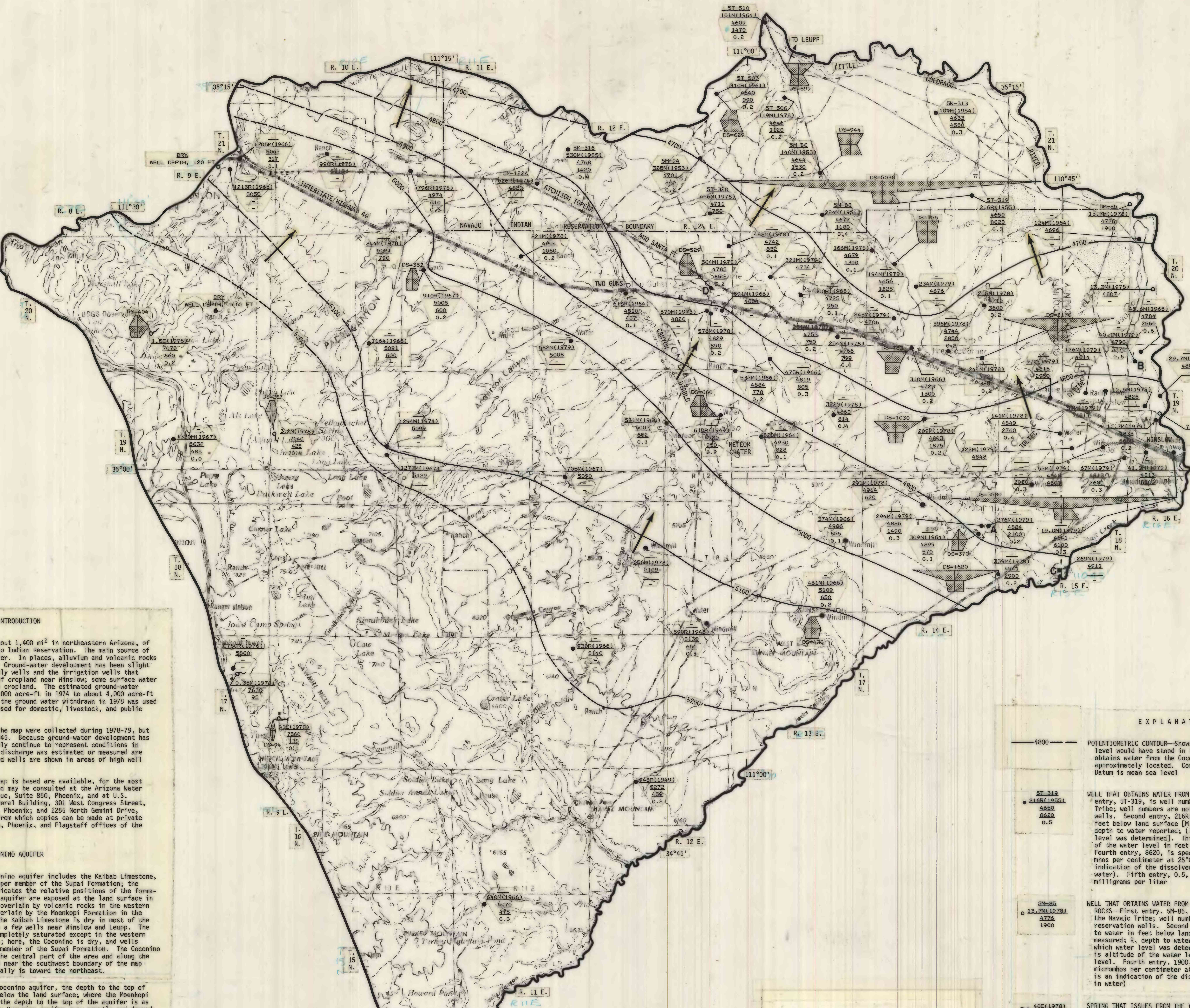

INTRODUCTION

The Canyon Diablo area includes about 1,400 mi^2 in northeastern Arizona, of which about 60 mi^2 is in the Navajo Indian Reservation. The main source of ground water is the Coconino aquifer. In places, alluvium and volcanic rocks yield water to wells and springs. Ground-water development has been slight except for the Winslow public-supply wells and the irrigation wells that furnish water to about 650 acres of cropland near Winslow; some surface water also is used for irrigation of the cropland. The estimated ground-water withdrawal increased from about 2,000 acre-ft in 1974 to about 4,000 acre-ft in 1978. Slightly more than half the ground water withdrawn in 1978 was used for irrigation, and the rest was used for domestic, livestock, and public supplies.

