EXPLANATION

4800 — POTENTIOMETRIC CONTOUR, COCONINO AQUIFER—Shows altitude at which water level would have stood in tightly cased well. Dashed where approximately located. Contour interval 100 feet. Datum is mean sea level

● 5T-514
304R(1964)
4651
8330
1.3
WELL THAT PENETRATES THE COCONINO AQUIFER—First entry, 5T-514, is well number or name assigned by the Navajo Tribe; well numbers are not shown for off-reservation sites. Second entry, 304R(1964), is depth to water in feet below land surface [R, depth to water reported; M, depth to water measured; (1964), year in which water level was determined]. Third entry, 4651, is altitude of the water level in feet above mean sea level. Fourth entry, 8330, is specific conductance in micromhos per centimeter at 25°C (specific conductance is an indication of the dissolved-solids concentration in water). Fifth entry, 1.3, is fluoride concentration in milligrams per liter

▲ 5T-511A
95R(1963)
4845
WELL THAT PENETRATES THE CHINLE FORMATION—First entry, 5T-511A, is well number or name assigned by the Navajo Tribe; well numbers are not shown for off-reservation sites. Second entry, 95R(1963), is depth to water in feet below land surface [R, depth to water reported; (1963), year in which water level was reported]. Third entry, 4845, is altitude of the water level in feet above mean sea level

○ 7T-515
53R(1958)
5952
4500
1.4
WELL THAT PENETRATES THE N AQUIFER—First entry, 7T-515, is well number or name assigned by the Navajo Tribe. Second entry, 53R(1958), is depth to water in feet below land surface [R, depth to water reported; M, depth to water measured; (1958), year in which water level was determined]. Third entry, 5952, is altitude of the water level in feet above mean sea level. Fourth entry, 4500, is specific conductance in micromhos per centimeter at 25°C (specific conductance is an indication of the dissolved-solids concentration in water). Fifth entry, 1.4, is fluoride concentration in milligrams per liter

◍ 1714 — EXPLORATION HOLE—Number, 1714, is depth of hole in feet

CHEMICAL-QUALITY DIAGRAM—Shows major chemical constituents in milliequivalents per liter. The diagrams are in a variety of shapes and sizes, which provides a means of comparing, correlating, and characterizing types of water

Milliequivalents per liter
Cations: Sodium, Calcium, Magnesium
Anions: Chloride, Bicarbonate, Sulfate
20 10 0 10 20

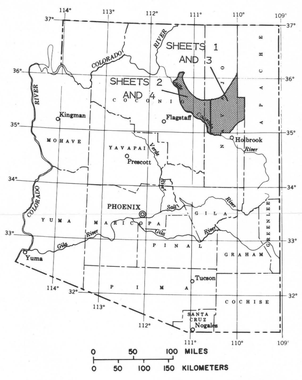
DS=800 — DISSOLVED SOLIDS—Number, 800, is dissolved solids in milligrams per liter

APPROXIMATE BOUNDARY OF THE N AQUIFER

CONFINED / UNCONFINED — APPROXIMATE BOUNDARY BETWEEN CONFINED AND UNCONFINED CONDITIONS IN THE N AQUIFER—Queried where uncertain

GENERALIZED DIRECTION OF GROUND-WATER FLOW

ARBITRARY BOUNDARY OF GROUND-WATER AREA



INDEX MAP SHOWING AREA OF REPORT (SHADED)

INTRODUCTION

The Hopi area includes about 3,200 mi^2 in northeastern Arizona and is mostly in the Navajo and Hopi Indian Reservations; about 400 mi^2 of the area is south of the Navajo Indian Reservation boundary. Ground water occurs in several aquifers that are made up of one or more formations; the composite stratigraphic column indicates the relative position of the formations. The main sources of ground water are the Coconino aquifer, the Chinle Formation, the N and D aquifers, the Toreva and Bidahochi Formations, and the alluvium. The aquifers are separated by fine-grained rock units that inhibit the vertical movement of ground water.

Ground-water development has been slight, and the water is used mainly for public, domestic, and livestock supplies. In 1977 about 425 acre-ft of ground water was withdrawn in the Hopi area. The amount of ground water withdrawn annually is small compared to the potential recharge from precipitation; therefore, water levels generally are not affected by pumping from wells.

