II. Arizona's Unique Hydrology

Arizona's ecologic, hydrologic, and geographic diversity

Arizona is a large state with diverse ecological and geological conditions. Its geographical extent is equivalent to the combined size of Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, and New York. All four of the deserts of North America occur in Arizona, along with three mountain ranges at or above 10,000 feet in elevation. An atlas of information **(Table 2)** provides statistics concerning population, land ownership, rainfall, and temperature in Arizona.

Ecoregions -- Ecoregions **(Figure 1)** identify areas of relatively homogeneous ecological systems. These areas were delineated on a national scale based on geology, natural vegetation, and soils. Arizona contains portions of five of the 76 ecoregions recognized in the United States (Omernik, 1987).

Ecoregions in Arizona

Arizona/New Mexico Mountains – low to high mountains with grazed forests and woodlands.
Arizona/New Mexico Plateau – tablelands with considerable to very high relief and plains with high mountains. The Plateau is differentiated from the Colorado Plateau by its semi-humid grassland.
Colorado Plateau – tablelands with considerable to very high relief, plains with high mountains, grazed open woodland, and some irrigated agriculture.
Southern Basin and Range – desert valleys with desert shrubland associations, separated by low mountains.
Southern Deserts – desert shrubland associations on desert plains, with abrupt high mountains providing "sky islands" containing higher elevation ecosystem communities.

Hydrologic Provinces – The U.S. Geological Survey has also divided the state into three physiographic and hydrographic provinces based on the occurrence of water, geology, and altitude (Anderson et al., 1992) **(Figure 2)**.

Hydrologic Provinces in Arizona

Basin and Range – broad, gently sloping valleys, separated by sharply rising mountain ranges ("sky islands") receive more precipitation than the desert lowlands (20 inch annual average at Chiricahua National Monument, compared to 4-12 inches annually in the low deserts). The basins are filled with several thousand feet of sediments overlain with stream alluvium. This alluvium forms the most productive aquifers in Arizona, from which approximately 97% of all ground water is pumped (Wilson, 1991). Depths to ground water range from land surface near perennial streams to as much as 1,300 feet below land surface near the mountain front.
Central Highlands – is a geologic and physiographic transition between the other two provinces. The type and distribution of aquifers vary, with alluvial aquifers occupying relatively small basins, aquifers in consolidated sedimentary rocks, and fractured aquifers in hard rocks. Most perennial streams in the state originate in this province, which receives the highest annual precipitation (16-32 inches.)
Plateau Uplands – underlain by extensive consolidated sedimentary rock formations. Most of the ground water in this province is withdrawn from these formations more than 1000 feet deep, although localized alluvial aquifers also provide some ground water. This province has annual precipitation ranging from 10-25 inches. The eastern half is a barren plateau, with isolated alluvial deposits occurring only as narrow strips along large drainages, while the western half (north of the Grand Canyon) is wooded plateaus and mountain peaks which rise higher than 8,000 feet in elevation.

Population – The 2000 census data indicates that most of Arizona's population (60%) is located in the Phoenix metropolitan area. Since 1990 the state's population has increased 40%, with the Phoenix area growing from 2,120,000 to 3,252,000 (45%).

Table 2. Arizona Atlas

Population	5,131,000 people (2000 Census) (40% increase since 1990) Phoenix metro area 3,252,000 (14th largest metro area in the US) Tucson metro area 844,000 Yuma metro area 160,000 Flagstaff metro area 122,366
Surface Area	113,635 square miles
Population Density (average)	45 persons per square mile (US density is 80 persons per square mile)
Land Ownership	28% Indian Lands 17% Bureau of Land Management 17% Individual and Corporate 15% Forest Service 13% State of Arizona 10% Other federal, county, municipal
Elevation Variation	Highest point 12,630 feet above sea level (Humphrey's Peak) Lowest point 70 feet above sea level (near Yuma)
Annual Long-term Average Precipitation[a]	Lowest 3 inches (Yuma) Highest 27 inches (McNary) Phoenix metro 7 inches
Temperature[a]	Average Daily: Highest 88 °F (Yuma) Lowest 45 °F (Flagstaff) Record temperatures: Highest 128 °F (Lake Havasu City) Lowest -40 °F (Hawley Lake)
Average Annual Withdrawal (acre-feet) [b]	Ground Water 4,264,000 acre-feet (1971-1990) Surface Water 2,961,000 acre-feet (1971-1990)
Approximate Acres of Riparian Areas[c]	266,786 acres located on 3,530 miles of perennial streams 165,000 acres located on 10,000 miles of intermittent streams

(a) Arizona Climatological Laboratory, 1994 (verbal communication)
(b) Arizona Department of Water Resources, 1994.
(c) Arizona Game and Fish Department, 1993 (perennial streams), 1997 (intermittent streams).

