CONVERSION FACTORS

For readers who prefer to use metric units rather than inch-pound units, the conversion factors for the terms used in this report are listed below:

Multiply inch-pound unit	By	To obtain metric unit
foot (ft)	0.3048	meter (m)
square mile (mi^2)	2.590	square kilometer (km^2)
acre-foot (acre-ft)	0.001233	cubic hectometer (hm^3)
gallon per minute (gal/min)	0.06309	liter per second (L/s)

EXPLANATION

3000 — POTENTIOMETRIC CONTOUR, REGIONAL AQUIFER—Shows altitude at which water level would have stood in most tightly cased wells. Dashed where approximately located. Contour interval 200 feet. Datum is mean sea level

Tv / 120 / 56M(1978) / 3054 — WELL THAT PENETRATES THE REGIONAL AQUIFER—First entry, Tv, is principal geologic formation from which the well obtains its water (see composite stratigraphic column for explanation of letter symbol); queried where uncertain. Second entry, 120, is depth of well in feet. Third entry, 56M(1978), is depth to water in feet below land surface [M, depth to water measured; R, depth to water reported; F, flowing well; (1978), year in which water level was determined]. Fourth entry, 3054, is altitude of the water level in feet above mean sea level

Tb / 800 / 752M(1966) / 5203 — WELL THAT PENETRATES AN AQUIFER OTHER THAN THE REGIONAL AQUIFER—First entry, Tb, is principal geologic formation from which the well obtains its water (see composite stratigraphic column for explanation of letter symbol). Second entry, 800, is depth of well in feet. Third entry, 752M(1966), is depth to water in feet below land surface [M, depth to water measured; R, depth to water reported; F, flowing well; (1966), year in which water level was determined]. Fourth entry, 5203, is altitude of the water level in feet above mean sea level

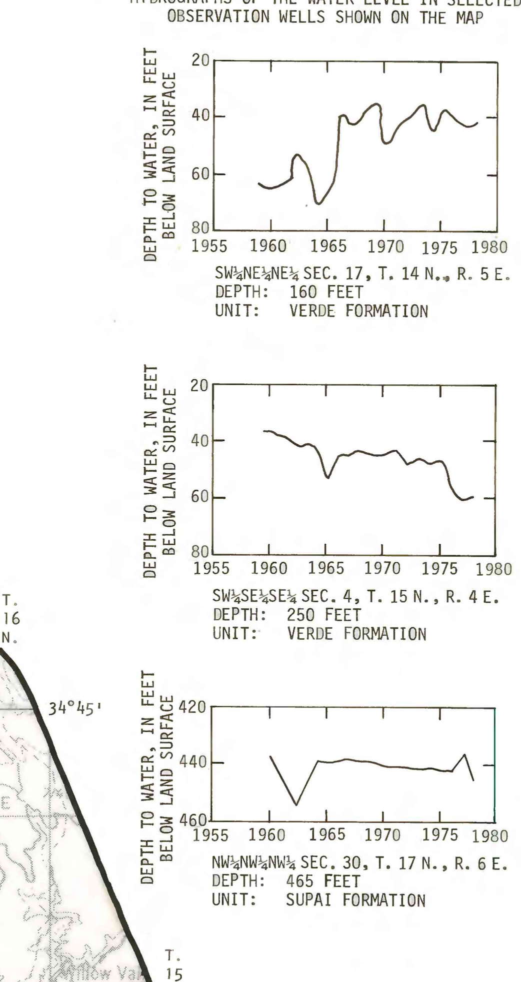
Pc / 75E(1959) / 4120 — SPRING THAT ISSUES FROM THE REGIONAL AQUIFER—First entry, Pc, is geologic formation from which the spring issues (see composite stratigraphic column for explanation of letter symbol). Second entry, 75E(1959), is discharge of spring in gallons per minute [M, discharge measured; E, discharge estimated; (1959), year in which discharge was determined]. Third entry, 4120, is altitude of the land surface in feet above mean sea level

