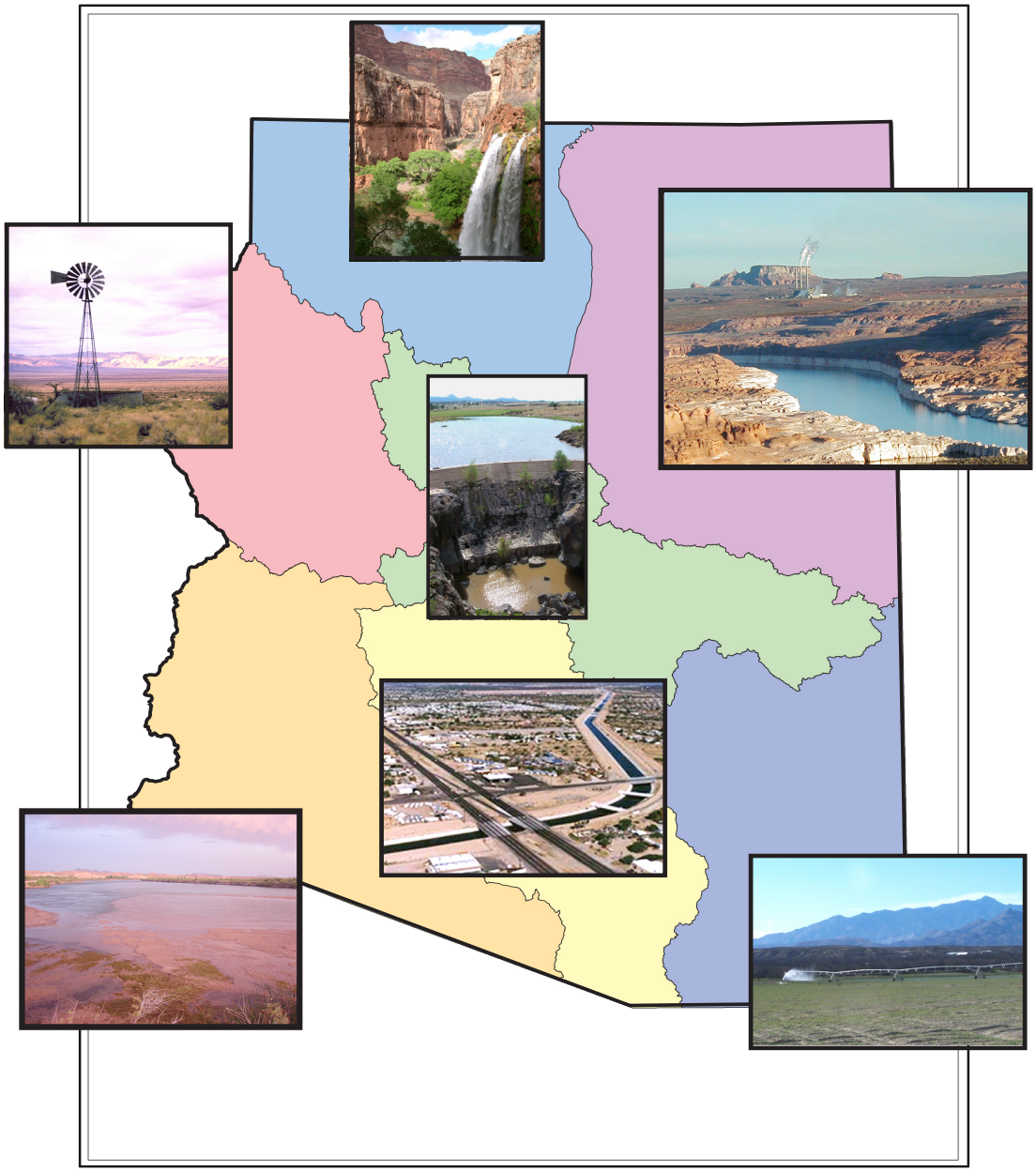
ARIZONA WATER ATLAS

VOLUME 1 INTRODUCTION



Arizona Department of Water Resources

DRAFT

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ARIZONA WATER ATLAS

VOLUME 1 INTRODUCTION

The Arizona Water Atlas (Atlas) is a compilation of currently available water-related information for the State of Arizona. Water is managed differently within the state's five active management areas (AMAs) than it is in areas outside AMAs. This difference influences the organization and to some extent, the content of the Atlas. The Atlas is composed of nine volumes. In addition to this introductory volume there are individual planning area volumes (Volumes 2-7) for each of the six planning areas outside of AMAs. These planning areas are composed of groundwater basins as shown on Figure 1-1. The AMAs are considered a separate planning area and are described in Volume 8 of the Atlas. Volume 9 is a summary volume for the entire state. The term "rural" is often used to describe the non-AMA areas of the state. Although this is somewhat of a misnomer since there are many cities and towns outside the AMAs that are large, diverse and face water supply issues similar to the AMAs, the term is widely used and appears in the Atlas.

The primary objectives of the Atlas are to present an overview of water supply and demand conditions, to provide water resource information for planning and resource development purposes and to help identify the needs of communities throughout Arizona, particularly those outside the AMAs. The emphasis on areas outside AMAs is in recognition of the more immediate need for water resource information by decision-makers and the public for local planning, water management and general information purposes in these areas. The Arizona Department of Water Resources (Department), legislative leaders and local groups have long recognized the need to support Arizona water resource planning efforts outside AMAs. Adoption of the 2004 Arizona Drought Plan and associated legislation, initiation of the Statewide Water Conservation Program, establishment of a Rural Water Legislative Study Committee (2005-2007), formation of a Statewide Water Advisory Group to focus on programs for water resources development and management outside of AMAs (2006) and recent legislative funding, provide additional resources to address Arizona's water information and planning needs.

SECTION 1.0 Atlas Purpose and Scope

The purposes of the Arizona Water Atlas are to:

1. Provide a comprehensive overview of regional water supply and demand conditions that has not been available on a statewide basis for over ten years;
2. Identify water resource issues facing Arizona communities;
3. Identify missing information and how it could be improved; and
4. Initiate a renewed and more systematic effort by the Department to assist Arizona water planning efforts and the development of solutions.

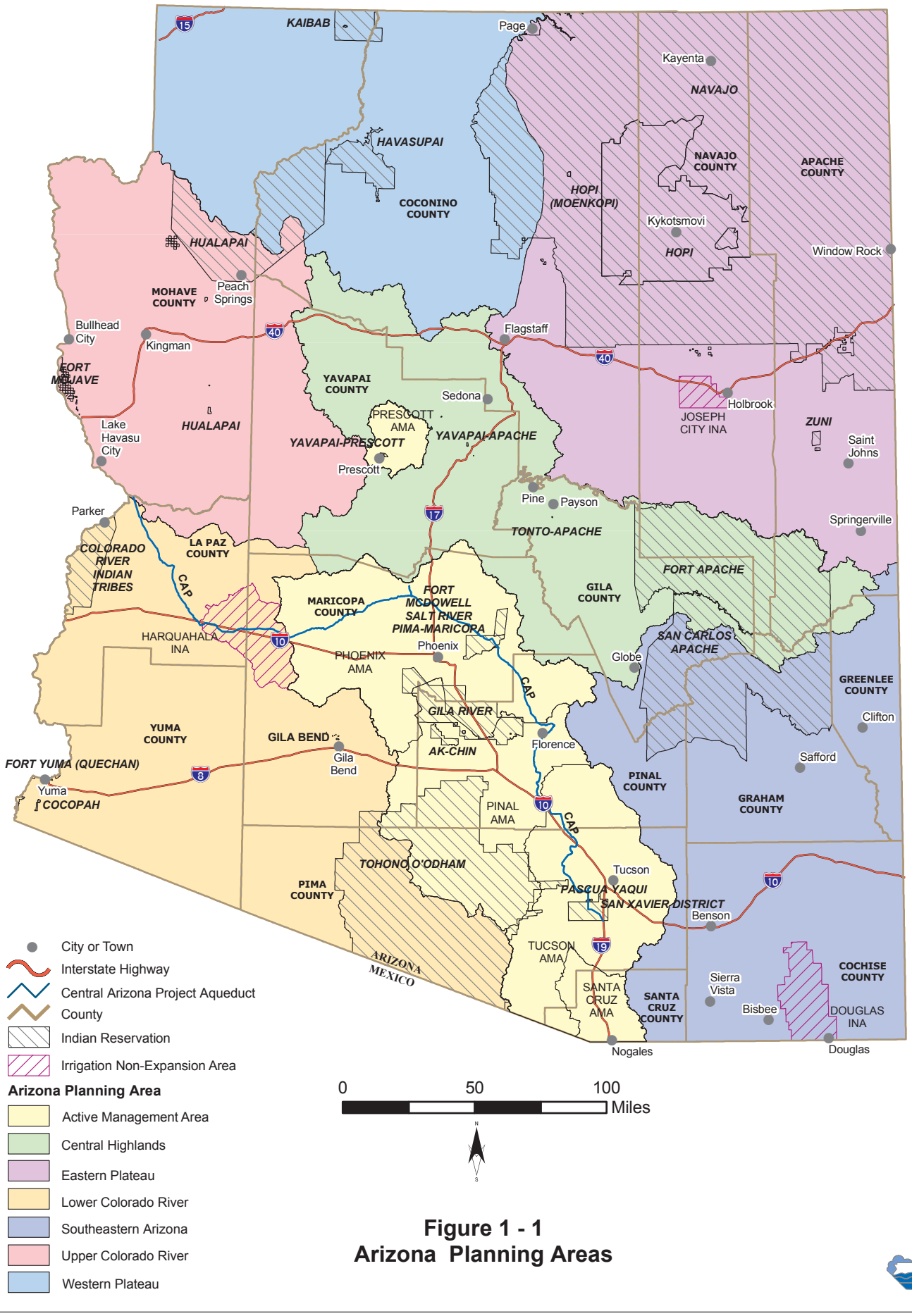


Figure 1 - 1
Arizona Planning Areas

The information contained in Volumes 2-8 of the Atlas has been compiled from a number of sources, discussed in Section 1.3, Data Sources and Methods, and has been reviewed and synthesized. New investigations, except as noted, were not undertaken. Because multiple data sources were utilized, the Atlas is the first comprehensive compilation and presentation of certain data. In some cases, such as certain water demand figures, information is based on estimates because measurement and reporting of water withdrawals, diversions and uses are generally not required outside AMAs.

While the Atlas includes a listing of water resource issues, proposing solutions is outside its scope. Instead, the Atlas provides some of the necessary information and identifies data necessary for development of solutions by local stakeholders.

SECTION 1.1 Atlas Organization

The Atlas is organized into nine volumes; this Introduction, six non-AMA planning area volumes, an AMA planning area volume and a summary volume. "Planning areas" are composed of groupings of groundwater basins and were utilized as an organizational theme in the 1994 *Arizona Water Resources Assessment (Assessment)*. A groundwater basin is a relatively hydrologically distinct body or related bodies of groundwater (A.R.S. § 45-402(13)). The *Assessment* and the 1975 *Inventory of Resource and Uses* prepared by the Arizona Water Commission are the only previous comprehensive studies that provide a statewide overview of Arizona's water supply, demand and related issues. The planning area concept provides for a more regional perspective on supply, demand and issues identification. Volume 1, *Introduction* is intended to be a companion report to each of the other volumes. It is anticipated that most readers would be primarily interested in a particular region, so they would need only a specific planning area volume in addition to the *Introduction.*

This volume contains a synopsis of geography and climate, a general overview of state water resources and management, a summary of water planning and water resource investigations, data sources and methods used to compile the Atlas, and Appendices. This volume contains few maps and tables compared to the planning area volumes (see Table of Contents).

Volumes 2 through 8 each contain an overview of one planning area and a separate section for each of the groundwater basins or AMAs within the planning area. Each volume generally includes the following planning area maps, tables and figures, with some variations:

Planning Area Maps, Figures and Tables

- Arizona planning areas and groundwater basins (map)
- Planning area with basins (map)
- Average temperature and precipitation in the planning area 1930-2002 (figure)
- Average monthly precipitation and temperature (figure)
- Planning area-specific climate (figure)
- Precipitation departures from average 1000-1988 (figure)
- Arizona Water Protection fund grants in the planning area (table)
- Location of instream flow applications and permits (map)
- Instream flow applications and permits (table)
- Listed threatened and endangered species in the planning area (table)
- Population (figure)
- Contamination sites (map)

- Cultural water demand (tables and figures)
- Planning area water resource issues (tables)

Each basin or AMA section in the planning area volumes contains discussion and data on basin geography, land ownership, climate, surface-water conditions, groundwater conditions, water quality, cultural water use characteristics, water resource issues and includes references and further readings. The planning area volumes and associated basins or AMAs are:

Planning Area Volumes, Basins and AMAs

Volume 2 Eastern Plateau Planning Area (1 groundwater basin)
- Little Colorado River Plateau Groundwater Basin

Volume 3 Southeastern Arizona Planning Area (14 groundwater basins)
- Aravaipa Canyon Basin
- Bonita Creek Basin
- Cienega Creek Basin
- Donnelly Wash Basin
- Douglas Basin
- Dripping Springs Wash Basin
- Duncan Valley Basin
- Lower San Pedro Basin
- Morenci Basin
- Safford Basin
- San Bernardino Valley Basin
- San Rafael Basin
- Upper San Pedro Basin
- Willcox Basin

Volume 4 Upper Colorado River Planning Area (9 groundwater basins)
- Big Sandy Basin
- Bill Williams Basin
- Detrital Valley Basin
- Hualapai Valley Basin
- Lake Havasu Basin
- Lake Mohave Basin
- Meadview Basin
- Peach Springs Basin
- Sacramento Valley Basin

Volume 5 Central Highlands Planning Area (5 groundwater basins)
- Agua Fria Basin
- Salt River Basin
- Tonto Creek Basin
- Upper Hassayampa Basin
- Verde River Basin

Volume 6 Western Plateau Planning Area (6 groundwater basins)
- Coconino Plateau Basin
- Grand Wash Basin
- Kanab Plateau Basin
- Paria Basin
- Shivwits Basin
- Virgin River Basin

Volume 7 Lower Colorado River Planning Area (11 groundwater basins)
- Butler Valley Basin
- Gila Bend Basin
- Harquahala Basin
- Lower Gila Basin
- McMullen Valley Basin
- Parker Basin
- Ranegras Plain Basin
- San Simon Wash Basin
- Tiger Wash Basin
- Western Mexican Drainage Basin
- Yuma Basin

Volume 8 Active Management Area Planning Area (5 AMAs)

Phoenix AMA	Pinal AMA
Prescott AMA	Santa Cruz AMA
Tucson AMA	

Volume 9 is an executive summary of the water resource information and issues contained in Volumes 2-8 and includes a discussion of future directions.

Volumes 2-7 contain numerous maps, figures and tables, with accompanying text as applicable, for each of the 46 groundwater basins in rural Arizona. Volume 8 will contain similar information for the AMAs. The AMA volume may contain additional information. Maps, figures and tables, and some of their primary components are listed below. Please refer to the Acronym index for agency and station names.

Basin and AMA Maps and Figures

1. Geographic features
2. Land ownership
3. Precipitation and meteorological stations
   Location of NOAA, NWS, AZMET, Pan ET, SNOTEL and Snowcourse stations keyed to climatic data table
4. Surface water conditions
   Major rivers and streams, unit runoff contours, location of flood warning gages, USGS stream gages, reservoirs $\geq$500 acre-feet keyed to stream gage, flood gage and large reservoir tables
5. Perennial/intermittent streams and major (>10gpm) springs
   Location of perennial and intermittent streams and location of major springs keyed to major springs table
6. Groundwater level conditions
   Current depth to water, groundwater level changes since 1991 in selected wells, general groundwater flow direction, keyed to selected basin hydrographs
7. Selected basin hydrographs
8. Measured and reported well yields
   Well yields measured by USGS and the Department and reported for >10 inch diameter wells
9. Water quality conditions
   Location of wells, springs and mine sites with drinking water exceedences, impaired lakes and stream reaches, and effluent dependent reaches, keyed to water quality exceedences table
10. Location of water uses
    Active agricultural lands, power plants, large mines and water provider service areas
11. Water adequacy and inadequacy determinations
    Location of Water Adequacy and Inadequacy determinations issued, keyed to table with subdivision information and reason for the inadequacy determination

Basin and AMA Tables

1. Climatic data
   - NOAA and NWS stations: name, period of record, elevation, minimum and maximum average temperature, average seasonal and average annual rainfall
   - Pan Evaporation stations: name, period of record, elevation, average annual evaporation
   - AZMET stations: name, period of record, elevation, average annual reference ET

- SNOTEL/Snowcourse stations: name, period of record, elevation, monthly snow water equivalent

2. Stream gage data
   - Streamflow: gage name, drainage area, period of record, total years of record, mean basin elevation, average seasonal flow, minimum, median, mean and maximum annual flow
   - Flood/ALERT gages: name, identification number, station type, installation date, operator
3. Large and small reservoirs and stockponds
   - Large reservoirs (>500 acre-feet or 50 acres or greater surface area): name of lake/reservoir and dam, owner/operator, maximum storage/surface acres, purpose/use, jurisdiction
   - Small reservoirs, (15 to 500 acre-feet or 5 to <50 acre surface area): total number and maximum storage/surface acres
   - Stockponds (up to 15 acre-feet capacity): total number
4. Springs
   - Major springs (10 gpm or greater): name, location, discharge rate, measurement date
   - Minor springs (1 to 10 gpm discharge): name, location, discharge rate, measurement date
5. Groundwater data: basin area, major aquifer(s), well yields, estimated natural recharge and groundwater in storage,number of index wells, date of last well sweep
6. Water quality exceedences
   - Wells, springs and mines: site type, location, water quality standard, parameter(s) exceeded
   - Lakes and streams: site type, name, length of impaired stream reach/area of impaired lake, water quality standard, parameter(s) exceeded
7. Effluent generation: facility name/ownership, city/location served, volume treated, disposal method, treatment level, population served/not served, year of record
8. Cultural water demand: historic, current and projected population, historic and current number of wells < 35gpm and >35gpm, historic and current agricultural, municipal and industrial surface water diversions and groundwater pumpage
9. Water adequacy and inadequacy determinations: subdivision name, application number, location, number of lots, water provider and reason for inadequate determination

SECTION 1.2 Background

1.2.1 Geography

Arizona encompasses about 114,000 square miles of land with great geographical diversity. Hydrologically, the state has been divided into groundwater basins and sub-basins within those basins. These groundwater basins and sub-basins do not necessarily correspond with surface watersheds and subwatersheds, due in part to subsurface geology that can impact groundwater flow and cause it to vary from surface water drainage patterns. There are three main geographic regions or physiographic provinces in the state: the Basin and Range Lowlands, the Plateau Uplands and the Central Highlands Provinces. The provinces and their relationship to the planning areas are shown in Figure 1-2.

Figure 1-2 Physiographic Provinces of Arizona

The Basin and Range Lowlands Province of southern and western Arizona is characterized by long, broad, alluvial valleys separated by north-south trending mountain ranges. Thick, productive regional aquifers are found in this province. The Upper Colorado River, Lower Colorado River and Southeastern Arizona Planning Areas are primarily within the Basin and Range Lowlands Province, which include the communities of Kingman, Lake Havasu City, Yuma, Sierra Vista and Safford. With the exception of the Prescott AMA, the AMA planning area is within this province including the large metropolitan areas of Phoenix, Tucson and Casa Grande.

The Plateau Uplands Province covers the northern portion of the state and is characterized by layered sedimentary rocks that have eroded into canyons and plateaus. The Plateau Uplands Province includes the Eastern Plateau and Western Plateau Planning Areas and a small part of the Central Highlands and Upper Colorado River Planning Areas. This province contains regional aquifers consisting of layered sedimentary rocks and thin deposits of alluvium that form unconfined aquifers along some streams. Communities dependent on the groundwater supplies in this region include Flagstaff, Pinetop-Lakeside, and Kayenta.

The Central Highlands Province is the smallest in terms of area and forms the transition zone between the Basin and Range Lowlands Province and the Plateau Uplands Province. Most of the Central

Highlands Planning Area, the far eastern part of the Upper Colorado River Planning Area, the Prescott AMA and the northern part of the Southeastern Arizona Planning Area are within this province. The province is characterized by a relatively narrow band of mountains composed of igneous, metamorphic and sedimentary rocks. Groundwater is found in thick alluvial deposits, layered sedimentary rocks, thin alluvial deposits along major streams and fractured crystalline, sedimentary and volcanic rocks. (ADWR, 1994a; ADWR, 1994b). Many rapidly growing communities utilize water supplies in this province including Prescott, Sedona, Cottonwood and Payson. This province contains most of the state's perennial streams. Because of high elevations, steep gradients and the predominance of hardrock, much of this area has minimal water storage capabilities and high runoff compared to the Basin and Range Lowlands Province.

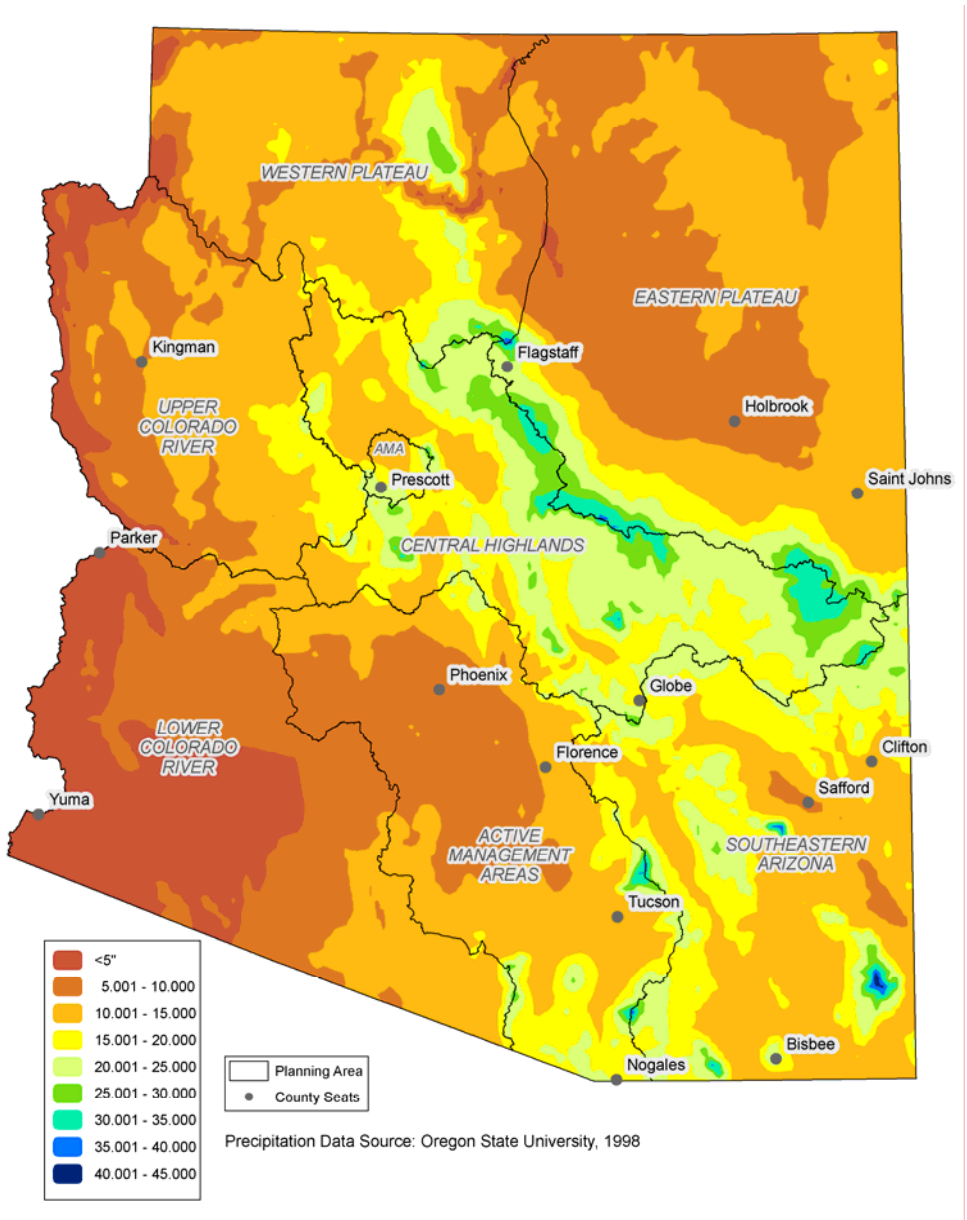
1.2.2 Climate

Climate and drought are discussed in some detail in this section to provide background information and context to the planning area climate data presented in subsequent Atlas volumes. Climate information is a critical component of water resource planning and management.

Arizona's climate is characterized by five main features: warm temperatures, aridity, strong precipitation seasonality, high year-to-year (interannual) variability and strong decade-to-decade persistence. The wide elevational differences result in significant climate variability between the mountains of the Central Highlands Province and the low elevation deserts. The Plateau Uplands Province, although relatively high in elevation, is very dry. Average annual rainfall in Arizona ranges from 3 inches in Yuma to over 36 inches in the higher elevations along the Mogollon Rim and in the White Mountains. State precipitation variability is shown in Figure 1-3.

Precipitation is characterized by two climatically unrelated precipitation seasons: the summer, "monsoon" season, generally from July to mid-September and a winter season from November through mid-April (Figure 1-4). This seasonality is more pronounced in the east-central (Central Highlands Planning Area) and southeastern (Southeastern Arizona Planning Area) parts of the state where the summer precipitation can account for up to 60 percent of the annual total. By contrast, the Upper Colorado River Planning Area receives the majority of precipitation in the winter. Statewide, mid-April through June are reliably dry, as westerly winds shift to the north and the monsoon circulation begins to develop. Mid-September through early November is usually dry, but eastern Pacific tropical storms can cause high precipitation during this time of year.

Figure 1-3 Statewide Precipitation



The summer precipitation season occurs when moist, tropical, unstable air from the Gulf of Mexico moves northwest into Arizona. Storms of short duration but high intensity occur in the afternoon and evening as the warm, moist air is forced up mountain slopes and sufficiently cooled. These storms are typically most intense over the mountainous sections of the state. Winter rains occur when middle latitude cyclonic storms originating in the Pacific Ocean move east across the state. More than 75% of the winter precipitation falls as snow in the higher elevations. (ADWR, 1994a; ADWR, 2005).

Figure 1-4 Average statewide Arizona monthly precipitation and temperature, 1971-2000

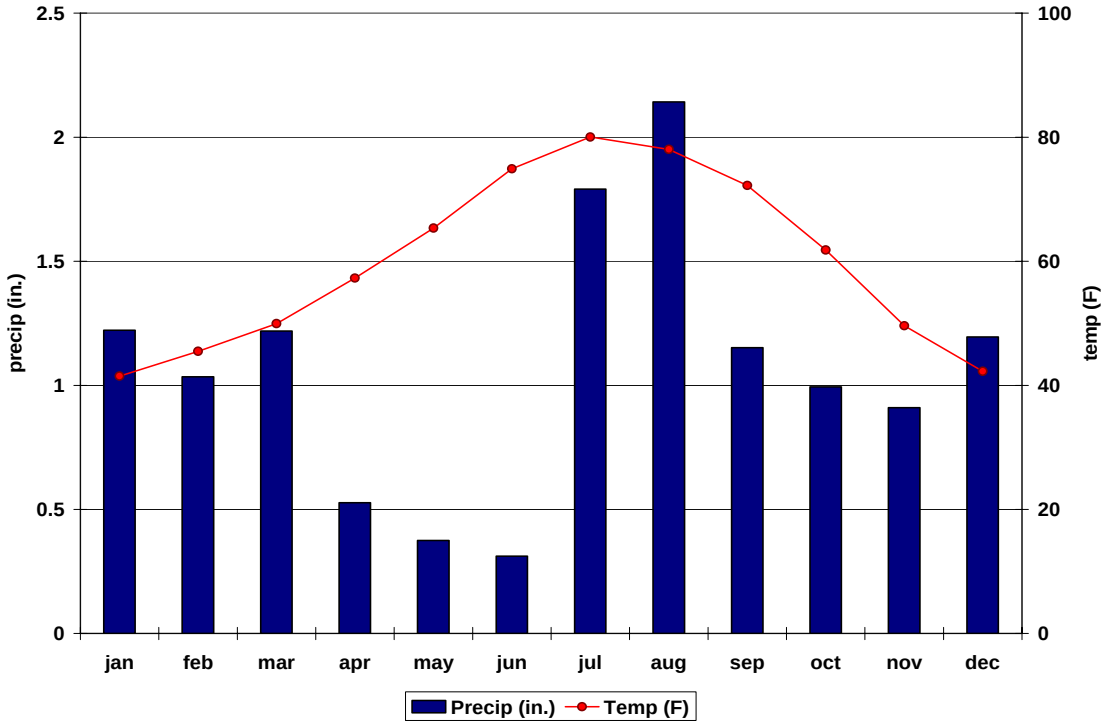


Figure author: Michael Crimmins, University of Arizona Cooperative Extension.

Arizona's precipitation is characterized by a high degree of year-to-year variation. One of the key factors, during winter in particular, is the El Niño-Southern Oscillation (ENSO), a multi-season to multi-year variation in equatorial Pacific Ocean temperatures and associated atmospheric circulation. The ENSO is the strongest and most important influence on interannual climate and weather variations in Arizona. When El Niño-Southern Oscillation is in the El Niño phase, Arizona frequently receives above average winter precipitation. When El Niño-Southern Oscillation is in the La Niña phase, Arizona is frequently dry due to a more northern storm track. These phases recur every 3 to 7 years on average and can persist for months to years, impacting precipitation totals over Arizona. During the past two decades, several La Niña episodes (e.g. 1989-90, 1995-96, 1998-2001) have initiated Arizona droughts (GDTF, 2004a). The La Niña of 2005-2006 resulted in virtually no snowpack in Arizona until mid-March, with 29 of the 34 snow measuring sites monitored by the NRCS reporting no snow as of March 1, 2006, the least amount recorded since measurements began in the late 1930's.

Arizona's Colorado River water supplies derive primarily from snow in the western Rocky Mountains of Wyoming, Colorado, and Utah, whereas Arizona surface water supplies, such as in the Salt and Verde River systems, derive chiefly from snow along the Mogollon Rim and high peaks on the Colorado Plateau.

Winter precipitation is more hydrologically effective than summer precipitation because winter precipitation is more widespread, is generally of low intensity and long duration, it coincides with cooler temperatures and lower evaporation rates and, when stored as snow, it is released gradually. These factors result in greater infiltration than summer rainfall events, where rain falls in the form of spatially discontinuous thunderstorms and is subject to extremely high evaporation rates.

Temperature and associated evapotranspiration rates also vary widely in Arizona. Average daily temperatures range from the mid 90's (˚F) below 500 feet elevation to the high 50's (˚F) at elevations above 8,000 feet. In most areas of the state, temperatures increase 30 to 40 degrees between January and July (ADWR, 1994a). Climate can also vary widely within planning areas. Measured climate data are described in detail in the planning area volumes.

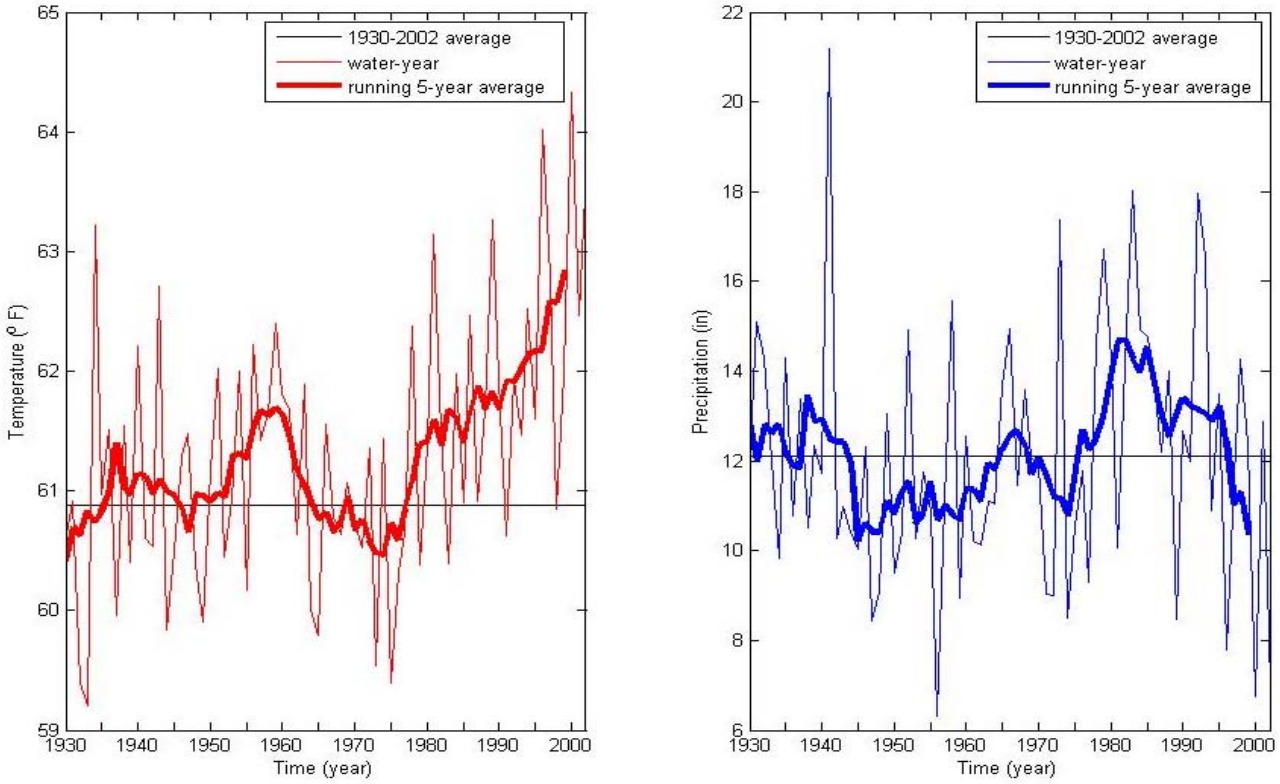
The most significant feature of temperature records since 1930 is the trend toward increasing temperatures during the last 30-40 years (Figure 1-5). In some regions, increased temperatures are due primarily to the urban heat island effect from heat-retaining paved area and buildings replacing desert landscapes in major urban areas. Temperatures in rural communities have also increased, though not at the same rate and not in every town. The mid-to-late twentieth century is the warmest period in a southern Colorado Plateau tree-ring temperature reconstruction (Salzer and Kipfmueller, 2005), as well as in reconstructions of summer season precipitation for a region stretching from west Texas to eastern California (Sheppard et al., 2002). High temperatures typically result in higher cultural water demands and increased evaporation and evapotranspiration rates.

Drought

Decadal-scale Pacific Ocean circulation persistence can result in long-term drought, which can drastically reduce water supplies as demonstrated in the extremely dry conditions between 1999 and 2005 and during the 1950s. Table 1-1 shows that 2004 was the year of lowest capacity in most of the state's reservoirs during the period of 1971-2005. When these sustained circulation patterns are characterized by warm tropical Pacific Ocean temperatures, the result can be above average precipitation such as the post-1976 wet period which lasted until approximately 1998 (Figure 1-5). This wet period is also reflected in the high capacity reservoir level data in Table 1-5. Some reservoirs, including Lake Powell and Lake Mead, exceeded their maximum useable capacity during this period and spilled.

When Arizona's high interannual precipitation variability is superimposed on persistent decadal variations, the result is individual wet years during periods of prolonged drought. This is shown in Figure 1-5.

