand, particularly for power generation is a large cultural demand component in the planning area,

Table 2.0-13 Industrial demand in the Eastern Plateau Planning Area

	1991-1995	1996-2000	2001-2005
Type	**Water Use** (acre-feet)		
Mining Total	**11,144**	**11,445**	**6,241**
Surface water[1]	6,984	7,005	1,441
Groundwater[2]	4,160	4,440	4,800
Power Plant Total	**52,918**	**56,943**	**63,279**
Surface water	23,418	24,843	27,179
Groundwater	29,500	32,100	36,100
Golf course Total	**1,266**	**1,326**	**1,596**
Surface water	87	87	87
Groundwater	1,179	1,239	1,509
Dairy/Feedlot Total	**472**	**524**	**546**
Groundwater	472	524	546
Paper Mill Total	**17,092**	**15,530**	**11,452**
Groundwater	17,092	15,530	11,452
TOTAL	**82,892**	**85,768**	**83,114**

Sources: ADWR 2008c, USGS

[1] Diverted pursuant to an exchange agreement between Phelps Dodge Corporation and the Salt River Valley Water Users Association. Phelps Dodge provided water to SRP from Show Low Lake but this water was accounted for as water used by the Morenci Mine in the Southeastern Arizona Planning Area. This agreement and associated diversions ceased in 2002.

[2] Includes water withdrawn from tribal lands leased by Peabody Coal.

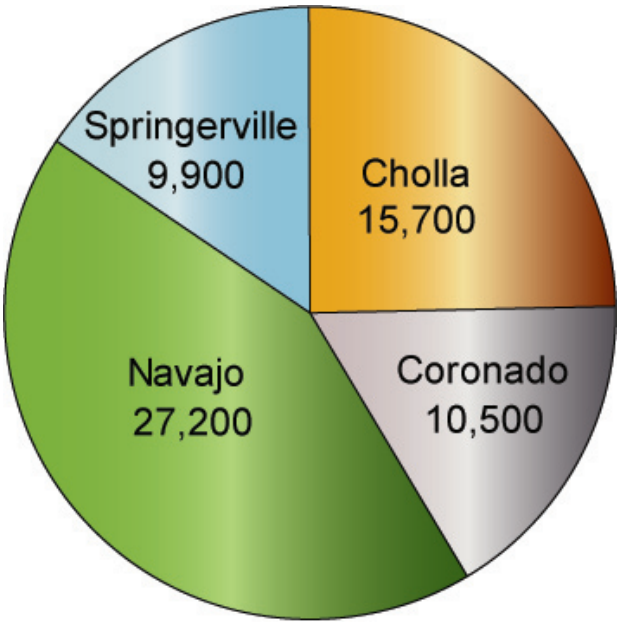
representing about 49% of the total planning area demand during the 2001-2005 time period.

Mine water use includes sand and gravel operations, coal mines on Black Mesa south of Kayenta and historically, surface water diversions from Show Low Lake and Blue Ridge/C.C. Cragin Reservoir for mining use outside the planning area. These diversions ceased in 2002 and Phelps Dodge Corporation relinquished its certificated rights to both water sources in 2005. Peabody Western Coal Company (PWCC) operates two mines on Black Mesa: the Black Mesa Coal Mine and the Kayenta Mine. Until recently, these mines annually shipped approximately 12 million tons per year of low-sulfur subbituminous coal and pumped approximately 4,400 AFA. Over 3.8 million gallons of groundwater per day were required to slurry coal to the Mohave Generating Station (MGS) near Laughlin, Nevada. Coal is also sent to the Navajo Generating Station (NGS) at Page by rail (Grahame and Sisk, 2002). By 2005, the 273-mile slurry pipeline ceased operation, in part because of Southern California Edison's failure to upgrade pollution control devices at the MGS, as required by a lawsuit brought by a consortium of environmental groups. As a result of the closure, PWCC amended its mining permit application to the Office of Surface Mining (OSM) and a final Environmental Impact Statement (EIS) was issued in November 2008. The proposed project would consolidate the operations of the Kayenta Mine and the adjacent Black Mesa Mine, which previously supplied coal to the MGS, under a single permit. Water use at the Black Mesa Complex would be reduced to an average of 1,236 acre-feet of N-aquifer water per year (OSMRE, 2008). In December 2008, OSM approved the project and issued a life-of-mine permit that would allow operations to continue until 2026. This decision is being appealed.