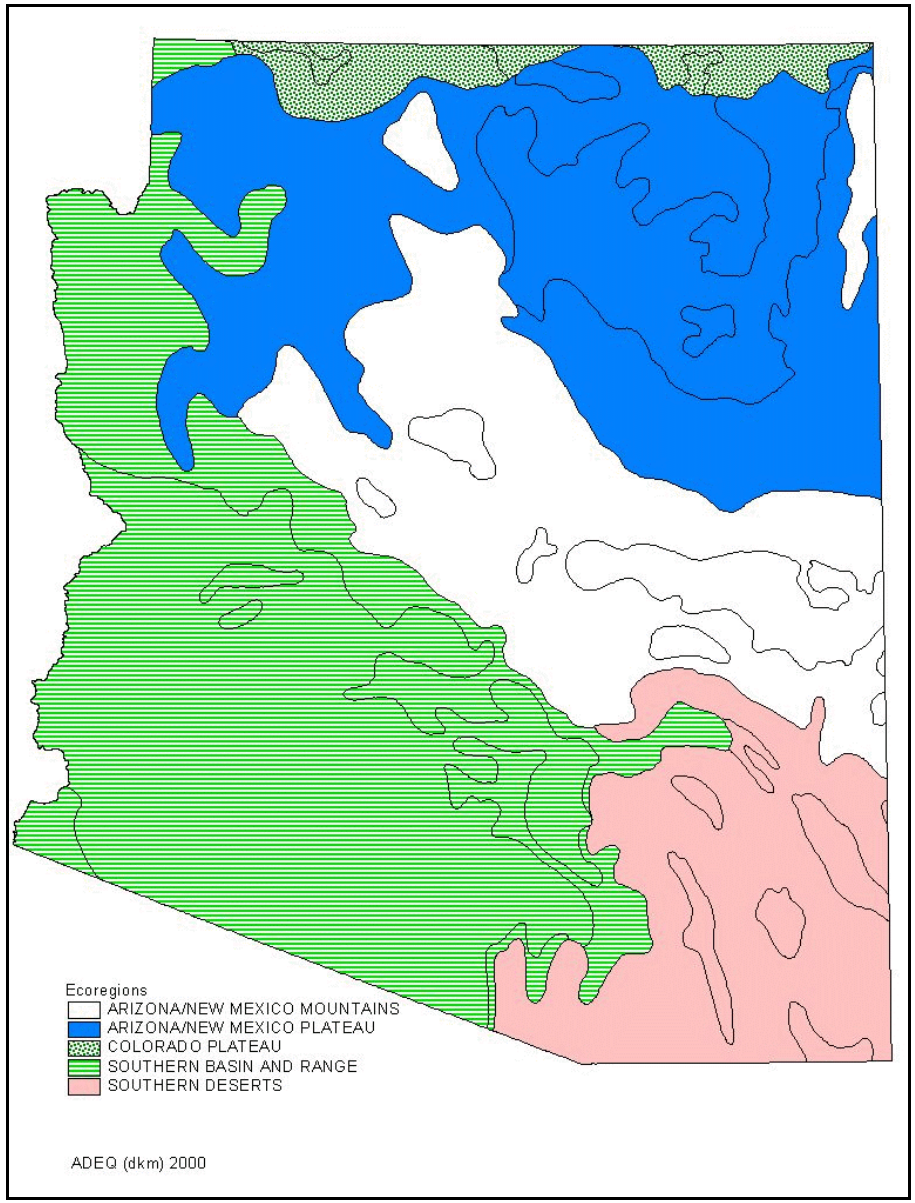


Figure 1. Arizona's Ecoregions

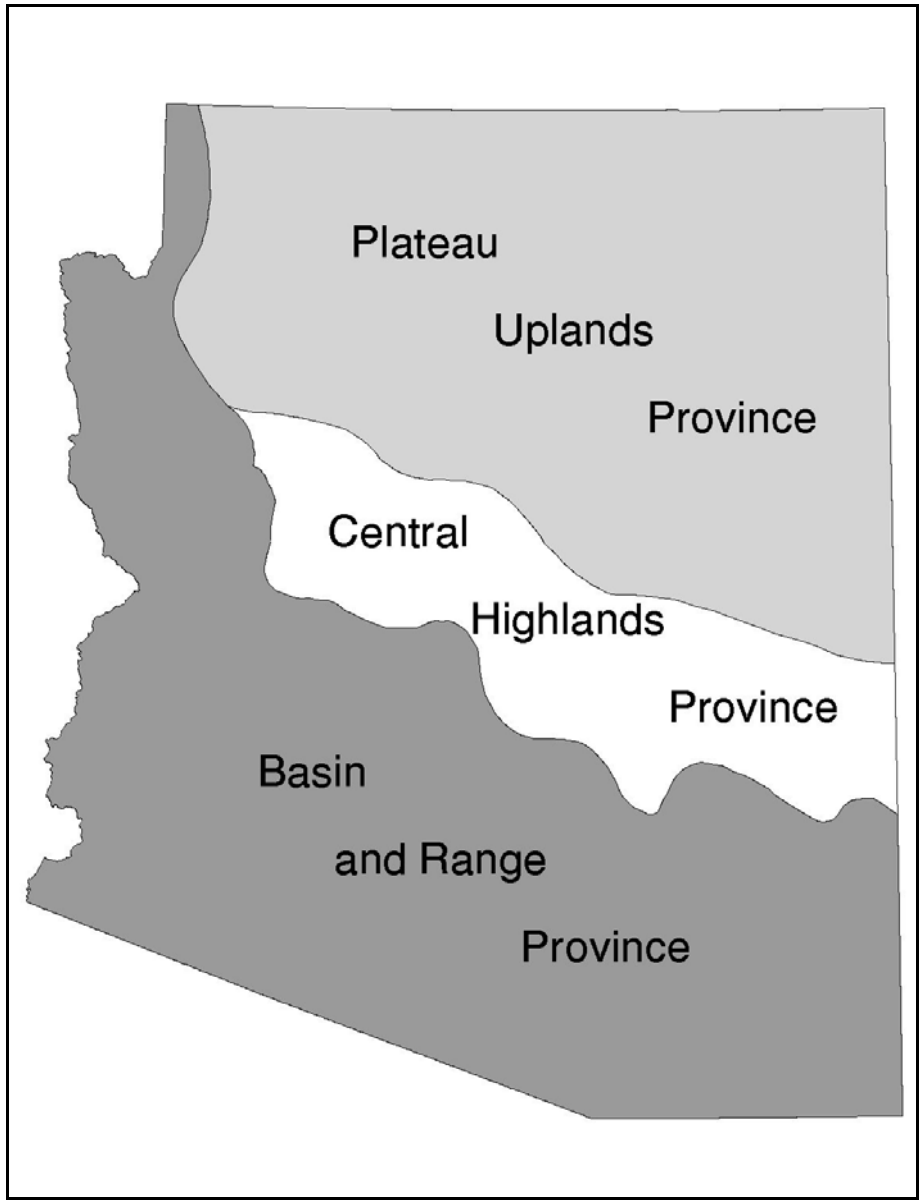


Figure 2. Arizona's Hydrologic Provinces

Land Ownership – Only 17% of the land within Arizona is privately owned, the remainder is owned by federal and state agencies and Indian Nations **(Table 2 and Figure 3)**. Land ownership can suggest land uses. For example, urban areas of population growth are generally restricted to privately owned lands, and irrigated agriculture primarily is associated with private and Indian lands. On the other hand, some activities such as mining and grazing are widespread across all types of ownership.

A significant part of the state (28%) is owned by Indian Nations **(Table 2 and 3)**. Some of the maps in this report indicate where Tribal lands occur. Although waters on Indian lands are not assessed in this report, these waters are an integral part of the state's water resources. Some of the Indian Nations publish their own water quality assessment reports which should be read in conjunction with this report to understand water quality conditions across Arizona.

Hydrologic Flow and Climate-- Many of Arizona's streams are not perennial (do not contain water year round), but instead flow only part of the year (intermittent flow), or only in response to precipitation (ephemeral). An estimate of Arizona's water resources is provided in **Table 2**. A map of streams with perennial flow **(Figure 4)** was created based on riparian area research by the Arizona Game and Fish Department (AGFD 1993 and 1997). This map illustrates generalized conditions but more research is needed in most watersheds to accurately depict hydrologic flow conditions.

The ephemeral and intermittent nature of Arizona's streams is largely due to climatic conditions, particularly precipitation and temperature **(Figure 5 and 6)**. However, ground water pumping, diversions into canals, and the creation of reservoirs has also had a significant influence on the amount of water in Arizona's streams.

Stream Flow Classification

Perennial: Flows continuously throughout the year.