Figure 1-5 Average water-year (October-September) temperature (left) and total water-year precipitation in Arizona from 1930-2002



Horizontal lines are average temperature (60.9 °F) and precipitation (12.1 in), respectively. Light lines are yearly values and highlighted lines are 5-year moving average values. Data are the average of monthly records from 25 U.S. Historical Climate Network (HCN) stations from the National Climate Data Center (http://cdiac.ornl.gov/epubs/ndp/ushcn/monthly.html). Figure author: Ben Crawford, CLIMAS.

Table 1-1 Arizona mean, high capacity and low capacity reservoir levels from 1971 through 2005, expressed in percent of total reservoir capacity (design flood pool)

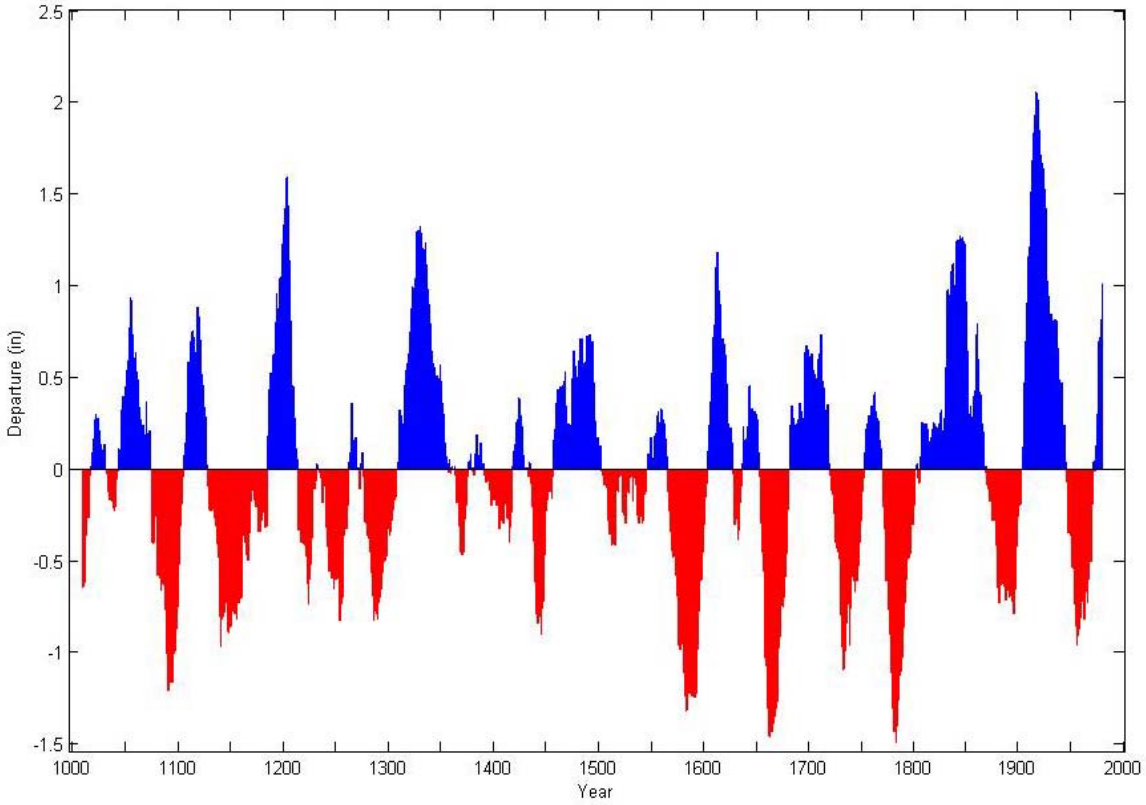
Reservoir Name	Average Capacity	High Capacity	High Capacity Year	Low Capacity	Low Capacity Year
Lake Powell	70%	98%	1983	31%*	2005
Lake Mead	77%	98%	1983	51%	2004
Lake Mohave	89%	98%	1971	74%	2000
Lake Havasu	88%	96%	1982	77%	1980*
Show Low Lake	62%	100%	1993	58%	2004
Lyman Reservoir	45%	86%	1985	11%	2004
San Carlos	42%	100%	1980	3%	2004
Verde River Basin System	56%	91%	1992	43%	2004
Salt River Basin System	59%	77%	1979	43%	2004

Sources: USDA Natural Resources Conservation Service, Casey C. Thornbrugh, CLIMAS.
USBR data, Don Gross, ADWR
* Lake Havasu 2004 low capacity was 79%

Tree-ring records of drought and winter precipitation show dry episodes longer and more severe than any that have occurred during the last 100 years. In Arizona, notable multi-year droughts occurred in almost every century in the last 1,000 years. Particularly notable are winter-season droughts during the 1100s, the 1200s, the early 1400s, the late 1500s, the late 1600s, the late 1700s, the late 1800s and the mid-1900s (Figure 1-6). Tree-ring records of Colorado River streamflow show periods of extended low flows, such as those in the 1580s, the early 1620s to 1630s, the 1710s, the 1770s, and the 1870s (C. Woodhouse, NOAA Paleoclimate Program, personal communication to G. Garfin, 2005). These episodes were either more severe or longer in duration than low flow periods experienced in more recent times. The low flow period of the late 1500s is associated with widespread drought conditions across North America (Stahle et al., 2000).

Such periods of widespread drought are characterized by low stream flows in the Upper Colorado River Basin as well as interior Arizona river basins, such as the Salt-Verde-Tonto river system. Records show that the Upper Colorado River Basin streamflow is seldom out of synch with Salt-Verde-Tonto river system streamflow (Hirschboeck and Meko, 2005; http://fp.arizona.edu/khirschboeck/srp.htm). This has serious implications for water supply availability in parts of Arizona.

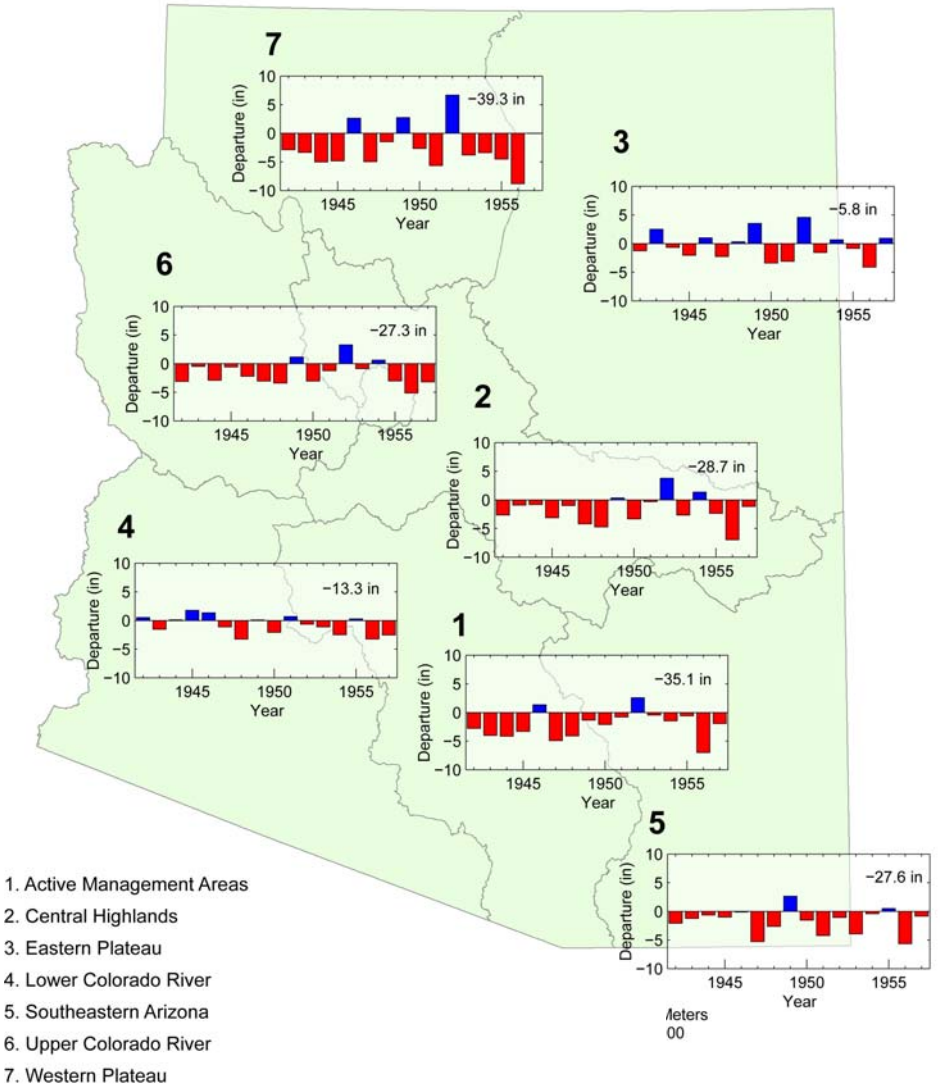
Figure 1-6 Arizona statewide winter half year (November-April) precipitation departures from average (shown as 0), 1000-1988, reconstructed from tree rings



Data are presented as a 20-year moving average (e.g. the value for 1951 is the average of 1942-1961) to show variability on decadal time scales. The statewide winter half-year average precipitation for 1000-1988 is 5.8 in. annually. Data: Fenbiao Ni, University of Arizona Laboratory of Tree-Ring Research and CLIMAS. Figure author: Ben Crawford, CLIMAS.

Planning area and AMA water deficits for the prolonged drought of 1942-1957 are shown in Figure 1-7. It is evident that planning areas were affected to varying degrees during this period. For example, the Eastern Plateau Planning Area was the least impacted, with many years of above normal precipitation and a modest cumulative deficit of -5.8 inches over the drought period. While the current drought may reflect similar precipitation conditions to those of the drought of the late 1940s to 1950's, temperatures during the last decade are almost 2 degrees higher (see Figure 1-5). This warming trend will affect the severity of drought conditions.

Figure 1-7 Planning area water-year (October-September) precipitation departures from average for the 1942-1957 drought period



For each planning area, data from U.S. Historical Climate Network (HCN) stations from the National Climatic Data Center (http://cdiac.ornl.gov/epubs/ndp/ushcn/monthly.html) were used to calculate the total departure (upper right of each bar graph). Figure author: Ben Crawford, CLIMAS.

1.2.3 Water Resources Overview

Colorado River Water and the Central Arizona Project

Arizona has an annual allotment of 2.8 million acre-feet (maf) of Colorado River water for consumptive use. Consumptive use (CU) is defined here as diversions from the mainstream of the Colorado River minus returns. Of this total, over 1.3 maf of CU is available for use by municipal, industrial and agricultural users along the Colorado River in the Upper and Lower Colorado River Planning Areas. In addition, the community of Page in the Eastern Plateau Planning Area diverts water from Lake Powell for municipal use pursuant to Arizona's 50,000 acre-feet Upper Basin entitlement. The remaining amount of Colorado River water may be diverted annually via the Central Arizona Project (CAP) delivery system to users in the Phoenix, Tucson and Casa Grande areas. (Figure 1-1). CAP water is diverted from the Colorado River at Lake Havasu into a 336-mile aqueduct system that lifts the water more than 2,900 vertical feet through a series of pumping plants to users in central Arizona. The Central Arizona Water Conservation District (CAWCD) operates and maintains the CAP.

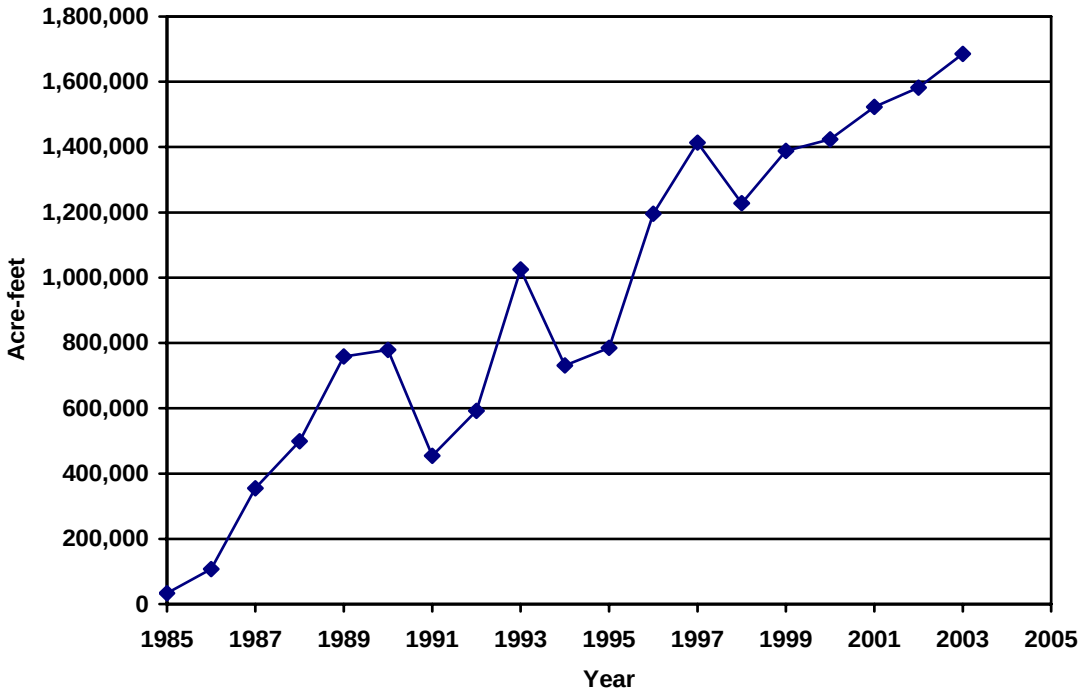
When the entitlements to Colorado River water were identified in the Colorado River Compact in 1922, the River data showed an average annual flow of approximately 16.4 million acre-feet at Lees Ferry below Lake Powell (See Appendix E). However, recent analysis of three centuries of river flow indicates an average annual flow of 13.5 maf, and very erratic annual flows, ranging from 4.4 maf to over 22 maf (Gelt, 1997). A tree-ring based assessment completed in 2005 found that for the period 1521-1964, the mean annual flow at Lees Ferry was about 14.2 maf (Hirschboeck and Meko, 2005). This situation highlights the importance of the Colorado River dams and reservoirs to store water for use during dry periods. Currently, the Lower Basin (Arizona, California and Nevada) is fully utilizing its 7.5 million acre-foot annual entitlement. Upper Basin (Colorado, New Mexico, Utah and Wyoming) demand is approximately 5 million acre-feet per year and Mexico is utilizing its full 1.5 million acre-foot per year entitlement.

There is a priority system associated with Colorado River contracts in the event of shortages of supply. Contract priority is an important consideration in water resource planning. The first water to be shorted within Arizona is the CAP and water users of similar priority along the mainstream of the Colorado River. Along the Colorado River the communities of Bullhead City, Lake Havasu City, and Mohave Valley Irrigation District in Mohave County, and Ehrenberg, Parker and Cibola Irrigation District in La Paz County have low priority contracts. The City of Yuma and the Wellton-Mohawk Irrigation District in the Lower Colorado River Planning Area have higher priority contracts.

The Arizona Water Banking Authority (AWBA) was established in 1996 to store unused Colorado River water to meet future needs. Without the AWBA, Arizona may not have used its full allocation for many years. The primary functions of the AWBA are: to provide a stored reserve of water to communities dependent on the CAP during times of drought on the Colorado River; to assist Colorado River communities during times of shortage by providing water exchange mechanisms; to replenish depleted aquifers with CAP water to meet water management goals; to provide a pool of water for use in Indian water rights settlements. The AWBA can also contract with similar authorities in California and Nevada to allow these states to annually store unused Colorado River water in Arizona. In the future, Arizona users will recover (pump) the stored water (less a 5% "cut to the aquifer") and the interstate partner will draw a similar quantity directly from the Colorado River.

Shown in Figure 1-8 are annual diversions of CAP water from the Colorado River. The amount of water diverted over the years varies for several reasons, including demand and supply availability due to a number of different conditions. The AWBA, the in-lieu recharge program and CAP pricing structures for agricultural users have promoted CAP utilization since the mid-1990s.

Figure 1-8 Central Arizona Project annual diversions 1985-2003



Other Surface Water

The Salt, Verde and Gila Rivers are essential supplies for water users in central Arizona. The Salt River Project (SRP), through the Salt River Valley Water Users' Association, a private corporation, delivers a total of almost 1 million acre-feet of surface water from the Salt and Verde Rivers and groundwater to its service area in the Phoenix AMA. SRP manages several dams on the Salt and Verde Rivers that produce hydroelectricity and has substantial surface water rights in the Salt and Verde watersheds. These claims have implications for rural water users in these watersheds. Water supplies utilized by the towns of Cottonwood, Clarkdale, Camp Verde, Payson and others are derived from the watersheds of the Salt and Verde Rivers. The water supplies of the upper Gila River communities of Safford, Thatcher and others are impacted by senior surface water rightholders downstream of their communities and by Indian water rights settlements. Surface water from the Gila River (pursuant to the Globe-Equity Decree), has historically been the primary water supply for the San Carlos Irrigation and Drainage District in the Pinal AMA (see Appendices A and E).

In other parts of Arizona, local surface water supplies are used by municipal, industrial and agricultural users. Principal surface water resources include the Little Colorado River, San Pedro River, Verde River, other rivers and streams, captured runoff in reservoirs, and springs. These supplies may be more drought sensitive than the larger regional systems. Communities that utilize surface water include, Eager, Flagstaff, Jerome, Tombstone and Williams. Industrial users of substantial volumes of surface

water include the Navajo Generating Station at Page, the Southpoint Power Plant in the Lake Mohave Basin, and the Morenci Mine in the Morenci Basin. Surface water is used for agricultural irrigation in several basins in the Eastern Plateau, Central Highlands and Southeastern Arizona Planning Areas, including agricultural users in the Verde River, Upper San Pedro and Salt River Basins. A more detailed description of surface water supplies is found in Volumes 2-8.

Groundwater

Groundwater is an important water supply for many water users across the state. However, while a number of hydrologic studies and groundwater models have been completed in the AMAs, there is often less known about the groundwater conditions outside AMAs. Although the Department conducts water level and water quality measurements periodically outside AMAs, fewer comprehensive studies have been done in these areas.

Some areas of the state have relatively deep alluvial aquifers with substantial amounts of groundwater in storage. This is generally true for the southern part of Arizona including much of the Pinal, Phoenix and Tucson AMAs. In other areas however, hydrologic conditions are less favorable. Aquifers may be thin or unproductive, particularly in mountainous areas, or depth to groundwater may be very great. This is the case in the Payson area and in much of the Santa Cruz AMA, where thin or fractured aquifers make them responsive to precipitation events and susceptible to drought. Poor water quality can also be an issue. For example, some of the regional aquifers of the Eastern Plateau are characterized by high levels of total dissolved solids, and in some cases are unsuitable for use.

With the exception of the Lower Colorado River Planning Area, groundwater is the primary water supply utilized outside AMAs for cultural uses. This is also the case within the AMA planning area. In 2003, groundwater was the primary water supply utilized in every AMA. As drought and growth stress the availability of surface water supplies, communities that historically have relied on surface water are exploring groundwater resource options including drilling additional wells and acquiring land for wellfield development. Groundwater conditions are described in more detail for each planning area in Volumes 2-8.

Effluent

Access to renewable water supplies, especially outside AMAs, may be physically or legally limited. An exception is effluent, which increases with sewered population growth. Effluent is currently utilized in a number of communities for turf irrigation and recharge. Communities outside AMAs that reuse effluent for irrigation include Benson, Flagstaff, Lake Havasu City, Payson, Sierra Vista, and Yuma. Fort Huachuca and the City of Sierra Vista recharge effluent at constructed recharge facilities. Other communities have plans for reuse in the future.

Effluent is an important supply in the Tucson and Phoenix AMAs. Almost 68,000 acre-feet of effluent was delivered to the Palo Verde Nuclear Generating Station in the Phoenix AMA for cooling purposes in 2003. Another 34,100 acre-feet was delivered to municipal and industrial users for park and golf course irrigation. In the Tucson AMA almost 10,000 acre-feet was delivered for turf irrigation use in 2003.

Cultural Water Demand

Cultural water demand refers to the quantity of water diverted from streams and reservoirs, pumped from wells or treated and delivered for municipal, industrial and agricultural purposes. This term should

not be confused with "consumptive use", which refers to the amount of the cultural water demand that is lost from the hydrologic system. For example, not all surface water diverted to irrigate crops is permanently lost; a portion of the water applied to fields may flow back to streams (return flow) or infiltrate to underlying aquifers (incidental recharge). Similarly, a portion of the water pumped from wells to meet municipal demands is incidentally recharged or can be recovered as effluent from wastewater treatment plants.

Data sources and the methods used to estimate cultural water demands for the Atlas, as well as the limitations of these estimates, are described in Section 1.3.5, *Cultural Water Demand*. Data presented here provide a general assessment of water demands in Arizona by municipal, agricultural and industrial users. Sectors are defined similarly to those used for the AMAs and definitions of these sectors are found in the *Definitions* section.

Water demand data within AMAs is collected annually by the Department, but reporting issues, agency priorities and the complexity of the water accounting systems have prevented consistent, annual compilation of each AMA's data. Outside AMAs, annual water use reporting to a designated agency is the exception. Private water companies must annually report pumpage and deliveries to the Arizona Corporation Commission (ACC) but information on water use by other water providers, including public utilities and water improvement districts, must be gathered separately. Agricultural and industrial water use by individual water users is not typically reported regularly to any agency. The primary data source for well pumpage outside of AMAs was the USGS 2005 report *Water Withdrawals for Irrigation, Municipal, Mining, Thermoelectric-Power, and Drainage Uses in Arizona Outside of Active Management Areas, 1991-2000* and supporting data. The USGS 2005 report also includes surface water diversions for agricultural use where metered. In areas where surface water diversions are not metered, the Department estimated the diversions by sector. Therefore, the water demand estimates in Table 1-2 are compiled from a variety of sources, which should be taken into consideration when interpreting the estimates.

Table 1-2 AMA water demand data is primarily from 2003 water withdrawal and use reports submitted by groundwater rightholders. Indian demand is generated primarily from CAP and other delivery reports (for agriculture) and estimates of population and GPCD (for municipal). Exempt well demand is estimated from the number of domestic, exempt wells. Detailed information about water supply and demand is provided by basin for areas outside of AMAs in Volumes 2-7 and for AMAs in Volume 8.

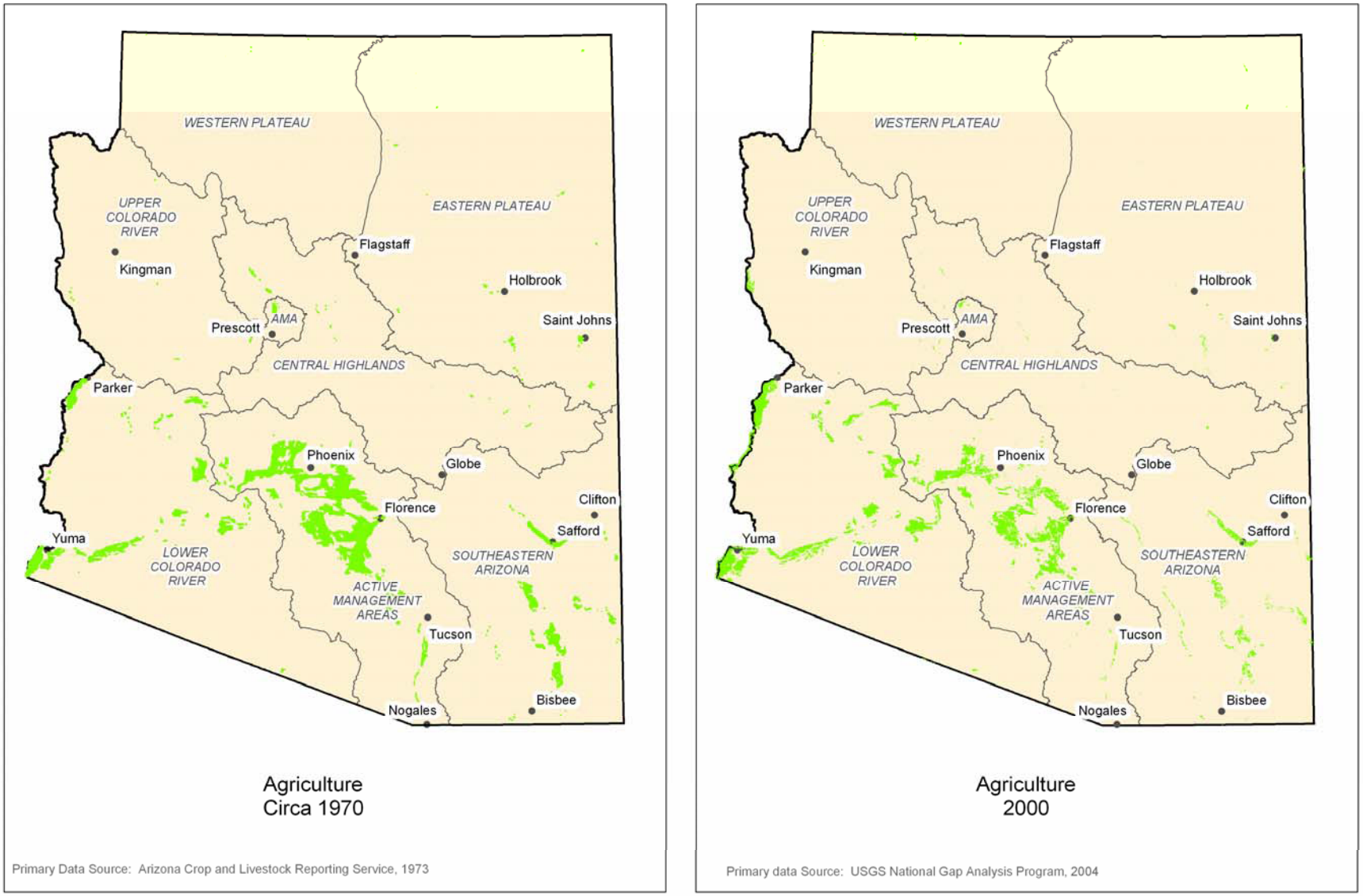
Table 1-2 Cultural water demand by non-AMA and AMA water demand sectors in 2003.

Water Demand Sector/Supply	AMA Demand (acre-feet)	Non-AMA Demand (acre-feet)
Municipal	**1,369,100**	**197,600**
SW	373,900	44,300
GW	479,300	153,300
CAP[1]	421,900	----
Effluent	94,000	ND
Agricultural	**1,767,400**	**3,669,100**
SW	165,700	2,132,000
GW	947,300	1,537,100
CAP[2]	585,000	----
Effluent	69,400	ND
Industrial	**222,100**	**180,700**
SW	24,800	41,900
GW	173,700	138,800
CAP[3]	1,800	----
Effluent	21,200	----
Other[4]	600	----
Indian	**420,600**	**Use included above**
SW	130,300	----
GW	145,100	----
CAP[5]	140,000	----
Effluent	5,200	----
Total	**3,779,200**	**4,047,400**

ND = not determined
[1] Includes direct use and recharge credit recovery
[2] Includes direct use and in-lieu. (see definitions section)
[3] All CAP used is "direct use", no in-lieu
[4] Multiple water supplies that cannot be separately determined
[5] All CAP used is direct use

Total cultural water demand was greater outside AMAs than within AMAs in 2003. The demand associated with the AMA population centers and the large volume of agricultural water use outside AMAs is clearly shown in Table 1-2. The agricultural sector is the largest cultural water demand sector both within and outside AMAs and the volume of agricultural water use outside AMAs is almost as large as the total cultural water demand within AMAs. The extent and distribution of irrigated agricultural land in Arizona is shown for circa 1970 and 2000 in Figure 1-9. The resolution of the older map is of lesser quality than the more recent map but in general, agriculture has declined in most planning areas with the exception of the Lower Colorado River. There were notable agricultural declines in the AMAs and in parts of the Southeastern Arizona Planning Area. Industrial demand is relatively comparable within and outside AMAs.

Figure 1-9 Agricultural lands in Arizona, Circa 1970 and 2000



Figures 1-10 and 1-11 show the water supplies utilized within AMAs and water supplies utilized outside AMAs by source and percentage of the total supply. Groundwater is water pumped from wells while surface water is water diverted from streams and springs. CAP refers to all CAP used including CAP water used "in-lieu" of groundwater pumping by the agricultural sector and recovery of CAP recharge credits by municipal users. In AMA water budgets, the "in-lieu" CAP is accounted for as a "debit" to the groundwater supply because credits are accrued by the "storer" that may recovered in the future through groundwater pumping. Effluent is also used outside of AMAs but it was not possible to quantify the demand. It is expected that this supply is less than 1% of the total.

Figure 1-10 Water supplies utilized by cultural water demand sectors within AMAs in 2003 (by source and percentage of total)

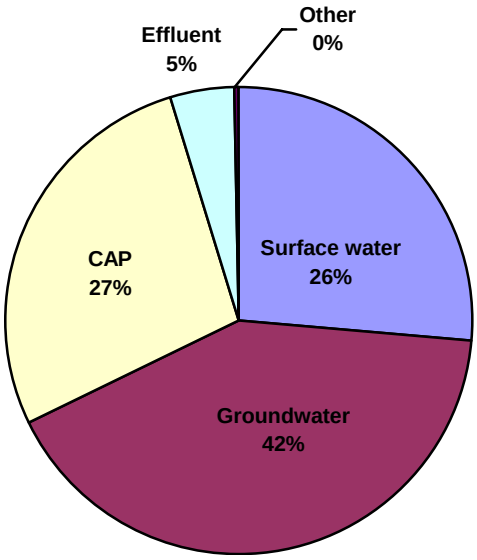


Figure 1-11 Water supplies utilized by cultural water demand sectors outside AMAs in 2003 (by source and percentage of total)

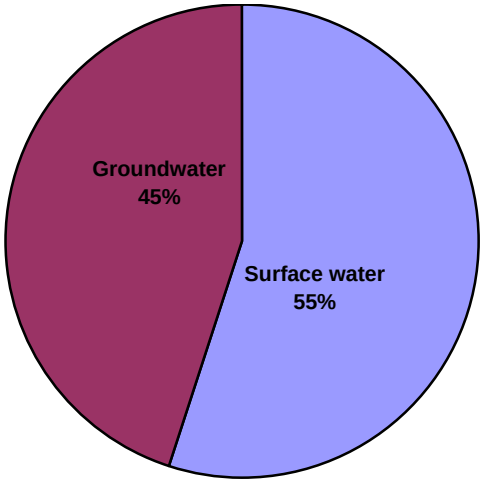


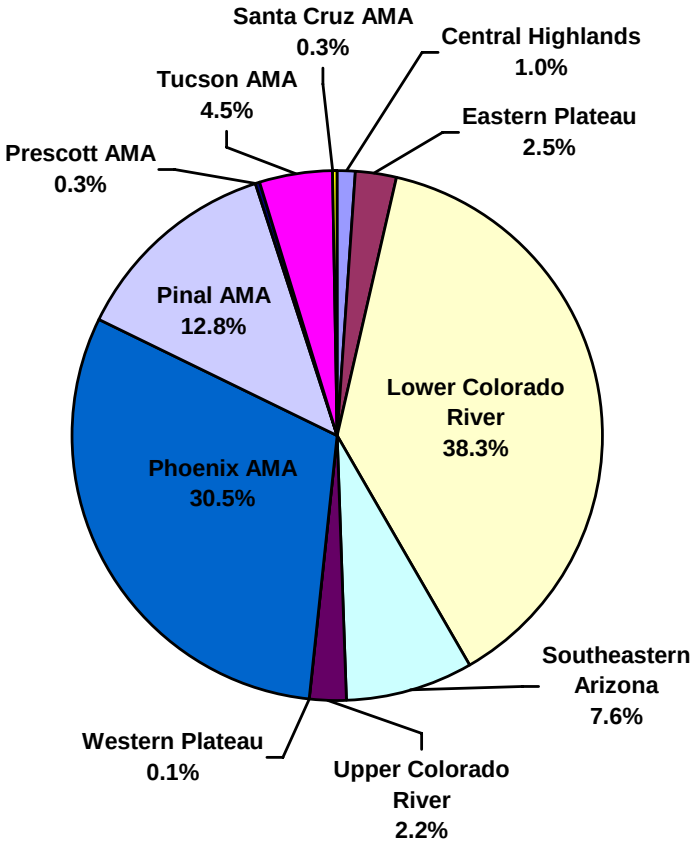
Table 1-3 provides a summary of water demand by sector and water supply for each of the non-AMA planning areas. Water demand varies significantly by volume, source of water and by sector. For example, agricultural surface water diversions in the Lower Colorado River Planning Area are almost 73% of all the water used outside AMAs, and agricultural and industrial water demand vary significantly between planning areas. The importance of groundwater as a municipal supply in most planning areas is evident. Agricultural water demand is the largest demand sector by far in all but one of the planning areas and is served by significant amounts of both surface and groundwater. Industrial demand, (associated with power plants, mining, dairies, feedlots and turf irrigation), is a significant percentage of the total water demand in all planning areas (7% to 42%) with the exception of the Lower Colorado River. Figure 1-2 shows the relative water demand of each planning area as a percentage of the total state water demand.

Table 1-3 Non-AMA planning area cultural water demand by sector in 2003 (in acre-feet)

SECTOR/ SUPPLY	PLANNING AREA					
	Central Highlands	Eastern Plateau	Lower Colorado River	South-eastern Arizona	Upper Colorado River	Western Plateau
Municipal	**25,000**	**30,200**	**50,000**	**38,300**	**51,200**	**2,900**
Surface Water	4,000	4,200	34,000	300	700	1,100
Groundwater	21,000	26,000	16,000	38,000	50,500	1,800
Agricultural	**36,000**	**83,000**	**2,940,000**	**514,000**	**92,000**	**4,100**
Surface Water	22,500	48,500	1,900,000	102,000	57,500	1,500
Groundwater	13,500	34,500	1,040,000	412,000	34,500	2,600
Industrial	**18,900**	**83,000**	**7,900**	**40,300**	**29,500**	**1,100**
Surface Water	7,400	26,500	2,600	1,100	4,000	300
Groundwater	11,500	56,500	5,300	39,200	25,500	800
TOTAL	**79,900**	**196,200**	**2,997,900**	**592,600**	**172,700**	**8,100**

*Planning area totals rounded to nearest thousand if greater than 100,000

Figure 1-12 Each planning area's percentage of total cultural water demand in 2003



Water Budget

A water budget is an accounting of inflows and outflows of water from a basin. Typical surface water and groundwater components of inflow and outflow are listed below. Surface water inflows include: precipitation, surface water entering the basin, baseflow, irrigation return flow and effluent discharge. Groundwater inflows include natural groundwater recharge (mountain front recharge and stream channel recharge from precipitation), groundwater underflow into the basin, artificial recharge from recharge facilities and incidental recharge. Surface water outflows include evaporation from bodies of water, streamflow leaving the basin and diversions for cultural water use. Groundwater outflows include evapotranspiration, groundwater underflow, baseflow to surface water and well pumpage for cultural water use. Cultural water demand is often the largest component of outflow from a basin. Streamflow, (composed of baseflow, snowmelt and precipitation) or groundwater recharge is often the largest component of inflow.

Inflow	Outflow
Surface Water	
• Precipitation** • Surface water entering basin from precipitation events and snowmelt ** • Baseflow to surface water* • Irrigation return flow • Effluent discharge*	• Evaporation* • Surface water exiting basin** • Surface water diversions (agricultural, municipal, industrial, stock water)**
Groundwater	
• Natural groundwater recharge** • Groundwater underflow into basin • Artificial and incidental recharge*	• Evapotranspiration (riparian vegetation) • Groundwater underflow exiting basin • Baseflow from groundwater to surface water* • Well pumpage (agricultural, municipal, industrial, stock water)**

* related or cursory data are presented in the Atlas for the component

** detailed data is presented in the Atlas for the component

Estimates of natural groundwater recharge, streamflows, precipitation and cultural water demands in non-AMA planning areas are presented by basin in Volumes 2-7 and for AMAs in Volume 8. Other components of outflow and inflow are not well quantified in the Atlas or are not quantified at all. Those not quantified are often difficult to estimate but should be considered when constructing a water budget. These include incidental recharge, irrigation return flow, baseflow, evapotranspiration, evaporation and underflow. For example, phreatophyte evapotranspiration is difficult to quantify but may represent a large water demand "sector" in some basins, such as in the Upper San Pedro.