Power plants include the Navajo Generating Station (Page), the Coronado Generating Station located six miles northeast of Saint Johns, the Springerville Station located northeast of Springerville and the Cholla Generating Station near Joseph City. The NGS uses water from Lake Powell pursuant to an Upper Basin Colorado River contract which entitles it to receive up to 34,000 acre-feet of water per year. In recent years about 27,200 AFA has been diverted for use at the NGS. All other facilities pump groundwater. Average annual demand by power plants for the period 2001-2005 is shown in Figure 2.0-20.

In addition to coal-fired power plants, the planning area has a solar system at the Springerville Generating Station, a biomass power plant that began operation in June 2008 at Snowflake and a second proposed biomass facility at Eagar. A previous biomass plant at Eagar was closed in 2008. The Snowflake White Mountain Biomass 24-megawatt power plant uses woody waste and recycled paper fibers from the adjacent Catalyst Paper Co. paper mill (formerly the Abitibi paper mill). Sources of woody waste are from forest thinning projects,

Figure 2.0-20 Average Annual Water Demand by Electrical Generating Stations in the Eastern Plateau Planning Area, 2001-2005 (in acre-feet)



small-diameter trees burned in the Rodeo-Chedeski fire and leftover wood from sawmills. The plant supplies power locally and has long-term power-purchase agreements with Arizona Public Service Co. and Salt River Project. The water demand of the plant is not known.

There are ten industrial golf courses in the planning area, including seven in the Pinetop-Lakeside/Show Low area. An annual average of about 1,600 acre-feet of primarily groundwater was used for industrial golf course irrigation during 2001-2005. Because of cooler temperatures, higher precipitation and short growing season, relatively little water is required for golf course irrigation at most locations.

During 2001-2005, an estimated 124,000 swine were raised annually at four feedlot facilities near Snowflake. These feedlots have been in existence since the early 1980s. In addition, a small dairy is located near Taylor. Combined water demand by the dairy and feedlots is estimated at between 450 to 600 acre-feet of groundwater a year.

Located about 23 miles southwest of Holbrook, the Catalyst Paper Co. purchased the Abitibi paper mill in April 2008. Waste water from the operation is discharged to Dry Lake and is used to irrigate primarily pasture east of SR 377. In 2005, approximately 11,900 acre-feet of effluent was generated while 14,000 acre-feet of groundwater was pumped. This suggests that about 85% of the annual groundwater withdrawal is recovered and used for irrigation.

2.0.8 Water Resource Issues in the Eastern Plateau Planning Area

A number of water resource issues have been identified in the planning area by community groups through the distribution of surveys and from other sources. Primary issues are the accessibility of groundwater supplies in some areas due to hydrologic conditions and water quality problems. There are also infrastructure deficiencies that influence access to water supplies. A number of communities lack financial resources for infrastructure development or repair and drought has impacted surface water supplies. The ability to meet future water demands is a concern for many communities. The North Central Arizona Water Supply Study (which includes Flagstaff and the western portion of the planning area and the Western Plateau Planning Area) concluded that by 2050 the region's groundwater pumping would not be sustainable and that unmet demands will be more than 7,000 acre-feet annually. Many Navajo communities also currently face critical water shortages. Water hauling is commonplace on the reservation, in part because widely scattered housing makes direct water delivery impractical in many areas. Hauling is also common at some locations outside of the reservation.

Planning and Conservation

Many communities in the planning area are rapidly growing and physical and legal availability of water is a challenge in some places. As mentioned previously, the communities of Flagstaff, Pinetop-Lakeside, Show Low, Snowflake, and Taylor are required to include a water resources element in their general plans because of their size and/or rate of growth. Although not required by law to include a water resources element in the county's comprehensive plan, Coconino County has done so. The County Plan emphasizes conservation in tandem with resource development and recognizes the importance of incorporating climatic variability into water resource planning (Coconino County, 2003).

The City of Flagstaff adopted a Regional Plan with a Water Resources Element in 2002. The water resources element includes information on the water and wastewater system and an analysis of future growth and water requirements

(City of Flagstaff, 2001). Flagstaff has an active conservation program that includes an extensive reclaimed water system, education, and a staggered landscape watering schedule.

The Natural Resources Conservation Service (NRCS) has produced rapid watershed assessments (RWA) for the Silver Creek, Chevelon Canyon and Little Colorado River Headwaters Watersheds. A RWA is a concise report containing information on natural resource conditions and concerns at the 8-digit HUC level. They are intended to provide sufficient information and analysis to generate an appraisal of the conservation needs of the watershed as well as serve other uses (NRCS, 2008, 2007a, 2007b).