Intermittent: Flows continuously only at certain times of the year, as when it receives water from a spring or from another surface source such as melting snow (i.e., seasonal).

Ephemeral: Channel is at all times above the water tables, and flows only in direct response to precipitation.

Table 3. An Estimate of Arizona's Water Resources

WATERSHED NAME	STREAMS (miles)						LAKES (acres)				Ground water ESTIMATED* STORAGE (acre-feet)
	Non-Indian Land			Indian Land			Non-Indian Land		Indian Land		
	Perennial	Intermittent	Ephemeral	Perennial	Intermittent	Ephemeral	Perennial	Non-perennial	Perennial	Non-perennial	
Bill Williams	185	655	5035	0	0	0	1,832	11,950	0	0	32,500,000
Colorado-Grand Canyon	480	260	14,870	125	5	3,740	68,398	13,412	389	0	509,500,000
Colorado-Lower Gila	375	145	13,545	75	0	535	36,866	0	244	0	272,300,000
Little Colorado-San Juan	640	1,655	9,635	305	170	15,310	16,051	6,831	5,295	118	413,000,000
Middle Gila	165	1,210	5,460	0	10	1,105	10,318	55,746	240	0	222,410,000
Salt	510	1,190	2,785	825	0	4,275	25,544	0	1,858	0	***
San Pedro-Willcox-Yaqui	195	665	6,610	0	0	6,395	1,319	29,471	0	0	112,000,000
Santa Cruz-Magdalena-Sonoyta	85	500	7,245	0	20	35	1,366	0	926	0	176,900,00**
Upper Gila	445	970	6,305	105	50	3,795	2,289	0	9,523	11,119	86,300,000**
Verde	450	2,115	5,990	15	5	230	4,603	3,636	6	0	29,550,000
STATE TOTAL	3,530	9,365	77,480	1,450	260	35,420	168,586	121,046	18,481	11,237	***
	Total on Non-Indian 90,375			Total on Indian 37,130			Total on Non-Indian 289,632		Total on Indian 29,718		
	Total miles in Arizona 127,505						Total acres in Arizona 319,350				

Stream miles and lake acres are based on USGS digitized hydrology at 1:100,000, and have been rounded to the nearest five miles. Reservoir acres along the Colorado River include only the acres within Arizona. Waters include manmade reservoirs and ponds of any size. Ground water estimates of supply come primarily from Arizona Department of Water Resources, with some estimates from US Geological Survey.

Non-perennial lake acres include ephemeral lakes, playas, and storm water retention areas that have been specifically named as a surface water in Arizona's surface water quality standards.
* Estimates to 1200 feet below ground surface (acre-feet).
** Indicates that no estimate is available for one or more ground water basins in the watershed.
*** Indicates insufficient data to make an estimate.