Water is often lost from municipal and agricultural water distribution systems due to leaks and breaks from water lines and storage tanks, illegal connections and evaporation. These may represent components of incidental recharge, evaporation, or cultural demand. In some cases water line losses can be significant. One third of the respondents to a system water loss question in the 2003 Rural Water Resources Questionnaire reported losses of over 10% with losses of up to 60% reported. Within AMAs there are system water loss requirements for municipal, agricultural and industrial water users. Reducing system losses eliminates unnecessary pumping and related costs and may postpone or eliminate the need to secure other supplies to meet system water demands.

Evaporative losses are also associated with uncovered agricultural conveyance systems and irrigation. Evaporation from reservoirs and ponds is significant and varies widely across the state. Evaporation rates range from less than 3 feet/year in the mountains of central Arizona to greater than 8 feet/year along the Colorado River in western Arizona (NOAA, 1982). Regardless of the variability, the total quantity of water lost to evaporation from these sources is substantial.

In the 1950's, average evaporative losses from reservoirs and ponds in Arizona were estimated to total 148,000 acre-feet per year (USGS, 1962). By comparison, these losses were estimated to total 198,200 acre-feet per year in the early 1970's (Arizona Water Commission, 1975) and 221,400 acre-feet in 2000 (BOR, 2004). Note that the estimates do not include major reservoirs located along the Colorado River.

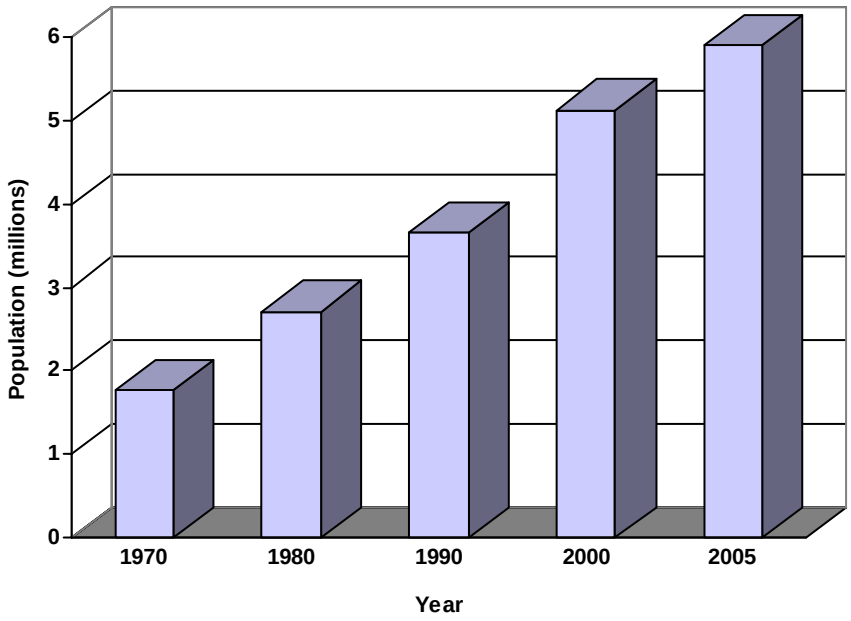
In 2000, evaporative losses from Lakes Powell, Mead, Mohave and Havasu were estimated to total another 1,993,000 acre-feet.

Artificial recharge is water that is recharged to the aquifer through recharge projects, which may be recovered in the future. Incidental recharge is water that percolates to the aquifer after use such as water used for irrigation of farmland or turf facilities, effluent discharge to water courses and septic tank losses. The amount of incidental recharge is affected to a large extent by population, the population not served by a centralized wastewater treatment facility, irrigation efficiency and the method of effluent discharge.

Population

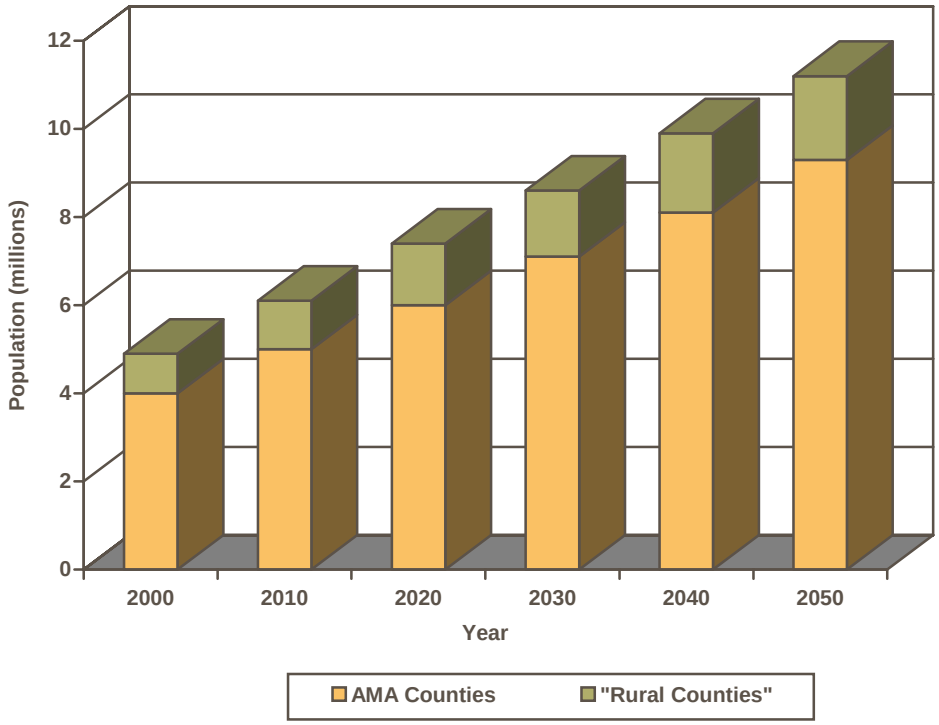
Arizona continues to rank as the nation's second fastest growing state, growing at a rate of about 3% per year. Growth from 1970 to 2005 is shown in Figure 1-13. Arizona grew by about 1 million residents a decade between 1970 and 1990, and then grew from 3.6 million to 5.1 million inhabitants, a 40% increase, in the decade from 1990 to 2000. By July 2005, another 800,000 people moved to Arizona, a 15.8% increase since the 2000 census (Arizona Workplace Informer, 2006).

Figure 1-13 Arizona population 1970-2005



Some rural Arizona counties are currently growing at rates comparable to that of Maricopa County, which contains the rapidly growing Phoenix metropolitan area. Mohave County was the fastest growing county in Arizona between 1990 and 2000 with a 65.8% increase (Arizona Workforce Informer, 2006). Between 2000 and 2005, Mohave, Yavapai and Yuma Counties experienced more than an 18% population growth. Arizona Department of Economic Security projections indicate that by 2050 an additional 1 million people will live in rural Arizona counties and an additional 5 million people will live in AMA counties as shown in Figure 1-14.

Figure 1-14 Projected population growth in Arizona 2000-2050



(www.workforce.az.gov/admin/uploadedPublications/526_coproj97)

Rapid population growth and drought are having significant impacts on water supplies and infrastructure in some areas. Figure 1-15 and Table 1-4 show Arizona communities with population growth greater than 2% per year and 5% per year between the 1990 and 2000 Censuses. The highest growth rates and greatest concentration of high growth rate communities are located in the AMAs, particularly in smaller communities near larger cities. It should be noted that some high growth rates may be due in part to annexation of unincorporated land with its associated population. This is the case with the town of Marana in the Tucson AMA. Although some incorporated cities, such as Sierra Vista and Safford, did not experience more than a 2% annual growth rate between the censuses, unincorporated areas adjacent to them grew rapidly.

Figure 1 - 15
High Growth Rate Communities
in Planning Areas and Groundwater Basins

Table 1-4 Communities with average annual growth rates > 2%.

Planning Area/ Community	Average Annual Growth Rate	1990 Census	2000 Census	Projected 2050 Pop. (DES)
ACTIVE MANAGEMENT AREAS				
Marana	57.3%	2,187	14,718	124,232
Oro Valley	32.3%	6,670	28,190	79,607
Tucson Estates	26.6%	2,662	9,755	NA
Gilbert	23.5%	29,122	97,535	339,556
Surprise	19.4%	7,122	20,915	235,977
Prescott Valley	16.3%	8,904	23,390	72,336
Goodyear	15.0%	6,258	15,650	293,050
Three Points	14.2%	2,175	5,273	NA
Picture Rocks	10.2%	4,026	8,139	NA
Fountain Hills	8.5%	10,030	18,545	54,941
Chandler	8.5%	89,862	166,105	322,164
Sun Lakes	8.2%	6,578	11,936	NA
Peoria	8.0%	50,675	91,415	358,317
Buckeye	8.0%	4,436	8,000	438,897
Arizona City	7.6%	1,940	3,420	7,442
Dewey-Humboldt	7.6%	3,640	6,400	18,106
Carefree	7.6%	1,657	2,910	5,448
Avondale	7.5%	16,169	28,280	157,403
Queen Creek	6.7%	2,667	4,455	122,312
Sun City West	6.5%	15,997	26,344	NA
Chino Valley	6.2%	4,837	7,810	18,230
Florence	6.1%	7,321	11,760	13,359
Scottsdale	5.7%	130,075	204,005	374,482
Avra Valley	4.8%	3,403	5,038	NA
Ak-Chin Village	4.6%	353	516	1,011
Catalina	4.4%	4,864	7,025	NA
Cave Creek	4.2%	2,925	4,150	16,615
Glendale	4.2%	147,864	209,300	341,189
Blackwater	3.6%	400	545	989
Mesa	3.4%	288,104	385,440	664,700
Eloy	3.2%	7,211	9,550	13,218
Phoenix	3.1%	983,392	1,289,125	2,567,878
Green Valley	3.1%	13,231	17,283	NA
Prescott	2.9%	26,592	34,366	65,670
Apache Junction	2.5%	18,092	22,621	33,738
CENTRAL HIGHLANDS				
Lake Montezuma (CDP)	6.2 %	1,841	3,344	4,969
Big Park (CDP)	5.7%	3,024	5,245	11,363
Payson	5.0%	8,377	13,620	29,444
Clarkdale	4.8%	2,144	3,422	6,571
Kachina Village (CDP)	4.5%	1,711	2,664	4,397
Cottonwood	4.5%	5,918	9,179	24,109
Camp Verde	4.2%	6,243	9,451	19,300
Cottonwood-Verde Village(CDP)	4.2%	7,037	10,610	10,905
Black Canyon City (CDP)	4.1%	1,811	2,697	4,939
Whiteriver (CDP)	3.3%	3,775	5,220	9,181
Sedona	2.8%	7,720	10,192	19,591
Globe	2.1%	6,062	7,486	9,827
EASTERN PLATEAU				
Lukachukai (CDP)	30.1%	113	1,565	*
Pinon (CDP)	9.8%	468	1,190	*
Teec Nos Pos (CDP)	9.7%	317	799	1,092
Kaibito (CDP)	9.6%	641	1,607	2,269
Heber-Overgaard (CDP)	5.6%	1,581	2,722	2,761

Table 1-4 Communities with average annual growth rates > 2% (cont.)

Planning Area/ Community	Average Annual Growth Rate	1990 Census	2000 Census	Projected 2050 Pop. (DES)
Show Low	4.4%	5,020	7,695	13,353
Pinetop-Lakeside	4.0%	2,422	3,582	6,064
Taylor	2.8%	2,418	3,176	5,565
LOWER COLORADO RIVER				
San Luis	13.8%	4,212	15,322	47,244
Fortuna Foothills (CDP)	10.2%	7,737	20,478	64,043
Quartzite	6.0%	1,876	3,354	7,077
Wellton	5.6%	1,066	1,829	2,377
Yuma	3.5%	56,966	77,515	154,855
Somerton	3.2%	5,282	7,266	16,296
Ajo (CDP)	2.4%	2919	3705	NA
SOUTHEASTERN ARIZONA				
Whetstone (CDP)	6.2%	1,289	2,354	2,548
Swift Trail Junction (CDP Safford)	6.2%	1,203	2,195	6,574
Sierra Vista SE (CDP)	4.5%	9,237	14,348	16,854
Peridot (CDP)	2.8%	957	1,266	3,192
San Carlos (CDP)	2.4%	2,918	3,716	4,220
Safford	2.3%	7,359	9,232	18,776
Benson	2.1%	3,824	4,711	4,806
Tombstone	2.1%	1,220	1,504	1,789
Duncan	2.1%	662	812	1,217
UPPER COLORADO RIVER				
Mohave Valley (CDP)	7.0%	6,962	13,694	22,160
Lake Havasu City	5.6%	24,363	41,938	94,457
Dolan Springs (CDP)	5.5%	1.090	1,867	2,054
Kingman	4.7%	12,722	20,069	38,737
Bullhead City	4.4%	21,951	33,769	71,423
New Kingman/Butler (CDP)	2.4%	11,627	14,810	39,033
WESTERN PLATEAU				
Colorado City	3.2%	2,426	3,334	9,010

CDP=**census designated place -** A geographic entity that serves as the statistical counterpart of an incorporated place for the purpose of presenting census data for an area with a concentration of population, housing, and commercial structures that is identifiable by name, but is not within an incorporated place. (U.S. Census Bureau, www.census.gov)

- Projections less than 2000 census
- NA=not available

The state 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 include planning for water resources in their comprehensive plans. County plans are required to identify known legally and physically available water supplies, estimate future water demand, and describe how demand will be served by currently available supplies or provide a plan to obtain the necessary supplies. All AMA counties, but only two counties entirely outside AMAs (Mohave and Yuma), fit the population criteria The Act also requires that twenty-three communities outside AMAs include a water resources element in their general plans. References to completed plans are listed in Volumes 2-8 of the Atlas. These plans may contain useful information for water resource planning.

1.2.4 Water Management Overview

Water management in Arizona is composed of a complex system of rules and management authorities that differ for each type of water and by area. These are summarized here and described in more detail in Appendices A, D and E.

One of the most fundamental divisions is that laws governing surface water are distinct from those governing groundwater. Surface water is subject to the doctrine of prior appropriation, based on the tenet of "first in time, first in right." Two general stream adjudications are in progress involving the Gila River and Little Colorado River systems to determine the nature, extent and priority of surface water uses and rights.

Rights to groundwater are subject to the beneficial use doctrine. Outside AMAs there is essentially an unlimited ability to withdraw groundwater as long as it is put to reasonable and beneficial use. The only exception is in the three areas designated as Irrigation Non-Expansion Areas, where the irrigation of new agricultural lands is restricted. Within AMAs the ability to withdraw groundwater is subject to a system of rights and permits pursuant to provisions of the Arizona Groundwater Management Act, A.R.S. § 45-401 *et seq*. (Code).

There has been considerable investment in water resource development and planning in many parts of Arizona, particularly within the AMAs, due to the availability of financial resources, major water supplies and restrictions imposed by the Groundwater Code. Outside AMAs, similar resources and mandatory water management provisions do not exist. Nevertheless, a number of non-AMA communities have recognized the need for water resource planning and have had sufficient resources to develop renewable water supplies, conservation programs and water management plans. Legislation passed in 2005 requires development of water system plans by community water systems state-wide beginning in 2007.

Statewide Water Resources Management Programs

The Code was adopted in 1980 to settle disputes among groundwater users, to secure federal funding for the Central Arizona Project (CAP), and to mitigate severe overdraft conditions in several parts of the state. The Code created three levels of management: AMAs, irrigation non-expansion areas (INAs) and statewide provisions. The AMAs have the highest degree of groundwater management controls. Within AMAs the Code established management goals for each AMA, a system of groundwater rights, a data collection system, well spacing rules, mandatory conservation requirements, and 100-year assured water supply requirements for new developments. INAs were established in certain rural farming areas where the groundwater overdraft was less severe. The management objective in INAs is to protect existing water uses and prevent further declines in groundwater supplies through prohibition of new irrigation acreage. In INAs, larger water users are required to report use. Statewide, the Department licenses well drillers, issues Notices of Intent to Drill for well drilling and regulates well construction. There are also statewide provisions for groundwater transportation. An overview of Arizona water law is found in Appendix A.

Groundwater cannot be transported between groundwater basins outside AMAs or from a groundwater basin outside an AMA into an AMA, except for specific transfers as specified in statute. A.R.S. §§ 45-544 and 45-551. These statutes are designed to protect hydrologically distinct sources of groundwater supplies and the economies in rural areas by ensuring the groundwater is not depleted in one groundwater basin to benefit another.

Within AMAs mandatory water metering and reporting requirements for groundwater rightholders has resulted in the systematic collection of water use data, which is compiled in AMA management plans. A series of 5 consecutive management plans are statutorily required for each AMA (A.R.S.§§ 45-564 through 568). The management plans contain conservation requirements for the agricultural, municipal and industrial water use sectors, as well as water use data, and provide the framework for the day-to-day implementation of Code mandates and Department policies for each AMA.

The Code also contains provisions that address water supplies for subdivided lands. Within AMAs new subdivisions are subject to Assured Water Supply (AWS) provisions. (A.R.S. §§ 45-576 *et seq*.) The Code and the associated AWS Rules adopted by the Department prohibit the sale or lease of subdivided land without demonstration of a 100-year assured water supply. The water use must also be consistent with the management goal of the AMA, which requires use of renewable (non-groundwater) supplies or replenishment of groundwater use. Local governments cannot approve a subdivision plat and the Arizona Department of Real Estate cannot issue a public report for the sale of lots without an AWS determination. Volume 8 contains information on assured water supply determinations for the AMAs.

Outside AMAs, A.R.S.§ 45-108 requires subdivision developers to obtain a determination from the Department regarding the availability of water supplies unless the subdivision will be served by a municipal provider that has been designated as having an adequate water supply. Developers must either obtain a Water Adequacy Report that demonstrates that sufficient water of adequate quality is available for at least 100 years or disclose any "inadequate" determination in the public report and all promotional materials. The ability to market lots without demonstrating an adequate water supply is an issue in a number of rural areas, where local governments may have limited authority to restrict development of subdivisions that may lack sufficient water supplies. Volumes 2-7 contain information on water adequacy and inadequacy determinations for each groundwater basin.

Community Water System Planning

In 2005, the Arizona Legislature passed House Bill 2277, which expands water use reporting an planning statewide. Although the legislation was developed in response to a recommendation by the Governor's Drought Task Force (see Section 1.2.5), it contains the broader objective of improving water management planning at the state and local levels. The legislation requires all community water systems to submit a Water System Plan that includes a Water Supply Plan, a Drought Preparedness Plan and a Water Conservation Plan. It also requires all community water systems to submit an annual report of water withdrawals, diversions and deliveries. Community water system is defined as a public water system that serves at least 15 service connections used by year-round residents or that regularly serves at least 25 year-round residents. A.R.S. § 45-341

The Water Supply Plan must describe the community water system's sources of water, service area, transmission system facilities, monthly system production data, historic demand for the past five years and projected demands for the next five, ten and twenty years. A.R.S. § 45-342(H). The Drought Preparedness Plan must include drought and emergency response strategies, a plan of action to respond to water shortage conditions and provisions to inform and educate the public. A.R.S. § 45-342(I). The Water Conservation Plan may include a variety of measures to reduce water demand. Large water systems (serving more than 1,850 people) must submit plans to the Department by January 1, 2007 and small community water systems by January 1, 2008. Extensions of the deadline and exemptions from the Water Conservation Plan may be granted. Submittal of joint plans is allowed and updates to plans are required every five years. Providers with an AWS are exempt from submitting a Water Supply Plan. The Director is required to provide a water plan form to small providers and to develop a guidance

document to assist in the preparation of the Water System Plan.

1.2.5 Water Planning and Water Resource Investigations

Statewide Reports

Prior to publication of the Atlas, the only Department document that provided a broad overview of water supply and demand conditions as well as an analysis of water resource management issues statewide was the *Arizona Water Resources Assessment, 1994 (Assessment)*. The *Assessment* is composed of two Volumes: *Volume I; Inventory and Analysis* and *Volume II; Hydrologic Summary*. The *Assessment* discusses statewide water issues and water supply, demand and management issues for six planning areas, including the AMAs. The Atlas partially retains the purpose and content of the *Assessment.* The Atlas includes more groundwater basin information than the *Assessment.* The description of basins and planning areas is shortened to allow the presentation of more data and maps. The Atlas contains less information about water law, policies and programs than the *Assessment*.

The 1994 *Assessment* was built upon the *State Water Plan* prepared by the Arizona Water Commission, the predecessor to the Department. The *State Water Plan* was published in three phases from 1975 to 1978 and was intended to provide necessary water resource information for water management decision-making. The three phases included: *Phase I, Inventory of Resource and Uses; Phase II, Alternative Futures;* and *Phase III-Part 1, Water Conservation*. Other Phase III reports were envisioned but not produced. The Plan pre-dates the formation of the AMAs and presented information on a state and county basis.

Active Management Area Management Plans

To help achieve the water management goal of each AMA, the Groundwater Code directs the Department to develop and implement water conservation requirements for the agricultural, municipal and industrial water use sectors in five consecutive management periods (1980-2025). The Code generally requires that each consecutive management plan contain more rigorous water conservation requirements. These requirements are published in separate management plans for each AMA (A.R.S. §§ 45-564 through 45-568). In addition to conservation requirements, the management plans contain a water quality assessment and management program, an augmentation and recharge program and conservation assistance programs. Management plans contain water demand information and data and provide the framework for implementation of Code mandates and Department policies (see Appendix A).

Rural Watershed Initiative Program

The Department has provided technical and financial assistance to non-AMA watershed partnerships since the late 1990's through its Rural Watershed Initiative Program. In 1999, the Rural Watershed Initiative (Initiative) received an appropriation of $1.2 million from the Legislature to assist the groups with development of information to support water resources planning in their areas. Although funding has diminished since then, matching funds from other entities have sustained key projects partially funded by the Initiative. A key component of the Initiative approach is that it helps local citizens find solutions that match the specific problems in their own regions. Seventeen watershed groups have formed to conduct water resource studies and evaluate management options (Figure 1-16).

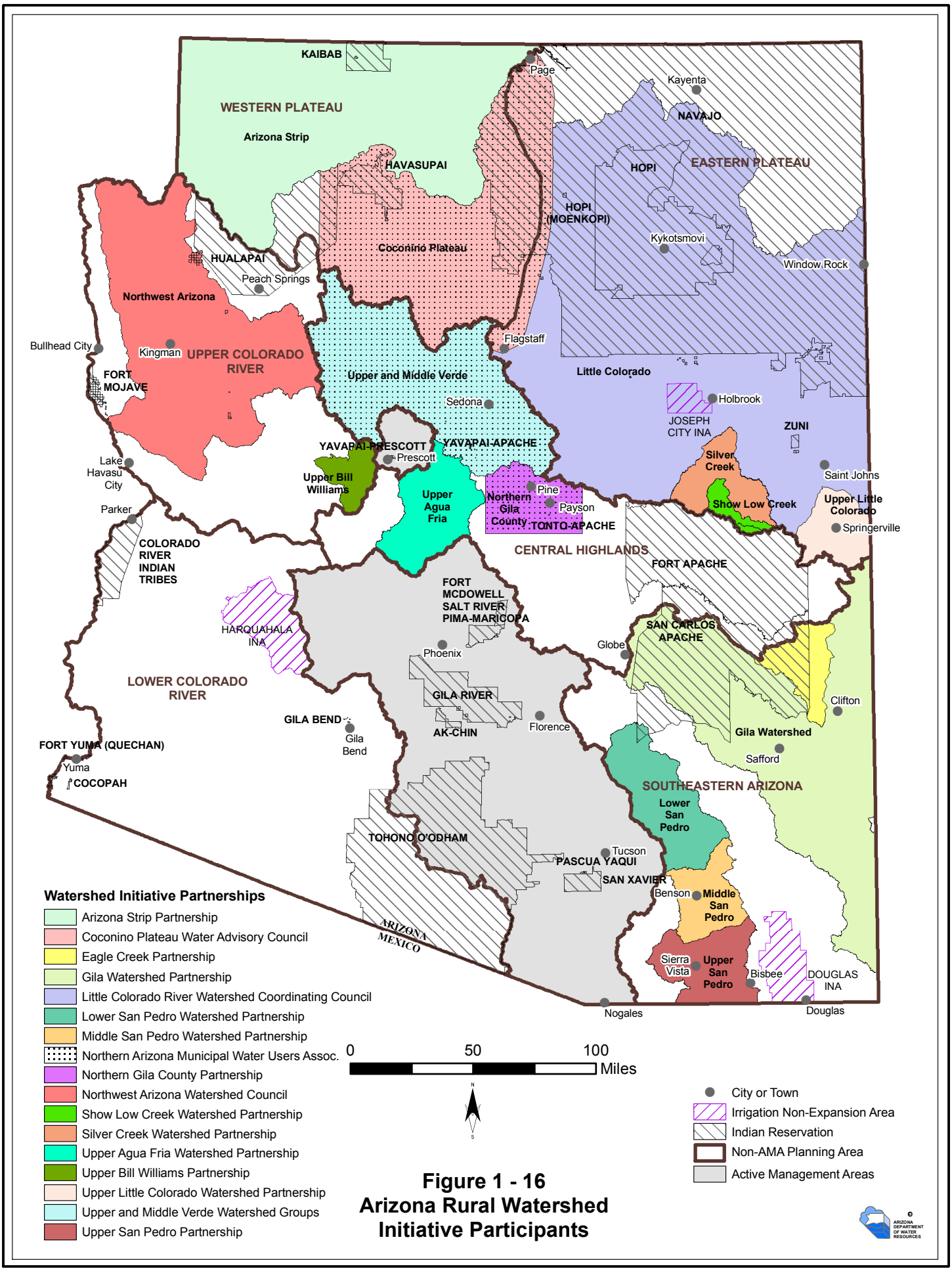


Figure 1 - 16
Arizona Rural Watershed Initiative Participants

Several of the watershed groups were already in place as part of a water quality planning effort by the Arizona Department of Environmental Quality (ADEQ).

The watershed groups vary substantially in terms of resources, staff support, and accomplishments. Of the 17 watershed groups, 15 are actively working on regional solutions to water problems with the goal of developing a comprehensive water resource management plan for their region. In some areas, especially those with significant resources such as the Upper and Middle Verde and the Upper San Pedro, efforts have already produced results in the form of completed and on-going studies, plans, and specific activities to address availability of water. Because of the lack of technical and financial resources and the limited availability of hydrologic data, efforts in other areas may take longer to produce tangible results. Studies and other information associated with these groups have been incorporated into the Atlas and a summary of participants, issues and projects is provided in Appendix B.

Statewide Water Advisory Group

A Statewide Water Advisory Group was formed in April, 2006 to address issues and identify mechanisms, including legislation necessary to encourage and support local initiatives for planning, financing, developing and managing water supplies in non-AMA groundwater basins. At the time of publication of this volume, the process is in its early stages, with the objective of a proposal drafted for introduction during the 2007 Legislative session.

Arizona Drought Preparedness Plan

Governor Napolitano signed Executive Order 2003-12 on March 20, 2003 to address the impact of prolonged drought conditions that began in 1998. The Executive Order established the Governor's Drought Task Force (Task Force) to develop a drought plan for Arizona. The Task Force adopted a mission statement to develop a sustainable drought planning and response process for Arizona that includes:

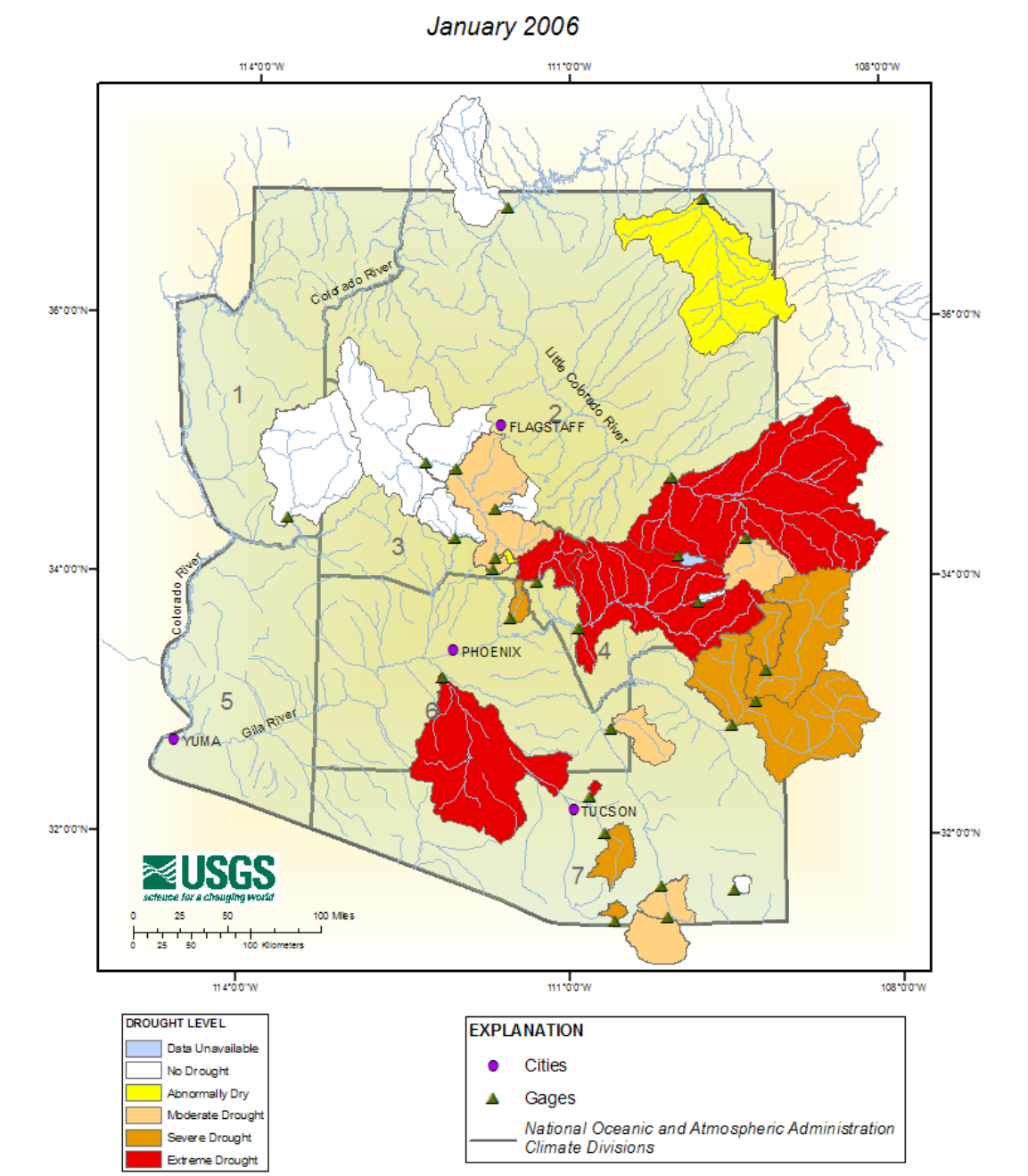
- Timely and reliable monitoring of drought and water supply conditions in the state and an assessment of potential impacts;
- A vulnerability assessment of key sectors, regions, and population groups in the state and possible actions to mitigate potential impacts; and
- Assistance to stakeholders in preparing for and responding to drought impacts, including development of a statewide water conservation strategy and public awareness program. (GDTF, 2004b).

The Task Force adopted the *Arizona Drought Preparedness Plan* in October 2004, and it established a process to allow for ongoing drought monitoring, planning and response. Arizona's drought planning process includes the following three components: a Potable Water Plan to be implemented during emergency short-term drought conditions; the Drought Preparedness Plan, which is the long-term drought mitigation plan with the Operational Drought Plan as its response component; and a Statewide Water Conservation Strategy that is intended to support drought preparedness and promote a water conservation ethic statewide regardless of drought status.

The Task Force adopted a Potable Water Plan for the summers of 2003 and 2004 to address the potential for drought-induced potable water supply shortages. The Potable Water Plan addresses short-term water supply needs for political subdivisions under emergency conditions where there is a risk to public health and welfare. It is intended to monitor, assess and respond to immediate problems and directs at-risk water providers to the appropriate response mechanism. In both years, emergency legislation was passed to allow for the transportation of groundwater across groundwater basins, under specific conditions, to address drought emergencies.

The Drought Preparedness Plan focuses on the need for drought planning by rural communities that often have fewer water supply options during times of drought. Ongoing drought monitoring is critical to the planning process and a Monitoring Technical Committee meets regularly for this purpose. The Monitoring Technical Committee tracks climate changes, forecasts likely future conditions, and determines drought status. One of the Monitoring Committee's efforts has been to better understand how historic droughts have varied spatially and temporally by evaluating historic stream gage data within selected watersheds. Maps similar to Figure 1-17 are created to show drought levels in selected watersheds. Drought levels were identified in the Operational Drought Plan as shown in Table 1-6. Drought indicator data, which could be inches of precipitation, cubic feet per second of stream flow, etc. are expressed as percentiles to allow for comparative analysis. A percentile is a value below which a given percentage of the observations lie. For example, if the observed value for a particular indicator is greater than the lowest 40% of observations during a particular period of record, the drought level is "0", or no drought. The committee will continue to evaluate the results of this effort for applicability for drought prediction and monitoring purposes.

Figure 1-17 Drought levels based on monthly streamflow discharge, January 2006.



Source: Arizona Department of Water Resources, February Drought Monitor Report, 2006.

The Monitoring Technical Committee produces monthly reports, posted on the Department's website (www.azwater.gov). These reports provide an overview of drought conditions in Arizona that include: short-term and long-term drought condition maps; an assessment of reservoir storage; a climate assessment including temperature, precipitation and vegetation status; streamflow and runoff conditions; streamflow forecasts; water conservation tips; and climate and drought forecasts.

Table 1-5 Drought levels based on indicator percentiles.

LEVEL	DESCRIPTION	PERCENTILE
0	No Drought	40.01-100.0%
1	Abnormally Dry	25.01-40.00%
2	Moderate Drought	15.01-25.00%
3	Severe Drought	5.01-15.00%
4	Extreme Drought	0.00-5.00%

Source: Historical Drought Levels of 27 Selected Watersheds in Arizona, USGS, Digital Data Series DDS-62-1, 2005.

The *Arizona Drought Preparedness Plan* also relies on the participation of Local Area Impact Assessment Groups (LAIAG), organized at the county-level to coordinate drought public awareness and to locally monitor drought conditions, identify local impacts and implement mitigation strategies. The LAIAGs provide important local information to the Monitoring Technical Committee that is used to determine drought stage. Primary participants in the LAIAGs are local governmental entities, landowners, water providers, irrigation districts, non-governmental agencies, tribes, federal land management agencies and others. The Interagency Coordinating Group, composed of state and federal entities, advises the Governor of changes in drought status and provides recommendations for improving monitoring, implementation and response.

The Statewide Conservation Program serves two primary functions: to support drought response and to create a water conservation ethic statewide. The statewide effort is intended to expand the reach of existing programs, create new conservation tools for rural communities, promote water education, create guidelines for efficient water use and provide funding and program implementation guidance. In the near-term, the Department's Conservation Office is focusing on technology transfer, education and assistance. Assistance will include help with conservation planning outside AMAs.

The Drought Task Force recommended that the Governor seek legislative authority for the Department to require that all potable water systems develop a drought plan that would identify response options and drought mitigation strategies to reduce drought vulnerability. The Task Force also recommended that the Legislature authorize the Department to require that municipal water systems annually submit water supply information.