As mentioned previously, all community water systems in Arizona are required to submit a water system plan as part of the State's Drought Preparedness Plan. The system water plan includes a water supply plan, water conservation plan, and drought preparedness plan. Water providers are required to develop the plan to ensure they reduce their vulnerability to drought and prepare to respond to potential water shortage conditions.

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

Watershed Groups and Studies

Several watershed groups have formed in the Eastern Plateau Planning Area to address a variety of water resource issues. Some groups encompass areas outside of the planning area. Groups that are currently active in various locations within the planning area are the Coconino Plateau Water Advisory Council, Northern Arizona Municipal Water Users Association, Little Colorado Watershed Coordinating Council (formerly the Little Colorado River Multi-Objective Management Partnership (LCRMOM)), Pinetop-Lakeside Watershed Enhancement Partnership, the Silver Creek Watershed Partnership, the Upper Little Colorado River Watershed Partnership and the Navajo Nation. A complete description of participants, activities, reports and issues is found in Appendix D. Primary issues identified by these groups that apply to the Eastern Plateau Planning area can be summarized as follows:

Growth:

- Excessive growth in some areas
- Proposed development in Greer and impacts on the Little Colorado River
- Unregulated lot splits

Water Supplies and Demand:

- Limited and deep groundwater supplies
- Drought sensitive supplies
- Numerous water haulers and few hauling stations that are sometimes cutoff during drought
- Limited surface water supplies for Page
- Limited groundwater data for entire region
- Potential impacts on groundwater system from power plants
- Seasonal demands impacting ability to meet peak demands
- Competition for supplies

Legal:

- Potential limitation of groundwater usage resulting from Indian reserved groundwater rights
- Uncertainty of Indian water right settlements (Little Colorado River & Colorado River)

- Access to water development activities on public lands
- Competition from Phoenix/Tucson for CAP reallocation water
- Upper Basin/Lower Basin Colorado River issues affecting potential for use
- Unresolved surface water adjudication
- Current definition of an adequate water supply with passage of SB 1575

Water Quality:

- Minor arsenic issues in Woody Mtn. Well field (9-14 ppb)
- Arsenic and TDS in some areas

Environmental:

- Endangered Species Act implications on groundwater usage and impacts on perennial streams
- Potential for groundwater development impact on threatened and endangered species, springs and riparian areas
- Impact of invasive species (tamarisk)

Funding:

- Limited funding resources for planning, projects, infrastructure and studies
- Extremely high cost of water augmentation projects
- Funding for Colorado River water infrastructure
- Funding for water delivery infrastructure

Drought:

- Drought impacts on surface water supplies and springs resulting in impacts on agriculture and cattle ranching
- Potential impacts on tourism due to drought

Other:

- Political differences between some communities
- Perception of no real water supply problem
- Several high hazard unsafe dams

Potential future and current water supply shortfalls have lead to discussions among the Coconino Plateau Advisory Council regarding water supply development/augmentation alternatives (Heffernon and Muro, 2001). A study to identify potential supply alternatives for the area was completed by the Bureau of Reclamation in 2005 and the North Central Arizona Water Supply Study was completed in 2006. All the proposed alternatives to address shortfall included a pipeline to deliver Lake Powell water to various demand centers (USBOR, 2006). A number of other hydrologic and planning studies have been conducted in the planning area, especially in the Flagstaff area. The Department completed a Hydrologic Map Series Report of southern Navajo County in 2007 which covers the area south of the Navajo Nation to the Mogollon Rim. The NEMO Watershed Based Plan for the Little Colorado Watershed was completed in 2006. NEMO (Non-point Education for Municipal Officials) is intended to help communities protect their natural resources while still accommodating growth. Other planning area studies are found in the reference sections of this volume.

Surveys

The Department conducted a rural water resources survey in 2003 to compile information for the public and help identify the needs of 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. A report of the findings from the survey was completed in 2004 (ADWR, 2004).

Thirty-seven water providers and jurisdictions in the Eastern Plateau Planning Area responded to the survey and of these, 23 ranked 18 issues. In the planning area, infrastructure and water supply issues were ranked among the top five issues by a many respondents. In a separate question, a majority of respondents noted at least one drought impact. Primary drought impacts noted were increased demand, increased peak demand and lowered groundwater levels.

The Department conducted another, more concise survey of water providers in 2004.