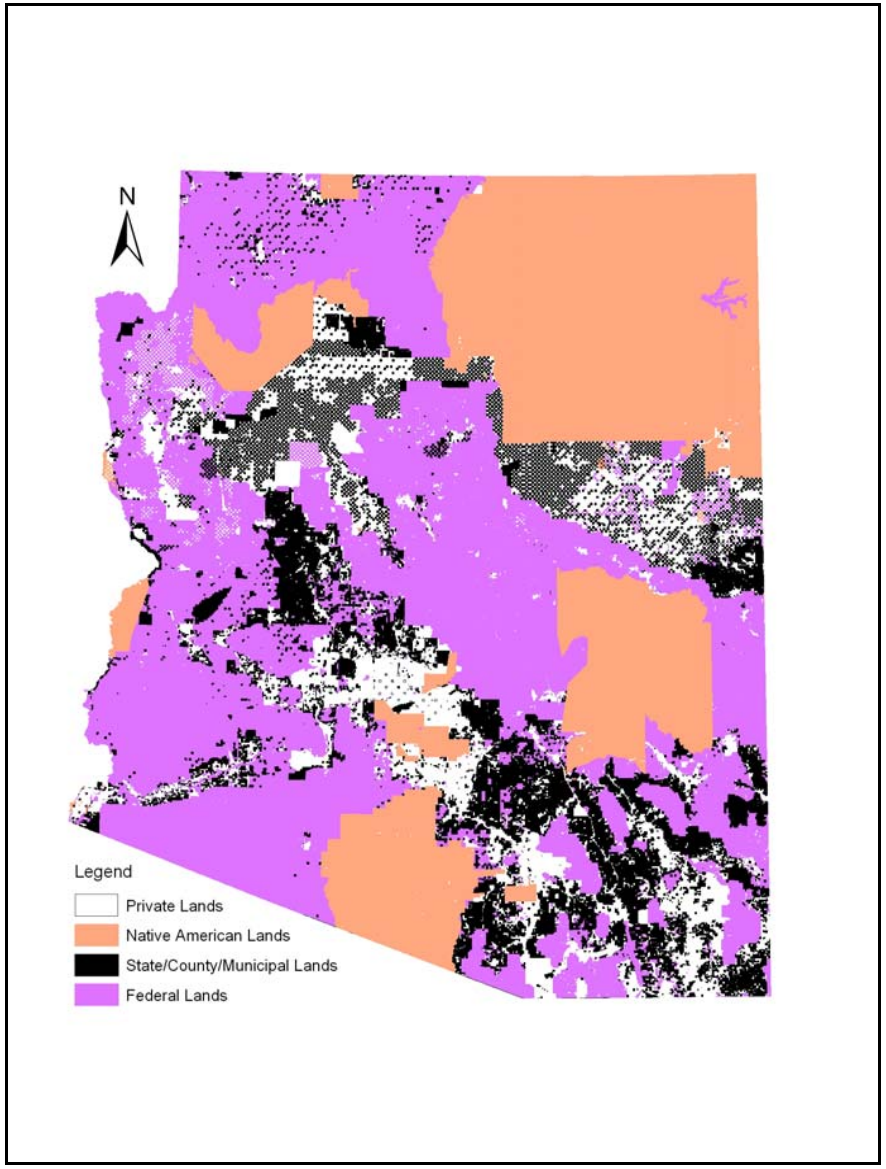


Figure 3. Land Ownership in Arizona

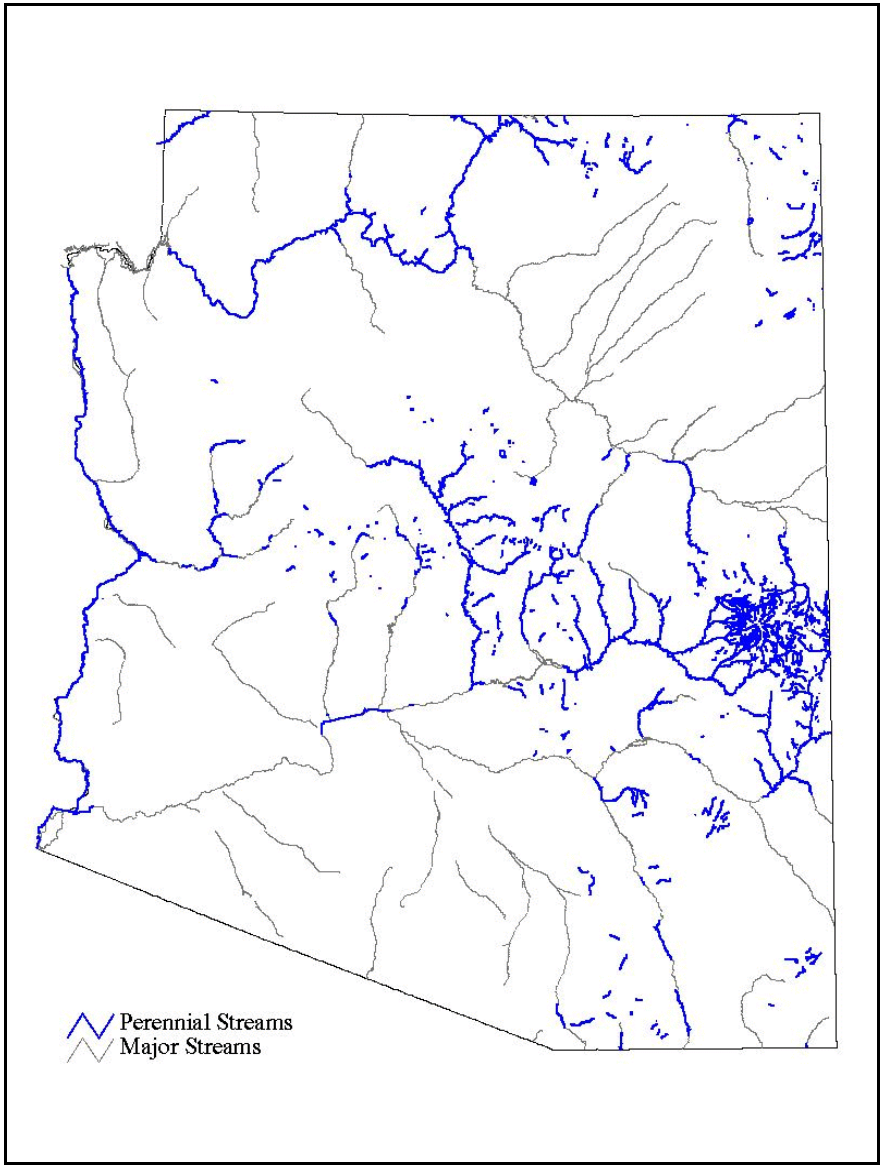


Figure 4. Perennial Streams in Arizona

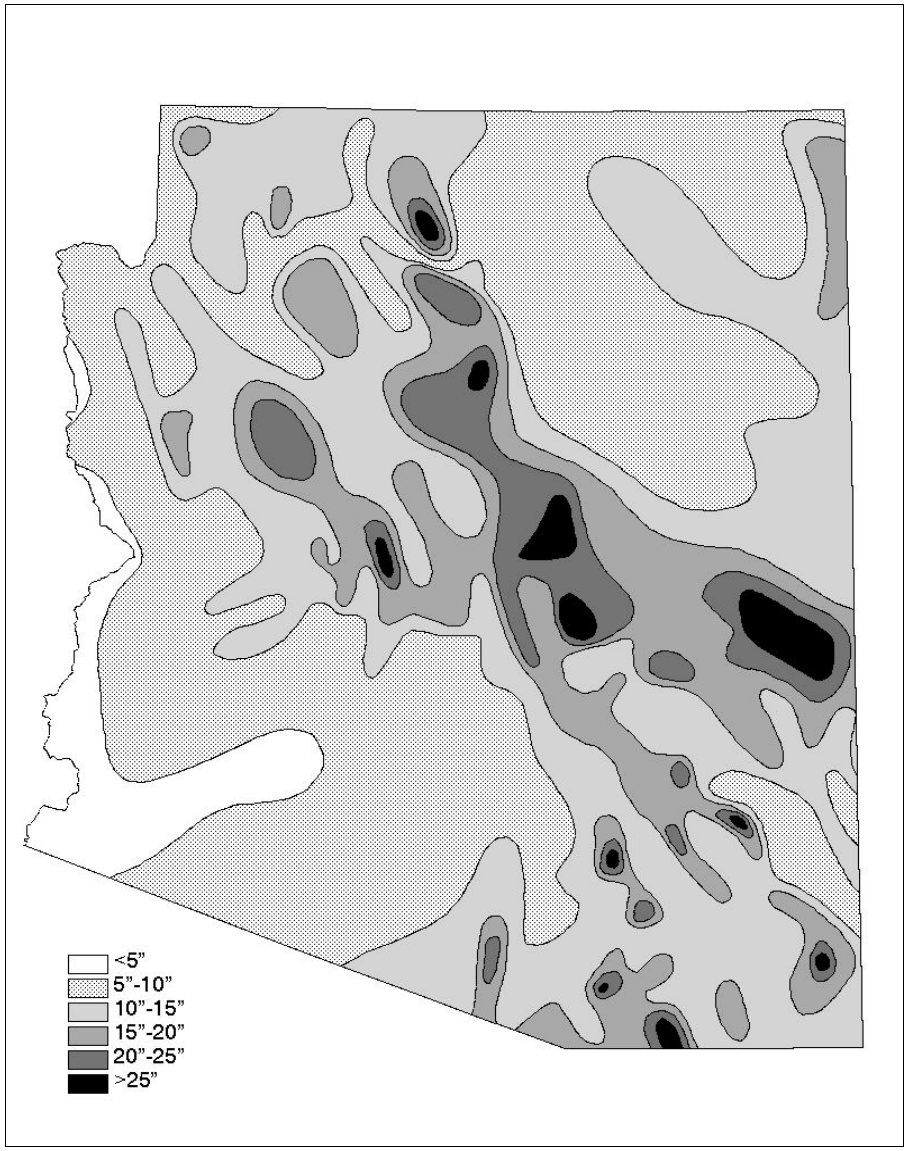


Figure 5. Mean Annual Precipitation Distribution in Arizona

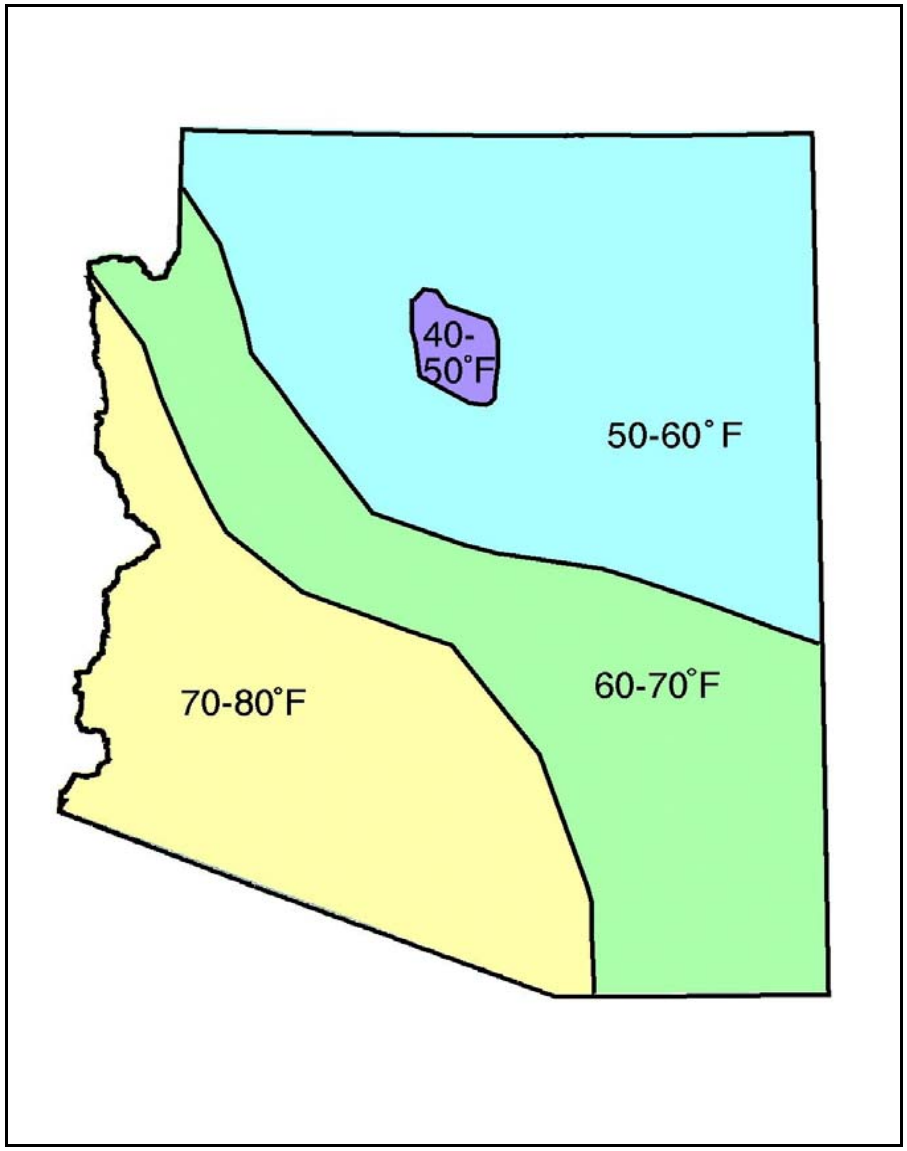


Figure 6. Mean Annual Temperature Distribution in Arizona

Watersheds, hydrologic unit areas, and basins

To manage water quality and quantity concerns, this large and diverse state has been subdivided into surface water hydrologic unit areas, basins, watersheds, ground water basins, and Active Management Areas. These areas are delineated hydrologically rather than politically (e.g., counties, cities, ownership), because water quality and quantity concerns are largely determined by drainage and hydrological flows. Water quality issues do not end at a political boundary.

- **Hydrologic unit areas** – The U.S. Geological Survey divided and subdivided the United States into drainage areas or surface water hydrologic units. Each drainage area was assigned a unique code number, an eight digit Hydrologic Unit Code (HUC) **(Figure 7, including table)**.

> **A HUC divided --** One HUC (15060106) was divided at Granite Reef Dam because diverting all of the surface water flow from the Salt River into canals makes the western half of this HUC more closely hydrologically interconnected with the Middle Gila Basin than the Salt River Basin.

- **Surface water basins --** ADEQ grouped the 84 HUCs in Arizona into 13 Surface Water Basins **(Figure 8)** based on hydrologic relationships defined by the HUC numbering system. These surface water basins are used to organize surface waters in Arizona's surface water standards.

- **Watersheds --** ADEQ also used the HUCs to organize the state into 10 Watersheds **(Figure 9)**. These watersheds were developed to synchronize ADEQ activities within a geographic area such as focused monitoring and surface water permit issuance, and to foster local stakeholder interest and involvement in water quality concerns (see discussion in Chapter III and Volume II). As shown by comparing **Figure 8 and Figure 9,** most Watersheds and Surface Water Basins are similar; however, three watersheds were created by combining basins and one basin (the Colorado River) was split into two watersheds. These new delineations were made to facilitate watershed management group meetings, and considered probable shared water quality concerns, shared land uses, and geographical proximity.