Tb / 2.7M(1977) / 3540 — SPRING THAT ISSUES FROM AN AQUIFER OTHER THAN THE REGIONAL AQUIFER—First entry, Tb, is geologic formation from which the spring issues (see composite stratigraphic column for explanation of letter symbol). Second entry, 2.7M(1977), is discharge of spring in gallons per minute [M, discharge measured; E, discharge estimated; (1977), year in which discharge was determined]. Third entry, 3540, is altitude of the land surface in feet above mean sea level

GENERALIZED DIRECTION OF GROUND-WATER FLOW

ARBITRARY BOUNDARY OF GROUND-WATER AREA

HYDROGRAPHS OF THE WATER LEVEL IN SELECTED OBSERVATION WELLS SHOWN ON THE MAP



INTRODUCTION

The upper Verde River area includes about 2,600 mi^2 in north-central Arizona. The northern part of the area is in the Plateau uplands province, and the southern part is in the Central highlands province, which is the transition zone between the Plateau uplands province to the north and the Basin and Range lowlands province to the south (see index map). The Mogollon Rim escarpment, which has a topographic relief of as much as 2,000 ft, trends northwest across the central part of the area and forms the demarcation line between the Plateau uplands and Central highlands provinces.

The area is drained by the southeast-flowing Verde River and its tributaries. The Verde River and most reaches of its major tributaries—Sycamore, Oak, Beaver, and West Clear Creeks—are perennial. Although springs in the headwaters of Fossil Creek discharge ample water to maintain perennial flow in the creek, the flow is diverted into a flume, is used to generate electricity, and then is discharged into the Verde River.

Ground-water development has been slight and is concentrated along the Verde River between Clarkdale and Camp Verde, along Oak Creek, near Rimrock, and in T. 20 N., Rs. 7 and 8 E. In 1978 about 8,000 acre-ft of ground water was withdrawn for domestic, public-supply, industrial, and irrigation uses.

Only the springs for which discharge data are available are shown on the maps, and only selected wells are shown in areas of high well density. Most of the data were collected during 1977-78, but some were collected as early as 1946. Because ground-water development has been slight, the earlier data probably are representative of conditions in 1978.

The hydrologic data on which these maps are based are available, for the most part, in computer-printout form and may be consulted at the Arizona Water Commission, 222 North Central Avenue, Suite 850, Phoenix, and at U.S. Geological Survey offices in: Federal Building, 301 West Congress Street, Tucson; Valley Center, Suite 1880, Phoenix; and 2255 North Gemini Drive, Building 3, Flagstaff. Material from which copies can be made at private expense is available at the Tucson, Phoenix, and Flagstaff offices of the U.S. Geological Survey.

GEOHYDROLOGY

The Plateau uplands province is underlain by a bedded sequence of sedimentary rocks, which in ascending order include the Tapeats Sandstone, Martin Formation, Redwall Limestone, Naco Formation, Supai Formation, Coconino Sandstone, Toroweap Formation, Kaibab Limestone, and Moenkopi Formation. (See the composite stratigraphic column.) In places these rocks are overlain by basalt flows and alluvium. In the Central highlands province, the sedimentary rocks above the Supai Formation have been removed by erosion. The Supai and underlying rocks probably are present in most of the Central highlands province but, in many places, are covered by the Verde Formation, undifferentiated Tertiary sedimentary rocks, basalt flows, and alluvium. The Verde Formation is present mainly between Sycamore Creek and Cottonwood basin, and the Tertiary sedimentary rocks are present near Perkinsville and Drake. Near the southwest boundary, rocks that overlie the Martin Formation have been removed by erosion, and in places the metamorphic and igneous rocks are exposed at the land surface.

The upper Verde River area is underlain by a regional aquifer that consists of several hydraulically connected formations. In places ground water also is present in the igneous rocks and basalt flows and in the alluvium along the channels and flood plains of streams.