In response, the Arizona Legislature passed House Bill 2277 in 2005, which requires community water systems to develop and submit a water system plan to the Department. The plans are intended to improve water management planning, including drought preparedness, at the state and local levels. Certain regulated systems within AMAs are exempt from some of the plan requirements because those requirements would be redundant, such as the annual water use report already required by the Code. The legislation requires water resource planning and statewide water use reporting in a consistent manner, which will identify data gaps and provide information to help the State better identify and respond to water system needs (see also Section 1.2.4). Detailed information on the Arizona Drought Preparedness Plan and House Bill 2277 requirements can be found at www.azwater.gov.

Rural Questionnaires

In March 2003, the Department sent a questionnaire to over 600 rural water providers, jurisdictions (cities and towns), counties and tribal governments in order to gather information on drought impacts in support of preparation of the Arizona Drought Preparedness Plan. Further, it was hoped that information could be gathered about water supply, water use, issues and needs in rural Arizona. The cover letter that accompanied the questionnaire was signed by a number of governmental leaders including the Governor, the President of the Senate and the Speaker of the House. A total of 177 responses were returned, which is considered a very good response rate. Results from the survey were published in October 2004. (ADWR, 2004; www.azwater.gov.)

The 2003 Questionnaire was extensive and included 3 different questionnaires, each tailored to the category of respondent: Water Provider, Jurisdiction and County/Tribal. The questions asked are summarized below for each set of questionnaires.

Water Provider Questionnaire

Water demand
- Number of current and past domestic connections and current population
- Amount of water served to any non-residential customers, by type
- Amount of water used by source
- Whether zoning requirements or homeowners association restrictions result in increased water use

Wells and measurement
- Whether wells and delivery connections are metered
- Number and status of wells (active/inactive)

Growth/Expansion
- Expansion potential of water company and of any others in area
- Projected new large customers

Domestic Wells
- Whether a large number of domestic wells exist in the service area and whether they create problems

Sewer v. Septic
- The percentage of the units in the service area served by a centralized wastewater system

Water-related Issues
- Rank a list of issues including storage, pumping capacity, water levels in wells, need for additional supplies, aging infrastructure, water quality, water rates, drought, etc.

Water Rates
- Rate structure and volume of the average monthly domestic bill in summer and winter

Water Conservation program
- Type of conservation program present and what type of assistance would be most valuable

Drought
- Drought impacts, whether a drought plan is in place and what type of drought assistance would be useful

Water management
- Suggestions for improving water management

Jurisdiction Questionnaire
Water providers • Types of providers serving the jurisdiction and which are most likely to expand to serve new customers *Water Demand* • Estimated percentage of type of water delivered and population within jurisdiction • New non-residential users proposed • Whether domestic wells are a significant source of water *Land Use/Water Use* • Whether lot splitting is a significant concern and if it posed a water supply problem • Whether zoning or homeowners association restrictions result in increased water use *Sewer v. Septic* • The percentage of the units in the service area served by a centralized wastewater system *Water-related Issues* • Rank a list of issues including storage, pumping capacity, water levels in wells, need for additional supplies, aging infrastructure, water quality, water rates, drought, etc. *Water Conservation program* • Type of conservation program present and what type of assistance would be most valuable Drought • Drought impacts, whether a drought plan is in place and what type of drought assistance would be useful *Plans/Management* • Existence of a water supply plan or water resources element, or a drought plan • Impression of Growing Smarter program • Suggestions to improve water management
County and Tribal Questionnaire
Planning • Existence of a water supply plan or water resources element in county plan • Evaluation of current planning process for water planning perspective • Existence of a water element in comprehensive plan if not required • Impression of Growing Smarter program *Land Use/Water Use* • Identification of lands without adequate water supplies for current users • Any proposed new large developments or large commercial/industrial facilities planned and category of use • Whether lot splitting is an issue *Water-related Issues* • Rank a list of issues including storage, pumping capacity, water levels in wells, need for additional supplies, aging infrastructure, water quality, water rates, drought, etc. *Legislation/Assistance* • What legislation or state assistance would be of greatest benefit to ensure future water supplies *Water Conservation program* • Type of conservation program present and what type of assistance would be most valuable *Drought* • Drought impacts, whether a drought plan is in place and what type of drought assistance would be useful

The 2003 Questionnaire Report contains detailed results for the three categories of respondents. The results from the water-related issues section for water providers and jurisdictions is shown in Table 1-7 for each planning area. As shown, infrastructure problems appear to be widespread and include aging infrastructure in need of replacement, inadequate sources of capital to pay for infrastructure improvements, and lack of central wastewater treatment and collection systems. Water supply problems were also widely reported in the Eastern Plateau, and Upper and Lower Colorado River Planning Areas. Respondents in the Central Highlands and Lower Colorado River Planning Areas reported water quality issues: primarily the ability to meet the arsenic standard set by EPA and concern about the proximity of wells to sources of contamination. Although drought was not a major concern for the majority of water

providers and jurisdictions, at least one drought impact was reported by the majority of respondents in the Southeastern Arizona, Central Highlands and Eastern Plateau Planning Areas. (Because there was only one respondent from the Western Plateau, issues were not identified.)

Although the questionnaires were tailored to the three different groups of respondents, there were some common questions. Growth was anticipated by most respondents, but few expected that growth would include large users such as industrial facilities or prisons. Relatively few respondents in any category had a water conservation program and of those that did, most programs consisted of water conservation materials. This likely reflects a lack of resources for anything more extensive, because many respondents mentioned the desire to expand their program.

Table 1-6 2003 Rural Questionnaire issues identification by planning area (from Rural Water Resources 2003 Questionnaire Report).

	PLANNING AREA					
	Central Highlands	Eastern Plateau	Lower Colorado River	South-eastern Arizona	Upper Colorado River	Western Plateau
Number of Water Provider and Jurisdiction Respondents	46	37	27	29	18	1
Number of Water Provider and Jurisdiction Respondents that Ranked Issues	24	23	17	14	11	
ISSUES						
Infrastructure	X	X	X	X	X	
Water Supply		X	X		X	
Water Quality	X		X			
DROUGHT IMPACT						
Majority of Respondents Noted a Drought Impact	X	X		X		

Half of the jurisdictions, two-thirds of the counties, all the tribes and forty percent of the water providers that responded mentioned that they had been affected by the drought but very few reported having a drought plan. While priority issues varied between groups, four were mentioned consistently among the top three: the need for additional water supplies for future needs, lowering water tables, aging infrastructure, and inadequate sources of capital to pay for infrastructure improvements. Interestingly, while many respondents reported that domestic wells were a significant source of water for households in their area, few mentioned that they caused any water supply problems.

To support this initial information gathering effort and to collect additional information to include in the Atlas, the Department conducted a second, brief, direct-contact survey in 2004, focused on 360 rural water providers. Because of the direct contact effort, some level of response was received from 246 water providers, a 65% response rate. The 2004 survey lacked the drought and growth impact focus of the 2003 survey but included questions about water demand and supply, water-level trends, the degree of metering, water quality and issues.

The highest priority issue identified from this survey was the lack of capital for infrastructure repair. This mirrors the 2003 questionnaire results. Other priority issues were drought, inadequate supplies for the future, meeting the arsenic standard and infrastructure problems.

Table 1-8 shows a summary of results from the 2004 survey. The issues list is not identical to the 2003 survey and the rating system was different. Respondents were asked to rank issues on a scale of 0-3 with "3" representing a major concern, "2" a moderate concern, "1" a minor concern and "0" no concern. Similar to the 2003 report, issues have been compressed into categories. The infrastructure category includes infrastructure in need of replacement and inadequate capital to pay for infrastructure improvements. The water supply category includes inadequate supply for either current or future demand. The storage and capacity category includes inadequate storage capacity to meet peak demand and inadequate well capacity to meet peak demand. With the exception of drought impact (because there was only one question compared to two each for the other issue categories), an "X" indicates that a majority of respondents identified an issue as a major or moderate concern. More detail from both the 2003 and 2004 surveys is provided in the planning area volumes.

Table 1-7 2004 Rural Questionnaire issues identification by planning area.

	PLANNING AREA					
	Central Highlands	Eastern Plateau	Lower Colorado River	South-eastern Arizona	Upper Colorado River	Western Plateau
Number of Water Provider Respondents	71	44	14	56	30	10
Number of Water Provider Respondents that Ranked Issues	66	39	14	46	23	10
ISSUES						
Infrastructure	X	X	X	X	X	
Water Supply	X		X	X	X	X
Storage/Capacity		X	X	X	X	
Majority of Respondents Noted a Drought Impact	X			X	X	

Arizona Department of Water Resources Studies, Reports and Activities

The Department collects surface water and groundwater data statewide and produces technical documents, reports and special studies of critical areas. The Department's Hydrology Division provides data, technical assistance and hydrologic reviews to all divisions of the Department and to local water users, state agencies and the federal government. This hydrologic information is often organized by groundwater basin or by AMA. The Department cooperates with the United States Geological Survey (USGS) on production of USGS Water Withdrawals Reports. The report *"Water Withdrawals for Irrigation, Municipal, Mining, Thermoelectric-Power, and Drainage Uses in Arizona Outside of Active Management Areas, 1991-2000"* (Scientific Investigations Report 2004-5293), with unpublished updates, was used for the water demand estimates in the Atlas in most cases.

The Groundwater Modeling Section of the Department's Hydrology Division develops numerical groundwater flow models for various areas in the state. Models for the Phoenix, Pinal and Prescott and Tucson AMAs have been completed and a model for the Santa Cruz AMA is nearing completion. Outside the AMAs, the Department has developed a Yuma area model to test the effect of increased drainage well pumpage and lining of irrigation canals on high water-table levels in urbanized sections of the Yuma Valley. This model was provided to the U.S. Bureau of Reclamation, which operates and maintains it. The Department also developed a groundwater flow model of the Sierra Vista subwatershed of the Upper San Pedro Basin and used it to simulate several different potential growth

patterns and potential effects on surface water flows *(ADWR Modeling Report No.10 and Supplement, 1996).*

The Department's Basic Data Unit annually collects groundwater level measurements from approximately 4,000 wells statewide. Of these, there are approximately 2,000 "index wells". Hundreds of water quality samples are also collected annually as funding allows. The Unit develops Hydrologic Map Series (HMS) Reports that show groundwater conditions by basin. To date the Department has produced 34 HMS reports, 27 of which are of areas outside the AMAs. The Department has also produced six hydrologic monitoring reports: two for the Phoenix AMA, three for the Prescott AMA and one for the Santa Cruz AMA. These reports are available from the Department. Groundwater data are stored in the Department's ORACLE Groundwater Site Inventory database (GWSI). GWSI is a field-verified database consisting of thousands of wells including locations, current and historic water-level information, discharge and field water quality data. This database is available from the Department on CD in a Microsoft Access version.

The Department's Basic Data Unit has also begun using automated groundwater data collection devices in the past few years. The continuous record of water-levels allows data users to monitor the hydrologic behavior of groundwater systems more completely and to assess changes more accurately. They also allow changes in aquifer storage capacity to be tracked on a frequent basis and to better relate changes in water levels to groundwater pumpage and riparian demand. A primary purpose of the automated sites is to collect additional data in areas subject to rapid change, such as high growth areas or areas that are sensitive to change. Monitoring sites are also selected to characterize large geographic areas and general aquifer conditions. There are plans to make the transducer data continuously available through the Department's website. The Department and the USGS operated 52 automatic water-level recording sites outside AMAs in 2005 shown on Figure 1-18. There are plans to add additional sites, if funding permits, in areas where hydrologic data are needed. Flagstaff, Williams, Vidler Water Company (Harquahala Basin) and Tucson Electric Power Company (Little Colorado River Plateau Basin) operate an additional 29 recording sites. A map of automatic water-level recording sites in AMAs is provided in Volume 8.

The Department's Geophysics/Surveying Unit gathers, processes and interprets land subsidence and aquifer storage data and supports other departmental programs as needed. The data consist primarily of Global Positioning System (GPS) positions and elevations at discrete points, absolute and relative gravity values at discrete points and Synthetic Aperture Radar satellite data that cover several critical areas of the State. Much of the unit's activities have been conducted within the State's AMAs, primarily for subsidence monitoring. The unit has also mapped depth to bedrock in the Hassayampa subbasin of the Phoenix AMA. However, the unit has also performed GPS measurements at rural WQARF sites and, in 2006 began conducting gravity surveys in several groundwater basins in the Upper Colorado River Planning Area in support of a hydrologic investigation of rural watersheds effort in cooperation with the USGS. Micro-gravity measurements can yield data on aquifer storage capacity.

The Water Quality Assurance Revolving Fund (WQARF) was created under the Environmental Quality Act of 1986 to support hazardous substance cleanup efforts in the state. The Department's WQARF Technical Support Unit provides hydrologic support and technical review of many water quality-related activities that involve the Department. The WQARF unit has published site-specific well construction and abandonment procedures for areas in Yuma and for the Pinal Creek WQARF site. Additional areas of water quality concern have been identified for special well construction standards including portions of the town of Quartzite.

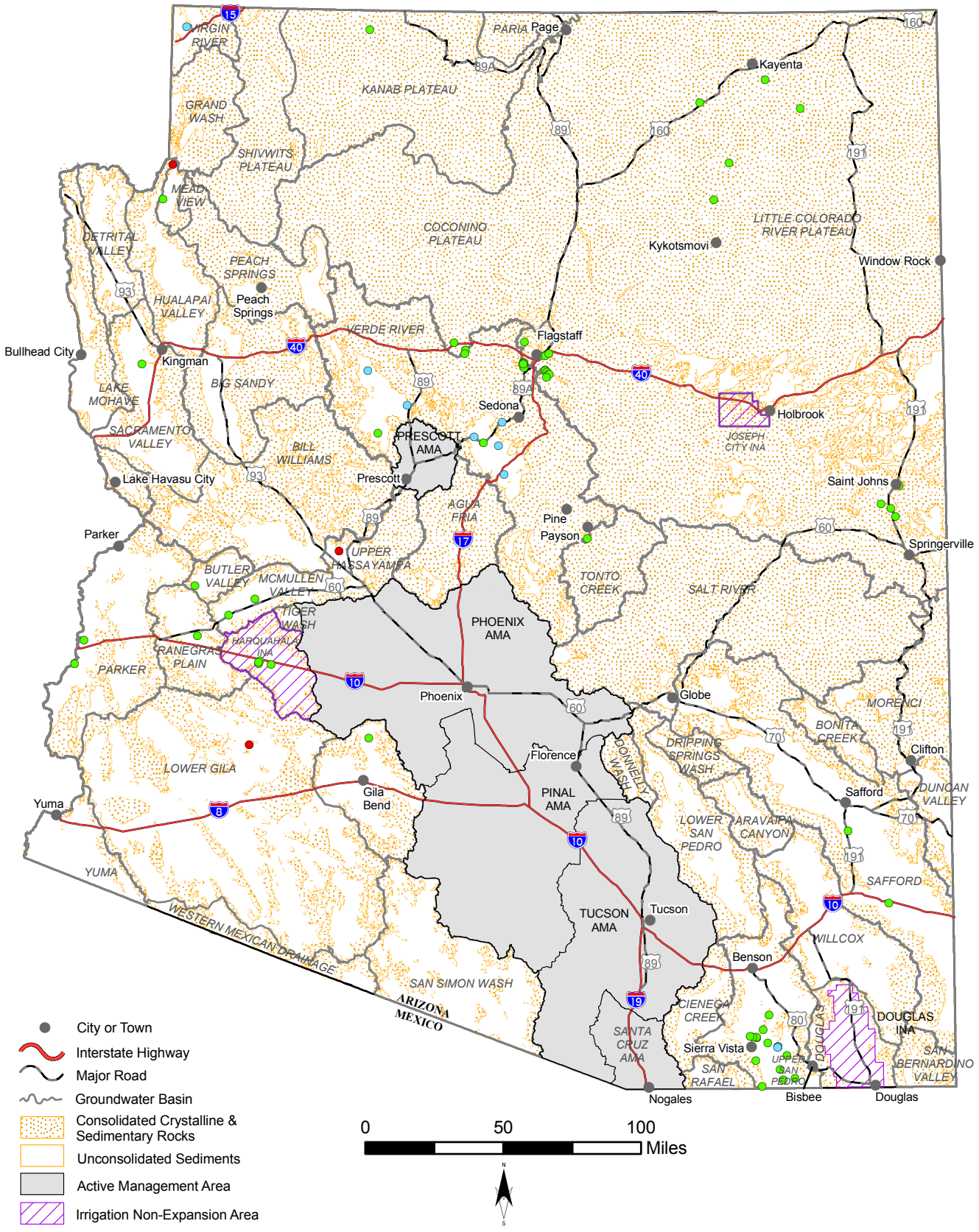


Figure 1 - 18
Automatic Water - Level Recording Sites in Non-AMA Groundwater Basins as of 2005

The Department's Dam Safety and Flood Mitigation Division is responsible for the safety of all non-federal dams in Arizona. It conducts field investigations to evaluate whether safety deficiencies exist and to develop action plans to remove deficiencies. The Division also reviews applications for proposed dams and monitors new dam construction and the repair of existing dams to reduce the likelihood of catastrophic dam failure. The Flood Mitigation Section participates in flood mitigation programs, administers the Community Assistance Program, assists in delineating floodplains and developing flood control projects, sets state standards for floodplain management and coordinates the planning, design, and construction of flood warning systems. The Section works closely with other state and local entities to administer the National Floodplain Insurance Program and to augment the statewide flood-warning network. Data on non-federal dams and on flood warning system gages for non-AMA groundwater basins are presented in Volumes 2-7 and for AMAs in Volume 8.

The Department staffs the Arizona Water Protection Fund (AWPF), administered by a fifteen member Commission. The AWPF was established to provide funding to support projects that enhance and restore rivers, streams and riparian habitats in Arizona. A number of AWPF Grants have been disbursed to fund projects in rural Arizona. A description of the AWPF including a list of grants and a map showing the location of projects by planning area is found in Appendix C.

Notable Department studies conducted outside AMAs include:

- Numerous Hydrologic Map Series Reports (1980-present)
- Numerical Model and Scenario Simulations of the Yuma Area Groundwater Flow Model Arizona, California, and Mexico: in Cooperation with the Yuma County Flood Control District (1993).
- Arizona Water Resources Assessment (1994).
- The Arizona Riparian Protection Program Legislative Report (1994).
- Groundwater Flow Model of the Sierra Vista Subwatershed and Model Scenarios of Future Groundwater and Surface Water Conditions of the Upper San Pedro Basin (2 reports, 1996).
- Verde River Watershed Study (2000).
- Upper San Pedro Basin Active Management Area Review Report (2005).

A number of studies have been conducted by the Department within AMAs. These include:

- Numerous Hydrologic Map Series Reports (1980-present).
- First Management Plans (1980-1990) for the Phoenix, Pinal, Prescott, and Tucson AMAs.
- Second Management Plans (1990-2000) for the Phoenix, Pinal, Prescott, and Tucson AMAs.
- Third Management Plans (2000-2010) for the Phoenix, Pinal, Prescott, Santa Cruz and Tucson AMAs.
- Santa Cruz AMA Hydrologic Monitoring Report (1997-2001).
- Prescott AMA Hydrologic Monitoring Reports (2000-2001; 2001-2002; 2002-2003).
- Phoenix AMA Annual Status Reports (Comprehensive Hydrologic Monitoring Plan) (2001-2002; 2002-2003; 2003-2004).
- Numerous groundwater modeling reports for the Pinal, Phoenix, Prescott and Tucson AMAs.

The two general stream adjudications in Arizona are the Gila River System and Source and the Little Colorado River System and Source. The Department provides technical and administrative support to the stream adjudication court and the special master, including investigation of surface water rights claims and preparation of technical reports. By statute, the Department is required to prepare and publish comprehensive Hydrographic Survey Reports (HSRs) for each of the watersheds within the two adjudications. HSRs are multi-volume publications that involve intensive data collection and field

inspection efforts including detailed information regarding hydrology and water rights claims. Preliminary, final and supplemental HSRs and other adjudications-related reports are:

- Hydrographic Survey Report for the Silver Creek Watershed, ADWR, November 30, 1990.
- Hydrographic Survey Report for the San Pedro River Watershed, ADWR, November 20, 1991
- Hydrographic Survey Report for the Upper Salt River Watershed, ADWR, Draft December 1992.
- Technical Assessment of the Fort McDowell Indian Community Water Rights Settlement, ADWR, May 1993.
- Little Colorado River Settlement Committee Group "A" – In-Basin Negotiating Committee Inventory of Irrigation, Reservoirs, and Stockponds in the Upper Little Colorado River Watershed, ADWR, July, 1994.
- Little Colorado River Settlement Committee Group "A" – In-Basin Negotiating Committee Inventory of Irrigation and Reservoirs in the Lower Little Colorado River Watershed, ADWR, September 1994.
- Hydrographic Survey Report for Indian Lands in the Little Colorado River System, ADWR, September 1994.
- Hydrographic Survey Report for the Gila River Indian Reservation, ADWR, December 1996
- Technical Assessment of the San Carlos Apache Tribe Water Rights Settlement, ADWR, May 1999.
- Supplemental Contested Case HSR for Phelps Dodge's Claims to Show Low Lake, January 2005.

Federal, Tribal, Local and Other State Agency Roles in Water Management

The role of Indian Nations in water supply and management in Arizona, is becoming increasingly important. With approximately 28% of Arizona land held in Trust by the federal government for the benefit of Native Americans, the determination of Indian water rights and water use by Indian communities have a significant impact on water supplies and water management in the state. Non-AMA areas affected by Indian water rights include the Coconino Plateau Basin, the Little Colorado River Basin, the Lower San Pedro Basin, the Upper Gila River, the Verde River Basin, the Mogollon Rim, Northwestern Arizona south of the Colorado River in the rapidly developing greater Kingman area and in the Yuma and Parker Basins. Indian settlements are also a major factor in water management in the Phoenix, Pinal and Tucson AMAs.

Passage of the Arizona Water Settlements Act of 2004 (P.L. 108-451), the largest settlement in terms of dollars and volume of water in the West, represents a major milestone in providing certainty about water supplies in much of central and parts of southeastern Arizona. The settlement involves 40 parties in six counties and provides 653,500 acre-feet of water to the Gila River Indian Community and 76,000 acre-feet to the Tohono O'odham Nation.

The Act and its side agreements have significant implications for water management and access to water in parts of rural Arizona. These agreements include limits on access to water, restriction of agricultural irrigation to historic acreage, caps on water use that may affect municipal and industrial use, and limits on the number of new wells in certain areas. There is a prohibition against the construction of new large reservoirs in the Upper San Pedro Basin and a blanket waiver from future lawsuits in Cochise County in exchange for no limits on agriculture. While the settlement creates limitations on non-Indians, it does not adjudicate their rights nor does it restrict groundwater use except in designated impact zones. Passage of the law requires substantive changes to state law.

The Fort McDowell Indian Community (FMIC) settlement in 1990 entitles the FMIC to an annual entitlement of 35,950 acre-feet from the Verde River and CAP. Provisions of the settlement allow for 100-year leases of the CAP portion to off-reservation users in Maricopa, Pima, and Pinal and Counties. The City of Phoenix has a lease of 4,300 acre-feet per year.

The San Carlos Apache Tribe Settlement Act of 1992 awarded an annual entitlement to the Tribe of 71,435 acre-feet of water from the Salt River, Gila River, Black River and CAP. The CAP portion may be leased to off-reservation users within Graham, Greenlee, Maricopa, Pima Pinal, and Yavapai, counties. There are a number of parties to the settlement agreement, which includes a 100-year lease for a portion of the Tribe's CAP water with the City of Scottsdale. The water rights claims of the Tribe to the Gila River side of the reservation still need to be resolved.

The water rights claims of the Navajo Nation, the Hopi Tribe, and the San Juan Southern Paiute within the Little Colorado River Plateau (LCR) Basin are still unresolved. These claims involve both the Little Colorado River and the Colorado River. Claims to the Colorado River are complicated by provisions of the Law of the River, which restrict transfers between the Upper Basin and the Lower Basin. Discussions have included proposed pipelines to move water from various sources to areas within the LCR Basin, including partnerships with non-Indian entities. Talks also continue with the San Carlos Apache Tribe regarding uses in the upper Gila River. A complete description of Indian Water Rights settlements is found in Appendix D.

A number of federal agencies have water supply and management authorities in Arizona, in part because 48% of the state is comprised of federal land. Federal agencies and laws are discussed in more detail in Appendix E.. Management of the Colorado River involves a complex array of management authorities, determined over the years by federal laws, court cases, interstate compacts and an international treaty, collectively called "the Law of the River." These laws have resulted in dam construction, apportionment of Colorado River water to the basin states and to Mexico, salinity reduction requirements and other actions that affect water management in Arizona. The Bureau of Reclamation administers the Colorado River reservoirs and contractual arrangements for the use of Colorado River water and is involved with regional planning activities, water conservation programs and water augmentation feasibility studies.

The USGS gages streamflows, conducts scientific analyses of hydrologic resources, and produces reports on Arizona water use by sector and source. The U.S. Forest Service (USFS) develops plans that include watershed management criteria to protect and enhance runoff and holds many surface water rights for various uses. The U.S. Bureau of Land Management (BLM) is a major landowner in the state and has responsibility for some key water management areas such as the San Pedro Riparian National Conservation Area. The U.S. Environmental Protection Agency (EPA) implements national programs that include watershed management, groundwater protection, water quality standards, toxic waste cleanup and border-region environmental programs.

In addition to the Department, other state agencies and authorities influence water management in Arizona. The CAWCD is a multi-county, tax-levying public improvement district of the state, responsible for operating and maintaining the CAP and managing the construction repayment costs to the federal government. The CAWCD Board sets policy, including pricing and delivery scheduling priorities. In recent years, Arizona has utilized its entire allotment of Colorado River water, either by direct use or through storage in underground aquifers.

Many communities in rural Arizona are served by private water companies that are regulated by the Arizona Corporation Commission (ACC). The ACC is a constitutionally formed commission with an elected 5-member board. Among its responsibilities is regulatory authority over private water and private sewer companies. It regulates rates and authorizes curtailment tariffs that allow a utility to request that customers reduce water consumption when the demand is greater than the production.

Private water companies lack many of the water management tools available to public utilities and are generally required to keep cost of service low. However, the ACC is increasingly considering rate increases to allow renewable supply utilization and for modest water conservation programs.

Public water systems have rate-setting and water use ordinance authorities. The larger municipal utilities are more likely than private water companies to have long-range management plans, construct effluent conveyance systems and have the financial resources to implement conservation and other water management programs.

Funding water infrastructure improvements is a major problem in some areas. Community development block grants through the Arizona Department of Commerce and the Greater Arizona Development Authority (GADA) are a source of funding. In addition, the Water Infrastructure Finance Authority (WIFA), an independent state Agency, offers below market interest on loans to finance the construction, rehabilitation and/or improvement of drinking water, wastewater, wastewater reclamation and other water quality facilities and projects.

The Arizona Department of Environmental Quality (ADEQ) has a Water Quality division. Core responsibilities include pollution control, monitoring and assessment, compliance management, cleanups of contaminated soil and water, education, outreach and financial assistance and policy development. Its programs influence water supply planning and operations at the local level. (See Appendix A).

SECTION 1.3 Data Sources and Methods

This section describes the sources of data and methods of analysis for tables and maps presented in Volumes 1-7 of the Atlas. Volume 8, AMA Planning Area, will contain additional information, requiring discussion of supplementary data sources and methods that will be included in that volume. These descriptions may not completely explain some of the details of the data evaluation and analysis in all cases. More detailed information may be obtained by contacting the Department's Statewide Water Conservation and Strategic Planning Division.

1.3.1 Adequacy Determinations

Information related to the Department's water adequacy determinations is presented on basin-scale maps (*Location of Water Adequacy and Inadequacy Determinations)* and summarized in a table for each basin (*Water Adequacy and Inadequacy Determinations)* in Volumes 2-7. The tables include subdivision names, number of lots, location data, Department application numbers, determination dates, reasons for inadequate determinations, and water providers.

Sources for this information come from the Department and include electronic databases maintained by the Office of Assured and Adequate Water Supply and paper files stored in the Hydrology Division. Database queries were reviewed and some information was excluded from the Atlas based on subdivision location, duplicate applications, etc. Paper files were also reviewed to complete information that had not been entered into the databases such as number of lots and reasons for inadequate determinations.

Sources for assured water supply determinations come from the Department and include electronic databases maintained by the Office of Assured and Adequate Water Supply and paper files stored in the Hydrology Division.

Each determination of the adequacy of water supplies available to a subdivision is based on the information available to the Department and the standards of review and policies in effect at the time the determination is made.

1.3.2 Aquifers

Flow Direction

Groundwater flow directions are presented on basin-scale maps (*Groundwater Level Conditions).* This information was taken from a variety of technical reports prepared by the Department and the USGS. Flow directions are not shown for some basins, either because of insufficient groundwater level data and/or complex subsurface geology. The flow directions that are shown in the Atlas generally reflect long-term, regional aquifer flow in the basin and are not meant to depict temporary or local-scale conditions.

Major Types

Major aquifer types are listed in a table for each basin (*Hydrogeologic Data)* and are generally described in the text for each planning area volume. Information on aquifer types was taken from Volume II of the Department's 1994 *Arizona Water Resources Assessment.* To ensure consistency and simplify comparison between basins, aquifer descriptions from the 1994 *Assessment* were reviewed and grouped in the Atlas into five basic aquifer types:

- Basin fill;
- Igneous and metamorphic rocks;
- Recent stream alluvium;
- Sedimentary rock; and
- Volcanic rock.

In some basins, two or more of these aquifer types are found. Also, several aquifers in Arizona have been given specific names related to their geologic formation or location. Where known and applicable, this information is included in the Atlas. The aquifers in most basins can be further described by their rock type or sediment grade (e.g. sandstone vs. limestone) and position in the geologic sequence (e.g. upper vs. lower basin fill). This level of detail is not provided in the Atlas, but for reference, can be found in the 1994 *Assessment*.

Recharge and Storage

Estimates of aquifer recharge and storage are listed in a table for each basin (*Hydrogeologic Data).* The estimates are based on one or more of six primary data sources:

- *Phase I; Arizona State Water Plan* published by the Arizona Water Commission in 1975;
- A 1986 study by the USGS of predevelopment hydrologic conditions in the alluvial basins of Arizona and adjacent states;
- A 1990 internal report by the Department summarizing water resources information for the groundwater basins;
- Volume II of the Department's 1994 *Arizona Water Resources Assessment*;

- A 1995 report by the USGS describing groundwater flow models developed for selected alluvial basins in south-central Arizona and parts of adjacent states; and,
- Various hydrologic reports and maps prepared by the USGS and the Department for select basins and subbasins across Arizona.

In many cases, these data sources provide information for areas that do not exactly coincide with the Department's groundwater basins. It was often necessary to adjust reported recharge and storage values to account for these differences in basin area as well as the location of the border between basin fill and bedrock and zones of high recharge (i.e. along or near mountain fronts).

Aquifer recharge is a difficult hydrologic parameter to measure and, on a regional level, it is usually determined indirectly either through development of water budgets and/or use of groundwater flow models. The recharge estimates presented in the Atlas generally represent long-term, natural (predevelopment) conditions. Wet and dry periods are averaged and artificial recharge is not considered. Such factors can significantly affect aquifer recharge in a given year. Aquifer storage is also a difficult parameter to measure and the estimates in the Atlas were usually based on a combination of point data from wells and results from large-scale surface geophysical surveys. Where aquifers consist of consolidated rock and storage is controlled by fractures, storage estimates can be highly unreliable. In light of these uncertainties, the Atlas often provides more than one estimate of aquifer recharge and storage for each basin.

1.3.3 Climate

Average Annual Precipitation

Average annual precipitation, in inches, is shown on basin-scale maps (*Meteorological Stations and Annual Precipitation*). Contour lines and color-coding are used on the maps to delineate areas of equal and similar precipitation. This precipitation information comes from the Spatial Climatic Analysis Service (SCAS) at Oregon State University. Using an analytical tool called PRISM (Parameter-elevation Regressions on Independent Slopes Model), SCAS analyzed regional precipitation data averaged over the period 1961-1990 and prepared digital precipitation maps for the United States in 1998. The Department downloaded the PRISM map for Arizona from the SCAS website.

Evaporation Stations

Evaporation data collected from AZMET and pan stations are summarized in a table for each basin (*Climatic Data*) and station locations are shown on basin-scale maps (*Meteorological Stations and Annual Precipitation*). Arizona Meteorological Network (AZMET) stations are operated in southern and Central Arizona and provide weather-based information to agricultural and horticultural interests. Pan stations refer to Class A evaporation pans that are used to estimate evaporation rates from natural surfaces such as shallow lakes and wet soils. Summary tables in the Atlas list the name and elevation of these stations, their period of record, and average annual evaporation rates in inches. Note that the pan evaporation rates listed are usually adjusted by multiplying by 0.7 or 0.8 before being used to estimate natural conditions. Reference evapotranspiration (Eto) rates are listed for the AZMET stations and refer to the amount of water evaporated and transpired by well-maintained, well-watered turf grass.

Data from the AZMET stations were downloaded from a website maintained by the University of Arizona Cooperative Extension, and data from the pan stations were downloaded from a website

maintained by the Western Regional Climate Center (WRCC). Pan data were presented as monthly averages, which the Department summed for all months and presented as an annual average. Some pan stations did not measure evaporation rates during winter months and others estimated those rates using other meteorological data.

Several factors can affect evaporation rates, including air temperature, humidity, and wind. The data presented in the Atlas represent conditions at the measuring stations and provide a general indication of average evaporation rates in the basin. Care should be taken when using these data for site-specific studies.

Precipitation and Temperature Stations

Precipitation and temperature data from a network of weather stations are summarized in a table for each basin (*Climatic Data*) and station locations are shown on basin-scale maps (*Meteorological Stations and Annual Precipitation*). The summary tables list the name and elevation of these stations, their period of record, and temperature and precipitation data. Temperature data include average minimum and maximum temperatures in degrees Fahrenheit and in which months these extremes occur. Precipitation data include average seasonal precipitation and average annual precipitation in inches. Seasons are defined in the Atlas as follows:

- Winter – January through March;
- Spring – April through June;
- Summer – July through September; and
- Fall – October through December.

The weather stations presented are part of a cooperative network maintained by the National Oceanic and Atmospheric Administration (NOAA) and the National Weather Service (NWS). Data from these stations has been compiled by the WRCC and posted on its website. Statistics presented in the summary tables were downloaded directly from this website. Several factors can affect temperature and precipitation rates, particularly elevation and other geographic features. The data presented in the Atlas represent conditions at the measuring stations and provide a general indication of average temperature and precipitation conditions in the basin. Care should be taken when using these data for site-specific studies.

Snowfall Stations

Snowfall data from Snowcourse and Snowpack Telemetry (SNOTEL) stations are summarized in a table for each basin (*Climatic Data*) and station locations are shown on basin-scale maps (*Meteorological Stations and Annual Precipitation*). The summary tables list the name and elevation of these stations, their period of record, and snowpack measurements. The average snowpack at the beginning of each month is presented as inches of snow water content, also referred to as the snow water equivalent. Only those months when snow surveys are usually conducted (January through June) are included.

Snowcourse and SNOTEL stations are operated by the Natural Resources Conservation Service (NRCS). Data from these stations have been compiled by NRCS and posted on its website. Statistics presented in the summary tables were downloaded directly from this website. Many factors can affect snowpack depths such as aspect, elevation and forest cover and NRCS takes great care to locate snow course and SNOTEL stations that provide representative data. Nevertheless, the data presented in the

Atlas represents conditions at the measuring stations and only provides a general indication of average snowfall conditions across the highlands of some basins. Care should be taken when using these data for site-specific studies.

