Groundwater Hydrology in the Verde River Basin

Highland Basins

The Highland Basins include the Salt River, Tonto Creek and Verde River basins, and the northern half of the Agua Fria Basin. Basin-fill aquifers in the highlands are limited in areal extent and are hydrologically connected with stream alluvium. Consolidated rock aquifers surround and underlie the basin-fill aquifers and contribute underflow. Basin-fill aquifers also receive inflow from stream infiltration and mountain front recharge. Where the basin-fill aquifers are discontinuous, underflow between them may be restricted (Anderson, et al., 1992).

Verde River Basin

The Verde River Basin is a relatively large basin that encompasses part of the Coconino Plateau in its northern portion with the Mogollon Rim defining its eastern boundary. It is characterized by steep canyons, rugged mountains and by broad alluvial valleys in the north and west-central portions of the basin. The basin is divided into the Big Chino, Verde Valley and Verde Canyon sub-basins as shown in **Figure 5.5-6** and **Figure 5.5-8**.

Natural recharge and groundwater in storage estimates for the basin, sub-basins and local areas are listed in **Table 5.5-6**. Groundwater recharge estimates for the entire basin range from 107,000 AFA to more than 138,000 AFA. Groundwater in storage is estimated to range from 13 maf to more than 22 maf for the entire basin. Few water level measurements were taken in the basin in both 1990-'91 and 2003-'04 (**Figure 5.5-6**). Water level change measurements taken during different time periods are shown for the Big Chino Sub-basin (**Figure 5.5-6A**) and the Verde Valley Sub-basin (**Figure 5.5-6B**) and are discussed in the sub-basin sections below. Well yield varies throughout the basin with the most productive wells located in the Big Chino Sub-basin (**Figure 5.5-8**). The median well yield for the entire basin is 260 gpm reported on registration forms for 262 large (>10-inch) diameter wells.

A number of hydrogeologic studies of the Big Chino and Verde Valley sub-basins, and to a lesser extent the Verde Canyon Sub-basin, have been conducted and are briefly referenced here. These studies, many of them recent, contain detailed information about the groundwater and surface water systems in the basin and are referenced in this section and in the Verde River Basin references and supplemental reading. Each sub-basin is discussed below from north to south across the basin.

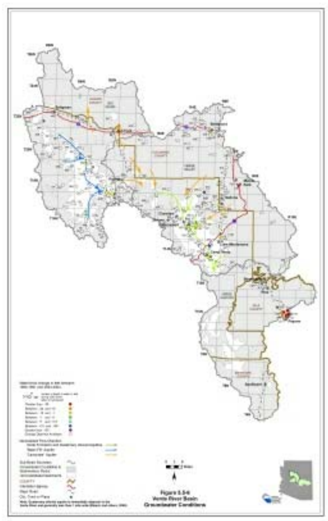
Big Chino Sub-basin

Table 5.5-6 Groundwater Data for the Verde River Basin

Basin Area, in square miles:	[illegible]	
Major Aquifer(s):	Name and/or Geologic Units	
	Recent Stream Alluvium	
	Basin Fill with Interbedded Volcanic Rock	
	Sedimentary Rock (Verde Formation)	
	Sedimentary Rock (C and R Aquifers)	
	Igneous and Metamorphic Rock	
Well Yields, in gal/min:	Range 10-2,008 Median 102 (55 wells measured)	Measured by ADWR and/or USGS
	Range 1-5,500 Median 250 (262 wells reported)	Reported on registration forms for large (> 10-inch) diameter wells
	10-1000	ADWR (1994)
	Range 0-2,500	USGS (1994)
Estimated Natural Recharge, in acre-feet/year:	107,470 (average for Verde Valley Sub-basin during 1990 - 2003)[1]	Blasch and others (2006)
	30,300 (average for Big Chino Sub-basin during 1990 - 2003)[2]	Blasch and others (2006)
	31,770 (Big Chino Sub basin during 1996 and 1997)[3]	ADWR (2000)
	1,835 (Town of Payson only)	Southwest Groundwater Consultants (1998)
	>138,000	ADWR (1994)
	107,000	Freethey and Anderson (1986)
Estimated Water Currently in Storage, in acre-feet:	6,800,000 (portion of Upper Big Chino Sub-basin)	Southwest Groundwater Consultants (2005)
	10,000,000 (Big Chino Sub-basin to 1,200 feet)	McGavock (2005)
	9,230 (Pine/Strawberry area)[4]	ADWR (1990)
	28,000,000 (to 1,200 feet)	ADWR (1990)
	13,000,000 (to 1,200 feet)	Freethey and Anderson (1986)
	>22,000,000	Arizona Water Commission (1975)
Current Number of Index Wells:	[illegible]	
Date of Last Water-level Sweep:	2004 ([illegible] wells measured)	