Table 2.0-14 Water resource issues ranked by survey respondents in the Eastern Plateau Planning Area

Issue	Percent of 2003 respondents that ranked issue as one of the top 5 (of 18)	Percent of 2004 respondents reporting issue was a moderate or major concern
Inadequate storage capacity to meet peak demand	39	31
Inadequate well capacity to meet peak demand	26	28
Inadequate water supplies to meet current demand	17	13
Inadequate water supplies to meet future demand	39	31
Infrastructure in need of replacement	52	49
Inadequate capital to pay for infrastructure improvements	43	56
Drought related water supply problems	35	26

Note: 2003 respondents included 17 water providers and 6 jurisdictions. 2004 respondents included 39 water providers.

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, 44 water providers in the Eastern Plateau Planning Area, with a total of approximately 46,500 service connections, were willing to participate and provide information on water supply, demand, infrastructure and to rank a list of seven issues.

In the 2004 survey, water providers were asked to rank issues from 0 to 3 with 0 = no concern, 1 = minor concern, 2 = moderate concern and 3 = major concern. Of the 44 water providers that responded to the survey, 39 ranked issues. These respondents include most of the largest water providers in the planning area including City of Flagstaff, City of Holbrook, City of Show Low, Town of Snowflake, Winslow Municipal Water and Doney Park Water Company. Although responses to the 2003 questionnaire are not directly comparable to the 2004 survey due to differences in the form and wording of the surveys, responses to the same issues are similar as shown in Table 2.0-14.

Tribal Issues

Water supply availability is an issue on tribal lands in the planning area. A Navajo Department of Water Resources (NDWR) White Paper identified the need for an increased water supply to help support needed basic services on the reservation (NDWR, 2002). The tribe is investigating the feasibility of transporting water by pipeline to several areas and is conducting groundwater development investigations. This included a plan to investigate the alluvial aquifer in the Bird Springs area located east of Leupp at the southern edge of the Navajo Reservation Boundary northwest of Winslow, to analyze the feasibility of well field development (NDWR, USBOR & USIHS 1999). Subsequently, the USGS issued a report in 2005 evaluating the C-aquifer in this area as a potential supply

for Peabody Coal and the Navajo and Hopi (Hoffman and others, 2005). The Hopi Tribe is also engaged in supply development activities and recently purchased off-reservation ranches near Winslow and Springerville for potential irrigation development or other purposes (HKM Engineering, 2005).

One of the water development challenges on the Navajo Reservation is that resolution of problems requires the coordination of multiple agencies and private resources. In addition, the population has limited economic resources that make large capital investments difficult and the widely dispersed population results in large distances between water sources and water users. Although the Navajo Nation has adopted a Drought Plan and conducts numerous planning activities, additional regional water planning, investigation of a regional conveyance system, improving water service to domestic water haulers and water conservation and reuse were identified as needs. (NDWR, 2002)

In addition to the aforementioned issues, the Hopi and Navajo are concerned about the impact to their water supply by Peabody Western Coal Company (PWCC) extracting N-aquifer water for coal mining activities at the Black Mesa Project. The N-aquifer is the primary source of drinking water for the Hopi. This pumping is believed to be affecting water supplies in some areas (Hopi Tribe, 2005). Approximately 4,400 acre-feet of water per year had been extracted from the aquifer to transport coal through a slurry pipeline from the Black Mesa Coal Mine to the Mohave Generating Station (MGS) at Laughlin, Nevada. The MGS suspended operation in December 2005. As originally proposed in early 2004 and analyzed in a draft EIS in November 2006, the Black Mesa Project included construction of a new water-supply system and a 108-mile long water-supply pipeline from a new well field in the Coconino aquifer near Leupp, Arizona, to the mine complex to replace/reduce N-aquifer pumping (OSMRE, 2008). The draft EIS received over 18,000 comments, largely related to concerns about groundwater use. After the draft EIS was issued, attempts to reopen the MGS were suspended and PWCC amended its Office of Surface Mining (OSM) permit application accordingly (OSMRE, 2008).

In November 2008, the final EIS for the Black Mesa Project was released. The proposed project would consolidate the operations of the Kayenta Mine, which supplies 8.5 million tons of coal per year via a 75-mile railway to the Navajo Generating Station, and the adjacent Black Mesa Mine, which previously supplied coal to the MGS, under a single permit. Water use at the Black Mesa Complex would be reduced to an average of 1,236 acre-feet of N-aquifer water per year for mining-related and domestic purposes (OSMRE, 2008). In December 2008, OSM approved the project and issued a life-of-mine permit that would allow operations to continue until 2026. A coalition of tribal groups and conservationists appealed the decision in January 2009 citing, among other factors, concerns over groundwater depletion (Arizona Republic, 2009).

Reservoir on the Navajo Reservation. Additional regional water planning, investigation of a regional conveyance system, improving water service to domestic water haulers and water conservation and reuse were identified as needs by the Navajo Department of Water Resources.