Trends in Precipitation and Temperature

Long-term trends in precipitation and temperature are shown statewide in Section 1.2.2 of this volume, and by planning area in Volumes 2 through 8. Trend data are presented graphically with explanatory text. This information was contributed by researchers at the University of Arizona, including the Institute for the Study of Planet Earth, which is responsible for the Climate Assessment for the Southwest (CLIMAS) program.

1.3.4 Contamination Sites

Contamination sites are shown on planning area maps (*Contamination Sites*). Included are the locations of U.S. Department of Defense (DOD), Voluntary Remediation Program (VRP), Superfund (listed on the National Priorities List or NPL) and WQARF sites as well as leaking underground storage tanks (LUST).

The data provided by ADEQ included locations for all LUST sites in Arizona, regardless of reported contaminant levels or whether remediation had been completed. For purposes of the atlas, LUST sites are only shown where contamination is either suspected or known to exist and remediation is required to meet soil and water quality standards. LUST sites that meet applicable standards and/or have been remediated and closed-out are not included.

1.3.5 Cultural Water Demands

Location of Major Water Use

Locations of major water use are shown on basin-scale maps (*Cultural Water Demands*). Included on the maps are agricultural lands, low- and high-intensity developments, mines and power plants. The primary data source for the water use maps was a land cover study of the southwestern United States, completed by the USGS in 2004. Land cover types were mapped in this study at a 5- to 12-acre resolution using Landsat satellite imagery collected between 1999 and 2001. The Department supplemented the data with the locations of active power plants and mines.

Due to its resolution, use of Landsat imagery to map land cover types requires a high degree of interpretation and some areas of water use, particularly agricultural lands, may be misclassified. The Department reviewed the USGS land covers to ensure that they were reasonable and made edits as needed. It should also be noted that the Landsat imagery used by the USGS is now over five years old, and some land cover types may have changed since the imagery was taken.

Surface Water Diversions

Annual surface water diversions for agriculture, industrial, and municipal uses are listed in a table for each basin (*Cultural Water Demand*). Data on surface water diversions is also summarized by planning area in the text for these volumes.

Diversion data for the period 1971-1990 were taken from the Department's 1994 *Assessment*. A variety of sources were utilized to determine more recent surface water diversions for the period 1991 through 2003. ADEQ furnished a list of municipal water providers who utilize surface water and the ACC supplied annual reports for some of these providers indicating how much surface water they were diverting and/or delivering. USGS provided data on surface water diversions for agriculture for those basins where the diversions have been metered. Most other surface water diversions had to be determined by the Department through one or more methods including review of existing Department, BOR, county, and consultant reports; analysis of recent aerial photography; Internet and records research; questionnaires and phone interviews; consultation with the USGS; and, limited fieldwork. The Department's Colorado River Management Section was an important data source and provided records of Colorado River water users, locations and annual diversion volumes.

In many cases, the Department had to estimate the quantity of surface water being diverted because the records were nonexistent, imprecise or incomplete. For example, to estimate unmetered surface water diversions for agriculture, the Department made assumptions about the number of cropped acres and water duty. For some irrigated areas, diversion amounts were adjusted to account for basin boundaries. Similarly, for most golf courses determined to be using surface water, the Department estimated diversions based on the number of holes and local irrigation needs for turf. The quantity of surface water diverted by municipal water providers was estimated in some cases based on the number of hookups, an assumed per capita use rate and delivery losses.

As previously mentioned, the quantity of surface water diverted for agricultural, industrial, and municipal use was often unmetered and had to be estimated by the Department. Historic diversions were assumed to represent current conditions and vice versa. if information was not available. Assumptions were also made where water demands were met by combining surface water diversions and well pumpage, but the precise volume of each was not known. Furthermore, it is likely that several relatively small surface water diversions were simply not identified by the Department and not included in the Atlas. The values presented in the Atlas should, therefore, not be considered precise, but they provide an estimate of these diversions and indicate where surface water is an important water source to meet cultural demands. The following conventions were used to round cultural demand values met by surface water diversions:

- 0 to 1,000 acre feet – round to the nearest 50 acre-feet;
- 1,000 to 10,000 acre-feet – round to the nearest 100 acre-feet;
- 10,000 to 100,000 acre-feet – round to the nearest 500 acre-feet; and
- 100,000 to 1,000,000 acre-feet – round to the nearest 1,000 acre-feet.

Finally, it should be noted that surface water diverted into reservoirs and stockponds and through fish hatcheries were not included in the cultural demand tables. Practically all of the surface water diverted by fish hatcheries passes through the facilities and is released for use downstream. Surface water diverted into reservoirs and stockponds may or may not be released for use downstream and some of the stored water may be lost to evaporation.

Well Pumpage

Annual well pumpage for agricultural, industrial, and municipal uses is listed in a table for each basin (*Cultural Water Demand*). Data on well pumpage are also summarized by planning area in the text of the planning area volumes. Well pumpage data for the period 1971 through 1990 are from the

Department's 1994 *Assessment*. For the period 1991 through 2003, the primary data source for well pumpage was the USGS, which describes its methodology, assumptions, and data limitations in the 2005 report *Water Withdrawals for Irrigation, Municipal, Mining, Thermoelectric-Power, and Drainage Uses in Arizona Outside of Active Management Areas, 1991-2000.*

The Department had to adjust the USGS pumpage values for a few basins where mining companies pump from the same wells to supply both industrial and municipal needs and, in other basins where springs have been identified as a water source. The USGS accounted for water use from springs as well pumpage, whereas the Department considers these to be surface water diversions. In addition, the USGS did not evaluate water use by feedlots and golf courses. The Department considers both to be industrial uses and, for the Atlas, estimated well pumpage following methods similar to those used to estimate surface water diversions. To estimate well pumpage for feedlots, the Department identified feedlots by using ADEQ's list of active feedlots in Arizona and, based on the type and number of animal units at each feedlot, applied a consumptive rate.

The quantity of well pumpage for agricultural, industrial and municipal use was not always metered, requiring estimation in some cases. Historic pumpage was assumed to represent current conditions, and vice versa, if information was unavailable. Assumptions were also made where water demands were met by combining well pumpage and surface water diversions, but the precise volume of each was unknown. Lastly, it is likely that several relatively small well withdrawals were simply not identified by the USGS or the Department and are not included in the Atlas. The values presented in the Atlas should, therefore, not be considered precise, but they provide an estimate of pumpage and indicate where well water is an important water source to meet cultural demands. The following conventions were used to round cultural demand values met by well pumpage:

- 0 to 1,000 acre feet – round to the nearest 50 acre-feet;
- 1,000 to 10,000 acre-feet – round to the nearest 100 acre-feet;
- 10,000 to 100,000 acre-feet – round to the nearest 500 acre-feet; and,
- 100,000 to 1,000,000 acre-feet – round to the nearest 1,000 acre-feet.

1.3.6 Drought

Section 1.2.5 of this volume presents drought information for the entire state including a description of Arizona's Drought Preparedness Plan. A statewide map (*Drought Levels Based on Monthly Streamflow Discharge – January 2006)* shows recent drought conditions for selected watersheds. A table (*Drought Levels Based on Percentiles*) presents drought levels identified in the Operational Drought Plan.

Drought is also discussed under the Climate Section of this volume, which contains several graphs and a table. Further discussion of drought conditions in each planning area is presented in Volumes 2 through 8. Drought information was provided by the Department's Drought Planning Section, University of Arizona Cooperative Extension, CLIMAS/Institute for the Study of Planet Earth, and the USGS.

1.3.7 Effluent

Facility Data

Information on facilities that treat and discharge effluent is summarized in a table for each basin (*Effluent Generation*). For each treatment facility, the tables list the name, owner, plant location, population served, volume of effluent treated/generated annually (and the year measured), effluent disposal methods, levels of treatment, and the unserved population.

Primary data sources were the Clean Water Needs (CWN) Surveys sponsored by the Water Infrastructure Financing Authority (WIFA), and annual reports provided by the ACC. CWN Surveys are conducted every four years and are used to assist treatment facilities in obtaining funding. To capture data for as many treatment facilities as possible, survey results from 1996, 2000 and 2004 were used for the Atlas. The ACC regulates private treatment plants and requires that operators file annual reports that sometimes included data on effluent production. The data were supplemented, when possible, with information from facility operators, from ADEQ, (which issues facility discharge permits), and Department reports.

Wastewater treatment is a dynamic industry with frequent changes in plant names, treatment levels and effluent volumes. Although the last CWN survey was conducted in 2004, updated information was not available for all facilities. The Department used the most recent data available, which for some facilities is nearly 10 years old.

Effluent Dependent Waters

The location of effluent-dependent waters, including lakes and stream reaches, are shown on basin-scale maps (*Water Quality Conditions)*. A recent (2005) GIS cover of effluent- dependent waters in Arizona was provided by ADEQ. These reaches are also listed and described by ADEQ in their surface water quality rules (A.A.C. R18-11-113).

1.3.8 Land Ownership

Land ownership information is presented on basin-scale maps (*Land Ownership*) and summarized in the text. Included on the maps are the location of major landowner types (e.g. private, BLM, NPS, etc.) and the percentage that each type comprises of the total basin area. Data on current land ownership was downloaded from the Arizona Land Resource Information System (ALRIS) website maintained by the Arizona State Land Department (SLD).

1.3.9 Lands Survey

A number of Atlas maps show township and range lines. Most lands in Arizona have been mapped according to a rectangular coordinate system known as the Public Lands Survey. Under this survey, lands are divided into “townships” and “sections.” A township is a square parcel of land six miles on each side that is subdivided into 36 equal parts called sections. A section covers one square mile or 640 acres. Because of the earth’s curvature, surveying errors and other factors, not all townships are square, not all townships contain 36 sections, and not all sections contain 640 acres.

Townships are located relative to a point that forms at the intersection of an east-west "baseline" and a north-south "meridian." Locations are referenced as being so many six-mile units, called "Townships", north or south of the baseline and so many six-mile units, called "Ranges," east or west of the meridian. Most of Arizona's townships were surveyed relative to the point of intersection of the Gila and Salt Rivers, referred to as the Gila and Salt River Baseline and Meridian. Approximately 20 townships in Apache County were surveyed from the Navajo Baseline and Meridian established in New Mexico, and a small portion of land near the town of Yuma was surveyed from the San Bernardino Baseline and Meridian established in California.

Townships surveyed from the Gila and Salt River Baseline and Meridian are plotted on all basin-scale maps in the Atlas. This information was digitized from USGS Quads. Townships surveyed from the Navajo and San Bernardino Baselines and Meridians have not been plotted, but these are included on the base map that was used to prepare *Geographic Features* maps. Note that in some areas in Arizona no townships have been surveyed. These include a large portion of the Navajo and Hopi Indian Reservations in northeastern Arizona, a small portion of the San Carlos Indian Reservation in east-central Arizona, and several Spanish land grants in southeastern Arizona. To provide general mapping reference, Department staff protracted these unsurveyed areas extending townships based on the Gila and Salt River Baseline and Meridian into these areas. These unofficial townships are included on maps in the Atlas.

1.3.10 Population

Population data are listed in a table for each basin (*Cultural Water Demands)*. The tables include yearly estimates of population from 1980-2003 and population projections every 10 years from 2010-2050. Data from the U.S. Bureau of Census (Census) were used to estimate past populations and Arizona Department of Economic Security (DES) 1997 data were used for population projections. (The data were the latest available at time of publication).

The Census provided spatial data for the years 1980, 1990 and 2000, which were organized into tracts (largest), groups, and blocks (smallest). Using GIS software, the Department divided the Census blocks into their respective basins and, as necessary, proportionally split by area those blocks that covered two or more basins. Populations between Census years were estimated by straight-line interpolation.

DES provided projections of how the population in Census places, such as towns and cities, would change in the future. The Department identified the Census places in each basin and applied the projected DES population change, as a percentage, to the 2000 Census data. If more than one Census place occurred in the same basin, the projected changes were averaged and applied across the basin. For three basins (Dripping Springs Wash, Paria, and San Simon Wash) there was insufficient data to make population projections and it was assumed that basin populations have been and will remain the same from 2001 through 2050.

1.3.11 Reservoirs

Location, Capacity and Use

Information on large and small reservoirs is summarized in a table for each basin (*Large and Small Reservoirs and Stockponds*) and locations of the large reservoirs are shown on basin-scale maps (*Surface Water Conditions*). Natural water bodies, such as dry and intermittent lakes, as well as man-made reservoirs, are included.

Large reservoirs are defined in the Atlas as water bodies with a maximum storage capacity of 500 acre-feet or greater, or where capacity data were unavailable to the Department, a maximum surface area of 50 acres or greater. Small reservoirs are defined as water bodies with a capacity of greater than 15 but less than 500 acre-feet, or a maximum surface area of between 5 and 50 acres. The tables list the name of each large reservoirs and the name of the dam (if different), the owner/operator, the maximum storage or surface area, its use (recreation, power, water supply, etc.) and jurisdiction (federal, state, tribal or private). The tables also list the total number of small reservoirs in a particular basin and their combined maximum storage capacity and surface area.

Reservoir information was obtained from 5 primary data sources:

- National Inventory of Dams maintained by the U.S. Army Corps of Engineers;
- The Department's database of jurisdictional and non-jurisdictional dams in Arizona;
- Arizona Game & Fish Department's waterways file and lake classification study;
- Digital versions of 1:100,000 scale USGS topographic maps; and
- The Department's registry of surface water right filings (see further discussion in this section under 'Stockponds') and adjudication reports.

For consistency, the Atlas lists maximum storage capacities for most large reservoirs. When these values were not available, normal storage capacities are presented and noted or, as described above, maximum surface area is presented. Several reservoirs were identified by more than one data source. To avoid duplication, reservoir locations were compared and the most recent data source was typically used. In most cases, reservoir locations presented in the Atlas represent the center of the reservoir, but in some cases, it marks the middle of the dam.

For the purpose of establishing dam jurisdiction, large reservoirs located on federal lands, such as national forests and national parks, were assumed to be under federal jurisdiction. Similarly, large reservoirs located on tribal lands were assumed to be under tribal jurisdiction. Some reservoirs listed in the data sources probably no longer exist, either because they have filled in with sediment and/or have been breached. Where more recent information indicates that a dam has filled with sediment or has been breached, it was not included in the Atlas.

Storage Trends

Historic trends in the storage of several major reservoirs in Arizona is described in the text and summarized in a table (*Arizona Mean Reservoir Levels from 1971-2005)* in Section 1.2.2 of this volume. This information was compiled by CLIMAS using data from NRCS and from the Department's Colorado River Section.

1.3.12 Rural Watershed Initiative Partnerships

Arizona's Rural Watershed Initiative Partnerships are described and shown on a state-scale map (*Rural Watershed Initiative Partnerships)* in Volume I, Appendix B. The table presents a list of all active partnerships, their activities, accomplishments, and identified issues. The same information is presented in tables by planning area in Volumes 2 through 7.

The Regional Water Planning Office at the Department tracks the status of the partnerships and provided the partnership information presented in the Atlas. Note that the issues identified by partnership participants may not represent all of the water resource issues currently faced in rural Arizona.

1.3.13 Rural Water Issues

Rural water issues are summarized in tables (*2003 Rural Questionnaire Issues Identified by Planning Area* and *2004 Rural Questionnaire Issues Identified by Planning Area*) with explanatory text for the entire state in Section 1.2.5 of this volume and in Volume 9 as well as in separate tables (*Planning Area Issues Identified from the 2003 and 2004 Rural Questionnaires*) for each planning area in Volumes 2 through 7. Issues were primarily identified through two questionnaires sent out by the Department in 2003 and 2004. Results from the 2003 questionnaire are summarized in the Department's *Rural Water Resources 2003 Questionnaire Report*. Other issues were identified through Arizona's Rural Watershed Initiative Program.

Data from the Department's questionnaires were entered into a database and queried for various attributes such as total responses, responses by location, issues ranking, type of respondent, etc. Note that the 2003 and 2004 questionnaires were not identical and some questions were asked differently. Also, the number of respondents did not represent a statistically valid sample. Therefore, any conclusions drawn from the questionnaires should, not be considered representative of all of rural Arizona or even representative of a given planning area or basin. Issues can vary dramatically by respondent and location.

1.3.14 Springs

Major and minor springs are listed in a table for each basin (*Springs*). A spring was considered 'major' if its discharge was 10 gallons per minute (gpm) or greater and 'minor' if its discharge was between 1 and 10 gpm. The tables include the name of the major and minor springs, their location (latitude/longitude), the most recent discharge measurement, and the measurement date. The tables also include an estimate of the total number of springs, regardless of discharge, that have been mapped in the basin. Locations of the major springs are shown on basin-scale maps (*Perennial/Intermittent Streams and Major ($\geq$10 gpm) Springs)*.

Spring data were obtained from a variety of sources, most notably the USGS, which maintains a database of spring discharge records. Reports by universities and public land agencies such as the U.S. Forest Service, National Park Service, and BLM were also useful. To estimate the total number of springs in each basin, the Department downloaded GIS covers from ALRIS and the National Hydrography Data Set (NHD) that incorporate spring locations from the USGS Geographic Names Information System (GNIS or Geonames) database and from USGS Digital Line Graphs (DLGs). ALRIS and NHD do not indicate how or when the USGS located these springs. It is not known whether

a detailed, ground survey would now identify more springs or, in light of recent drought conditions, less spring sites.

Many of the springs with discharge data were listed in more than one data source. To avoid over-counting, the Department compared spring names, locations, discharge rates, and dates of measurement and removed obvious duplicates. Topographic maps were also checked to verify that the springs had been mapped. Those springs not verified on topographic maps were included in the Atlas but noted accordingly. For most springs, the location and point of discharge measurement were, for practical purposes, the same. But in some areas, particularly the Grand Canyon, access was poor and discharge measurements had to be made at a point significantly downstream of the spring orifice.

The Atlas generally presents the most recent discharge measurement identified at a spring site. However, for springs fed by shallow water sources, discharge rates can vary dramatically from year to year or even from day to day. To address this issue, some springs were included in the Atlas even if their last discharge measurement had dropped below 10 gpm for major springs or 1 gpm for minor springs. For these springs, the date of measurement is an earlier date when the discharge was greater.

1.3.15 Stockponds

An estimate of the total number of stockponds is listed in a table for each basin (*Large and Small Reservoirs and Stockponds*). The estimates are based on analysis of the Department's surface water registry. The registry includes the following water right filings:

- Applications to appropriate public water, permits and certificates of water right (Department file numbers beginning with "33", also known as "33s");
- Water right registrations filed pursuant to the Water Rights Registration Act of 1974 ("36s");
- Stockpond registrations filed pursuant to the Registration of Stockponds Act of 1977 ("38s");
- Statement of claimants filed by Indian tribes, or the federal government on their behalf, as part of the Gila River and Little Colorado River Adjudications ("39s"); and,
- Court decreed water rights ("4As" and "BBs").

Only those filings for ponds with a capacity of 15 acre-feet or less were considered. Because the same stockpond can often have 2 or more associated filings, an effort was also made to avoid overcounting the number of ponds by comparing stockpond names and locations and eliminating duplicates. Stockpond locations were not verified through field investigations or by analysis of topographic maps and aerial photographs. As a result, it is unknown whether additional ponds exist but were never claimed, or whether the ponds that were claimed are still in use. In areas of the state where stockpond locations have been previously verified, estimates based only on water right filings appear to be within an order of magnitude.

1.3.16 Streams

Diversions (see Cultural Water Demands)

Flood Warning (ALERT) Gages

The location of flood warning gages is shown on basin-scale maps (*Surface Water Conditions*) and information related to these gages is summarized in a table for each basin (*Stream Gage Data*). The tables include the name and identification number of the gaging stations, station types (precipitation, stage, repeater, or some combination of these), dates of installation, and who is responsible for operation and maintenance (flood control districts, cities, etc.).

This information was obtained from the Department's Office of Water Engineering, which maintains a database of flood warning equipment across Arizona. The Department's database was queried in Fall 2005 and the information presented in the Atlas was accurate at that time. According to staff at the Office of Water Engineering, new flood warning gages are routinely added to the ALERT (Automated Local Evaluation in Real Time) network so the current number of stations may be greater than presented.

Flow Gages

The location of USGS streamflow gages is shown on basin-scale maps (*Surface Water Conditions*) and information related to the gages is summarized in a table for each basin (*Stream Gage Data*). The tables include the following information for all continuous flow gages, active or discontinued, with at least one year of record:

- Name and identification number of the station;
- Area and mean elevation of the gaged drainage basin;
- Period of record;
- Average seasonal streamflows, as a percentage of annual flow;
- Annual streamflow statistics (minimum, median, mean, and maximum); and,
- Number of years of annual streamflow data used to calculate statistics.

The Atlas does not include data from USGS peak flow gages or from continuous flow gages with less than one year of record.

Gage information was obtained from various USGS sources including their National Water Information System (NWIS) on-line database, recent (Water Years 2002 and 2003) Water-Data Reports, and a 1998 report that summarizes streamflow data and drainage basin characteristics for selected gaging stations. The Department calculated average seasonal streamflows using mean monthly streamflow data downloaded from NWIS. It should be noted that mean streamflow values in the Southwest may be affected by a few, larger flows, which are common in the region. Seasons were defined in the Atlas as follows:

- Winter – January through March;
- Spring – April through June;
- Summer – July through September; and
- Fall – October through December.

Annual streamflow statistics were similarly calculated, but using mean annual streamflow data downloaded from NWIS. Note that annual statistics were not necessarily run on a gage's entire period of record, as the USGS only calculates annual mean streamflows for years with a complete 12-month dataset. Note also that annual statistics are only presented for gages with 3 or more years of record and all calculations are based on the Calendar Year, not Water Year. Average seasonal streamflows were calculated using data collected through September 2005 and annual streamflow statistics were calculated using data collected through December 2004.

Streamflow statistics are affected by the length of record (e.g. 3 years vs. 50 years of data) as well as the hydrologic conditions occurring when the data were collected (e.g. drought vs. wet period). In addition, isolated conditions may affect streamflow at one station but not at another station nearby. In light of these constraints, the statistics presented in the Atlas should only be used as a general indication of streamflow conditions in the basins and not for site-specific studies.

Instream Flow

Information on instream flows is summarized in a table for each planning area (*Instream Flow Applications and Permits)* and shown on planning-area maps *(Location of Instream Flow Applications and Permits*). The tables include the name of stream reaches with instream flow claims, the name of applicants who have filed for instream flow rights, application numbers and dates of filing and, whether applications have been permitted and certificated by the Department. This information was provided by the Water Management Support Section at the Department, which maintains a database that tracks the status of instream flow applications.

Intermittent and Perennial Reaches

Recent perennial and intermittent streams are shown on basin-scale maps (*Perennial/Intermittent Streams and Major (≥10 gpm) Springs)* and on planning-scale maps *(Location of Instream Flow Permits and Applications*).

Locations of perennial streams were taken from a 1993 report prepared by the Arizona Game and Fish Department (AGFD) as part of the Statewide Riparian Inventory and Mapping (SRIM) Project. In that report, AGFD identified perennial reaches based on a 1981 AGFD map that AGFD revised after consultation with several government agencies (the Department, ADEQ, BLM, and USFS), private sector hydrologists, and academicians. Locations of intermittent streams were taken from a 1997 AGFD report prepared during the last phase of the SRIM Project. Intermittent stream reaches were identified on topographic maps by staff of AGFD, BLM, NPS, and USFS.

Due to the prolonged drought currently affecting Arizona, some of the perennial stream reaches identified by AGFD may now be intermittent and some of the intermittent reaches may now be ephemeral. As climatic conditions change in the future, it is expected that many of these streams will likely return to their previously classified flow conditions, except where impacted by development.

Major Drainages

Major stream drainages are shown on basin-scale maps (*Surface Water Conditions*). Drainage locations were taken from ALRIS, which provides a GIS cover of Arizona streams. The ALRIS stream cover is based on 1:100,000 scale USGS topographic maps that were enhanced with data from EPA and several state agencies.

ALRIS classifies streams into five cartographic orders based generally on drainage basin size. Cartographic Order 1 streams drain the largest areas and include major rivers like the Colorado, Verde, Salt, Gila, etc. The *Surface Water Conditions* maps show the location of Cartographic Order 1, 2 and 3 streams and includes stream names for the first two orders.

Runoff

Average annual or 'unit' runoff contours are plotted on basin-scale maps (*Surface Water Conditions*). The contours show the magnitude and spatial variation in runoff, in inches per year, based on streamflow data collected by the USGS during 1951 through 1980. The data reflects the runoff in tributary streams, rather than in major rivers, as an indication of how runoff varies regionally with precipitation and other geographic features.

The streamflow data were compiled by the USGS in 1985 and, in 1987, a 1:2,000,000-scale unit-runoff contour map of the conterminous United States was published. The map has since been digitized and posted on the USGS website, the Department downloaded it for use in the Atlas.

1.3.17 Water Protection Fund

Information on Water Protection Fund grants is summarized in a table (*Arizona Water Protection Fund Grant Summary)* and shown on a state-scale map *(Arizona Water Protection Fund Grant Locations)* in Appendix C of this Volume. The table includes grant numbers issued through FY 2005, project titles and categories, and associated groundwater basins. Similar information is also presented in tables by planning area in Volumes 2 through 8.

The tables and map are based on a database maintained by the Department's Drought, Conservation, and Riparian Planning Section. For purposes of the Atlas, Water Protection Fund projects were grouped into categories by type (watershed restoration, revegetation, research, etc.) and organized by groundwater basin.

1.3.18 Water Quality

Water quality data are summarized in tables for each basin (*Water Quality Exceedences*) and sample locations are shown on basin-scale maps (*Water Quality Conditions*). The maps show the location of wells, springs, and mines that have exceeded drinking water standards and lakes and streams that are impaired for designated uses. Tables for the wells, springs, and mines list the type of sampling site, its location (township, range and section), and which water quality parameters have exceeded standards for drinking water. Tables for the lakes and streams list the name and type of impaired water body, its length (streams) or area (lakes), and which water quality parameters have exceeded designated uses standards. Sample dates and parameter concentrations are not included in the tables, but this information has been compiled by the Department and is available for review.

Water quality data for the wells, springs, and mines were obtained from the following primary sources:

- The Department's Groundwater Site Inventory (GWSI) database;
- USGS's National Water Inventory System (NWIS) database;
- ADEQ's Safe Drinking Water (SDW), Rural Watershed Study, and Arsenic databases; and
- Various technical reports prepared by the Department, ADEQ and USGS.

Data on impaired lakes and streams comes from ADEQ's 2005 report *The Status of Water Quality in Arizona – 2004, Arizona's Integrated 305(b) Assessment and 303(d) Listing Report*.

Several of the well, spring, and mine sites have been sampled more than once and/or results from the same sampling date are listed in more than one data source. An effort was made to remove duplicate data using available information on site location. The water quality data presented in the Atlas indicate areas where water quality exceedences have previously occurred. Additional areas of concern may currently exist where water quality samples have not been collected or sample results were not reviewed by the Department. For example, as part of ADEQ's Underground Storage Tank (UST) and Aquifer Protection Permit (APP) programs, literally thousands of water quality samples have been collected and analyzed. Results from these analyses were not included in the Atlas. What is included for these and other environmental programs is a current (2006) map from ADEQ that shows the location of contaminated sites across the state (See *Contamination Sites,* section 1.3.4).

Finally, please note that the water quality exceedences presented in the Atlas may or may not reflect current aquifer conditions and probably do not reflect the quality of water being supplied by local water providers in the area. The latter are required by state law to supply water that meets drinking water standards. The Atlas indicates areas where private well owners and surface water users may want to test the quality of their water or restrict its use.

1.3.19 Wells

Automated Recorder Sites

The location and type of automatic water-level recorders are shown on a statewide map (*Automatic Water-level Recorder Sites as of 2005*) in Section 1.2.5 of this volume and in Volume 8 for AMAs. Automatic water-level recorders collect numerous measurements daily, filling in the gaps between annual measurements. The types of recorders include analog or chart, digital, and real-time digital. Information on recorder sites comes from the Department's Basic Data Unit, USGS, and the Cities of Flagstaff and Williams. It is assumed that the recorders are currently operational. Well inspections are needed to verify this assumption for all sites.

Basin Sweeps

The date of the most recent well sweep and the number of wells measured during the sweep is listed in a table for each basin (*Hydrogeology*). Information on well sweeps comes from the Department's Groundwater Site Inventory (GWSI) database. A well sweep refers to a large number of measurements of water levels in wells throughout a basin. While efforts are made to target specific wells, the process is largely random in nature, and is intended to provide the best aerial and vertical coverage in the basin. It is not intended to, and does not include every well in the basin.

Index Sites

The number of index wells is listed in a table for each basin (*Hydrogeology*). Water levels in index wells are measured manually at specific times, or continuously using automatic recording devices. These wells are representative of aquifer conditions over a large geographic area and their measurement allows a lower density of monitoring to occur in years between basin sweeps.

Information on index wells came primarily from the Department's GWSI database. This was supplemented with information from the USGS, other federal entities (Fort Huachuca, NPS, and USBR), an Indian Tribe (Navajo Nation), a city (Flagstaff), and two utilities (SRP and TEPCO).

Number of Completions

Numbers of registered water supply wells are listed in a table for each basin (*Cultural Demands*). The tables include the total number of wells completed through 1980, the number of new wells completed in 5-year increments from 1981 through 2000, and the number of new wells completed between 2001 and 2003. Also included is the total number of wells drilled without completion dates.

Information on well completions comes from the Department's well registry, commonly referred to as the "Wells 55" database. Wells in the registry were queried first by basin and reported pump capacity. This resulted in two well lists for each basin – wells with a maximum pump capacity of 35 gallons per minute (gpm) or less and wells with a maximum pump capacity greater than 35 gpm. In the AMAs, wells with a maximum pump capacity of greater than 35 gpm are "non-exempt" wells and wells with a maximum pump capacity of 35 gpm or less are "exempt" wells. The resulting well lists were then filtered to exclude registrations for wells that apparently were never drilled and/or those wells not used for water supply purposes.

The Department's wells registry only lists data for wells that have been registered with the Department, as required by statute. For the purpose of the Atlas, no attempt was made to verify the accuracy of the data or to conduct field surveys to determine whether additional wells have been drilled but never registered or whether the wells that were drilled and registered are still operable today. For example, wells drilled on Indian Reservations are generally not counted since the tribes have no requirement to register these wells with the Department.

Pumpage (see Cultural Water Demands)

Recent Water-Level Depths

Recent (2003 or 2004) depths to water in wells are shown on basin-scale maps (*Groundwater Level Conditions*). Depth values, in feet below land surface, are presented on the maps next to each well symbol. Most of the water level data were taken from the Department's GWSI database. These data were supplemented with measurements made by the USGS, other federal entities (Fort Huachuca, NPS, and USBR), an Indian Tribe (NTUA), a city (Flagstaff), and two utilities (SRP and TEPCO).

All water levels were reviewed and data that appeared unreasonable were excluded from the Atlas. Some of the included data were adjusted first to ensure consistency and account for the different measurement methods used.

Water-level Changes

Water-level changes in wells are shown on basin-scale maps (*Ground-water Level Conditions*) and on hydrographs for each basin (*Selected Basin Hydrographs*). The maps use colored dots to show how water levels have changed over a 13-year period that began in about fall 1990 and ended in spring 2004. Five different colors are used to represent the range of recorded water-level changes. A positive change indicates a rise in water level over the period and negative change indicates a decline. The hydrographs show water-level changes for selected wells over the 30-year period from January 1975 to January 2005. Included on the hydrographs are a well identifier, total well depth, principal aquifer, and water use. Care was taken to select wells that were representative of aquifer conditions both horizontally and vertically.

Most of the water-level data used to generate the maps and hydrographs were taken from the Department's GWSI database. These data were supplemented with measurements made by the USGS, other federal entities (Fort Huachuca, NPS, and USBR), an Indian Tribe (Navajo Nation), a city (Flagstaff), and two utilities (SRP and TEPCO). All water levels were reviewed and data that appeared unreasonable were excluded from the Atlas. Some of the included data were adjusted to ensure consistency and account for the different measurement methods used.

An effort was made to use data collected during the period when the wells were not actively being pumped or only minimally pumped. This period was typically from about September through about May. However, in some areas, like the Navajo Reservation, water-level data from wells were less abundant and the data used in the Atlas may have been affected by pumping.

Yields

Wells yields are listed in a table for each basin (*Hydrogeology*) and shown on basin-scale maps (*Well Yields*). The maps use colored dots to show the location of well yields measured by the Department and USGS. Five different colors are used on the maps to represent the range of recorded well discharges. The tables list summary statistics for these and other estimates of well yield.

Information on well yields was primarily taken from databases maintained by the Department (GWSI and Wells55) and USGS (NWIS). Also used was a 1990 internal report by the Department that summarizes water resources information by basin and a 1994 annual report by USGS on groundwater conditions across Arizona. To estimate well yields using the Wells55 database, only wells with a casing diameter greater than 10 inches were considered. It was assumed that such 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.

Many factors can affect well yields, including local and regional aquifer properties, well design, the size and condition of the pump, and the age of the well. The data presented in the Atlas provides a general indication of the quantity of water that can be produced from basin aquifers under optimal well conditions. Actual well yields may be significantly lower than those presented based on the factors described.

SECTION 1.4 Observations

This section contains brief observations regarding the data and information compiled in the Atlas and its utility and constraints. Also summarized are water resource planning considerations including regional cooperation and statewide influences.

Data Compilation and Analysis

The process of compiling data for the Atlas revealed that water resource data are often dispersed and not always readily available. The methods section above does not fully reflect the level of effort required to assemble the data presented in the Atlas. Differences in database design and other factors can make data sharing between water-resource agencies and institutions difficult.

It is also apparent that a number of databases contain inconsistent or occasionally incorrect data and there is a critical need for quality control. Agencies have different data classification systems and regulatory or management definitions. These conditions need to be recognized when collecting and evaluating data. Database maintenance can be a challenge for cash-strapped agencies that often lack the necessary resources to devote to data management and data retrieval therefore can be a challenge. In cases where data is collected through a public reporting process, the quality of the data is dependent on the accuracy of public measurement and reporting.

Data Access

The Atlas structure is intended to provide water-related information on a variety of scales; from a relatively local level (groundwater basins) to a more regional perspective (multiple-basins and planning areas). This should help support some non-AMA planning efforts. An objective of the Atlas is to improve access to this information by regular updates and construction of a data retrieval system and eventually an interactive product. Regular data exchange between water resource agencies and institutions would help this effort.

Water Resource Planning, Assistance and Coordination

Water resource data is critical to evaluate conditions and develop water resource plans. However, planning and financial assistance may also be needed by communities and regional partnerships. Lack of financial resources for infrastructure improvements was cited by a majority of respondents to the rural surveys conducted in 2003 and 2004. It is clear that additional mechanisms need to be developed to address this need.

Planning assistance has been provided by the Department under the Rural Watershed Initiative Program since the late 1990's but the program has not been consistently funded at a level sufficient to conduct all necessary studies. Some planning assistance is also offered by the Department for development of Water System Plans required by HB 2277, primarily through a guidance document and workshops. Additional water resource planning assistance would be helpful to many smaller communities.

A number of non-AMA Partnerships work collaboratively to address local water resource issues. Through inter-jurisdictional agreements, some have entered into long-term commitments to identify solutions, fund projects and meet management goals. The 2005 legislation requiring water system plans (HB2277) supports collaborative efforts by authorizing development of joint water supply plans by two

or more water providers serving the same area. In some areas, stakeholders desire regulatory tools to manage water supplies and are evaluating options to expand their authorities. This may require a coordinated statewide effort to develop the necessary management mechanisms. It is clear that working collaboratively provides multiple benefits including opportunities for information sharing, resource development, consistency in conservation messaging, and cost-sharing.