Because the ground-water system in the Hopi area has not been changed greatly by development, a large number of water-level measurements and water-quality data collected prior to 1977 are used in this report to show conditions in 1977. A few water-level measurements were made south of the Navajo Indian Reservation boundary in 1977.

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.

COCONINO AQUIFER

The Coconino aquifer underlies the entire Hopi area but is exposed only along the valley of the Little Colorado River. Depth to the top of the aquifer ranges from about 100 ft below the land surface in the southwestern part of the area to about 3,000 ft below the land surface in the northern part. The Coconino aquifer consists of the Coconino Sandstone and possibly its lateral equivalent—the De Chelly Sandstone—in the northern and eastern parts of the area (Cooley and others, 1969, p. 13), the uppermost beds of the underlying Supai Formation, and the overlying Kaibab Limestone and Toroweap Formation in the western part of the area.

The Kaibab Limestone is composed of sandy limestone, dolomitic limestone, and chert interbedded with thin sandstone and siltstone units. The Toroweap Formation is composed of very fine to medium-grained sandstone and silty lenses. The Coconino Sandstone and the De Chelly Sandstone are crossbedded and are composed dominantly of well-sorted, well-rounded, fine- to medium-grained quartz sand. The upper part of the Supai Formation is composed of fine- to medium-grained sandstone units interbedded with subordinate siltstone units.

The Coconino aquifer has not been developed as a source of water in most of the area owing to the great depth of burial in the northern and eastern parts and the large concentrations of dissolved solids in the water in the southwestern part. In the southern part of the area where the Coconino aquifer supplies water to wells, ground-water movement generally is toward the northwest. Data are not available to indicate the direction of movement and quality of the water in the northern and eastern parts. The Coconino aquifer is saturated throughout most of the area, and the ground water occurs under confined conditions, except along the valley of the Little Colorado River where the confining beds of the Moenkopi Formation have been removed by erosion. The Coconino aquifer yields 10 to 50 gal/min to wells; however, where the aquifer is fractured sufficiently, greater yields may be possible.

In the southwestern part of the area the ground water from the Coconino aquifer generally is of poor chemical quality. Dissolved-solids concentrations in the water range from 2,930 to 16,800 mg/L (milligrams per liter). The recommended maximum contaminant level for dissolved solids in public water supplies is 500 mg/L, as proposed in the secondary drinking-water regulations of the U.S. Environmental Protection Agency (1977b, p. 17146) in accordance with provisions of the Safe Drinking Water Act (Public Law 93-523). The U.S. Environmental Protection Agency (1977a, b) has established national regulations and guidelines for the quality of water provided by public water systems. The regulations are either primary or secondary. Primary drinking-water regulations govern those contaminants in drinking water that have been shown to affect human health. Secondary drinking-water regulations apply to those contaminants that affect esthetic quality. The primary regulations are enforceable either by the Environmental Protection Agency or by the States; in contrast, the secondary regulations are not Federally enforceable. The secondary regulations are intended as guidelines for the States. The regulations express limits as "maximum contaminant levels," where contaminant means any physical, chemical, biological, or radiological substance or matter in water. Specific conductance, which is shown on the maps, varies with the concentration of ions in solution and is an indication of the dissolved-solids concentration in the water. The dissolved-solids values may be estimated by multiplying the specific conductance by 0.6.

Concentrations of chloride and sulfate in the water from all sampled wells that tap the Coconino aquifer exceed the recommended limit of 250 mg/L in public water supplies (National Academy of Sciences and National Academy of Engineering, 1973, p. 89). Fluoride concentrations range from 0.2 to 1.3 mg/L. The maximum contaminant level for fluoride in public water supplies differs according to the annual average maximum daily air temperature (Bureau of Water Quality Control, 1978, p. 6). The amount of water consumed by humans, and therefore the amount of fluoride ingested, depends partly on air temperature. In the Hopi area the annual average maximum daily air temperature is about 69°F, and the maximum contaminant level for fluoride is 1.8 mg/L.