Resolution of Indian water rights settlements is a critical issue in the planning area. The Navajo Nation, Hopi Tribe, Zuni Tribe and the San Juan Southern Paiute Tribe have been negotiating with non-Indian water users in the Little Colorado River Plateau Basin, the State of Arizona and the federal government for several years in a settlement committee appointed by the LCR Adjudication Court (Court).

The non-Indian parties reached agreement with the Zuni Tribe over protection of its Zuni Heaven lands in Arizona, resulting in congressional approval in 2003. On December 31, 2008 the Department released a preliminary catalog of non-exempt registered wells in the Eastern Little Colorado River Basin for inspection and comment. The catalog was compiled in accordance with the Zuni Indian Tribe Water Rights Settlement, approved by the Court on November 27, 2006.

Talks have continued with the Navajo Nation and Hopi Tribe about possible settlement of their Little Colorado River Basin water right claims. The Department released a preliminary Hydrographic Survey Report (Hopi HSR) for the Hopi Reservation on December 31, 2008, prepared as part of the LCR Adjudication, which is pending before the Superior Court of Arizona in Apache County. The purpose of the Preliminary Hopi HSR is to provide the Hopi, the United States and interested parties with the opportunity to inspect the information that the Department has gathered and to file comments with the Department. The Navajo Nation filed a lawsuit in April 2003 against the Secretary of the Interior over the operation of the Colorado River. A Federal judge has entered a stay in that case to allow negotiations with the State of Arizona and non-Indian water users about possible Navajo Nation claims to the Colorado River.

2.0.9 Groundwater Basin Water Resource Characteristics

Section 2.1 presents data and maps on water resource characteristics of the Little Colorado River Plateau Basin, the only groundwater basin in the Eastern Plateau Planning Area. A description of the data sources and methods used to derive this information is found in Appendix A of Volume 1 of the Atlas. This section briefly describes general information that applies to the basins and the purpose of the information. This information is organized in the order in which the characteristics are discussed in Section 2.1.

Geographic Features

The geographic features map is 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 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. A key land ownership feature in the basin is the significant amount of private lands interspersed with state trust lands and to a lesser extent federal lands in a checkerboard pattern south of the Navajo Reservation. Prior to 1871, federal land grants of alternating one-square-mile sections of land along the right-of-way were given to railroads to promote railroad expansion. In addition, 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. Where the "school" section lands were previously claimed or on federal reservations, national forest, park

or Indian reservations, the state was given the right to select an equal amount of acreage of Federal land. The state is also allowed to trade lands for other federal lands or private lands to block up Trust land holdings (ASLD, 2006). These decisions have resulted in the pattern observed in the basin.

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 table 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 utilizing more than one source of information. Stream designations may not accurately reflect current conditions in some cases. Spring data was compiled from a number of sources in an effort to develop as comprehensive a list as possible. Spring data is important to many researchers and to the environmental community due to their importance in maintaining habitat, even from small discharges.

Groundwater Conditions

Several indicators of groundwater conditions are presented for the 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.

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.

Water Quality

Water quality conditions impact the availability of water supplies. Water quality data was compiled from a variety of sources as described in Volume 1, Appendix A. The data indicate areas where water quality exceedences have previously occurred, however additional areas of concern may currently exist where water quality samples have not been collected or sample results were not reviewed by the Department (e.g. samples collected in conjunction with the ADEQ Aquifer Protection Permit programs). It is important to note also that the exceedences presented may or may not reflect current aquifer or surface water conditions.

Cultural Water Demand

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

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

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

Water Adequacy Determinations

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

In addition to these subdivision determinations for which a water adequacy report is issued, water providers may apply for adequacy designations for their entire service area. If a subdivision is to be served water from one of these water providers, then a separate adequacy determination is not required. (See Section 2.0-5)

Developers of large, master-planned communities outside of AMAs may apply for an Analysis of Adequate Water Supply (AAWS). This type of application is generally used to prove that water will be physically available for the master-planned community. AAWS are issued based on the development plan or plat. If an AAWS is issued for groundwater, it reserves a specific volume of water for 10 years (for purposes of further adequacy reviews) only for the specific property that is the subject of the AAWS. (See Appendix A, Volume 1 for more information about the Adequacy Program).

REFERENCES

Arizona Department of Commerce (ADOC), 2008, Hopi Indian Reservation Community Profile: Accessed November, 2008 at www.azcommerce.com

_____, 2006, 2006-2055 Commerce Population Projections: Accessed March 2009 at http://www.azcommerce.com/EconInfo/Demographics/Population+Projections.htm

Arizona Department of Environmental Quality (ADEQ), 2006a, Active DOD, Superfund, WQARF and LUST contamination sites in Arizona: GIS cover, received February 2006.