Regional Aquifer

In the Plateau uplands province the regional aquifer consists of the Coconino Sandstone, Supai Formation, Naco Formation, Redwall Limestone, Martin Formation, and Tapeats Sandstone. In the Central highlands province the Coconino Sandstone has been removed by erosion, and between Sycamore Creek and Cottonwood basin the Verde Formation is the main unit of the aquifer. The presence and thickness of the units below the Verde Formation are unknown because only a few wells drilled near the edge of the Verde completely penetrate the formation.

The regional aquifer receives its recharge from infiltration of precipitation and streamflow, which infiltrate the strata that overlie the aquifer and move downward to intersect the water table. The Plateau uplands province is the main area of recharge, but some recharge occurs in the Central highlands province. Some ground water may enter the area across the northwest and east boundaries.

In the Plateau uplands province most of the ground water moves southwesterly toward the Mogollon Rim and into the Central highlands province. Near Upper Lake Mary, however, part of the ground water moves northwesterly to northeasterly and out of the area. In the Central highlands province ground water moves toward and parallel to the Verde River. Part of the ground water is discharged by springs along the river and its perennial tributaries. Near Cottonwood basin, the Verde Formation thins to extinction, and basalt flows crop out at the land surface. Whether or not a sequence of sedimentary rocks underlies the basalt flows is unknown, and the basalt flows may directly overlie the metamorphic and igneous rocks. Some ground water may move laterally from the Verde Formation into the basalt flows south of Cottonwood basin. In most places, however, water in the basalt flows is perched several tens to several hundred feet above the regional aquifer. Along the Verde River between Clarkdale and Cottonwood basin, the alluvium probably is hydraulically connected to the regional aquifer. Many wells drilled in the alluvium yield water similar in chemical quality to that of the water in the regional aquifer, and the water levels in wells that tap the alluvium are at altitudes similar to those in the regional aquifer. In most places, however, the alluvium is separated from the regional aquifer by several tens to several hundred feet of unsaturated rock.

In most of the area ground water in the regional aquifer is under unconfined, or water-table, conditions—that is, water levels in wells that tap the aquifer do not rise above the top of the saturated strata. In places, however, water in the aquifer is under confined, or artesian, conditions, and water levels in wells rise above the top of the saturated strata. Confined ground water occurs mainly in the Verde Formation but also may occur in other formations. Near Rimrock, Cornville, Page Springs, and Cottonwood, the artesian pressure is sufficient to cause some wells to flow at the land surface.

Wells that penetrate the regional aquifer generally are a few tens to nearly 1,700 ft deep; however, test holes that penetrate several formations in the regional aquifer were drilled to depths of more than 3,000 ft. The depth to water in the regional aquifer ranged from flowing at the land surface to 1,279 ft below the land surface. In the Verde Formation the water level is dependent on well depth because of the nonuniformity of the strata. In many places water levels differed by several tens of feet in wells of different depth within a few hundred feet of each other. In places perched ground water is present in several formations in the regional aquifer, and water levels may be above the regional water level. The contours on sheet 1 are representative of water levels in most wells, although water levels in some wells may differ significantly from those used to construct the contours. Along West Clear Creek and some reaches of the Verde River, water-level data are few to nonexistent; however, because the streams probably are hydraulically connected to the regional aquifer, the altitudes of the streambeds were used as control points to construct the contours. Although water levels do not appear to be declining on a regional basis, some water-level change has taken place in response to variations in recharge or to large ground-water withdrawals. The water level in an observation well in the SW¼SE¼SE¼ sec. 4, T. 15 N., R. 4 E., declined about 20 ft in 20 years, and the water level in an observation well in the SW¼NE¼NE¼ sec. 17, T. 14 N., R. 5 E., rose about 20 ft in 20 years. The water level in an observation well in the NW¼NW¼NW¼ sec. 30, T. 17 N., R. 6 E., declined slightly during the same period.