Statewide Perspective

Although the Atlas is organized by groundwater basins, planning areas and AMAs, it is evident that as Arizona grows, water resource utilization is increasingly influenced by statewide and regional conditions. For example, lack of snowpack in Colorado impacts the availability of Colorado River water supplies to some users in Arizona. This may result in the need to use local groundwater supplies in communities that have not found it necessary in the past to invest in groundwater infrastructure development. Elsewhere, communities that may have relied on an in-state surface water supply may need to forego use of the supply to satisfy water rights claims of senior downstream users. Scenarios like this illustrate that water management and planning often needs to extend beyond local boundaries and that there is an interrelationship between many areas of the state, whether they be within an AMA or outside an AMA. Many of the state's water resource managers and rural partnerships already recognize this reality. It is hoped that the information contained in the Atlas provides some of the tools to begin or enhance water planning efforts at both a local and more regional level.

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IN VOLUMES 2-8

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ACRONYMS AND ABBREVIATIONS

A.A.C.	Arizona Administrative Code
A.R.S.	Arizona Revised Statutes
AACD	Arizona Association of Conservation Districts
ACC	Arizona Corporation Commission
ADEQ	Arizona Department of Environmental Quality
ADWR	Arizona Department of Water Resources
AF	Acre-feet
AGFD	Arizona Game and Fish
ALERT	Automated Local Evaluation in Real Time
ALRIS	Arizona Land Resource Information System
AMA	Active Management Area
APP	Aquifer Protection Permit
ARS	Agricultural Research Service
AWPF	Arizona Water Protection Fund
AWS	Assured Water Supply
AZMET	Arizona Meteorological Network
AWBA	Arizona Water Banking Authority
BIA	Bureau of Indian Affairs (U.S.)
BLM	Bureau of Land Management (U.S.)
BOR	Bureau of Reclamation (U.S.)
CAGRD	Central Arizona Groundwater Replenishment District
CAP	Central Arizona Project
CAWCD	Central Arizona Water Conservation District
CCN	Certificate of Convenience and Necessity
CDP	Census Designated Place
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act - 42 U.S.C. Section 9601 *et seq.*
cfs	Cubic feet per second
CLIMAS	Climate Assessment for the Southwest
CODE	Arizona Groundwater Management Act - A.R.S. § 45-401 *et seq.*
COE	Corps of Engineers (U.S.)
CRWUA	Colorado River Water Users Association
CU	Consumptive use
CWA	Clean Water Act - 33 U.S.C. Section 1251 *et seq.*
Department	Arizona Department of Water Resources
DES	Arizona Department of Economic Security
DLG	Digital Line Graph
DOD	Department of Defense (U.S.)
DOE	Department of Energy (U.S.)
DOI	Department of Interior (U.S.)
DWID	Domestic Water Improvement District
EA	Environmental Assessment
EIS	Environmental Impact Statement
ENSO	El Nino/Southern Oscillation
EPA	Environmental Protection Agency (U.S.)
ESA	Endangered Species Act - 7 U.S.C. 136; 16 U.S.C. 460 *et seq.*

FMIC	Fort McDowell Indian Community
ft bls	Feet below land surface
GPCD	Gallons Per Capita Per Day
GPHUD	Gallons Per Housing Unit Per Day
gpm	Gallons per minute
GPS	Global Positioning Station
GRIC	Gila River Indian Community
GWSI	Groundwater Site Inventory
HCN	Historic Climate Network (U.S.)
HMS	Hydrologic Map Series
HOA	Home Owners Association
HSR	Hydrographic Survey Report
IBWC	International Boundary Water Commission
ID	Irrigation District
INA	Irrigation Non-expansion Area
ISPE	Institute for the Study of Planet Earth (University of Arizona)
LAIAG	Local Area Impact Assessment Group
LCR	Little Colorado River
LUST	Leaking Underground Storage Tank
maf	Million acre-feet
MCL	Maximum Containment Level
mg/l	Milligrams per liter
mgd	Million gallons per day
MSCP	Multi-Species Conservation Plan
NEPA	National Environmental Policy Act - 42 U.S.C. § 4321-4347
NAU	Northern Arizona University
NDEQ	Navajo Department of Environmental Quality
NDWR	Navajo Department of Water Resources
NHA	Navajo Housing Authority
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent to Drill a Well
NPDES	National Pollution Discharge Elimination System
NPL	National Priorities List
NPS	National Park Service (U.S.)
NRA	National Recreation Area
NRCD	Natural Resources Conservation District
NRCS	Natural Resources Conservation Service
NTUA	Navajo Tribal Utility Authority
NWIS	National Water Information System
NWS	National Weather Service
Pan ET	Pan evaporation
PCE	Tetrachloroethylene
P.L.	Public Law
ppb	Parts per billion
ppm	Parts per million
PRISM	Parameter elevation Regression on Independent Slopes Model
PWC	Private Water Company
RCD	Resource Conservation District

RCRA	Resource Conservation and Recovery Act – 42 U.S.C. § 6901 *et seq.*
RRA	Reclamation Reform Act - 43 U.S.C. § 390aa *et seq.*
RVID	Round Valley Irrigation District
SAWRSA	*Southern* Arizona Water *Rights* Settlement Act- P.L. 108-451 (2004)
SCAS	Spatial Climate Analysis Service
SDW	Safe Drinking Water Act- 43 U.S.C. § 300f *et seq.*
Secretary	U.S. Secretary of the Interior
SLD	Arizona State Land Department
SNOTEL	SNOwpack TELemetry
SPRNCA	San Pedro Riparian National Conservation Area
SRP	Salt River Project
TDS	Total dissolved solids
TEPCO	Tucson Electric Power Company
TCE	Trichloroethylene
TMDL	Total maximum daily load
TNC	The Nature Conservancy
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UST	Underground Storage Tank
VOC	Volatile organic compound
WAPA	Western Area Power Administration
WID	Water improvement district
WIFA	Water Infrastructure Funding Authority
WQARF	Water Quality Assurance Revolving Fund
WRCC	Western Regional Climate Center
WWTP	Wastewater treatment plant

DEFINITIONS

Acre-feet (AF): The amount of water it takes to cover one acre of land to the depth of one foot, approximately 325,851 gallons.

Active Management Area (AMA): A geographic area that has been designated pursuant to A.R.S.§ 45-411 as requiring active management of groundwater or, in the case of the Santa Cruz AMA, active management of any water, other than stored water, withdrawn from a well. Subsequent active management areas may be designated through local initiative or by the Director of ADWR.

Advanced primary treatment: The enhanced removal of suspended solids and organic matter in the wastewater treatment process through the use of chemicals and/or filtration.

Advanced treatment I: A wastewater treatment level that is more stringent than secondary treatment and reduces the organic and inorganic substances from the treated wastewater through the use of chemical and physical techniques. It is often referred to as tertiary treatment.

Advanced treatment II: Highest level of wastewater treatment with a BOD < 10 mg/l and/or the removal of nutrients.

Agricultural water use: Water applied to two or more acres of land to produce plants or parts of plants for sale for human consumption or for use as feed for livestock, range livestock or poultry.

Aquifer: A geologic formation that contains sufficient saturated materials to be capable of storing water and transmitting water in useable quantities to a well.

Aquifer recharge: Water added to the aquifer through seepage and infiltration.

Aquifer storage: Water stored underground for future use. Also, water stored pursuant to a permit issued under A.R.S. § 45-831.01, the Underground Water Storage, Savings and Replenishment Program.

Artificial recharge: Water recharged to the aquifer through recharge projects, which may be recovered in the future based on accrued recharge credits.

Baseflow: The part of a stream discharge that is not attributable to direct runoff from precipitation or melting snow. It is sustained by groundwater discharge and may be considered as normal day-to-day flow during most of the year.

Baseline: A surveyed line that serves as a reference to which surveys are coordinated and correlated.

Basin fill: Unconsolidated material such as sand, gravel and silt, eroded from surrounding mountains and deposited in a valley.

Basin sweep: A technique used to collect information on groundwater level conditions by measuring selected wells throughout a basin. Specific and randomly selected wells are measured to provide the best aerial and vertical coverage in the basin.

Calendar year: The 12-month period from January 1 to December 31.

Census blocks: A geographic area bounded by visible and/or invisible features shown on a map prepared by the U.S. Census Bureau. A block is the smallest geographic entity for which the Census Bureau tabulates decennial census data.

Census designated place: A geographic entity that serves as the statistical counterpart of an incorporated place for the purpose of presenting census data for an area with a concentration of population, housing, and commercial structures that is identifiable by name, but is not within an incorporated place.

Consumptive use: The part of the water demand that becomes unavailable for future use because it is evaporated or consumed by the use. Consumptive use also refers to diversions from the mainstream of the Colorado River minus the returns.

Contamination site: A geographic area where the quality of the water and/or soil quality is naturally hazardous to animals or humans or has been impaired by sewage, industrial wastes, or other materials and where remediation is either ongoing, scheduled for the future or not practicable.

Continuous flow gage: Mechanical device placed in a stream that measures the volume of water flowing at that specific location over an extended period of time.

Community Water System: A public water system, as defined in A.R.S. § 49-352(B), that serves at least fifteen service connections used by year-round residents of the area served by the system or that regularly serves at least twenty-five year-round residents of the area served by the system. A person is a year-round resident of the area served by a system if the person's primary residence is served water by that system.

Cultural Water Demand: The quantity of water diverted from streams and reservoirs and pumped from wells for municipal, industrial and agricultural purposes. It should not be confused with “consumptive use”, which refers to the amount of cultural water demand that is lost from the hydrologic system.

Deficit irrigation: The practice of reducing the number of irrigation applications to lower crop production costs while achieving acceptable yields.

Drinking water standards: Criteria developed by the Arizona Department of Environmental Quality and other state and local agencies, the US Public Health Service, and the US Environmental Protection Agency to assure safe water for human consumption.

Drought: A sustained natural reduction in precipitation that results in negative impacts to the environment and human activity.

Dry lake: A basin that formally contained a lake.

Effluent: Water that has been collected in a sanitary sewer for subsequent treatment in a facility that is regulated as a sewage system, disposal plant or wastewater treatment facility. Such water remains effluent until it acquires the characteristics of groundwater or surface water.

Effluent dependent water: Surface waters that would generally be ephemeral, except for the discharge of treated effluent.

Ephemeral stream: A stream or part of a stream that flows only in direct response to precipitation; it receives little or no water from springs, melting snow or other sources; its channel is at all times above the water table.

Evaporation pan: An open tank used to measure the amount of evaporation. The US Department of Commerce Weather Station Class A pan is 4 feet in diameter and 10 inches deep set so the top rim is 16 inches above ground.

Evapotranspiration: Loss of water from the land through transpiration of plants and evaporation from the soil and surface water bodies.

Exempt well: Within an AMA, a well having a pump with a maximum pumping capacity of 35 gallons per minute or less, which is used to withdraw groundwater for non-irrigation purposes. This term is also used to describe any well outside an AMA having a pump with a maximum pumping capacity of 35 gallons per minute or less.

Groundwater: Generally, water below the earth's surface but commonly applied to water in fully saturated soils and geologic formations.

Groundwater flow model: A digital computer model that calculates a hydraulic head field for the modeling domain using numerical methods to arrive at an approximate solution to the differential equation of groundwater flow.

Hydrographs: A graphic representation of the changes in the flow of water or the elevation of water levels over time.

Igneous rock: A rock formed by the crystallization of magma or lava.

Impaired: A lake or stream that is not meeting one or more surface water quality standards as established in A.R.S. § 49-231

Incidental recharge: The percolation of water to the water table after the water has been used. Components of incidental recharge include recharge that occurs from septic tanks, turf watering and effluent discharge.

Index well: A well that is measured during specific periods or continuously monitored by automatic recorders. These wells allow a lower density of representative monitoring to occur in the years between "sweeps".

Industrial demand: Water used by an industrial facility, such as a golf-course, dairy, feedlot, power plant, mine or paper mill, and that is served by the industrial facility's well.

Inflow: All water that enters a hydrologic system. Examples include mountain front and stream channel recharge, artificial and incidental recharge and baseflow and underflow into a system.

In-lieu water: Water that is delivered to a groundwater savings facility in an AMA or INA and that is used at the facility by the recipient on a gallon for gallon substitute basis for groundwater that otherwise would have been pumped from within the AMA or INA.

Irrigation non-expansion area (INA): A geographic area that has been designated pursuant to A.R.S. §§ 45-431 or 45-432 as having insufficient groundwater to provide a reasonably safe supply for the irrigation of cultivated lands at the current rate of withdrawal.

Instream flow right: A non-diversionary surface water right for recreation and wildlife purposes, including fish.

Intermittent lake: A lake that normally contains water for only a portion of the year or one that is only seasonally dry.

Intermittent stream: A stream or part of a stream that flows only at certain times of the year when it receives water from springs, snowmelt, surface run-off or other sources.

Jurisdictional dam: Any artificial barrier, including appurtenant works, for the impounding or diversion of water, 25 feet or more in height or with storage capacity more than 50 acre-feet, except:
(a) Any barrier that is or will be less than six feet in height, regardless of storage capacity;
(b) Any barrier that has or will have a storage capacity of fifteen acre-feet or less, regardless of height;
(c) Any barrier for the purpose of controlling liquid-borne material;
(d) Any barrier that is a release-contained barrier; or
(e) Any barrier that is owned, controlled, operated, maintained or managed by the United States government or its agents or instrumentalities if a safety program that is at least as stringent as the state safety program applies and is enforced against the agent or instrumentality.

Maximum storage capacity: Total storage space in a reservoir below the maximum attainable water surface elevation, including any surcharge storage.

Meridian: A surveyed line that serves as a reference to which surveys are coordinated and correlated.

Metamorphic rock: A rock that is the product of heat, pressure, and chemical activity so that some or all of its minerals are re-crystallized and may show preferred orientation.

Municipal demand: All non-agricultural uses of water supplied by a city, town, private water company, irrigation district, domestic water improvement district, water cooperative or private domestic well.

Non-exempt well: Within an AMA, a well having a pump with a maximum pumping capacity of more than 35 gallons per minute and used for non-irrigation purposes or any well used for irrigation purposes. This term is also frequently used to describe any well outside an AMA having a pump with a maximum pumping capacity greater than 35 gallons per minute.

Non-jurisdictional dam: An artificial barrier for impounding water that does not qualify as a jurisdictional dam.

Normal storage capacity: the total volume, in acre-feet, at the normal retention level, including dead and inactive storage and excluding flood control and surcharge storage.

Outflow: All water that leaves a hydrologic system. Examples include cultural water demand, phreatophyte use and underflow and baseflow out of the system.

Pan evaporation: Evaporation in inches from a standard Weather Bureau Class A pan.

Peak flow gage: A mechanical device that measures the maximum instantaneous discharge of a stream or river at a given location. Peak flow usually occurs at the time of maximum stage.

Perennial stream: A stream or part of a stream with surface flow throughout the year, drying only during periods of drought.

Period of record: The length of time represented in the data.

Phreatophyte: A deep-rooted plant that obtains it water from a permanent groundwater supply.

Primary treatment: The first stage in wastewater treatment where some solids and organic material are removed by screening and sedimentation. It removes about 35% of the biochemical oxygen demand (BOD) and less than half of the metals or toxic organic substances.

Range: In the U.S. Public Land Survey System, any series of contiguous townships aligned north and south and numbered consecutively east to west from a prime meridian to which it is parallel.

Recent stream alluvium: Unconsolidated clay, sand, silt or gravel that has been recently deposited, from a geological perspective, by a stream or running water along the stream channel, on its flood plain or at the base of a mountain slope.

Reference crop evapotranspiration (Eto): An estimate of the water used by a well-watered, full-cover grass surface, 8-11.5 cm in height (the reference crop).

Reservoir: An artificially created lake where water is collected and stored for future use.

Return Flow: The amount of water that reaches a groundwater or surface water source after release from the point of use and thus becomes available for further use. In other words, that part of a diverted flow, which is not consumptively used and returns to its original source or another body of water.

Run-off: The portion of precipitation that is not intercepted by vegetation, absorbed by land surfaces or evaporated and that flows overland into a depression, lake, stream or ocean.

Secondary treatment: The second stage in wastewater treatment that involves both chemical and biological processes. The screened wastewater is passed through a series of holding and aeration tanks and ponds further removing organic and inorganic substances. Disinfecting with chlorine may be included.

Secondary treatment with nutrient removal: An additional process in the secondary treatment of wastewater that removes nutrients such as nitrogen and phosphorus.

Section: In the US Public Land Survey System, one of the 36 subdivisions of a township. A section represents 1 square mile or 640 acres.

Sedimentary rock: A rock formed by the accumulation and consolidation of loose sediments in layered deposits.

Snowcourse: A permanent site where measurements of snow depth and snow water equivalent are taken at multiple locations by trained observers. A Snowcourse is generally 1,000 feet long and located in small meadows protected from the wind.

Snow water equivalent (SWE): The amount of water contained in the snowpack that would theoretically appear if the snow were melted all at once; also known as snow water content.

Spring: A place where water emerges naturally from the earth without artificial assistance onto the land surface or into a body of surface water.

Stockpond: An impoundment of any size that stores appropriable water and that is for the sole purpose of watering livestock and wildlife.

Superfund: The federal government's program to clean up the nation's uncontrolled hazardous waste sites, also known as "CERCLA," the Comprehensive Environmental Response, Compensation and Liability Act of 1980, 42 U.S.C. §§ 9601, *et seq.*

Surface water: An open body of water such as a stream, lake, or reservoir.

Surface water standards: Numeric and narrative criteria developed to ensure surface water quality for 6 designated uses; aquatic and wildlife, body contact, fish consumption, domestic water source, and agricultural use for irrigation or livestock watering.

Tertiary treatment: Wastewater treatment beyond the secondary or biological stage that includes the removal of nitrogen and phosphorus and a high percent of suspended solids through chemical and mechanical means such as additional filtration, carbon adsorption, distillation and reverse osmosis.

Township: A unit of survey in the U.S. Public Land Survey System that represents a piece of land that is bounded on the east and west sides by meridians approximately 6 miles apart.

Underflow: The downstream flow of water through permeable deposits underlying a stream.

Volcanic rock: A finely crystalline or glassy igneous rock resulting from volcanic action at or near the earth's surface.

Water Adequacy Program: The program implementing A.R.S. § 45-108, requiring a developer of subdivided land outside an AMA to obtain a determination from the Department regarding the availability of water supplies before the land may be marketed for sale or lease to the public, unless the land will be served by a water provider designated as having an adequate water supply. Under this regulatory program, developers are required to disclose a determination that the water supply is inadequate to potential buyers.

Water duty: The amount of water that is reasonable to apply to irrigated land to produce a crop. The water duty accounts for field location and soil type, and incorporates consumptive use, evaporation and seepage from the farm water delivery system and the water that is returned to the soil via percolation and runoff.

Water year: A 12-month period beginning on October 1 and ending on September 30. The water year is designated by the calendar year in which it ends, e.g. the 2006 water year ends September 30, 2006.

Well yield: The volume of water discharged from a well in gallons per minute or cubic meters per day.

APPENDICES

APPENDIX A: SUMMARY OF ARIZONA WATER LAW AND MANAGEMENT

Water management in Arizona is a complex system of laws, rules and management authorities that differ for each type and source of water. Surface water regulations are distinct from those governing groundwater. Arizona's Colorado River water apportionment is governed by interstate compact, federal Congressional acts and U.S. Supreme Court decisions, referred to as the "Law of the River". Indian Water Rights Claims and Settlements are an important component in water management in Arizona and are discussed in Appendix D. Effluent is regulated under a law separate from those that pertain to surface water or groundwater. There are also laws that regulate underground water storage, water exchanges and dams. The Arizona Department of Water Resources (Department) administers water management and water rights but several Arizona governmental agencies, authorities and districts also affect aspects of water management and utilization.

Surface Water

Arizona has adopted the doctrine of prior appropriation to govern the use of surface water. This doctrine is based on the tenet of "first in time, first in right" which means that the person who first puts the water to a beneficial use acquires a right that is better than later appropriators of the water. Beneficial use is the "basis, measure and limit to the use of water" A.R.S. § 45-141(B). Prior to June 12, 1919, a person could acquire a surface water right simply by applying the water to a beneficial use and posting a notice of the appropriation at the point of diversion. On June 12, 1919, the Arizona surface water code was enacted. Known as the Public Water Code, this law requires that a person apply for and obtain a permit in order to appropriate surface water. Surface water is defined by statute as:

"Waters of all sources, flowing in streams, canyons, ravines or other natural channels, or in definite underground channels, whether perennial or intermittent, floodwaters, wastewater, or surplus water, and of lakes, ponds and springs on the surface." A.R.S. § 45-101.

Water may be appropriated for domestic, municipal, irrigation, stock watering, water power, recreation, wildlife, including fish, nonrecoverable water storage or mining uses. A.R.S. § 45-151(A). Water cannot be wasted, and if not used by the senior appropriator, it must be allowed to flow to the next senior appropriator. Non-diversionary appropriation of surface water for recreation and wildlife, including fish, use is recognized as a beneficial use. (Arizona Court of Appeals decision, *Phelps Dodge Corp v. Arizona Dep't of Water Res.*, 211 Ariz.146, 118 P.3d 1110 (App.2005)). These rights are referred to as "instream flow rights."

The Department administers the surface water permit system, including permits for instream flow. Permits are issued for a specific location and amount of water. Surface water rights for municipal, domestic or irrigation may be severed and transferred to a new location but only pursuant to statutory procedures. *A.R.S. § 45-172*.

Adjudication of Surface Water Rights

A general stream adjudication is a judicial proceeding in which the nature, extent, and relative priority of the rights of all persons to use water in a river system and source are determined. Two general stream adjudications are in progress involving the Gila River and Little Colorado River systems. The Gila River Adjudication includes the Salt, Gila, San Pedro, and Verde River watersheds, which include most of

Southeastern and Central Arizona. The Little Colorado River Adjudication includes the Little Colorado River system in northeastern Arizona.

The Department provides technical and administrative support to the adjudication court and special master, "in all aspects of the general adjudication with respect to which the director possesses hydrological or other expertise." *A.R.S. § 45-256(A).* Thousands of claimants and water users are joined in these cases that will result in the Superior Court issuing a comprehensive final decree of water rights for both the Gila and Little Colorado river systems.

Surface Water Decrees

Decreed surface water rights are those that have been determined through judicial action in a state or federal court. Major court determinations in Arizona include the Kent, Benson, Allison, Norviel, Concho and Globe Equity Decree.

The Kent Decree (*Hurley v. Abbott* 1910) established rights to the Salt and Verde rivers for diversion by downstream landowners based on diversions occurring at that time from Granite Reef and Joint Head diversion dams. These lands are generally the Salt River Project service area, along with portions of the Salt River Pima-Maricopa and Fort McDowell Indian reservations. Rights to the lower Agua Fria River, the Salt River and the Gila River below the confluence were determined in the *Benson v. Allison* Decree in 1917 for the Buckeye Irrigation District and a portion of the Gila River Indian Reservation. The Little Colorado River major decree is known the Norviel Decree, which is comprised of four judicial actions (between 1914 and 1923) determining rights of landowners to divert surface water in and around St. 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. In 1935 the U.S. District Court entered a consent decree (Globe Equity No. 59) for all diversions of the mainstem of the Gila River from confluence with the Salt River to the headwaters in New Mexico, including the Gila River and San Carlos Apache reservations, and non-Indian landowners below and above Coolidge Dam.

Indian Water Rights Claims and Settlements (See Appendix D)

Federal Reserved Rights

The United States Supreme Court's decision in Winters v. United States, 207 U.S. 564 (1908) established that when the federal government creates an Indian reservation, it impliedly reserves for the reservation a right to an amount of water sufficient to effectuate the purposes of the reservation (this doctrine is know as the "Winters Doctrine"). This concept of "federal reserved rights" has been claimed for other federal lands. Water rights claims have been filed in the Gila and Little Colorado River adjudications for national parks and monuments, national forests and for military bases.

Groundwater

The withdrawal, use and transportation of groundwater in the state are regulated under the Arizona Groundwater Code (Code), title 45, chapter 2, Arizona Revised Statutes. The Code has three primary goals: 1) to control groundwater overdraft in certain parts of the state; 2) to provide a means to allocate groundwater to meet the needs of the state; and 3) to augment groundwater supplies through the development of renewable water supplies. The Code established the Arizona Department of Water

Resources to administer the Code provisions.

The Code contains regulatory provisions applicable statewide, such as well drilling requirements and restrictions on groundwater transportation. It also contains provisions applicable only in certain designated areas of the state. The most intensive regulation of groundwater is in the five areas of the state designated as active management areas (AMAs), where the focus is on conservation and achievement of the AMA's management goal. Outside AMAs, persons may generally withdraw and use groundwater for any reasonable and beneficial use, subject to the groundwater transportation laws. . However, in areas designated as irrigation non-expansion areas (INAs), irrigation acreage expansion is prohibited and metering and reporting requirements apply to certain groundwater withdrawals.

Statewide Provisions

Statewide, all wells must be registered with the Department, wells must be drilled by a licensed well driller and new wells must comply with well construction standards. With certain exceptions, wells proposed to recover water stored or saved underground pursuant to a storage permit must comply with well spacing requirements.

Arizona has been divided into hydrologic groundwater basins and sub-basins within some of those basins. Statutes governing the transportation of groundwater within and between basins are designed to protect hydrologically distinct sources of groundwater supplies and the economies in rural areas by ensuring the groundwater is not depleted in one groundwater basin to benefit another. In general, groundwater cannot be transported between groundwater basins outside AMAs or from a groundwater basin outside an AMA into an AMA except for certain transfers specified in statute. A.R.S. §§ 45-544 and 45-551 through 45-555. Groundwater can legally be transported within a sub-basin, or within a basin that has not been divided into sub-basins, without payment of damages. A.R.S. § 45-541 and A.R.S. § 45-544. Groundwater may also be transported between sub-basins in the same basin but is subject to payment of damages, except under certain conditions in AMAs. A.R.S. §§ 45-542 through 45-545.

Active Management Areas

The magnitude of overdraft in certain areas of the state led to the designation of four initial AMAs: the Prescott, Phoenix, Pinal and Tucson AMAs. In 1994, a southern portion of the Tucson AMA was separately designated as the Santa Cruz AMA. The geographic boundaries of AMAs are defined by groundwater basins and subbasins. The Phoenix, Prescott and Tucson AMAs have a management goal of safe-yield by 2025. A.R.S. § 45-562(A). Safe-yield, as defined in the Code, means "a groundwater management goal which attempts to achieve and thereafter maintain a long-term balance between the annual amount of groundwater withdrawn in an active management area and the annual amount of natural and artificial groundwater recharge in the active management area." A.R.S. § 45-561(12). The management goal of the Pinal AMA is to allow development of non-irrigation uses and to preserve existing agricultural economies in the AMA for as long as feasible, consistent with the necessity to preserve future water supplies for non-irrigation uses. A.R.S. § 45-562(B) The goal of the Santa Cruz AMA is to maintain a safe-yield condition and prevent local water tables from experiencing long-term declines. A.R.S.§ 45-562(C).

General water management requirements within AMAs include:

- Groundwater rights and permits including metering, reporting and fees
- Well regulations
- Agricultural land development restrictions
- Groundwater management plans, which include agricultural, municipal and industrial water conservation programs, an augmentation program, groundwater quality assessment, and a water management assistance program
- Assured water supply program requirements for new subdivisions to have long-term dependable water supplies consistent with the management goal

In AMAs there are regulatory distinctions between wells equipped with a pump that can pump more than 35 gallons per minute (gpm), "non-exempt wells" and those that are equipped to pump less, "exempt wells." Withdrawal of groundwater from a non-exempt well requires a legal authority. The Groundwater Code established grandfathered groundwater rights, service area rights and groundwater withdrawal permits to provide legal withdrawal authority. With certain exceptions, drilling a non-exempt well requires a well drilling permit and is subject to well spacing requirements adopted by the Department to prevent unreasonably increasing damage to surrounding land and other water users. With a few exceptions, any person withdrawing groundwater from a non-exempt well in an AMA must meter and report water use annually to the Department and is assessed an annual withdrawal fee based on the amount withdrawn and beneficially used. Withdrawal fees are used to fund conservation and augmentation programs and Arizona Water Banking Authority activities (described below). Information from the annual water use reports is used to estimate the volume of groundwater withdrawals, water stored, and water recovered in an AMA. Water budgets are constructed from these data to determine the relationship between water supply and demand and to gage progress toward meeting AMA management goals.

A person may withdraw groundwater from an exempt well for a non-irrigation use without a groundwater right or permit. However, a right or permit is required to withdraw more than 10 acre-feet of groundwater per year for non-irrigation uses other than domestic or stockwatering if the exempt well was drilled on or after April 28, 1983. Except under specific circumstances, not more than one exempt well can be drilled to serve the same purpose at the same location. Additionally, beginning on January 1, 2006, with certain exceptions, an exempt well may not be drilled on land if any part of the land is within 100 feet of the operating water distribution system of a municipal provider with an assured water supply designation as shown on a digitized service area map provided to the Department by the municipal provider. A.R.S. § 45-454. These restrictions do not apply outside AMAs as long as the groundwater is put to reasonable and beneficial use.

In AMAs, the Code directs the Department to develop and implement water conservation requirements for the agricultural, municipal and industrial water use sectors in five consecutive management periods. These requirements are published in Management Plans for each AMA. A.R.S. §§ 45-564 through 45-568. The Code generally requires that each consecutive management plan contain more rigorous water conservation requirements. Management plans contain water use information and data and provide the framework for the day-to-day implementation of Code mandates and the Department policies for each AMA.

Within AMAs new subdivisions must demonstrate to the Department that a 100-year water supply exists before the local platting authority (typically City or County Planning Departments) can approve a plat

and before the Arizona Department of Real Estate will issue a public report, allowing the land to be sold. The demonstration criteria include physical, legal and continuous availability of water of adequate quality for 100-years, the groundwater use must be consistent with the AMA management goal and management plan conservation requirements, and the developer must have the financial capability to construct the necessary delivery, storage and treatment systems.

Outside Active Management Areas

Outside AMAs, groundwater may generally be withdrawn and used for any reasonable and beneficial use, subject to the statewide provisions described above. In areas designated as INAs, however, additional restrictions and requirements apply (see *Irrigation Non-Expansion Areas* section below.

In 1973, the Arizona Legislature enacted a statewide water adequacy statute as a consumer protection measure A.R.S. § 45-108. The law was passed in response to incidences of land fraud involving the sale of subdivision lots that were later found to have insufficient water supplies. This law required developers to obtain a determination from the State Land Department regarding the availability of water supplies prior to marketing new subdivision lots. When the Groundwater Code was adopted in 1980, the provisions of A.R.S. § 45-108 were amended and now apply only to subdivisions located outside AMAs. Under A.R.S. § 45-108, the Department must evaluate a developer's water supply plans and determine whether there is an adequate water supply, unless the development will be served by a water provider that has been designated by the director as having an adequate water supply for its service area. The developer must provide a copy of the Department's evaluation to the State Real Estate Commissioner for disclosure to the public if water supplies are determined to be inadequate. However, the Department's evaluation does not affect whether lots may be platted or sold. The Groundwater Code contains more rigorous provisions for new subdivisions inside the AMAs (see *Active Management Areas* section above).

Irrigation Non-Expansion Areas

There are three INAs: the Douglas INA, Joseph City INA and Harquahala INA. In an INA irrigation is restricted to lands that were irrigated during the five-year period preceding designation of the INA. A.R.S. § 45-434. This restriction is intended to protect the remaining groundwater supply. Groundwater withdrawals for agricultural irrigation on more than 10 acres and non-irrigation withdrawals of more than 10 acre-feet per year from a non-exempt well must be measured and annually reported to the Department. A.R.S. § 45-437. Statewide provisions and the provisions applicable outside AMAs mentioned above also apply within INAs.

Colorado River Water and the Central Arizona Project

The Colorado River is a critical water supply for Arizona. Use of Colorado River water is primarily under the jurisdiction of the federal government and is discussed in more detail in Appendix E. The development of Colorado River water law is described in the "Law of the River", which includes a number of Congressional acts, Supreme Court decisions and multi state compacts, as well as an international treaty**.**

The "Law of the River" includes: the 1922 Colorado River Compact, which apportioned 7.5 million acre-feet per year to the upper basin states and 7.5 million acre-feet per year to the lower basin states; the Boulder Canyon Project Act of 1928, which authorized construction of Hoover Dam and established the individual lower basin state apportionments; the 1944 Water Treaty with Mexico, which guaranteed

delivery to Mexico of 1.5 maf per year; the Upper Colorado River Compact of 1948 that divided the water apportioned to the Upper Basin between the five states with territory in the Upper Basin (including Arizona); the Colorado River Storage Project Act of 1956, which authorized several dams including Glen Canyon Dam in Arizona; the United States Supreme Court's decision in *Arizona v. California* (1964) that confirmed Arizona's apportionment under the Boulder Canyon Project Act and assigned any surplus; and the Colorado River Basin Project Act (CRBPA) of 1968 which authorized the Central Arizona Project (CAP). Ratification and text of the 1944 Lake Mead Delivery Contract, the Colorado River Compact and the Upper Colorado River Basin Contract are found at A.R.S. §§ 45-1301 to 1331.

Central Arizona Water Conservation District

Under provisions of the CRBPA, Arizona authorized the Central Arizona Water Conservation District (CAWCD) in 1971 to provide a means for Arizona to repay the federal government for the reimbursable costs of construction and to manage and operate the CAP. The CAP transports about half of Arizona's Colorado River water entitlement of 2.8 million acre-feet per year to central Arizona.

The CAP brings Colorado River water through a 336–mile system of aqueducts, pumping plants and siphons designed to carry 1.5 million acre-feet of water each year from Lake Havasu through Phoenix to south of Tucson. One reservoir, Lake Pleasant, located in the Phoenix AMA, provides storage. CAP delivers untreated water to cities and water utilities, industrial users, agricultural users and Indian communities.

CAWCD is a tax-levying public improvement district of the state responsible for system maintenance and operations, repayment obligations, and creating water resource management programs. Operations are managed by the General Manager and senior management team. The General Manager reports to the 15-member CAWCD Board of Directors who are popularly elected from the CAP three-county service area that includes Maricopa, Pima, and Pinal counties. Board members serve staggered six-year terms and are responsible for establishing policy. (See: www.cap-az.com).

Arizona Department of Water Resources

The director of the Department is authorized to "consult, advise and cooperate with the secretary of the interior of the United States" on behalf of the state of Arizona in several areas: the secretary's authorities under the Boulder Canyon Project Act; contracts for delivery of main stream Colorado river water for use within Arizona; powers and duties of the secretary under provisions of the 1944 treaty with Mexico; exercise by the secretary of any authority conferred by any legislation enacted by Congress; and in respect to the development, negotiation and execution of interstate banking agreements. (A.R.S.§ 45-107).

Arizona Water Banking Authority

The Arizona Water Banking Authority was created in 1996 to protect Arizona's Colorado River interests and to provide for interstate banking opportunities. (A.R.S. § 45-2401 et.seq.). The AWBA's goal is to firm water supplies for CAP municipal and industrial users or on-River users in times of shortages on the Colorado River or during CAP service interruptions, to help meet the management objectives of the Code and to assist in the settlement of Indian water rights claims. The AWBA stores Arizona's unused Colorado River allotment in groundwater basins and can enter into Storage and Interstate Agreements with entities in Nevada and California to store water in Arizona under certain conditions. Information

about the Water Banking Authority is found at www.awba.state.az.us.