  Assessment information throughout this report is organized by watershed to facilitate stakeholder involvement in water quality concerns. However, specific water quality improvement efforts are generally addressed at a smaller drainage or sub-watershed scale.

- **Ground water basins and Active Management Areas --** ADEQ adopted the ground water basins and Active Management Areas created by the Arizona Department of Water Resources to manage ground water quantity and quality concerns. The delineation of ground water areas was based on physiography, surface drainage patterns, subsurface geology, and aquifer characteristics. These basins do not delineate aquifers in Arizona. Because surface water drainage patterns were considered in delineating ground water basins, most basins fit inside a watershed **(Figure 10).**

  Some ground water quality studies and most remedial actions are conducted in a smaller area such as an aquifer or a sub-basin based on sources of contamination.

> **Three Levels of Ground Water Management**
>
> The Arizona Ground Water Management Code administered by the Arizona Department of Water Resources establishes that ground water basins may be classified under two special levels of water quantity management:
> **The Active Management Areas** (AMAs) -- Four ground water basins have been designated as AMAs due to severe overdraft of ground water. The goal in these areas is to achieve "safe-yield" by 2025. The availability of non-ground water supplies to support future growth is an important issue in these areas although ground water will continue to be a necessary part of the water supply.
> **Irrigation Non-Expansion Areas** (INAs) – Irrigation is restricted within these ground water basins.
> **Regional Water Supply Agencies** – These are replenishment districts that are expected to acquire and facilitate delivery of water supplies to reduce ground water overdraft and replenish aquifers.