_____, 2006b, Brownfield Tracking System, Accessed June 2006 at www.azdeq.gov/databases/brownsearch.htm

_____, 2002, The Status of Water Quality in Arizona - 2002: Volume 1: Arizona's Integrated 305(b) Assessment and 303(b) Listing Report.

Arizona Department of Water Resources (ADWR), 2008a, Identification of Active Agriculture on the Navajo Reservation, unpublished analysis, December 2008.

_____, 2008b, Preliminary Hydrographic Survey Report for the Hopi Indian Reservation In re The General Adjudication of the Little Colorado River System and Source.

_____, 2008c, Industrial demand outside of the Active Management Areas 1991-2007: Unpublished analysis by ADWR Office of Resource Assessment Planning.

_____, 2006, Statement of claimants filed by Indian tribes or the United States on their behalf in the Gila and Little Colorado River Adjudications: ADWR Office of Planning and Adjudications Support.

_____, 2004, Rural Water Resources Study-Rural Water Resources 2003 Questionnaire Report.

_____, 1994a, Arizona Water Resources Assessment, Vol. II, Hydrologic Summary.

_____, 1994b, Hydrographic Survey Report for Indian Lands in the Little Colorado River System, September 1994.

_____, 1994c, Little Colorado River Settlement Committee Group "A" –In-Basin Negotiating Committee Inventory of Irrigation, Reservoirs, and Stockponds in the Upper Little Colorado River Watershed, In re the General Adjudication of the Little Colorado River System and Source.

_____, 1994d, Little Colorado River Settlement Committee Group "A" –In-Basin Negotiating Committee Inventory of Irrigation and Reservoirs in the Lower Little Colorado River Watershed, In re the General Adjudication of the Little Colorado River System and Source.

_____,1990, Hydrographic Survey Report for the Silver Creek Watershed, Volume 1: General Assessment In Re: The General Adjudication of the Little Colorado River System and Source.

_____, 1989, Hydrology of the Little Colorado River System. Special report to the Settlement Committee, In re the General Adjudication of the Little Colorado River System and Source.

Arizona Game and Fish Department (AZGF), 2008, Arizona Heritage Data Management System, accessed in 2008 at: http://www.azgfd.gov/w_c/edits/species_concern.shtml

_____, 1997 & 1993, Statewide riparian inventory and mapping project: GIS cover.

Arizona Land Resource Information System (ALRIS), 2005, Land Ownership: GIS cover, accessed in 2005 at http://www.land.state.az.us/alris/index.html

Arizona State Land Department (ASLD), 2006, Historical overview-Land Grant and Designation of Beneficiaries: Accessed February 2006 at http://www.land.state.az.us/history.htm.

Bills, D.J., M. Truini, M.E. Flynn, H.A. Pierce, R.D. Catchings and M.J. Rymer, 2000, Hydrology of the regional aquifer near Flagstaff, Arizona 1994-97: USGS Water Resources Investigations Report 00-4122.

Browne, D., ed., 1982, Biotic Communities of the Southwest-United States and Mexico, Special Issue of Desert Plants, Volume 4, Numbers 1-4. Published by the University of Arizona for the Boyce Thompson Southwestern Arboretum, 342 pp.

City of Flagstaff, 2009, Water Conservation: Accessed February 2009 at www.flagstaff.az.gov

_____, 2008, Reclaimed Water Hauling: Accessed September 2008 at www.flagstaff.az.gov

_____, 2001, Flagstaff Area Regional Land Use and Transportation Plan: Water Resources Element.

City of Show Low, 2007, City of Show Low General Plan.

Coconino County, 2003, Coconino County Comprehensive Plan: Water Resources Element.

Environmental Law Institute, 2002, An Analysis of State Superfund Programs: 50 State Study, 2001 Update.

Environmental Protection Agency (EPA), 2008, Abandoned Uranium Mines on the Navajo Nation: Accessed September 2008 at http://yosemite.epa.gov/r9/sfund/r9sfdocw.nsf/

Fenneman, N.M. and D.W. Johnson, 1946, Physiographic divisions of the conterminous U. S.: GIS cover.

Freethey, G.W. and T.W. Anderson, 1986, Predevelopment hydrologic conditions in the alluvial basins of Arizona and adjacent parts of California and New Mexico: USGS Hydrologic Investigations Atlas.