Effluent

Effluent is defined in A.R.S. § 45-101(4) as "water that has been collected in a sanitary sewer for subsequent treatment in a facility that is regulated pursuant to title 49, chapter 2. Such water remains effluent until it acquires the characteristics of groundwater or surface water." The determination that effluent is a separate kind of water was a result of an Arizona Supreme Court Decision in 1989, *Arizona Pub. Serv. Co. v. Long*, 160 Ariz. 429, 773 P.2d 988 (1989), in which the court held that, until it is returned to the ground as surface water or groundwater, effluent is neither surface water nor groundwater, and therefore a city that produces effluent is free to use it without regard to the laws governing surface water and groundwater. Because the supply is not groundwater, if 100% effluent is used to serve a use within an AMA, the use is not subject to regulations applicable to groundwater, such as conservation requirements and groundwater transportation laws. AMA management plans contain a number of regulatory incentives for effluent use, which is considered a renewable water supply.

Underground Water Storage

Underground water storage or recharge is a means of storing excess renewable water supplies (surface water, including CAP and Colorado River water, and effluent) for future use. The goals of the recharge program are to promote the use of renewable water supplies by allowing for storage and recovery, to allow water to be "transported" by storing water in one location but recovering a like quantity elsewhere, to reduce overdraft by storing water to prevent further water level declines, to use underground storage to address seasonal water demands and to augment the water supply.

The Underground Water Storage and Recovery program was established in 1986 by the Arizona Legislature. In 1994, the Legislature enacted the Underground Water Storage, Savings, and Replenishment Act, which further defined the recharge program. Persons wishing to store and/or recover water anywhere in the state through the recharge program must apply to the Department for the appropriate permits. Permit holders are required to file annual reports with the Department in which they must report the volume of water stored and/or recovered pursuant to the permit. A.R.S. §§ 45-801.01 through 45-898.01. Recharge and recovery is an increasingly important tool in the management of Arizona's water supplies, especially in meeting the goals of the Code.

Water Exchanges

Flexibility in accessing water supplies through exchanges can provide water management benefits. The 1992 Water Exchange Act authorizes and regulates the exchange of any type of water for any type of water with certain exceptions. A.R.S. § 45-1001 et seq. "Water exchange" is defined as "a trade between one or more persons, or between one or more persons and one or more Indian communities, of any water for any other water, if each party has a right or claim to use the water it gives in trade. This definition applies whether or not water is traded in equal amounts or other consideration is included in the trade." A.R.S. § 45-1001(6). The Act establishes four classifications of exchanges with different conditions applicable to each class. Regardless of the classification, every exchange is subject to the "giver rule", which generally provides that a person who receives water pursuant to an exchange: (1) may use the water without holding a right to that water; and (2) may use the water only in the same manner in which the person had the right to use the water that the person gave in the trade. Currently, water exchanges are most common within the Phoenix AMA.

Dams and Reservoirs

The director of the Department is responsible for supervision of the safety of dams in Arizona. A.R.S. § 45-1202(A). The statutory authority for the tasks performed under the Dam Safety Program is found in A.R.S. § 45-105(B)(3). and 45-1201, et seq. Rules for dam safety procedures are found in the Arizona Administrative Code, R12-15-1201 et seq. Statutes and rules define a dam as an artificial barrier over 25 feet in height or capable of storing more than 50 acre-feet of water, with certain exceptions. Dams owned and/or operated by the Federal government are generally exempt from state jurisdiction. Major program areas are rehabilitation of unsafe dams, inspection and oversight of existing dams, review of applications to construct, enlarge, alter or remove a dam and construction monitoring. Another responsibility is to review and assistance to dam owners in development of Emergency Action Plans.

Water Replenishment Districts and Water Authorities

Central Arizona Groundwater Replenishment District

In 1993, CAWCD was given groundwater replenishment authority, within the Phoenix, Pinal and Tucson AMAs. The division of CAWCD responsible for replenishing groundwater is the Central Arizona Groundwater Replenishment District (CAGRD). Membership in the CAGRD provides a mechanism for developers and water providers to satisfy the management goal criteria of the Assured Water Supply (AWS) rules. The CAGRD must replenish (recharge) the amount of groundwater used by members in excess of that allowed by the AWS rules. Water used for replenishment is primarily excess CAP water.

Mohave County Water Authority

The Mohave County Water Authority was formed in 1994 pursuant to legislative authorization. A.R.S. §§ 45-2201 through 45-2283. The Authority is authorized to acquire Colorado River water allocations on behalf of its members. Members of the Authority must have had a Colorado River contract as of January 1, 1993. The legislation approved the transfer of the right to delivery of 18,500 acre-feet per year of Colorado River water from a member for allocation to municipal and industrial uses.

Water-Related Agencies and Commissions

Arizona Department of Environmental Quality

The Arizona Department of Environmental Quality's (ADEQ) mission is to protect and enhance public health and the environment in Arizona. Established by the Arizona Legislature in 1986 in response to growing concerns about groundwater quality, ADEQ administers a variety of programs to improve the health and welfare of Arizona's citizens and ensure the quality of Arizona's air, land and water resources meets healthful, regulatory standards.

ADEQ has a programmatic Water Quality division. Core responsibilities include pollution control, monitoring and assessment, compliance management, cleanups of contaminated soil and water, education, outreach and financial assistance and policy development. Its programs influence water supply planning and operations at the local level. Effluent reuse, recharge projects and discharge of water to aquifers or stream beds must meet water quality standards. The Water Quality Assurance Revolving Fund (WQARF) was established to investigate and cleanup hazardous waste sites in Arizona. The Department has certain responsibilities under this program, including the adoption of provisions in

its management plans and AWS rules to encourage the beneficial use of groundwater withdrawn pursuant to a remedial action project. (See: www.azdeq.gov)

Arizona Corporation Commission

The Arizona Corporation Commission (ACC) is a constitutionally formed commission with an elected 5- member board. It oversees the process of incorporating or registering companies to do business in the state, registers and oversees securities offerings and dealers and enforces railroad and pipeline safety. Among its responsibilities is regulatory authority over private water companies and private sewer companies. It regulates rates and authorizes curtailment tariffs that allow utilities to request that customers reduce water consumption when the demand is greater than the production. (See: www.cc.state.az.us)

Arizona Water Protection Fund Commission (See Appendix C)

APPENDIX B: RURAL WATERSHED PARTNERSHIPS ISSUE SUMMARY (2005)

Rural watershed partnership participants, projects, accomplishments and issues are summarized below and grouped by planning area. Some partnerships include more than one planning area as noted.

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

MULTI-PLANNING AREA - Eastern Plateau, Western Plateau and Central Highlands			
Watershed Partnership	**Primary Participants**	**Projects & Accomplishments**	**Issues**
			? Extremely high cost of water augmentation projects
Northern Arizona Municipal Water Users Association (NAMWUA)	Prescott Prescott Valley Flagstaff Williams Cottonwood Clarkdale Sedona Payson Chino Valley	? Projected water demands through 2040 have been identified ? A request for 70,000 acre-feet of CAP reallocation water has been submitted to ADWR for consideration.	? Limited supplies to meet projected demands ? ESA issues impacting potential ground and surface water supplies ? Limited funding resources for planning, projects, infrastructure and studies ? Competition from Phoenix/Tucson for CAP reallocation water ? Funding for Colorado River infrastructure ? Water quality issues in Verde Valley and Flagstaff ? Upper Basin/Lower Basin issues with Colorado River affect potential for use

EASTERN PLATEAU PLANNING AREA			
Watershed Partnership	**Primary Participants**	**Projects & Accomplishments**	**Issues**
Little Colorado Watershed Coordinating Council (Formerly Little Colorado River Multi-Objective Management Partnership (LCRMOM))	Winslow Holbrook Navajo County NRCD/RCD NAU USBoR COE	? Development and Ecosystem Restoration Program study for the Montane Forest Regimes completed. ? Watershed reconnaissance study	? Potential impacts on groundwater from power plants ? Water quality issues involving arsenic and TDS ? Unresolved adjudication and Indian water rights settlements ? Limited groundwater data for entire region ? Invasive species (Tamarisk) ? ESA issues ? Drought impacts on surface water supplies ? Limited funding resources for planning, projects, infrastructure and studies
Navajo Nation	NDWR NTUA NDEQ NHA ADWR USBoR COE BIA HIS	? Survey of agricultural lands in Upper Basin ? Groundwater elevation survey of NTUA wells ? Water Quality ATLAS ? Navajo Drought Report ? Western Navajo Water Supply Study	? Lack of technical groundwater data ? Limited groundwater supplies to meet projected demands ? Water quality issues ? Prone to impacts from drought ? Unresolved water right claims to LCR & Colorado R. ? Upper Basin/Lower Basin issues with Colorado River ? Gallup to Window Rock Pipeline in jeopardy (financial, upper/lower basin issues, ESA and others)

EASTERN PLATEAU PLANNING AREA			
Watershed Partnership	**Primary Participants**	**Projects & Accomplishments**	**Issues**
Show Low Creek Watershed Partnership	Show Low Lakeside Pinetop Navajo County Show Low Creek Irrigation District Local Citizenry ADWR AZ Game & Fish	? Groundwater elevations study ? GPS survey of agricultural lands ? Development of a water resources management plan initiated. ? Development of a water budget initiated.	? Drought impacts on surface water supplies and springs resulting in impacts on agriculture and cattle ranching ? Seasonal demands impacting peak demands ? Growth ? Unresolved adjudication and Indian water rights settlements ? Limited funding resources for planning, projects, infrastructure and studies
Silver Creek Watershed Partnership	Snowflake Taylor Holbrook Winslow Show Low Navajo County Silver Creek ID Show Low Creek Watershed Partnership ADWR NAU	? Silver Creek channel and riparian restoration study completed. ? Value Engineering Analysis of Unsafe Dams completed ? Silver Creek HSR ? Development of a water budget initiated.	? Limited groundwater data ? Potential impacts on groundwater system from Cholla Power plant ? Drought impacts on surface water supplies for agriculture ? Several high hazard unsafe dams ? Unresolved adjudication and Indian water rights settlements ? Perception of no real supply problem ? Water quality concerns in some areas (salinity) ? Limited funding resources for planning, projects, infrastructure and studies
Upper Little Colorado River Watershed Partnership	Springerville Eagar Greer Nutrioso Apache County Round Valley Irrigation District Local Citizens and Special Interest Groups ADWR ADEQ AZG&F NRCS/RCD USFS USBoR	? Aerial mapping survey and GIS coverage of the Little Colorado River and tributaries completed. ? Geomorphic and biological assessment of the LCR completed. ? Stream riparian restoration project ? Round Valley Irrigation Delivery System partially upgraded. ? Preliminary water budget completed ? Reconstruction of River Reservoir Dam completed. ? Interconnection of Springerville and Eagar's wastewater treatment facilities is being pursued.	? Limited groundwater data ? Potential impacts to the groundwater system from TEPCO generating station. ? Unresolved adjudication and Indian water rights settlements ? Proposed development in Greer and impacts on Little Colorado River ? Drought impacts on forage for grazing and surface water availability for agriculture ? Potential impacts on tourism due to drought ? Funding issues for water delivery infrastructure ? Political differences between Springerville and Eagar ? Perception of no real supply problem ? Limited funding resources for planning, projects, infrastructure and studies

SOUTHEASTERN ARIZONA PLANNING AREA			
Watershed Partnership	**Primary Participants**	**Projects & Accomplishments**	**Issues**
Community Watershed Alliance/ Middle San Pedro Watershed	Cochise County Benson J-Six Mescal HOA St. David Irrigation District Pomerene Irrigation District Local Citizenry TNC ADWR NRCD ADEQ Coop Extension USGS USDA/ARS USGS USBoR	? Cursory groundwater study completed. ? AMA evaluation completed. ? Active agricultural fields identified and surveyed ? HSR completed ? 7-year comprehensive groundwater study and numeric model development initiated.	? Growth proposed in the Benson area ? Limited groundwater data ? Different perceptions of issues and goals within the area between Benson, irrigation districts, local citizenry, and the Upper San Pedro Partnership ? Unable to get principle players to the table to discuss water ? Unregulated lot splits ? New arsenic drinking water standard ? Limited funding resources for planning, projects, infrastructure and studies ? ESA issues ? Superfund site/poor quality groundwater conditions ? Potential impact of adjudication court subflow definition ? Limited funding resources for planning, projects, infrastructure and studies
Eagle Creek Partnership	Local ranchers & special interest groups ADWR	? Stream Reconnaissance study completed.	? Little or no groundwater data available ? Unresolved Indian water rights settlements ? Limited funding resources for planning, projects, infrastructure and studies
Gila Watershed Partnership	Safford Thatcher Pima Graham County Greenlee County Duncan ADWR AZG&F ADEQ Coop Extension BLM USFS USBoR NRCS/RCD	? Fluvial Geomorphology Study ? Water demand study ? Development of water resource management plan for the watershed area initiated ? Capped several saline wells contributing to the degradation in water quality of the Gila River ? Resin bush eradication project completed.	? Indian water rights settlement issues ? Poor quality surface and groundwater ? Growth associated with new Phelps Dodge mine and unregulated lot splits ? ESA issues throughout the watershed, critical habitat designation, and mitigation efforts ? Desire to maintain rural setting and especially maintaining agriculture at current or higher levels ? Lack of technical data on the groundwater system ? Invasive species issues impacting the surface water supply (tamarisk) ? Potential impacts of adjudication court subflow

SOUTHEASTERN ARIZONA PLANNING AREA			
Watershed Partnership	**Primary Participants**	**Projects & Accomplishments**	**Issues**
			definition ? New arsenic drinking water standard ? Drought impacts on surface water supplies, agriculture and cattle ranching ? Numerous high hazard unsafe dams in area ? Limited funding resources for planning, projects, infrastructure and studies ? Regular flooding in the Duncan-Virden area
Lower San Pedro Watershed Partnership-Redington NRCD	Redington Cascabel Local ranchers ADWR NRCD/RCD	? Watershed reconnaissance study completed.	? Unresolved adjudication and Indian water rights settlement issues ? Little or no groundwater data ? Opposition to government assistance in obtaining groundwater information ? Potential impacts of adjudication court subflow definition ? Limited funding resources for planning, projects, infrastructure and studies
Upper San Pedro Partnership	Sierra Vista Ft. Huachuca Cochise County Huachuca City Bisbee Tombstone TNC Huachuca Audubon Bella Vista Water ADWR ADEQ AACD NRCD State Land USF&W USFS BLM USDA/ARS USGS USBoR Coronado National Monument	? Comprehensive groundwater study ? Numeric groundwater model ? Phase I of Decision Support System model completed. ? San Pedro Riparian National Conservation Area Water Demand study ? Recharge study of detention basins ? Engineering design to transfer effluent from Huachuca City to Ft. Huachuca for treatment and recharge ? Partially funded transfer of treated effluent from new Bisbee wastewater treatment plant for use by Turquoise Valley golf course. ? Second iteration of water conservation & management plan	? Impacts on endangered species ? Federal mandate to achieve sustainability by 2011 ? Lawsuits from environmental groups ? Anticipated growth ? Potential impacts on riparian regime by continuation of current pumping ? Political obstacles from potential water augmentation projects ? Potential loss of Ft. Huachuca ? Interbasin transfer prohibition ? Potential impacts of adjudication court subflow definition ? Pumping impacts by Mexico on the San Pedro River and downstream users ? Unregulated lot splits ? Limited funding resources for planning, projects, infrastructure and studies

SOUTHEASTERN ARIZONA PLANNING AREA			
Watershed Partnership	**Primary Participants**	**Projects & Accomplishments**	**Issues**
		completed. ? Section 321 Report to Congress submitted annually. ? Funded more than $1,000,000 in conservation projects in watershed. ? Conduct public outreach and educational forums ? Appraisal study of five water augmentation projects initiated.	? High cost of augmentation projects

CENTRAL HIGHLANDS PLANNING AREA			
Watershed Partnership	**Primary Participants**	**Projects & Accomplishments**	**Issues**
Northern Gila County Partnership- (Mogollon Highlands)	Payson Pine Strawberry Gila County Brooks Utilities Rim Trails WID Pine Strawberry WID Local citizens and special interests Tonto Apache Nation ADWR SRP USFS USBoR USGS	? Comprehensive groundwater study and conceptual model completed. ? Conducting Water Resources Management Appraisal Study to identify current & future demands and alternatives for meeting projected demands. ? Strategic Plan completed ? Feasibility study and cost estimates for Blue Ridge Reservoir pipeline ? Obtained approximately 3,500 ac-ft of surface water from Blue Ridge Reservoir. ? Development of a numeric groundwater model initiated.	? Limited water resources to meet current demands. ? Environmental, supply, treatment, transportation and financing costs associated with augmentation from Blue Ridge reservoir ? Numerous private water companies, Arizona Corporation Commission and Domestic Water Improvement District conflicts ? Interbasin transfer conflicts resulting from Payson's ability to pump from two different basins ? Seasonal demand issues; peaking problems ? County encouragement of growth in Pine and Strawberry ? Unresolved Indian water rights settlements ? Environmental issues pertaining to Fossil Creek ? Limited groundwater data for entire region ? Costs associated with hauling water ? Access to water development on public lands ? Infrastructure needs for private water companies ? Limited funding resources for planning, projects, infrastructure and studies
Upper Agua Fria Watershed Partnership	Mayer Black Canyon City Cordes Lakes Yavapai County Spring Valley Local Citizens ADWR ADEQ Cooperative Extension State Lands BLM/Agua Fria Nat. Monument USFS	? Watershed Reconnaissance studies ? Active recharge site identification study.	? Proposed growth in the Mayer, Bensch Ranch and Spring Valley areas ? Limited groundwater supplies ? Little or no groundwater data ? Groundwater and surface water supplies are very drought sensitive ? Potential water quality attributed to local septic systems and discharges from Prescott Valley ? Poorly constructed and maintained infrastructure in some areas ? Limited funding resources for planning, projects, infrastructure and studies

CENTRAL HIGHLANDS PLANNING AREA			
Watershed Partnership	**Primary Participants**	**Projects & Accomplishments**	**Issues**
Upper and Middle Verde Watershed Groups (Yavapai County Water Advisory Council) (Verde Watershed Authority)	Prescott Prescott Valley Chino Valley Paulden Yavapai County Sedona Camp Verde Clarkdale Cottonwood Jerome 24 local special interest groups TNC Yavapai Apache Yavapai Prescott ADWR ADEQ SRP NRCD Cooperative Extension NAU USFS USGS USBoR USF&W	? Comprehensive groundwater study and conceptual model ? Study of geologic framework of aquifer units and groundwater flow paths of Verde River headwaters using aeromagnetic and gravity data. ? Verde River Watershed Study. ? Water educational forum conducted for WAC and public with ultimate goal of developing water management plan for Verde watershed area. ? Big Chino Subbasin Historical and Current Water Uses and Water Use Projectionsn study. ? Riparian demand study of Middle Verde ? Numeric groundwater model project initiated. ? Prescott AMA groundwater model. ? Study of groundwater flow paths for upper and middle Verde using stable isotopes. ? Prescott purchased JWK Ranch in Big Chino to import 8,717 ac-ft annually to Prescott and Prescott Valley ? Groundwater monitoring program in Big Chino initiated.	? Potential impacts resulting from the transfer of 8,717 ac-ft from Big Chino to Prescott and Prescott Valley ? 25,000 to 30,000 approved lots still outstanding in Prescott AMA ? Multiple developments currently under construction in the tri-city region of the AMA ? ESA issues associated with the Verde ? Proposed critical habitat area in Verde Valley for Willow Fly Catcher ? New Arsenic standards ? Pending Subflow decision ? Political and philosophical differences between AMA and Verde Valley ? Countywide growth and unregulated lot splits ? Indian water rights ? Yavapai Ranch Land exchange and Title II implementation (Verde Basin Partnership) ? Thousands of private domestic wells already permitted and more being requested daily ? Potential water quality impacts on groundwater system from the thousands of septic systems ? Potential development rumors of the CVCF Ranch in the Big Chino ? Limited funding resources for planning, projects, infrastructure and studies

WESTERN PLATEAU PLANNING AREA			
Watershed Partnership	**Primary Participants**	**Projects & Accomplishments**	**Issues**
Arizona Strip Partnership (Currently not active)	Fredonia Kanab, Utah Colorado City Local citizens ADWR BLM National Park Service USBoR USFS USGS	? Kanab Creek seeps and springs study ? Watershed reconnaissance study ? Database development	? Brackish groundwater ? Inadequate surface water supplies for agriculture ? Drought impacts on surface and groundwater supplies ? Interstate stream issues ? Flooding due to operation of Kanab Creek by Kanab, Utah ? Little or no groundwater data available ? Limited funding resources for planning, projects, infrastructure and studies

UPPER COLORADO PLANNING AREA			
Watershed Partnership	**Primary Participants**	**Projects & Accomplishments**	**Issues**
Northwest Arizona Watershed Council	Kingman Mohave County Dolan Springs Dolan Springs Water Co. Local citizens Hualapai Nation ADWR ADEQ Cooperative Extension BLM USFS USFS	? Groundwater reconnaissance survey of 3 basin area. ? Coordinated the clean-up of numerous wildcat dumpsites. ? Water Resource Management Plan for watershed area initiated. ? Comprehensive groundwater study and conceptual model initiated. ? Relative gravity survey of Detrital Basin.	? Limited groundwater supplies ? Huge growth projected for all three basins. ? Detrital Basin envisioned as bedroom community of Las Vegas with the completion of the bypass bridge over the Colorado River. ? Drought impact on private water suppliers, which impacts water haulers ? Potential for subsidence from proposed development ? Limited groundwater data. ? Potential impact from large industrial users in the Big Sandy basin ? Water quality concerns (hexavalent Chromium) ? Potential problems with developments proposed within the Colorado River accounting surface area ? Mohave County claims they will deny any subdivision that cannot obtain adequate water supply determination ? Limited funding resources for planning, projects, infrastructure and studies

UPPER COLORADO PLANNING AREA			
Watershed Partnership	**Primary Participants**	**Projects & Accomplishments**	**Issues**
Upper Bill Williams Partnership (Currently not active)	Skull Valley Peeples Valley Yarnell Yavapai County Local Ranchers ADWR	? Preliminary water budget developed.	? Concern about Prescott potentially transferring water from the basin ? Highly vulnerable to drought impacts on both surface and groundwater supplies ? Poor infrastructure for private water suppliers ? Limited financial capability to upgrade infrastructure ? Little or no groundwater data ? Cultural opposition to understanding status of water supply ? Growth ? Unregulated lot splits ? Limited groundwater supplies ? Limited funding resources for planning, projects, infrastructure and studies

OTHER AREAS OF INTEREST:

? A proposal is being developed to operate a pilot desalinization plant on the Navajo Reservation near the Cholla power plant. The C aquifer north of I-40 is brackish and there is a desire to determine whether or not it is feasible to clean the water for use by the southern Navajo communities of Jeddito, Leupp, and possibly Dilkon. ADWR has been requested to participate in this project to operate the plant in conjunction with the Navajo.

? Douglas Basin is experiencing significant groundwater declines. Groundwater pumping is estimated at about 55,000 acre-feet per year, an increase from 30,000 in five years. ADWR has initiated a two-year groundwater study with the USGS for the Douglas Basin.

? Willcox Basin has been averaging 140,000 acre-feet of annual groundwater mining for the past 10 years causing some concern. A watershed partnership for this area is currently being organized and ADWR has initiated a two-year groundwater study of the Willcox Basin with the USGS.

? A Cienega Creek watershed group has been meeting fairly regularly to evaluate water conditions.

APPENDIX C: ARIZONA WATER PROTECTION FUND

The Arizona Water Protection Fund (AWPF) was established in 1994 by the Arizona State Legislature (A.R.S. § 45-2101 et seq.) in order to provide a source of funding for "a coordinated effort for the restoration and conservation of the water resources of the state….designed to allow the people of this state to prosper while protecting and restoring this state's rivers and streams and associated riparian habitats, including fish and wildlife resources that are dependent on these important habitats".

Riparian areas provide wildlife habitat, support biodiversity and serve many essential functions including water quality improvement, water quantity improvement, flood control and recreation. These conditions provide economic benefits including increased property values.

The AWPF is administered by a 15-member Commission appointed by the Governor, the President of the Senate and the Speaker of the House of Representatives. The composition of the Commission is specified by statute (A.R.S. § 45-2103(A)) and is intended to represent a variety of land, water use and riparian issue perspectives. In addition there are two ex officio members, the director of the department of water resources and the state land commissioner.

The AWPF funds projects through a competitive grant process. Any person, agency or organization can apply. All projects must be in Arizona, be consistent with state water law and support the overall goals of the AWPF. Grants may be used to:

- Develop or implement capital projects or specific measures that directly maintain, enhance and restore rivers and streams and associated riparian resources;
- Acquire CAP water or effluent for the purpose of protecting or restoring rivers and streams;
- Develop, promote and implement water conservation programs outside of the five active management areas;
- Support research and data collection, compilation and analysis; or
- Fund man-made water resource projects if the project benefits a river or stream and creates or restores riparian habitat.

Monies for the AWPF are from three sources: 1) the Arizona State Legislature; 2) Central Arizona Project fees for each acre-foot of water sold to out-of-state CAP water lessees and purchasers, and; 3) private gifts, grants or donations. By statute, the AWPF is to receive $5 million annually from the legislature. The Commission encumbers all of the funds necessary to ensure the funding of multi-year projects. Money is disbursed on a reimbursable basis.

As of FY 2005, 111 projects had been funded outside of active management areas and 32 projects had been funded within AMAs. Table C-1 lists the grant number, project title and type of project, organized by planning area, AMA and groundwater basin. The table includes a map number, which refers to grant locations shown on Figure C-1.

Table C-1 Arizona Water Protection Fund grant summary.

ACTIVE MANAGEMENT AREA PLANNING AREA				
AMA	**Map Number**	**AWPF Grant #**	**Project Title**	**Project Category**
Phoenix AMA	16	95-010	Assessment of the Role of Effluent Dominated Rivers in Supporting Riparian Functions	Research
Phoenix AMA	101	96-0005	Tres Rios River Management & Constructed Wetlands Project	Research
Phoenix AMA	171	97-038	Tres Rios Wetland Heavy Metal Bioavailability Design for Denitrification and Microbial Water Quality	Research
Phoenix AMA	180	97-042	Queen Creek Restoration and Management Plan	Research
Phoenix AMA	259	99-098	Rio Salado Habitat Restoration Project	Constructed Wetland & Revegetation
Phoenix AMA	278	00-114	The Papago Park Greenline Project	Exotic Species Control & Revegetation
Pinal AMA	12	95-008	Picacho Reservoir Riparian Enhancement Project	Habitat Protection
Prescott AMA	19	95-012	The Comprehensive Plan for the Watson Woods Riparian Preserve	Feasibility Study
Prescott AMA	118	96-0008	Watson Woods Vegetation Inventory	Research
Prescott AMA	119	96-0009	Watson Woods Riparian Preserve Visitor Management	Research
Prescott AMA	235	99-076	Watson Woods Preserve Herpetological Interpretive Guide and Checklist	Research
Prescott AMA	296	04-121	Lynx Creek Restoration	Stream Restoration
Prescott AMA	299	04-122	Watson Woods Riparian Preserve Restoration Feasibility Project	Feasibility Study

ACTIVE MANAGEMENT AREA PLANNING AREA				
AMA	**Map Number**	**AWPF Grant #**	**Project Title**	**Project Category**
Tucson AMA	5	95-002	Partnership for Riparian Conservation in Northeastern Pima County	Research
Tucson AMA	26	95-007	High Plains Effluent Recharge Project	Wetland Restoration
Tucson AMA	69	95-023	Sabino Creek Riparian Ecosystem Protection Project	Research
Tucson AMA	90	96-0010	Rehabilitating the Puertocito Wash on the Buenos Aires National Wildlife Refuge	Stream Restoration
Tucson AMA	133	96-0026	Riparian Restoration on the San Xavier Indian Reservation Community	Habitat Restoration & Revegetation
Tucson AMA	161	97-031	Lincoln Park Riparian Habitat Project (f.k.a. Atturbury Wash Project)	Habitat Restoration
Tucson AMA	163	97-033	Proctor Vegetation Modification	Exotic Species Control
Tucson AMA	215	98-062	Partnership for Riparian Conservation in Northeastern Pima County II	Revegetation
Tucson AMA	231	99-072	Leopard Frog Habitat and Population Conservation at Buenos Aires National Wildlife Refuge	Habitat Restoration
Tucson AMA	239	99-080	Cortaro Mesquite Bosque	Habitat Restoration & Revegetation
Tucson AMA	246	99-087	Rillito Creek Habitat Restoration Project	Habitat Restoration & Revegetation
Tucson AMA	253	99-094	Santa Cruz River Park Extension	Habitat Restoration & Revegetation
Tucson AMA	279	00-115	Tucson Audubon Society North Simpson Farm Riparian Recovery Project	Revegetation

ACTIVE MANAGEMENT AREA PLANNING AREA				
AMA	**Map Number**	**AWPF Grant #**	**Project Title**	**Project Category**
Tucson AMA	300	04-123	Tucson Audubon Society, Santa Cruz River Habitat Project, North Simpson Site, Phase 2	Revegetation
Tucson AMA	310	05-130	Riparian Restoration on the San Xavier District – Project Two	Revegetation
Santa Cruz AMA	80	95-024	Potrero Creek Wetland Characterization and Management Plan	Research
Santa Cruz AMA	178	97-041	Altar Valley Watershed Resource Assessment	Research
Santa Cruz AMA	265	00-103	Riparian Restoration on the Santa Cruz River – Santa Fe Ranch	Fencing & Revegetation
Santa Cruz AMA	314	05-132	Esperanza Ranch Riparian Restoration Project	Fencing & Revegetation

CENTRAL HIGHLANDS PLANNING AREA				
Groundwater Basin	**Map Number**	**AWPF Grant #**	**Project Title**	**Project Category**
Agua Fria	**99**	96-0007	Ash Creek Riparian Protection Project	Stream Restoration
Agua Fria	**283**	03-117	Lynx Creek Restoration at Sediment Trap #2	Stream Restoration
Salt River	**65**	95-021	Lofer Cienega Restoration Project	Fencing & Habitat Protection
Salt River	**66**	95-022	Gooseberry Watershed Restoration Project	Stream Restoration
Salt River	**242**	99-083	Cherry Creek Enhancement Demonstration Project	Stream Restoration
Salt River	**306**	05-128	Canyon Creek Riparian Restoration Project, Reach 4-5	Fencing & Habitat Protection
Tonto Creek	**55**	95-019	Quantifying Anti-Erosion Traits of Streambank Graminoids	Research
Tonto Creek	**258**	99-097	Dakini Valley Riparian Project	Fencing & Revegetation
Upper Hassayampa	**247**	99-088	Wickenburg High School Stream Habitat Creation	Constructed Wetland Restoration
Verde River	**1**	95-001	Stable Isotope Assessment of Groundwater and Surface Water Interaction – Application to the Verde River Headwaters	Research
Verde River	**6**	95-003	Sycamore Creek Riparian Management Area	Fencing
Verde River	**10**	95-004	Road Reclamation to Improve Riparian Habitat Along the Hassayampa and Verde Rivers	Revegetation
Verde River	**28**	95-006	Critical Riparian Habitat Restoration Along a Perennial Reach of a Verde River Tributary	Stream Restoration

CENTRAL HIGHLANDS PLANNING AREA				
Groundwater Basin	**Map Number**	**AWPF Grant #**	**Project Title**	**Project Category**
Verde River	**49**	95-017	Restoration of Fossil Creek Riparian Ecosystem	Research
Verde River	**160**	97-030	Walnut Creek Center for Education and Research – Biological Inventory	Research
Verde River	**190**	98-047	Upper Verde Adaptive Management Unit	Fencing
Verde River	**197**	98-050	Watershed Restoration of a High Elevation Riparian Community	Watershed & Stream Restoration
Verde River	**206**	98-055	Horseshoe Allotment: Verde Riparian Project II	Fencing & Upland Water Developments
Verde River	**208**	98-057	Upper Verde Valley Riparian Area Historical Analysis	Research
Verde River	**209**	98-058	Effects of Removal of Livestock Grazing on Riparian Vegetation and Channel Conditions of Selected Reaches of the Upper Verde River	Research
Verde River	**212**	98-059	Verde River Headwaters Riparian Restoration Demonstration Project	Channel Restoration
Verde River	**237**	99-078	Aquifer Framework and Ground-Water Flow Paths in Big and Little Chino Basins	Research
Verde River	**250**	99-091	Effects of Livestock Use Levels on Riparian Trees on the Verde River	Research
Verde River	**284**	03-118	Verde River Riparian Area Partnership Project	Exotic Species Control
Verde River	**292**	04-120	Verde River Headwaters 3-D Hydrogological Model Framework and Visualization	Research
Verde River	**315**	05-133	Verde Wild and Scenic River Fence Exclosure	Fencing

EASTERN PLATEAU PLANNING AREA				
Groundwater Basin	**Map Number**	**AWPF Grant #**	**Project Title**	**Project Category**
Little Colorado River Plateau	**96**	96-0003	Hoxworth Springs Riparian Restoration Project	Stream Restoration
Little Colorado River Plateau	**103**	96-0022	Saffell Canyon and Murray Basin Watershed Restoration	Feasibility Study
Little Colorado River Plateau	**108**	96-0025	Tsaile Creek Watershed Restoration Demonstration	Watershed Restoration
Little Colorado River Plateau	**130**	96-0002	Completion Phase: Hi-Point Well Project	Fencing
Little Colorado River Plateau	**159**	97-029	Demonstration Enhancement of Pueblo Colorado Wash at Hubbell Trading Post	Stream Restoration & Revegetation
Little Colorado River Plateau	**168**	97-037	Talastima (Blue Canyon) Watershed Restoration Project	Exotic Species Control & Fencing
Little Colorado River Plateau	**189**	98-046	EC Bar Ranch Water Well Project	Fencing & Water Developments
Little Colorado River Plateau	**198**	98-051	Evaluation of Carex Species for Use in Riparian Restoration	Research
Little Colorado River Plateau	**223**	99-067	EC Bar Ranch Wildlife Drinker Project	Livestock & Wildlife Water Developments
Little Colorado River Plateau	**238**	99-079	Little Colorado River Riparian Restoration Project	Constructed Wetland & Revegetation

EASTERN PLATEAU PLANNING AREA				
Groundwater Basin	**Map Number**	**AWPF Grant #**	**Project Title**	**Project Category**
Little Colorado River Plateau	**243**	99-084	Assessments of Riparian Zones in the Little Colorado River Watershed	Research
Little Colorado River Plateau	**248**	99-089	Town of Eager/Round Valley Water Users Association Pressure Irrigation Feasibility Study & Preliminary Design	Feasibility Study
Little Colorado River Plateau	**251**	99-092	Little Colorado River Enhancement Demonstration Project	Stream Restoration
Little Colorado River Plateau	**254**	99-095	Brown Creek Riparian Restoration	Fencing & Water Developments
Little Colorado River Plateau	**263**	00-101	Murray Basin and Saffell Canyon Watershed Restoration Project	Watershed Restoration
Little Colorado River Plateau	**266**	00-104	Continued Enhancement of Pueblo Colorado Wash at Hubbell Trading Post National Historic Site	Exotic Species Control & Stream Restoration
Little Colorado River Plateau	**267**	00-105	Hubbell Trading Post Riparian Restoration with Treated Effluent	Revegetation
Little Colorado River Plateau	**271**	00-108	Lake Mary Watershed Streams Restoration	Channel Restoration
Little Colorado River Plateau	**273**	00-110	Upper Fairchild Draw Riparian Restoration	Fencing & Revegetation

EASTERN PLATEAU PLANNING AREA				
Groundwater Basin	**Map Number**	**AWPF Grant #**	**Project Title**	**Project Category**
Little Colorado River Plateau	**276**	00-112	Town of Eagar/Round Valley Water Users Association Pressure Irrigation Feasibility Study and Preliminary Design – Additional Mapping for Water Quality Improvements in the Watershed	Feasibility Study
Little Colorado River Plateau	**277**	00-113	Polacca Wash Grazing Management	Fencing & Exotic Species Control w/ Revegetation
Little Colorado River Plateau	**285**	03-119	Wet Meadows for Water Quality and Wildlife – A Riparian Restoration Project	Fencing & Habitat Protection
Little Colorado River Plateau	**302**	05-125	Wilkins' family Little Colorado River Riparian Enhancement Project	Stream Restoration
Little Colorado River Plateau	**304**	05-126	X Diamond Ranch LCR Riparian Enhancement Project	Stream Restoration
Little Colorado River Plateau	**305**	05-127	EC Bar Ranch Reach 8 Water Well and Drinker Project	Water Developments