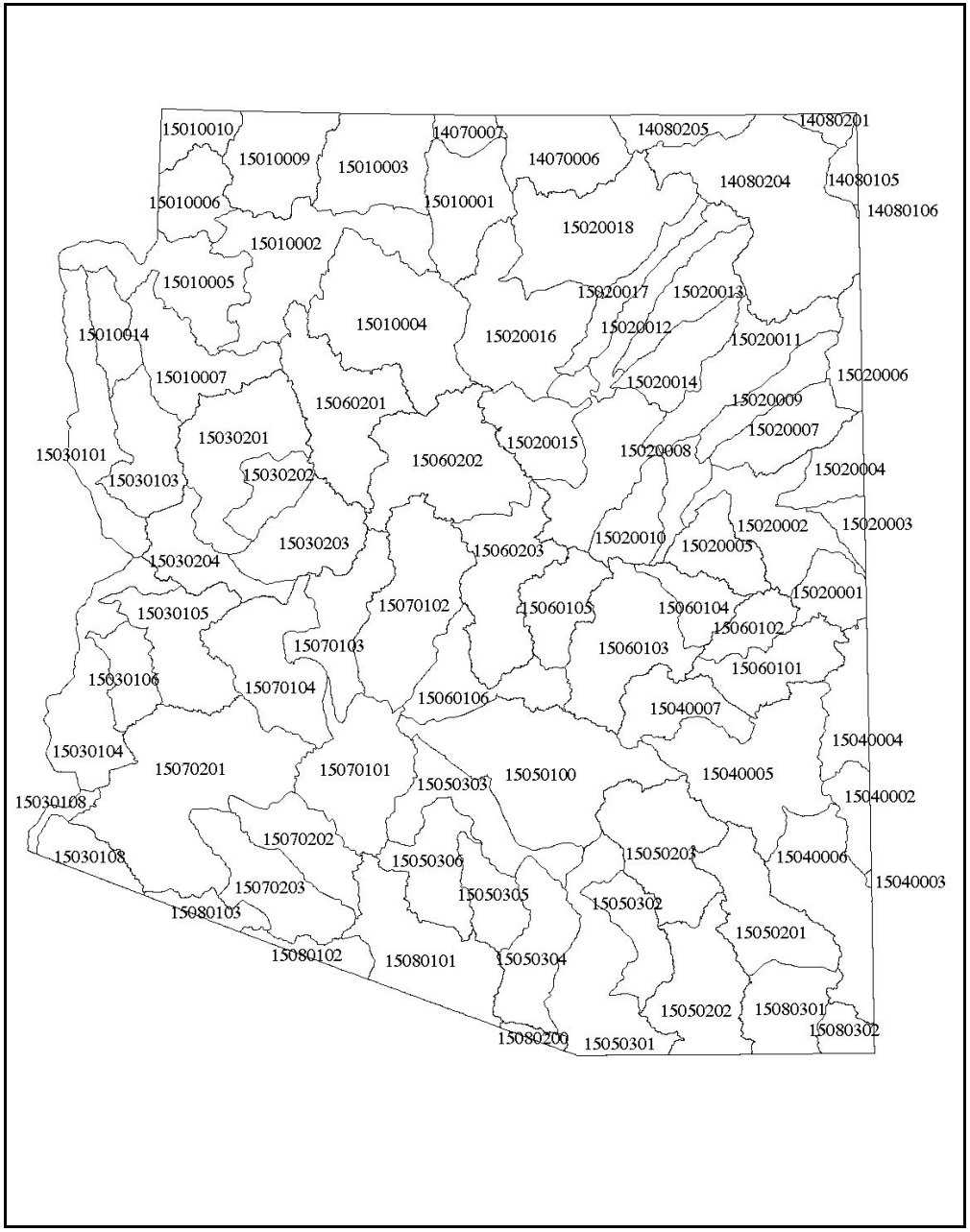


Figure 7. Hydrologic Unit Code (HUCs) Areas in Arizona

Names for the Eight-Digit Hydrologic Unit Code (HUC) Drainage Areas (for Figure 7)

HUC	NAME	WATER	HUC	NAME	WATER	HUC	NAME	WATER	HUC	NAME	W
15030201	Big Sandy	BW	15030108	Colorado (Yuma-Mexico)	CLG	15020014	Jadito Wash	LCR/SJ	15080101	San Simon Wash	SC/RIOS
15030202	Burro Creek	BW	15070201	Lower Gila	CLG	15020015	Diablo Canyon	LCR/SJ	15080102	Sonoyta Valley	SC/RIOS
15030203	Santa Maria River	BW	15070202	Tenmile Wash	CLG	15020016	Moenkopi Wash	LCR/SJ	15080103	Quitobaquito	SC/RIOS
15030204	Alamo Lake-Bill Williams	BW	15070203	San Cristobal	CLG	15020017	Dinnebito Wash	LCR/SJ	15080200	Rio Magdalena	SC/RIOS
14070006	Lake Powell	CGC	14080105	Chaco River	LCR/SJ	15050100	Gila (Coolidge Dam-Salt River)	MG	15050201	Willcox Playa	SP/WP/RY
14070007	Paria River	CGC	14080106	Sansotee Wash	LCR/SJ	15060106B	Salt (below Granite Reef Dam)	MG	15050202	Upper San Pedro	SP/WP/RY
15010001	Marble Canyon	CGC	14080201	San Juan	LCR/SJ	15070101	Gila (Salt River-Painted Rocks Dam)	MG	15050203	Lower San Pedro	SP/WP/RY
15010002	Grand Canyon	CGC	14080204	Chinle Valley	LCR/SJ	15070102	Agua Fria River	MG	15080301	Whitewater Draw	SP/WP/RY
15010003	Kanab Creek	CGC	14080205	Monument Valley	LCR/SJ	15070103	Hassayampa River	MG	15080302	Blackwater Draw	SP/WP/RY
15010004	Havasu Canyon	CGC	15020001	Upper Little Colorado (LCR)	LCR/SJ	15070104	Centennial Wash	MG	15040002	Upper Gila	UG
15010005	Lake Mead	CGC	15020002	LCR (Lyman-Puerco)	LCR/SJ	15060101	Black River	SALT	15040003	Arimas Valley	UG
15010006	Grand Wash	CGC	15020003	Carrizo Wash	LCR/SJ	15060102	White River	SALT	15040004	San Francisco River	UG
15010007	Truxton Wash	CGC	15020004	Zuni River	LCR/SJ	15060103	Roosevelt Lake	SALT	15040005	Gila Valley	UG
15010009	Fort Pierce Wash	CGC	15020005	Silver Creek	LCR/SJ	15060104	Carrizo Creek	SALT	15040006	San Simon Creek	UG
15010010	Virgin River	CGC	15020006	Upper Puerco River	LCR/SJ	15060105	Tonto Creek	SALT	15040007	San Carlos River	UG
15010014	Detrital Wash	CGC	15020007	Lower Puerco River	LCR/SJ	15060106A	Salt River (Roosevelt-Granite Reef)	SALT	15060201	Chino Valley	VD
15030101	Colorado (Hoover-Parker Dam)	CLG	15020008	LCR (Puerco-Dinnebito)	LCR/SJ	15050301	Upper Santa Cruz	SC/RIOS	15060202	Verde Valley	VD
15030103	Sacramento Wash	CLG	15020009	Leroux Wash	LCR/SJ	15050302	Pantano Wash	SC/RIOS	15060203	Lower Verde River	VD
15030104	Colorado (Parker-Imperial Dam)	CLG	15020010	Chevelon Canyon	LCR/SJ	15050303	Lower Santa Cruz	SC/RIOS			
15030105	Bouse Wash	CLG	15020011	Pueblo Colorado	LCR/SJ	15050304	Altar and Avra Valleys	SC/RIOS			
15030106	Tyson Wash	CLG	15020012	Orabi Wash	LCR/SJ	15050305	Aquirre Valley	SC/RIOS			
15030107	Colorado (Imperial-Yuma)	CLG	15020013	Polacca Wash	LCR/SJ	15050306	Santa Rosa Wash	SC/RIOS			