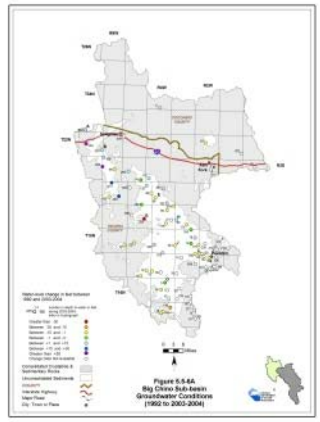
[1] Includes 10,300 AF of incidental and artificial recharge.
[2] Includes 4,300 AF of incidental and artificial recharge.
[3] Includes 8,010 AF of incidental recharge.
[4] This figure has been refuted as an overestimation by Morrison Maierle (2003).

Click to view Table 5.5-6 Groundwater Data for the Verde River Basin

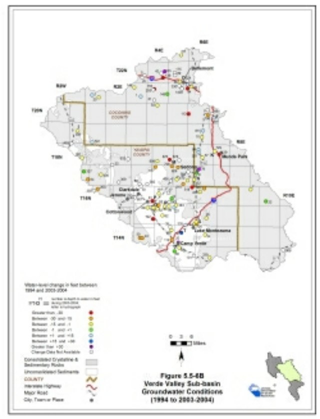


Click to view Figure 5.5-6 Verde River Basin Groundwater Conditions

The Big Chino Sub-basin has an area of about 1,850 square miles. The principal aquifer consists of basin-fill sediments interbedded with volcanic rocks of Cenozoic age that fill the sub-basin. This basin-fill aquifer is commonly referred to as the Chino Valley Unit and is the major source of water for irrigation and domestic purposes. Chino Valley runs northwest to southeast from Seligman to Paulden. Well yields in Chino Valley wells are commonly greater than 1,000 gpm to greater than 2,000 gpm. A carbonate aquifer comprised of Paleozoic rocks underlies most of the Big Chino Valley Sub-basin and the area north of the Verde River near Paulden. It is assumed that there is a hydraulic connection between the two aquifers in the Big Chino Valley and the Williamson Valley, which runs north-south along the southeastern sub-basin boundary. The general location of aquifers and other features are shown in the graphic from Wirt, 2005.

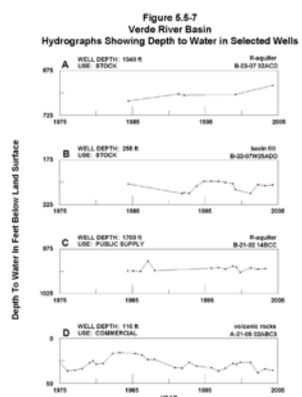


Click to view Figure 5.5-6A Big Chino Sub-basin Groundwater Conditions



Click to view Figure 5.5-11B Verde Valley Sub-basin Groundwater Conditions

Groundwater occurs under unconfined and confined (artesian) conditions in the basin-fill aquifer. Artesian conditions occur primarily where buried lava flows and coarse-grained sediments are interbedded with clays and volcanic ash. In the northwesternmost part of the sub-basin, basin-fill deposits may be as much as 2,500 feet thick. Further south and west of Paulden in the Williamson Valley, the thickness of the alluvium is estimated at 2,000 feet. In the eastern part of the Big Chino Sub-basin, the carbonate aquifer is the primary regional aquifer. This aquifer is dry west of the Mesa Butte Fault, which occurs north of Drake and runs northeastward, and between Williams and the Big Chino Valley (USGS, 2006). Alluvial sands and gravels along the major washes also yield water to wells and are utilized as a local water supply in the sub-basin.