Wells in the regional aquifer yield about 10 to 2,000 gal/min. Wells that tap the Supai Formation, Redwall Limestone, Martin Formation, or Tapeats Sandstone generally yield less than 50 gal/min unless they intersect fractures, faults, or solution cavities. A yield of more than 1,000 gal/min was reported for a well that taps the Redwall Limestone, but this is an unusually high yield. Wells that obtain their water from the Coconino Sandstone and Supai Formation generally yield less than 200 gal/min but may yield as much as 1,000 gal/min. Many wells that penetrate the Verde Formation yield less than 100 gal/min; however, the well yields generally reflect limits of the pumping equipment rather than the potential yield of the aquifer. Well yields of 200 to 300 gal/min are common, and yields of as much as 2,000 gal/min have been reported. Wells capable of these large yields probably intersect solution cavities in the limestone beds of the Verde Formation.

Springs that issue from the regional aquifer sustain the base flow in the Verde River and its tributaries. Springs discharge 1 to 18,600 gal/min.

Other Aquifers

In places ground water is present in the alluvium, basalt flows, and igneous rocks. Near Cherry, wells that penetrate the alluvium or igneous rocks generally yield less than 5 gal/min. Near Munds Park, wells that penetrate the alluvium and the basalt, which probably are in hydraulic connection, yield 5 to 450 gal/min. Wells that penetrate the alluvium along the channels and flood plains of the Verde River and its tributaries generally yield less than 50 gal/min, but where wells are drilled close to the Verde River or where the alluvium is hydraulically connected to the regional aquifer, well yields may be greater than 50 gal/min. Although the basalt flows cover a large part of the area, they yield water only where fractured and underlain by a poorly permeable unit. Well depth, water level, and yield vary from place to place and are dependent on the thickness of the basalt and degree of fracturing, which may vary greatly in a few hundred feet. The basalt generally yields less than 20 gal/min.

Several springs issue from the basalt, and discharge generally is less than 10 gal/min. In the north-central and extreme southeastern parts of the area, several springs issue from the Kaibab Limestone and Toroweap Formation. Most springs discharge less than 2 gal/min, but one spring discharged about 20 gal/min. The discharge fluctuates seasonally, and some springs cease to flow during periods of drought.

5 0 5 MILES
5 0 5 10 KILOMETERS

CONTOUR INTERVAL 200 FEET
WITH SUPPLEMENTARY CONTOURS AT 100-FOOT INTERVALS
DATUM IS MEAN SEA LEVEL

INDEX MAP SHOWING AREA OF REPORT (SHADED) AND ARIZONA'S WATER PROVINCES

Composite stratigraphic column for the upper Verde River area

System	Formation	Letter symbol for geologic unit
Quaternary	Alluvium	Qal
Tertiary	Basalt flows Sedimentary rocks Verde Formation	Tb Ts Tv
Triassic	Moenkopi Formation	Ŧm
Permian	Kaibab Limestone Toroweap Formation Coconino Sandstone	Pk Pt Pc
Permian and Pennsylvanian	Supai Formation Naco Formation	PIPs PIPn
Mississippian	Redwall Limestone	Mr
Devonian	Martin Formation	Dm
Cambrian	Tapeats Sandstone	Ꞓt
Precambrian	Metamorphic and igneous rocks	pꞒ

BASE FROM U.S. GEOLOGICAL SURVEY
FLAGSTAFF 1:250,000, 1954,
HOLBROOK 1:250,000, 1954,
PRESCOTT 1:250,000, 1954, AND
WILLIAMS 1:250,000, 1956

DEPTH OF WELL, DEPTH TO WATER, AND ALTITUDE OF THE WATER LEVEL

MAPS SHOWING GROUND-WATER CONDITIONS IN THE UPPER VERDE RIVER AREA, YAVAPAI AND COCONINO COUNTIES, ARIZONA—1978

BY
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