WATER = Watersheds; BW = Bill Williams, CGC = Colorado Grand Canyon, CLG = Colorado-Lower Gila, LCR/SJ = Little Colorado-San Juan, MG = Middle Gila, SALT = Salt, SC/RIOS = Santa Cruz-Rio Magdalena-Rio Sonoyta, SP/WP/RY = San Pedro-Willcox Playa-Rio Yaqui, UG = Upper Gila, VD = Verde

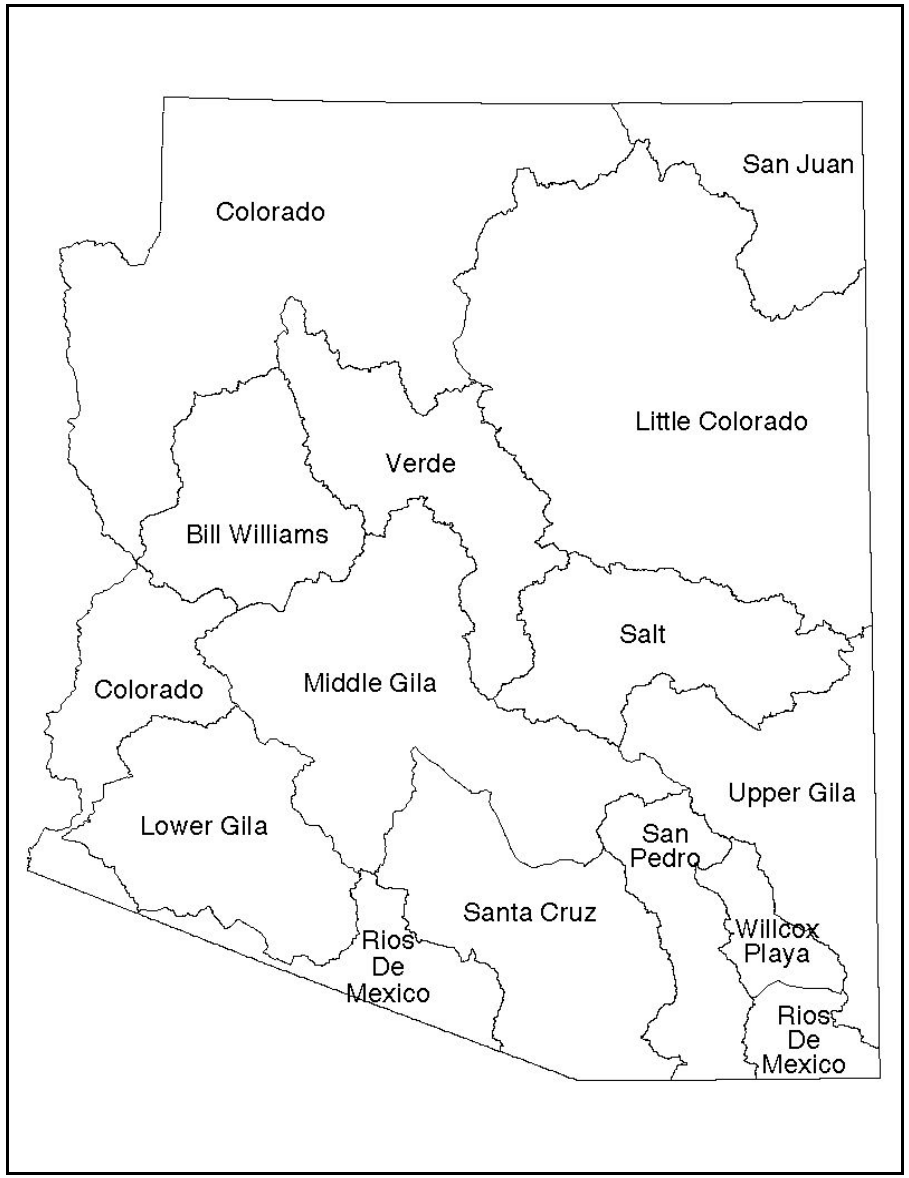


Figure 8. Arizona's Surface Water Basins

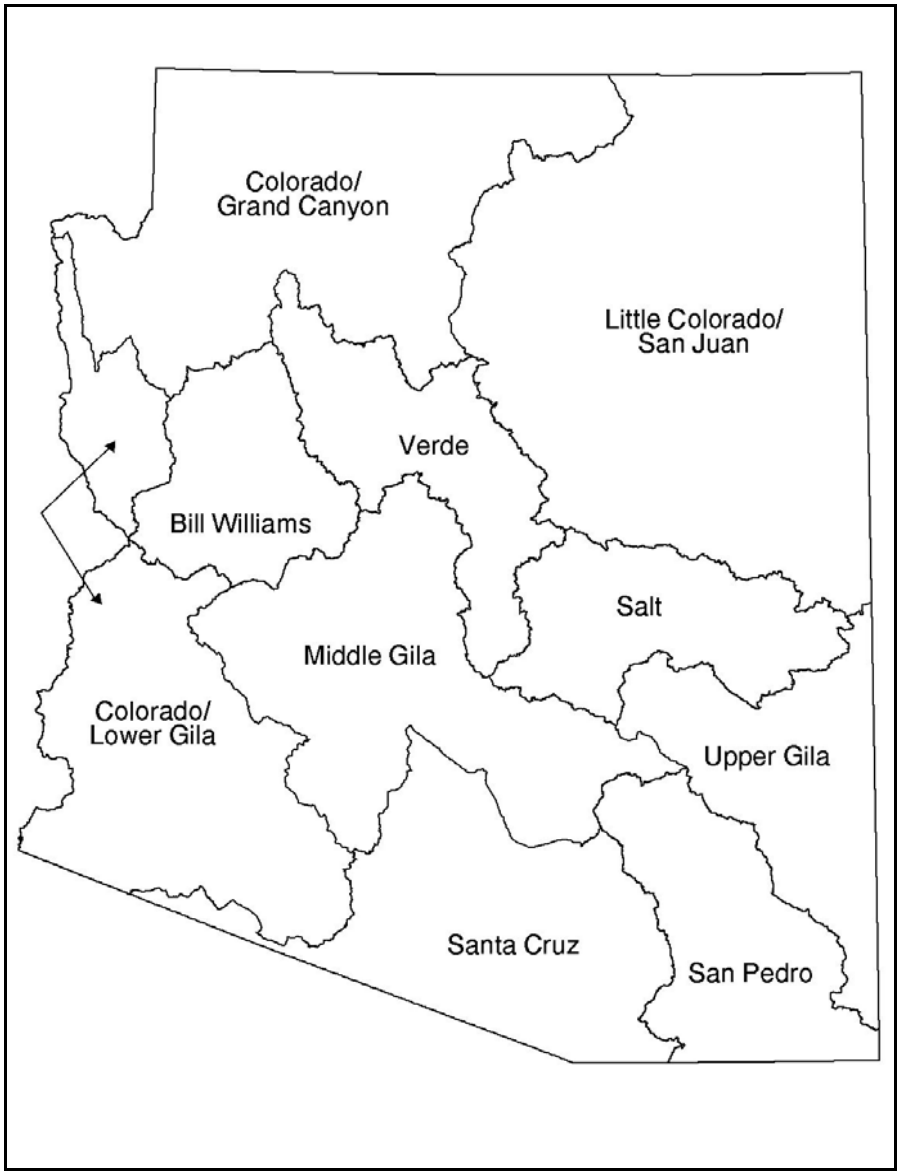
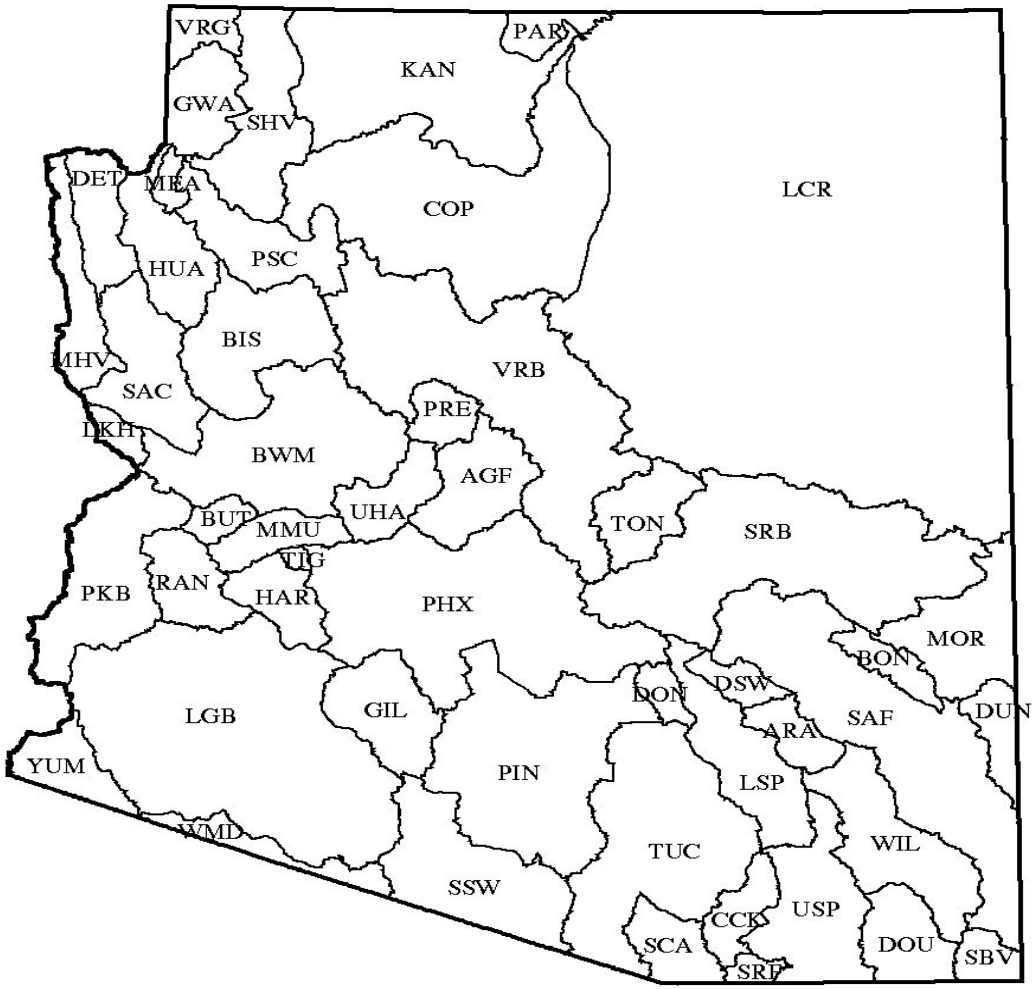


Figure 9. Arizona's Watersheds



Map Code	Basin Name	Map Code	Basin Name
AGF	Agua Fria	PAR	Paria
ARA	Aravaipa Canyon	PHX	Phoenix AMA
BIS	Big Sandy	PIN	Pinal AMA
BON	Bonita Creek	PKB	Parker
BUT	Butler Valley	PRE	Prescott AMA
BWM	Bill Williams	PSC	Peach Springs
CCK	Cienega Creek	RAN	Ranegras Plain
COP	Coconino Plateau	SAC	Sacramento Valley
DET	Detrital Valley	SAF	Safford
DON	Donnelly Wash	SCA	Santa Cruz AMA
DOU	Douglas	SBV	San Bernadino Valley
DSW	Dripping Springs Wash	SHV	Shivwits Plateau Basin
DUN	Duncan Valley	SRB	Salt River
GIL	Gila Bend	SRF	San Rafael
GWA	Grand Wash Basin	SSW	San Simon Wash
HAR	Harquahala	TIG	Tiger Wash
HUA	Hualapai Valley	TON	Tonto Creek
KAN	Kanab Plateau	TUC	Tucson AMA
LCR	Little Colorado River	UHA	Upper Hassayampa
LGB	Lower Gila	USP	Upper San Pedro
LKH	Lake Havasu	VRB	Verde River
LSP	Lower San Pedro	VRG	Virgin River Basin
MEA	Meadview	WIL	Willcox
MHV	Lake Mohave	WMD	West Mexican Drainage
MMU	McMullen Valley	YUM	Yuma
MOR	Morenci		

Groundwater Basin
State of Arizona Boundary

Figure 10. Ground Water Basins in Arizona