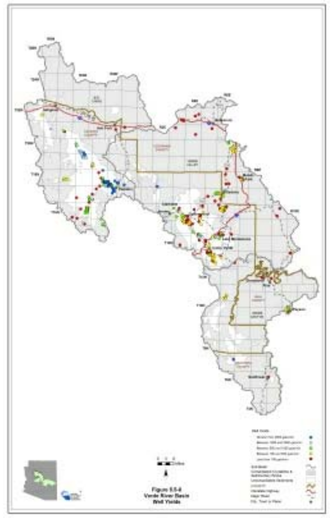


Groundwater flow in the basin-fill aquifer is toward the Big Chino Wash drainage and then south. Groundwater flow in the carbonate aquifer is toward the north (**Figure 5.5-6**). Recharge occurs from mountain front recharge along the Juniper and Santa Maria Mountains on the west side of the sub-basin, from Granite Mountain on the south and from Big Black Mesa and Bill Williams Mountain on the east side and from runoff in major washes. Recharge also occurs via groundwater inflow from the Little Chino Sub-basin (Prescott AMA) north of Del Rio Springs. In 1999, this groundwater inflow was estimated at 1,800 AFA (Nelson, 2002). The Williamson Valley and Paulden areas are the most arid regions in the Verde River Basin.

Groundwater outflow from the Big Chino Sub-basin occurs as base flow in the Verde River and is currently estimated at about 17,700 AFA. Base flow at the Verde River near Paulden (gage number 9503700, see **Figure 5.5-4**) has declined at an annual rate of about 380 AFA since the mid-1990s (USGS, 2006). The average annual recharge volume for the sub-basin was estimated at 30,300 AFA for the period 1990-2003 (Blasch and others, 2006). McGavock (2003) estimated that there was 10 maf of groundwater in storage in the sub-basin to a depth of 1,200 feet bls.

Figure 5.5-6A shows water level changes in the sub-basin from 1992 to 2003-'04 and water level elevation during 2003-'04. More than half the wells measured showed some decline although water level increases of more than 15 feet were measured in wells south of Seligman. Well yields exceeding 2,000 gpm are found along the Big Chino Wash drainage (**Figure 5.5-8**). Water quality is generally good in the sub-basin with some occurrence of arsenic at levels that equal or exceed the drinking water standard in wells in the Paulden area.

Click to view Figure 5.5-7 Verde River Basin Hydrographs Showing Depth to Water in Selected Wells



Click to view Figure 5.5-8 Verde River Basin Well Yields

Verde Valley Sub-basin

The Verde Valley Sub-basin is the largest sub-basin in the Verde River Basin with an area of about 2,500 square miles. The principal aquifer is the Verde Formation, which consists of a thick sequence of tertiary limestones and sandstones. The estimated depth of the formation reaches 4,200 feet based on aeromagnetic and gravity data (USGS, 2006). The formation flanks the Verde River for some distance from the Camp Verde area to north of Cottonwood. Other aquifers include the carbonate aquifer and an alluvial aquifer located along the Verde River. The carbonate aquifer, primarily sandstone of the Supai Formation and the underlying Redwall and Martin limestones is the main groundwater supply for Sedona. Locally perched groundwater in fractured or decomposed granite and in volcanic rocks provide small amounts of water in many locations. Groundwater occurs primarily under unconfined conditions although confined conditions occur locally within the Verde Formation. All three aquifers are hydraulically connected.