MOENKOPI FORMATION

The Moenkopi Formation occurs throughout the Hopi area, except in places along the valley of the Little Colorado River, and is exposed along the west and south borders of the area. The Moenkopi Formation consists of interbedded sandstone, conglomerate, siltstone, and mudstone units and lenses of gypsum and halite. In the Moenkopi Formation water occurs in the sandstone and conglomerate units; the siltstone and mudstone units and the gypsum and halite lenses generally restrict the movement of ground water. The Moenkopi may yield as much as 10 gal/min of water to wells, but the chemical quality of the water generally is poor. One well near the west boundary obtains water from the Moenkopi; the dissolved-solids concentration in the water is 4,200 mg/L, and sodium, chloride, and sulfate are the dominant ions.

CHINLE FORMATION

The Chinle Formation is present throughout the entire area, except in the southwestern part near the Little Colorado River, where it has been removed by erosion. The Chinle Formation consists of the Church Rock, Owl Rock, Petrified Forest, and Shinarump Members (Cooley and others, 1969, pl. 1; Stewart and others, 1972a, pls. 4 and 5). The Church Rock, Owl Rock, and Petrified Forest Members are composed mostly of siltstone, claystone, and some interbedded sandstone and generally yield less than 5 gal/min to wells. The Shinarump Member is composed of sandstone and conglomerate units. The member varies in thickness because it fills channels scoured in the underlying Moenkopi Formation and, in places, has been removed by erosion (Stewart and others, 1972a, p. 18-19). The Shinarump Member yields from about 1 to 30 gal/min to wells. Dissolved-solids concentrations in the water from the Chinle Formation generally exceed 500 mg/L. Calcium, sodium, bicarbonate, chloride, and sulfate are the dominant ions in the water. Fluoride concentrations range from 0.6 to 5.6 mg/L.

N AQUIFER

The N aquifer, which occurs in the northeastern and northern parts of the Hopi area, consists of the Navajo Sandstone, Kayenta Formation, Moenave Formation, and Wingate Sandstone. The N aquifer is composed of fine-grained sandstone and siltstone. The Navajo Sandstone is present only in the extreme northeastern part of the area; erosion has stripped off older formations of the N aquifer to the south and west.

The N aquifer yields less water in the Hopi area than in adjacent areas to the north and northeast and is water bearing only in the northeastern part of the area. In part of this area ground water in the N aquifer occurs under confined conditions. Well yields generally are less than 10 gal/min, but yields of as much as 45 gal/min have been reported. The water generally contains more than 600 mg/L of dissolved solids; the large concentrations of dissolved solids may be partly due to contributions of water from the overlying Bidahochi Formation. Sodium, bicarbonate, chloride, and sulfate are the dominant ions in the water. Fluoride concentrations range from 0.5 to 3.2 mg/L in the water from four wells.

Composite stratigraphic column for the Hopi area

System	Formation or member	
Quaternary	Alluvium Dune sand Playa deposits Extrusive igneous rocks	Sheets 3 and 4
Tertiary	Bidahochi Formation Upper member Volcanic member Lower member Extrusive and intrusive igneous rocks	Sheet 3
Cretaceous	Wepo Formation Toreva Formation Upper sandstone member Middle carbonaceous member Basal sandstone member Mancos Shale Dakota Sandstone	Sheet 3
Jurassic	Morrison Formation Cow Springs Sandstone Entrada Sandstone Carmel Formation	Sheet 3
Jurassic and Triassic(?)	Navajo Sandstone	Sheets 1 and 2
Triassic(?)	Kayenta Formation Moenave Formation	Sheets 1 and 2
Triassic	Wingate Sandstone Lukachukai Member Rock Point Member Chinle Formation Church Rock Member Owl Rock Member Petrified Forest Member Shinarump Member Moenkopi Formation	Sheets 1 and 2
Permian	Kaibab Limestone Toroweap Formation Coconino Sandstone De Chelly Sandstone Supai Formation Upper member	Sheets 1 and 2

CONVERSION FACTORS

For readers who may 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)

BASE FROM U.S. GEOLOGICAL SURVEY
MARBLE CANYON 1:250,000, 1956-63,
FLAGSTAFF 1:250,000, 1954,
HOLBROOK 1:250,000, 1954, AND
GALLUP 1:250,000, 1954

MAPS SHOWING GROUND-WATER CONDITIONS IN THE HOPI AREA, COCONINO AND NAVAJO COUNTIES, ARIZONA—1977

BY
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