GeoTrans, Inc. and Waterstone Environmental Hydrology and Engineering, Inc. (GeoTrans and Waterstone), 1999. A Three-Dimensional Flow Model of the D and N Aquifers, Black Mesa Basin, Arizona. Prepared for Peabody Western Coal Company.

Grahame, J.D. and T.D. Sisk eds., 2002. Canyons, cultures and environmental change: An introduction to the land-use history of the Colorado Plateau. Accessed February, 2006 at www.cpluhna.nau.edu

Hart, RJ, J.J. Ward, D.J. Bills and M.E. Flynn, 2002, Generalized hydrology and ground water budget for the C aquifer, Little Colorado River basin and parts of the Verde and Salt River basins, Arizona and New Mexico: USGS Water Resources Investigations Report 02-4026.

Heffernon, R. and M. Muro, 2001, Growth on the Coconino Plateau, Potential Impacts of a Water Pipeline for the Region, Morrison Institute for Public Policy.

Hoffmann, J. P., D.J. Bills, J.V. Phillips, K.J. Halford, 2005, Geologic, hydrologic, and chemical data from the C aquifer near Leupp, Arizona.

Hopi Tribe, 2005, Water resource and miscellaneous information: Accessed December 2005 at www.hopi.nsn.us.

HKM Engineering, Hopi Ranch Acquisitions: Accessed September 2005 at www.hkminc.com/Hopi.htm.

Intertribal Council of Arizona (ITCA), 2003, Navajo Nation: Accessed November 2008, at www.itcaonline.com

Leake, S.A., J.P. Hoffmann and J.E. Dickinson, 2005, Numerical ground-water change model of the C Aquifer and effects of ground-water withdrawals on stream depletion in selected reaches of Clear Creek, Chevelon Creek and the Little Colorado River, Northeastern Arizona: USGS Scientific Investigations Report 2005-5277, 29 p.

National Atlas of the United States, 2005, Federal Lands: GIS cover accessed in 2008 at http://nationalatlas.gov/maplayers.html

Natural Resources Conservation Service (NRCS), 2008, Little Colorado River Headwaters Watershed Arizona Rapid Watershed Assessment.

_____, 2007a, Chevelon Canyon Watershed-Arizona: Rapid Watershed Assessment.

_____, 2007b, Silver Creek Watershed-Arizona: Rapid Watershed Assessment.

Navajo Nation Department of Water Resources (NDWR), 2002a, Navajo Nation Drought Report.

_____, 2002b, Navajo Nation Irrigation Rehabilitation Strategy Draft: Department of Agriculture, white paper.

_____, 2001, Navajo Nation Land Plan Draft: Navajo Soil and Water conservation Districts, and Navajo Resource Conservation and Development

_____, 1999 NDWR, Water Management Branch, Hydrologeology of the Little Colorado River alluvial aquifer, Bird Springs Study Area; US Bureau of Reclamation and Bureau of Indian Affairs, final report.

NDWR, USBOR and US Indian Health Service, 2002, White Paper, Navajo Nation Municipal Water Development Strategy, Draft.

Neary, D. G., G.J. Gottfried and P.F. Ffolliott, 2003, Post-wildfire watershed flood responses; Proceedings of the 2nd International Fire Ecology Conference, American Meteorological Society, Orlando FL, Paper 65982, 8pp.

Office of Surface Mining Reclamation and Enforcement (OSM), 2008, Black Mesa Project Final Environmental Impact Statement.OSM-EIS-33, November 2008.

Olson, D. M, E. Dinerstein, E.D. Wikramanayake, N.D. Burgess, G.V.N. Powell, E.C. Underwood, J.A. D'amico, I. Itoua, H.E. Strand, J.C. Morrison, C.J. Loucks, T.F. Allnutt, T.H. Ricketts, Y. Kura, J.F. Lamoreux, W.W. Wettengel, P. Hedao, & K.R. Kassem, 2001, Terrestrial Ecoregions of the World: A New Map of Life on Earth. BioScience 51:933-938

Overby, A.E., 2007, Groundwater Conditions in Southern Navajo County, Arizona: April-August 2001; Hydrologic Map Series Report No. 37, Arizona Department of Water Resources.

Parra, I., M. Reed, E. vanderLeeuw, D.P. Guertin, L.R. Levick and K. Uhlman, 2006, NEMO Watershed Based Plan for the Little Colorado Watershed: Accessed October, 2008 at www.srnr.arizona.edu/nemo

Pinetop-Lakeside, 2004, Pinetop-Lakeside Regional Plan: Water Resources Element.