Most groundwater enters the sub-basin from the Coconino Plateau. Groundwater moves through the carbonate aquifer and discharges at springs and seeps along tributaries of the Verde River, or flows into the Verde Formation and stream-channel alluvium (USGS, 2006). The Oak Creek Fault system is an important influence on the transmission of water between aquifers and to the surface, as evidenced by the large number of major springs along Oak Creek (see **Figure 5.5-5**). Groundwater primarily flows toward the Verde River drainage and exits the sub-basin in the southeast through alluvium and volcanic rocks along the river (**Figure 5.5-6**).

Groundwater recharge to the Verde Formation aquifer is from high elevation precipitation along the Mogollon Rim and on the Coconino Plateau with additional contributions from stream infiltration. The carbonate aquifer also receives recharge from high altitudes along the Mogollon Rim, and from an area between the San Francisco Peaks and Bill Williams Mountain (USGS, 2006). Most recharge comes from winter precipitation. Groundwater recharge was estimated at 167,470 AFA on average during the period 1990-2003 (Blasch and others, 2006). An estimate of groundwater in storage is not available for the sub-basin. **Figure 5.5-6B** shows water level changes in the sub-basin from 1994 to 2003-'04 and water level elevation during 2003-'04. More than half the wells measured showed some decline although water level increases of more than 30 feet were measured at a few scattered locations. Reported well yields generally range from less than 100 gpm to 1,000 gpm in the sub-basin (**Figure 5.5-8**). Groundwater is generally of good quality at most locations, although the drinking water standard for arsenic has been equaled or exceeded in a number of wells (see **Table 5.5-7**).

Verde Canyon Sub-basin

There is relatively little groundwater development in the Verde Canyon Sub-basin with the exception of the Payson area. Basalt flows, conglomerates and semi-consolidated silt units cover a large part of the sub-basin. The groundwater system is complex, with disconnected recharge areas and multiple water-bearing zones. Because of its complexity, knowledge of the groundwater system is often limited to local analysis of spring and well data. Groundwater recharge originates primarily along the crest of the Mogollon Rim, where precipitation and snowmelt percolate through permeable volcanic, limestone or sandstone units (USGS 2005a). Spring discharge and stream base flow appear to be the largest components of aquifer outflow.

In Payson groundwater is withdrawn primarily from fractured and faulted granite. Most wells are shallow, although the Town of Payson has conducted exploratory drilling north of the town where deep water-bearing zones were found. A recent study suggests that a segment of the Diamond Rim fault system northeast of Payson may have groundwater supply potential (Gæaorama, 2006). The shallow water-bearing zones around Payson depend on winter recharge and are therefore very sensitive to drought. Water in deeper fracture systems in the area may be fed from the Mogollon Rim and less affected by drought. Water levels in wells measured in the Payson area in 2003-'04 varied from 115 feet to 339 feet bls. Water levels in most of these wells declined by more than 30 feet between 1990-'91 and 2003-'04 (**Figure 5.5-6**). Well yields in the area are typically less than 500 gpm.

In Strawberry, most wells are completed in the Schnebly Hill Formation, a sandstone unit that is the major component of the "Red Rocks" of Sedona. Well yields in the area typically range from 20 to 80 gpm. An exploratory well drilled near Strawberry in 2000 encountered water in the Redwall Limestone at about 1,380 feet (Corkhill, 2000). At nearby Pine most wells are completed in the Supai Formation, which is composed of sandstone, siltstone and mudstone with some interbedded limestone. Well yields in Pine are typically lower than Strawberry and range from 10 to 30 gpm. These relatively low well yields suggest a more localized groundwater system (USGS, 2005a). Little water level change data are available with one well near Pine showing a modest water level increase between 1990-'91 and 2003-'04. However, a nearby domestic well experienced a decline of about 160 feet between 1993 and 2003-'04 (**Figure 5.5-7**, hydrograph V). There is little water use in the southern half of the sub-basin where unconsolidated sediments are found.

Water quality is generally good in the sub-basin although the drinking water standards for arsenic, beryllium, cadmium, lead, selenium and organics have been equaled or exceeded in wells in the Payson area and for arsenic in Pine.

For information on surface water hydrology in the **Verde River Basin click here.**

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References and Supplemental Reading for the Verde River Basin