LOWER COLORADO RIVER PLANNING AREA				
Groundwater Basin	**Map Number**	**AWPF Grant #**	**Project Title**	**Project Category**
Parker	**92**	96-0016	‘Ahakhav Tribal Preserve	Habitat Restoration & Revegetation
Parker	**162**	97-032	‘Ahakhav Tribal Preserve – Deer Island Revegetation	Exotic Species Control & Revegetation
Yuma	**109**	96-0011	Lower Colorado River – Imperial Division Restoration	Wetland Restoration
Yuma	**115**	96-0023	Watershed Restoration at the Yuma Conservation Gardens	Watershed Restoration
Yuma	**301**	04-124	Yuma East Wetlands Riparian Revegetation Project	Exotic Species Control & Revegetation
Yuma	**317**	05-134	Quechan Indian Nation Yuma East Wetlands Restoration Project – Phase I	Exotic Species Control & Revegetation

SOUTHEASTERN ARIZONA PLANNING AREA				
Groundwater Basin	**Map Number**	**AWPF Grant #**	**Project Title**	**Project Category**
Aravaipa Canyon	**113**	96-0014	Klondyke Tailings Response Strategy Analysis (RSA)	Research
Cienega Creek	**38**	95-016	Refinement of Geologic Model, Lower Cienega Basin, Pima County, Arizona	Research
Cienega Creek	**120**	96-0006	Hydrogeologic Investigation of Groundwater Movement and Sources of Base Flow to Sonoita Creek and Implementation of Long-Term Monitoring Program	Research
Cienega Creek	**135**	96-0020	Cienega Creek Stream Restoration	Stream Restoration & Revegetation
Cienega Creek	164	97-034	Oak Tree Gully Stabilization	Upland Channel Restoration
Cienega Creek	**193**	98-049	Empire/Cienega/Empirita Fencing Project	Fencing
Cienega Creek	**224**	99-068	Lower Cienega Creek Restoration Evaluation Project	Research
Cienega Creek	**249**	99-090	Redrock Riparian Improvement	Fencing & Water Developments
Douglas	**220**	98-066	Hay Mountain Watershed Rehabilitation	Watershed Restoration
Duncan Valley	**36**	95-014	Gila Box Riparian and Water Quality Improvement Project	Fencing & Upland Water Developments
Lower San Pedro	**165**	97-035	Watershed Improvement to Restore Riparian and Aquatic Habitat on the Muleshoe Ranch CMA	Fencing & Watershed Restoration
Lower San Pedro	**175**	97-040	Bingham Cienega Riparian Restoration Project	Revegetation
Lower San Pedro	**185**	97-044	San Pedro River Preserve Riparian Habitat Restoration Project	Habitat Restoration

SOUTHEASTERN ARIZONA PLANNING AREA				
Groundwater Basin	**Map Number**	**AWPF Grant #**	**Project Title**	**Project Category**
Lower San Pedro	**225**	99-069	Riparian and Watershed Enhancements on the A7 Ranch – Lower San Pedro River	Fencing & Upland Water Developments
Lower San Pedro	**272**	00-109	Lower San Pedro Watershed Project	Feasibility Study
Lower San Pedro	**275**	00-111	Cooperative Grazing Management for Riparian Improvement on the San Pedro	Fencing & Upland Water Developments
Morenci	**236**	99-077	Blue Box Crossing	Channel Restoration
Morenci	**264**	00-102	Upper Eagle Creek Restoration on East Eagle Allotment: 4 Drag Ranch	Fencing & Upland Water Developments
Morenci	**308**	05-129	Georges Lake Riparian Restoration Project	Fencing & Habitat Protection
Safford	**100**	96-0012	Eagle Creek Watershed and Riparian Stabilization	Fencing & Upland Water Developments
Safford	**122**	96-0018	San Carlos Spring Protection Project	Fencing
Safford	**127**	96-0015	Abandonment of an Artesian Geothermal Well	Habitat Protection
Safford	**155**	97-028	Creation of a Reference Riparian Area in the Gila Valley – Discovery Park	Habitat Restoration
Safford	**166**	97-036	Stable Isotopes as Tracers of Water Quality Constituents in the Upper Gila River	Research
Safford	**200**	98-052	Tritium as a Tracer of Groundwater Sources and Movement in the Upper Gila River Drainage	Research
Safford	**203**	98-054	Fluvial Geomorphology Study and Demonstration Projects to Enhance and Restore Riparian Habitat on the Gila River from the New Mexico Border	Research
Safford	**245**	99-086	Abandonment of Gila Oil Syndicate Well #1	Habitat Protection

SOUTHEASTERN ARIZONA PLANNING AREA				
Groundwater Basin	**Map Number**	**AWPF Grant #**	**Project Title**	**Project Category**
Safford	**261**	00-099	Gila Reference Riparian Area, Discovery Park	Revegetation
San Rafael	**188**	97-045	Santa Cruz Headwaters Project	Fencing & Upland Water Developments
San Rafael	**256**	99-096	Upper Santa Cruz Watershed Restoration	Fencing & Upland Water Developments
Upper San Pedro	**15**	95-009	Regeneration and Survivorship of Arizona Sycamore	Research
Upper San Pedro	**32**	95-005	Preservation of the San Pedro River Utilizing Effluent Recharge	Constructed Wetland
Upper San Pedro	**37**	95-015	San Pedro Riparian National Conservation Area Watershed Rehabilitation/ Restoration Project	Revegetation & Upland Channel Restoration
Upper San Pedro	54	95-018	Autecology and Restoration of *Sporobolus Wrightii* Riparian Grasslands in Southern Arizona	Research
Upper San Pedro	**61**	95-020	Teran Watershed Enhancement	Upland Channel Restoration
Upper San Pedro	**124**	96-0013	Happy Valley Riparian Area Restoration Project	Fencing
Upper San Pedro	**140**	96-0001	San Pedro Riparian National Conservation Area Watershed Protection and Improvement Project	Fencing
Upper San Pedro	**153**	97-027	Lyle Canyon Allotment Restoration Project	Fencing & Upland Water Developments
Upper San Pedro	**227**	99-070	Lyle Canyon Allotment Riparian Area Restoration Project --- Phase 2	Fencing & Upland Water Developments
Willcox	**281**	03-116	Cottonwood Creek Restoration	Upland Channel Restoration

UPPER COLORADO RIVER PLANNING AREA				
Groundwater Basin	**Map Number**	**AWPF Grant #**	**Project Title**	**Project Category**
Big Sandy	**262**	00-100	Willow Creek Riparian Restoration Project	Revegetation
Bill Williams	**93**	96-0017	Big Sandy River Riparian Project	Fencing
Bill Williams	**151**	96-0021	Riparian Vegetation and Stream Channel Changes Associated with Water Management along the Bill Williams River	Research
Bill Williams	**244**	99-085	Kirkland Creek Watershed Resource Assessment	Feasibility Study
Bill Williams	**268**	00-106	Tres Alamos Dirt-Tanks-To-Aquatic-Habitat-Conversion	Fencing & Upland Channel Restoration
Lake Mojave	**232**	99-073	Colorado River Nature Center Backwater --- Phase 2	Feasibility Study

WESTERN PLATEAU PLANNING AREA				
Groundwater Basin	**Map Number**	**AWPF Grant #**	**Project Title**	**Project Category**
Coconino Plateau	**94**	96-0019	Response of Bebb Willow to Riparian Restoration	Stream Restoration
Coconino Plateau	**230**	99-071	Protection of Spring and Seep Resources of the South Rim, Grand Canyon National Park by Measuring Water Quality, Flow, and Associated Biota	Research
Coconino Plateau	**233**	99-074	Proposal to Inventory, Assess, and Recommend Recovery Priorities for Arizona Strip Springs, Seeps, and Natural Ponds	Research
Coconino Plateau	**252**	99-093	Coconino Plateau Regional Water Study	Research
Coconino Plateau	**313**	05-131	Management & Control of Tamarisk and Other Invasive Vegetation at Backcountry Seeps, Springs, and Tributaries in Grand Canyon National Park	Exotic Species Control
Kanab Plateau	**83**	96-0004	Hydrologic Investigation & Conservation Planning: Pipe Springs	Research
Kanab Plateau	**214**	98-061	Watershed Enhancement on the Antelope Allotment	Upland Water Developments
Kanab Plateau	**234**	99-075	Glen and Grand Canyon Riparian Restoration Project	Exotic Species Control & Revegetation

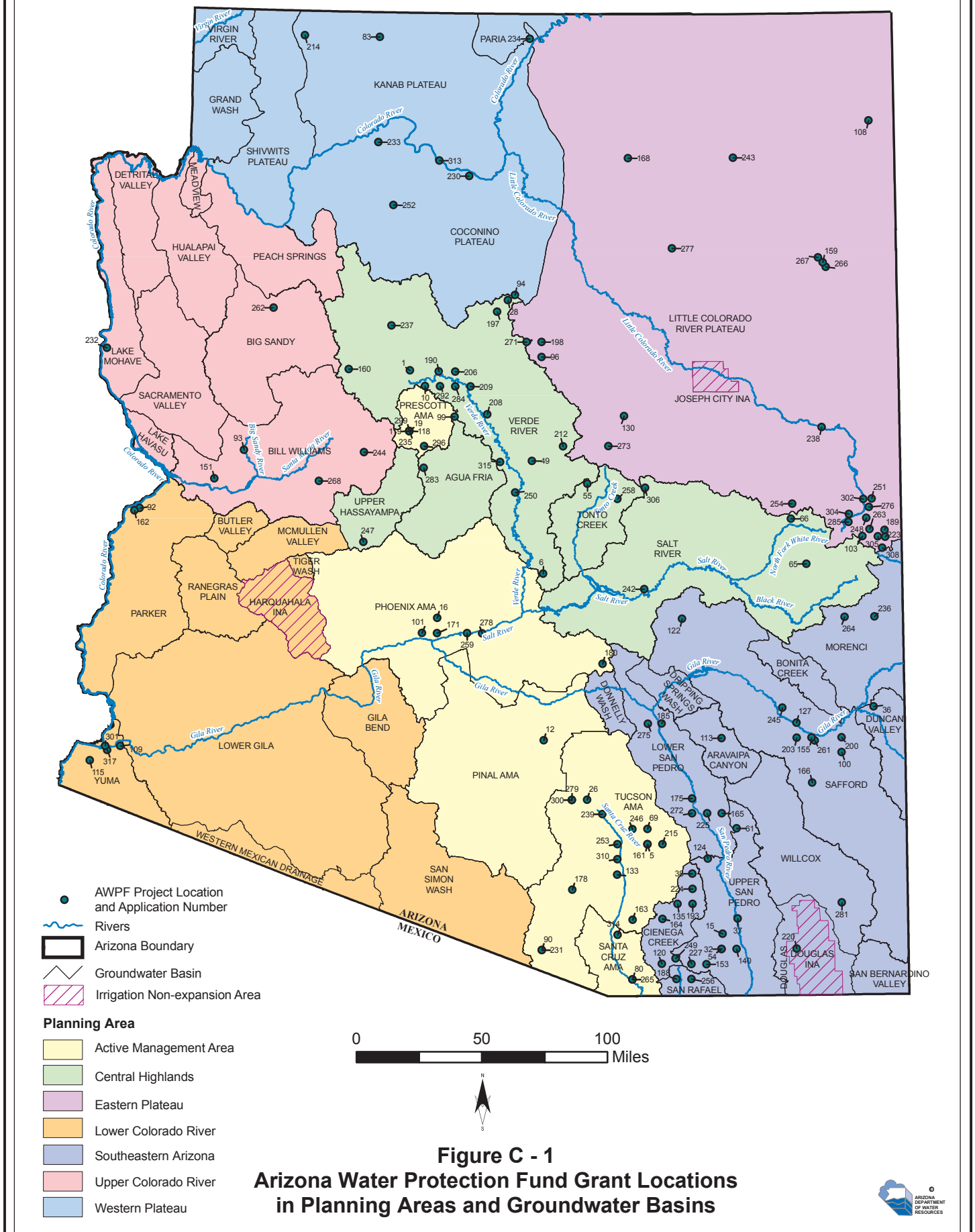

Figure C - 1
Arizona Water Protection Fund Grant Locations in Planning Areas and Groundwater Basins

APPENDIX D: INDIAN WATER RIGHTS CLAIMS AND SETTLEMENTS

In Arizona, as in most states, negotiation of Indian water rights claims has been litigation driven. Indian water right claims are based on "reserved water rights" for federal reservations established under the "Winters Doctrine." When the federal government established the Indian reservations it did not expressly claim associated water rights. In 1908, the U.S. Supreme Court in *Winters v. United States*, found that a federal reservation includes an amount of water necessary to fulfill the reservation's purpose. Priority dates are based on the date of the enactment of the treaty, act of Congress, or Executive Order establishing the reservation. In 1963, the Supreme Court further defined reserved water rights for Indian reservations by including the standard of practicably irrigable acreage as a method of quantifying the right.

Litigation to quantify Indian water rights claims is usually a lengthy and expensive process. Settlement of the tribal claims benefits private and public parties by providing the water certainty necessary to plan long-term economic development. Also, settlement may be less expensive than litigation. However, the greatest benefit of settlements may be the goodwill created by neighboring communities working together for Arizona's future.

When the settlement process begins, parties potentially impacted by the Indian water rights claims identify the sources of water necessary to satisfy the tribal needs. A federal negotiating team works with the parties to assure that federal requirements, including local cost contribution, are met. The Arizona Department of Water Resources (ADWR) participates in the settlement discussion, offering technical assistance and ensuring state water laws and policies are followed.

When local parties agree on a settlement, the issue is taken to the United States Congress for approval and funding. Generally, the congressional act ratifies the agreement among the parties, authorizes congressional appropriations, and may require a state contribution. The parties then finalize the implementing agreement, seek any necessary state appropriation, and seek approval of the court in either the Gila River General Stream Adjudication or the Little Colorado General Stream Adjudication.

Ak Chin Indian Community

By Congressional action in 1978 and 1984, the Ak Chin Indian Community was awarded an annual entitlement to 75,000 acre-feet (85,000 acre-feet in wet years) of water delivered via the Central Arizona Project (CAP) and other Colorado River water. Delivery of this water has commenced. In 1992, Congress amended the 1984 Act to authorize the Community to lease any unused CAP water to off-reservation users within the Tucson, Pinal and Phoenix Active Management Areas.

Tohono O'odham Nation

In 1982, the Southern Arizona Water Rights Settlement Act (SAWRSA) was enacted by Congress to address the water claims of the San Xavier and Shuck Toak Districts of the Tohono O'odham Nation. SAWRSA awarded the districts an annual entitlement to 37,800 acre-feet of CAP and 28,200 acre-feet of settlement water to be delivered by the Secretary of the Interior to the two districts. The districts may also pump a limited amount of groundwater. In addition to state and local financial contributions the City of Tucson contributed 28,200 acre-feet annually of effluent to be used by the Secretary to facilitate deliveries to the districts (through sale or exchange).

In December of 2004 the President signed into law P.L. 108-451, the Arizona Water Settlements Act. Title III of the Act amended the 1982 SAWRSA and provided a mechanism to implement the settlement. The amendment identified the source of the settlement water as CAP Non-Indian Agricultural priority water. The Nation may lease its CAP water within the CAP service area. State law has been amended to provide some additional protection to groundwater resources on the San Xaiver legislation, and to allow the Nation to store its CAP in an in lieu fashion. While the settlement has not yet been implemented, the parties are working to final approval before 2008. This will include dismissal of claims against the non-Indian parties in U.S. and State courts, and approval of the settlement by the State court.

The Tohono O'odham Nation's claims to water will not be completely satisfied until the water rights claims of the Sif Oidak District in Pinal County, commonly known as Chui Chu, are addressed. While that district currently has a contract for 8,000 acre-feet of CAP water, it has stated a need of nearly 100,000 acre-feet. The Nation has requested that a federal negotiating team be established so that negotiations can be commenced.

Salt River-Pima Maricopa Indian Community

In the Salt River-Pima Maricopa Indian Community Water Rights Settlement Act of 1988, Congress approved an agreement, which gave the Community an annual entitlement to 122,400 acre-feet of water plus storage rights behind Bartlett and modified Roosevelt Dams. The parties to the agreement were: Salt River Project, Roosevelt Water Conservation District, Roosevelt Irrigation District, Chandler, Glendale, Mesa, Phoenix, Scottsdale, Tempe, Gilbert, the Central Arizona Water Conservation District, the United States and the State of Arizona.

The sources of water for the Community under the settlement are from the Salt River, Verde River, groundwater and CAP water. The Community is allowed to pump groundwater, but must achieve safe-yield when the East Salt River sub-basin in the Phoenix Active Management Area does so. The Community has leased its 13,000 acre-feet CAP allocation to the Phoenix valley cities from 2000 to 2099. The Arizona State Legislature appropriated $3 million, which was added to $47 million from the United States for the Community's trust fund. This settlement was approved by the court in the Gila River General Stream Adjudication for incorporation into the final decree in that case.

Fort McDowell Indian Community

In 1990, Congress ratified an agreement between the Fort McDowell Indian Community (FMIC) and neighboring non-Indian communities, including Salt River Project, Roosevelt Water Conservation District, Chandler, Mesa, Phoenix, Scottsdale, Tempe, Gilbert, the Central Arizona Water Conservation District, the United States and the State of Arizona. Under that agreement, FMIC is provided an annual entitlement to 35,950 acre-feet of water from the Verde River and CAP. The 18,233 acre-feet of CAP in the water budget may be leased for 100 years or less off-reservation within Pima, Pinal, and Maricopa counties. A lease of 4,300 acre-feet to Phoenix has already been signed. This settlement also provides for a minimum stream flow on the Lower Verde River of 100 cfs. In accordance with the 1990 Act, a development fund was created with $23 million from the United States and with a $2 million appropriation by the Arizona State Legislature. The settlement was approved by the court in the Gila River General Stream Adjudication and will be incorporated into a final decree in that case.

San Carlos Apache Tribe

The water rights claims of the San Carlos Apache Tribe to the Salt River side of their reservation were settled through congressional enactment of the San Carlos Apache Tribe Settlement Act of 1992. The Tribe was awarded an annual entitlement to 71,435 acre-feet of water from the following sources: Salt River, Gila River, Black River and CAP. The 64,135 acre-feet of CAP water may be leased off-reservation within Pima, Maricopa, Pinal, Yavapai, Graham, and Greenlee counties. Groundwater may also be pumped from under the reservation.

The settlement agreement has been approved by the court in the Gila River General Stream Adjudication for incorporation into the final decree in that case. Parties include: Salt River Project, Roosevelt Water Conservation District, Phelps Dodge Corporation, the Buckeye Irrigation Company, the Buckeye Water Conservation and Drainage District, Chandler, Glendale, Globe, Mesa, Safford, Scottsdale, Tempe, Gilbert, Carefree, the Central Arizona Water Conservation District, the United States and the State of Arizona. This agreement includes a 100-year lease with the City of Scottsdale for a portion of the Tribe's CAP water.

In 1994, the Arizona State Legislature appropriated $3 million, which was added to $38.4 million from the United States, for the Tribe's development trust fund. The Adjudication Court approved the settlement in 1997. The water right claims of the San Carlos Apache Tribe to the Gila River side of the reservation will be the subject of separate discussions or litigation.

Yavapai-Prescott Indian Tribe

In 1994, Congress enacted the Yavapai-Prescott Indian Tribe Water Settlement Act. The Act settles the Tribe's water rights claims by: 1) confirming the Tribe's right to pump groundwater within the boundaries of the reservation, 2) providing for the relinquishment of the Tribe's CAP contract, the proceeds to be used for a water service contract with the City of Prescott, and 3) providing that the Tribe may divert a portion of the water from Granite Creek currently diverted by the Chino Valley Irrigation District.

The Act also provides authorization to the Tribe and the City of Prescott to market their CAP water to the City of Scottsdale, which has been completed. The Act required a state appropriation of $200,000, which was made in the 1994 session of the Arizona State Legislature and was added to the Tribe's CAP proceeds fund. The Gila River General Stream Adjudication approved this settlement for incorporation into the final decree in that case.

Gila River Indian Community

In December of 2004 the President signed into law P.L. 108-451, the Arizona Water Settlements Act. Title II of the Act provides approval of the Gila River Indian Water Settlement Agreement. It provides for a settlement water budget of an annual entitlement to 653,500 acre-feet from various sources: CAP allocations, the Gila, Verde and Salt rivers, effluent (through CAP exchange) and groundwater. It also provides a funding mechanism for on-reservation development of the Indian Community's farming operations. Among other provisions it provides leasing authority to the Indian Community of its CAP water as long as it is leased within Arizona. The parties to the settlement include many non-Indian neighbors: Salt River Project, Roosevelt Water Conservation District, San Carlos Irrigation and Drainage District, Hohokam Irrigation District, New Magma Irrigation District, Phoenix valley cities,

Central Arizona Irrigation and Drainage District, Maricopa-Stanfield Irrigation District, Gila Valley Irrigation District, Franklin Irrigation District, upper Gila valley towns and cities, the United States, Central Arizona Water Conservation District and the State of Arizona. The Indian and non-Indian water users who are parties in the *United States v. Gila Valley Irrigation District, et al., Globe Equity No. 59* (entered June 29, 1935), also known as the Globe Equity Consent Decree, have been in continuing litigation over the management and interpretation of the Decree since 1935. The Settlement Agreement and Title II of the Act include settlement of these difficult issues.

In 1997 the ADWR published a preliminary Hydrographic Survey Report on water uses and lands of the Gila River Indian Reservation. This report further defined the issues that led to a settlement of the adjudication litigation. The State has enacted legislation to better protect certain water resources of the Indian Community. All parties are working on the various implementation provisions, such as dismissal of the Indian Community claims in Federal and State courts, and approval of the Settlement by the State Court prior to 2008.

Little Colorado River Basin

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 basin, the State of Arizona and the federal government for several years in a settlement committee appointed by the Little Colorado General Stream Adjudication Court. The Arizona Department of Water Resources prepared a technical report for the parties and meetings have been held on a periodic basis. The court has issued a stay of the proceedings in 1994. Negotiations for all the tribes and non-Indian users broke down in 2000.

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. Talks, in a less formal setting, have continued with the Navajo Nation and Hopi Tribe about possible settlement of the Little Colorado River basin claims. Additionally, the Navajo Nation against the Secretary of the Interior filed a lawsuit in April of 2003 over the operation of the Colorado River. The 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.

APPENDIX E: FEDERAL AGENCIES AND LAWS

Federal agencies influence the use and management of water in Arizona. Federal agency authorities include the areas of flood control, water quality, and land and wildlife management. Many of the state's major water supply development projects were authorized and built by the federal government. Uses of the water from these projects are controlled by both federal and state laws. Summarized in Appendix E is a brief summary of key federal agencies and laws that affect water resource management in Arizona.

Key Federal Agencies

Bureau of Reclamation (BOR). The BOR administers the Colorado River Basin Project Act and contractual arrangements for the use of Colorado River Water. The BOR is responsible for construction of the major water supply development projects in Arizona (Hoover Dam and Power Plant, Glen Canyon Dam and Power Plant, Parker Dam and Power Plant, Davis Dam and Power Plant, the Salt River Project, Yuma Project and the Central Arizona Project). The BOR is also involved in regional planning activities, water conservation programs and water augmentation feasibility studies. www.usbr.gov

United States Geological Survey (USGS). The USGS gages streamflows, and water quality monitoring of surface water and groundwater. It conducts scientific analysis of hydrologic resources and produces reports on Arizona water use by sector and source. www.usgs.gov

U.S. Fish and Wildlife Service (USFWS). The USFWS manages federal wildlife refuges, administers the Endangered Species Act, reviews environmental impact statements and Biological Assessments and issues Biological Opinions. www.fws.gov

Bureau of Indian Affairs (BIA). The BIA is responsible for protecting Indian trust lands water rights. The agency has developed irrigation distribution systems in communities along the Colorado River and coordinated construction of Coolidge Dam with the Secretary of Interior. www.doi.gov/bureau-indian-affairs

Bureau of Land Management (BLM) and the National Park Service (NPS). These agencies manage over 17 million acres of land throughout the State. Management of these lands may involve federal reserved water rights, instream flow rights and land management activities that affect water runoff. The BLM manages the San Pedro Riparian National Conservation Area (SPRNCA). www.blm.gov, www.nps.gov

Natural Resource Conservation Service (NRCS). The NRCS plays an active role in managing and mitigating agricultural non-point source pollution. NRCS conservation specialists assist individual operators through technical assistance and cost-sharing programs that help users develop best management practices to reduce water quality and quantity impacts. The NRCS is an important participant in implementation of the Arizona Drought Plan, particularly the operation of the local area impact assessment groups. www.nrcs.usda.gov

U.S. Forest Service (USFS). The Forest Service manages watersheds through Forest Plans that include watershed management criteria to protect and enhance runoff. The Forest Service holds many surface water rights for various uses. www.fs.fed.us

U.S. Environmental Protection Agency (EPA). The EPA has federal oversight over the implementation of surface water and drinking water quality programs. It has a regulatory role in

governing some facilities that affect groundwater. This role involves oversight of state efforts regulating solid waste landfills, hazardous waste sites and underground storage tanks. The EPA also implements national programs on watershed management, toxic waste cleanup, and border-region environmental programs. www.epa.gov

U.S Army Corps of Engineers (COE). The COE conducts flood control studies and dam, levee and channelization projects to protect communities from flood damage. The COE regulates the placement of dredged or fill material into water of the U.S. (CWA, Section 404). www.usace.army.mil

Colorado River Management

The "Law of the River" as described briefly below, is a collection of federal and state laws, interstate compacts, Supreme Court decisions and international treaties that govern the operation and use of the Colorado River. In the Lower Colorado River Basin, the United States Secretary of the Interior (Secretary) is the Watermaster. Acting through the Bureau of Reclamation, the Secretary operates Colorado River dams and accounts for water use on an annual basis. Pursuant to Section V of the Boulder Canyon Project Act, the Secretary contracts with water users in the Lower Basin for water up to the total amount of each state's apportionment.

Colorado River Compact – 1922

In 1921, the seven Colorado River Basin states authorized the appointment of commissioners to negotiate a compact for the apportionment of the water supply of the Colorado River. Although the states were unable to negotiate an allocation of water for each state, an agreement was signed in November 1922, the Colorado River Compact (Compact) that divided the Colorado River Basin into the Upper Basin and the Lower Basin.

The Compact apportioned to the Upper Basin (Colorado, New Mexico, Utah, and a portion of Arizona) and to the Lower Basin (Arizona, California, and Nevada) the exclusive beneficial consumptive use of 7.5 million acre-feet of water to each basin annually. Because the Colorado River Basin includes a portion of Mexico, the Compact recognized Mexico's right to use River water. Water for this purpose was to be met from surplus water supplies in excess of the amounts apportioned to the Upper and Lower Basins. Any burden that might arise because of a water treaty with Mexico was to be shared equally by the two basins. The Compact recognized that the ability of the Upper Basin to meet the requirement to deliver 7.5 million acre-feet to the Lower Basin could be impacted by climatic factors, therefore the Compact only required the Upper Basin to restrict its use so that delivery to the Lower Basin would not be depleted below an aggregate of 75,000,000 acre-feet for any period of ten consecutive years.

Boulder Canyon Project Act - 1928

The Boulder Canyon Project Act (Project Act) authorized construction of the Hoover Dam and Power Plant and the All-American Canal. It also authorized Arizona, California and Nevada to enter into an agreement whereby the 7.5 million acre-feet of water apportioned to the Lower Basin by the Colorado River Compact would be apportioned as follows: to California, 4.4 million acre-feet per year; to Arizona, 2.8 million acre-feet per year; and to Nevada, 0.3 million acre-feet per year.

Mexican Treaty – 1945

In 1945, a treaty between the United States and Mexico involving waters of the Colorado, Rio Grande and Tijuana Rivers was enacted to address, among other things, a fixed entitlement for Mexico of 1.5 million acre-feet annually from the Colorado River. The Treaty also provided an additional 200,000 acre-feet in years of supply surplus. In years of extraordinary drought, Mexico's entitlement is to be reduced in the same proportion as consumptive uses in the U.S. are reduced.

Minute 242 was adopted and executed in 1973 in response to Mexico's concerns regarding the quality of Colorado River water being delivered to the Mexicali Valley. Minute 242 obligates the United States to implement measures that will maintain the salinity of the Colorado River waters delivered to Mexico at nearly the same quality as that diverted at Imperial Dam for use within the United States. The Colorado River Basin Salinity Control Act was signed into law on June 24, 1974, providing for the physical works necessary to implement Minute 242 without permanent loss of water to the Colorado River Basin states.

Upper Colorado River Basin Compact - 1948

This Compact divided the water apportioned to the Upper Basin by the Colorado River Compact between the five states with territory in the Upper Basin. Arizona was allocated 50,000 acre-feet per year with the remainder of the Upper Basin entitlement divided according to the following percentages: Colorado, 51.75; New Mexico, 11.25; Utah, 23.00; and Wyoming, 14.00.

Arizona v. California - 1964

On August 13, 1952, the State of Arizona filed a complaint with the U.S. Supreme Court against California and seven agencies within that state to resolve the contention by California that the Central Arizona Project should not be authorized. At California's insistence, the U.S. Congress would not authorize the Central Arizona Project until Arizona's right to the necessary Colorado River entitlement was clarified.

The Decree, handed down in 1964, confirmed that Congress had already apportioned, through the Boulder Canyon Project Act, the entitlement of water to the three Lower Basin states as follows: Arizona, 2.8 million acre-feet; California, 4.4 million acre-feet; and Nevada, 300,000 acre-feet. Any surplus above 7.5 million acre-feet was apportioned 50 percent to California and 50 percent to Arizona, except that Nevada was given the right to contract for 4 percent of the excess, which would come out of Arizona's share. The Decree also confirmed each of the Lower Basin state's entitlements to the flow of the tributaries within their boundaries, supporting Arizona's utilization of water from its in-state rivers, separate from its entitlement to its full 2.8 million acre-feet of Colorado River water.

The Decree left shortage allocation to the discretion of the Secretary after providing for satisfaction of present perfected rights in the order of their priority dates. These rights were defined as rights existing and used prior to the effective date of the Boulder Canyon Project Act.

Colorado River Basin Project Act - 1968

The Colorado River Basin Project Act on September 30, 1968 authorized construction of the Central Arizona Project and other water development projects in the Upper Basin. A significant concession was a provision that allowed existing California, Arizona, and Nevada Colorado River contractors to receive

a priority over the Central Arizona project in times when the useable supply from the River was inadequate to provide 7.5 million acre-feet to the Lower Basin states, with California's priority limited to its 4.4 million acre-foot entitlement.

The Act directed the Secretary to propose criteria for the "coordinated long-range operation of the reservoirs" in the Upper Basin with the operation of the reservoirs in the Lower Basin. To accomplish this, the Act required the development of an Annual Operating Plan, in consultation with representatives of the seven Basin states.

Federal Reserved Rights

In addition to the reserved water rights associated with Indian water claims under the "Winters" doctrine (described in Appendix D), federal reserved rights can be asserted on most federal, non-Indian lands. For example, surface water rights have been claimed in both the Gila River and Little Colorado River adjudications for national parks and monuments, military bases and national forests (Pearce, 2002). Federal reserved rights to groundwater have also been asserted. An Arizona Supreme Court Decision found that the federal reserved rights doctrine applied to groundwater as well as surface water. The decision found that a reserved right to groundwater could be found only where other waters are inadequate to accomplish the purpose of the reservation. *In Re: The General Adjudication of All Rights to Use Water in the Gila River System and Source*, 989 P.2d 739 (Ariz. 1999) *(Gila III); cert. denied* 120 Sup. Ct. 2705 (2000) (Pollack, 2003).

Summary of Key Federal Water Laws

The Clean Water Act (CWA) 33 U.S.C. Section 121 et seq. (1977)

The CWA of 1977 is an amendment to the Federal Water Pollution Control Act of 1972, which set the basic structure for regulating pollutant discharge to waters of the United States. This law gave the Environmental Protection Agency the authority to set effluent standards and continues the requirements to set water quality standards for all surface water contaminants. Under the CWA, it is unlawful to discharge any pollutant from a point source into navigable waters unless a National Pollutant Discharge Elimination Standard (NPDES) permit is obtained. The CWA provides a mechanism for EPA to delegate many of the permitting, administrative and enforcement aspects of the law to states (e.g. Arizona Department of Environmental Quality) while retaining oversight responsibilities (www.cyber-sierra.com/area9). NPDES permits are usually required for effluent or industrial wastewater being disposed of by discharge to waters of the state.

Impaired Waters

Section 303(d) of the Clean Water Act establishes a process for states to identify waters where implementing technology-based controls are inadequate to achieve water quality standards. States establish a priority ranking of these waters and, for the priority waters, develop total maximum daily loads (TMDLs). A TMDL identifies the amount of a specific pollutant or property of a pollutant, from point, nonpoint, and natural background sources, that may be discharged to a water body and still ensure that the water body attains water quality standards.
http://cfpubl.epa.gov/npdes/wqbasedpermitting/iwaters.cfm.

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) 42 U.S.C. Section 9601 et seq. (1980)

CERCLA, commonly referred to as the "Superfund" Program authorized the investigation and remediation of groundwater contaminated by releases of hazardous substances from waste sites and due to accidents, spills and other emergency releases of contaminants. EPA is required to annually update the National Priority List of Superfund sites. In Arizona, CERCLA establishes a comprehensive response program that is administered by ADEQ in cooperation with the EPA. The Department of Water Resources maintains an advisory role in this process (ADWR, 1999).

The Endangered Species Act (ESA). 7 U.S.C. 136; 16 U.S.C. 460 et seq. (1973)

The ESA provides a program for the conservation of threatened and endangered plants and animals and their habitats. This may involve aquatic and riparian habitat. All species of plants and animals, except pest insects, are eligible for listing as threatened or endangered. The Act is administered by the U.S. Fish and Wildlife Service and the National Oceanic and Atmospheric Administration -Fisheries for marine species. Species are protected through partnerships with the states and section 6 of the ESA encourages each State to develop and maintain conservation programs for resident listed species. Section 9 of the ESA makes it unlawful for a person to "take" a listed species which includes significant habitat modification or degradation. The ultimate goal of the law is to recover species so that they no longer need protection under the ESA (USFWS, 2005).

The Safe Drinking Water Act (SDWA). 43 U.S.C. Section 300f et seq. (1974)

The SDWA is the primary federal law regulating drinking water quality from all sources. The Act authorizes EPA to establish safe standards and requires all owners or operators of public water systems to comply with primary (health-related) maximum contaminant level standards. National secondary drinking water regulations set non-enforceable standards for the aesthetic quality of water such as taste, odor or color. ADEQ may adopt more stringent standards than those set by EPA.

Arsenic

In 2001, EPA lowered the allowable arsenic content in drinking water from 50 parts per billion to 10 ppb, effective January 23, 2006. This was a major issue for many of Arizona's communities because Arizona's soil has naturally high levels of arsenic. Approximately one-third of the states drinking water systems exceeded the standard at the time, including 287 small systems (serving fewer than 10,000 people). In response, ADEQ developed a strategy in conjunction with a coalition of business, academia, municipal government agencies and the scientific community to develop a compliance strategy called the Arsenic Master Plan. The plan is intended to identify effective low-cost methods to comply with the standard. www.azdeq/gov/environ/water/dw/arsenic.html.