Pinkham, R., and Davis, B., 2002, North Central Arizona Water Demand Study, Phase 1 Report. PMCL and Rocky Mountain Institute.

Reed, K.E., 2005, Renegotiating Urban Water Management in Flagstaff, Arizona-Origins and Implications of Conservation Policies, CLIMAS Report Series CL 1-04.

Reynolds, S.J., 1988, Geologic Map of Arizona: Arizona Geologic Survey Map 26.

Rothman, 1991, Navajo National Monument: A Place and Its People; Southwest Cultural Resources Center Santa Fe, New Mexico. Professional Papers No. 40, 1991

Salt River Project (SRP) 2006, C.C. Cragin Reservoir: Accessed April 2006 at www.srpnet.com/water/dams/blueridge.aspx.

SCA, 2007, Award for Water Conservation: Accessed September 2008 at www.sca.com

Seaber, P.R., E.P. Kapinos and G.L. Knapp, 1987, Hydrologic Unit maps; Geological Survey Water-Supply Paper 2294, 63pp.

Tellman, B., R. Yarde and M. Wallace, 1997, Arizona's changing rivers: How people have \ affected rivers: Water Resources Research Center, University of Arizona, Tucson, AZ.

TetraTech RMC. 2003. Summary Report – Page LeChee Water Supply Project Alternatives.

Town of Eagar, 2008, Town of Eagar 2007 Drinking Water Annual Water Quality Report.

_____, 2005, Public Works-Wastewater: Accessed September 2008 at www.eagar.com

_____, 2002, Town of Eagar General Plan; Water Resources Element

Town of Snowflake, 2007, Town of Snowflake General Plan; Presentation Draft 9/2007.

Truini, M., J.P. Macy and T.J. Porter, 2005, Groundwater, surface water and water chemistry data, Black Mesa area, Northeastern Arizona, 2003-2004: USGS Open file report 2005-1080.

U.S. Bureau of Land Management (BLM), 2006, Arizona Wilderness Areas: Accessed December 2006 at www.blm.gov/az/wildarea.htm

U.S. Bureau of Reclamation (USBOR), 2007, Consumptive Uses and Losses-Arizona Portion of the Upper Colorado River Basin Calendar Year 2005.

_____, 2006, North Central Arizona Water Supply Study, Report of Findings, U.S. Department of Interior, Denver, CO.

U.S. Census Bureau, 2006, on-line data files: Accessed January 2006 at www.census.gov

U.S. Department of Agriculture (USDA), 2008, Forest Insect and Disease Conditions in the Southwestern Region, 2007

_____, 2006, Forest Insect and Disease Conditions in the Southwestern Region, 2006.

U.S Department of Energy (DOE), 2008a, Annual Groundwater Report April 2007 through March 2008 Tuba City, Arizona, Disposal Site.

_____, 2008b, Tuba City, Arizona Disposal Site-Fact Sheet; Office of Legacy Management.

_____, 2007, Monument Valley, Arizona Processing Site-Fact Sheet; Office of Legacy Management.

U.S. Forest Service (USFS), 2007a, Wildland fire perimeters (Southwest Region): GIS Datasets accessed in 2007 at http://www.fs.fed.us/r3/gis/datasets.shtml

_____, 2007b, Wilderness areas: Accessed 2007 at www.fs.fed.us/rs/

U.S. Fish and Wildlife Service (USFWS), 2008, Endangered Species List by County: Accessed September, 2008 at www.fws.gov/arizonaes/documents/ and www.fws.gov/ifw2es/endangeredspecies/lists/default.cfm.

U.S. Geological Survey (USGS), 2009, Preliminary Data from 2008 Agricultural Ground Truthing in Select Basins: GIS data cover.

_____, 2008, Water withdrawals for municipal use on the Navajo and Hopi reservations: Data file received December, 2008

_____, 2007, Water withdrawals for irrigation, municipal, mining, thermoelectric-power, and drainage uses in Arizona outside of the active management areas 1991-2005, Data file received November 2007.

_____, 2005, 1:2,000,000-Scale Hydrologic Unit Boundaries: GIS Cover, accessed in 2007 at http://nationalatlas.gov/atlasftp.html?openChapters=chpwater#chpwater

U.S. National Park Service (NPS), 2008a, Petrified National Forest: Accessed November, 2008 at www.nps.gov/pefo/.

_____, 2008a, Canyon de Chelly National Monument: Accessed November, 2008 at www.nps.gov.cach/

Webb, R.H., S.A. Leake and R.M. Turner, 2007, The Ribbon of Green: Change in Riparian Vegetation in the Southwestern United States, University of Arizona Press, 462 pp.