Most of the data used to compile the map were collected during 1978-79, but some were collected as early as 1945. Because ground-water development has been slight, the early data probably continue to represent conditions in 1979. Only the springs for which discharge was estimated or measured are shown on the map, and only selected wells are shown in areas of high well density.

The hydrologic data on which the map is 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

In the Canyon Diablo area the Coconino aquifer includes the Kaibab Limestone, the Coconino Sandstone, and the upper member of the Supai Formation; the composite stratigraphic column indicates the relative positions of the formations. The units of the Coconino aquifer are exposed at the land surface in the central part of the area, are overlain by volcanic rocks in the western and southwestern parts, and are overlain by the Moenkopi Formation in the eastern and northeastern parts. The Kaibab Limestone is dry in most of the area but contributes some water to a few wells near Winslow and Leupp. The Coconino Sandstone is partly to completely saturated except in the western and southwestern parts of the area; here, the Coconino is dry, and wells obtain their water from the upper member of the Supai Formation. The Coconino aquifer receives its recharge in the central part of the area and along the Mogollon Rim, which is outside and near the southwest boundary of the map area. Ground-water movement generally is toward the northeast.

Where volcanic rocks overlie the Coconino aquifer, the depth to the top of the aquifer is as much as 700 ft below the land surface; where the Moenkopi Formation is at the land surface, the depth to the top of the aquifer is as much as 310 ft. Well depths in the Coconino aquifer vary greatly and depend on the formations penetrated; well depths generally decrease from southwest to northeast. A few exploration holes have been drilled in the area. The deepest exploration hole, which is in sec. 24, T. 19 N., R. 10 E., is 6,500 ft deep, penetrates the entire thickness of the Coconino aquifer, and is completed in Precambrian granite; water from the exploration hole is being used to water livestock. The depth to water in the Coconino aquifer generally becomes less from southwest to northeast.

Available data indicate little or no change in the depth to water in the Coconino aquifer in most of the area (hydrographs B-D). The water level in a well in sec. 13, T. 18 N., R. 14 E., however, declined nearly 7 ft from 1967 to 1979 (hydrograph A). The well is unused and is in the Winslow well field. Well yields range from 7 to 950 gal/min but probably are controlled more by pump type and size than by aquifer characteristics; however, well yields may be greater where the aquifer is highly fractured.

Drillers' logs indicate that ground water in the Coconino aquifer occurs under confined conditions in parts of the area. Near Winslow and Leupp, the Moenkopi Formation acts as a confining layer, and static water levels in wells were as much as 194 ft above where water was first found during drilling. Some wells penetrate local confining layers, and static water levels generally were no more than 36 ft above where water was first found; however, the static water level in a well in sec. 20, T. 19 N., R. 16 E., was 184 ft above where water was first found during drilling.

Dissolved-solids concentrations in water in the Coconino aquifer generally are between 180 and 5,000 mg/L (milligrams per liter). The water from a well in sec. 28, T. 18 N., R. 15 E., however, contained more than 100,000 mg/L dissolved solids between 1,076 and 1,210 ft below the land surface. The well was plugged back to 500 ft, and at depths of less than 500 ft the dissolved-solids concentration was less than 2,000 mg/L. Specific conductance, which is shown on the map, is an indication of the dissolved-solids concentration in water and varies with the concentration of ions in solution. The dissolved-solids values may be estimated by multiplying the specific conductance by 0.61, which is the approximate ratio of dissolved solids to specific conductance in water in the Coconino aquifer in the Canyon Diablo area. The 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 contaminants in drinking water that have been shown to affect human health. Secondary drinking-water regulations apply to 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.

In the western and southwestern parts of the area the dissolved-solids concentrations in water are less than 500 mg/L, and the dominant ions are calcium and bicarbonate. In the central part the dissolved-solids concentrations generally are less than 500 mg/L; however, the concentrations in water from a few wells exceed 500 mg/L. The dominant ions are calcium and sulfate. In the eastern and northern parts the dissolved-solids concentrations generally exceed 500 mg/L and are as much as 5,030 mg/L; the dominant ions are sodium and chloride. The chloride concentration generally exceeds the recommended limit of 250 mg/L for public water supplies (National Academy of Sciences and National Academy of Engineering, 1973, p. 61). The chloride concentration was 2,600 mg/L in the water from well 5T-319.

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 Canyon Diablo area the annual average maximum daily air temperature ranges from 59° to 72°F (Sellers and Hill, 1974, p. 306, 307, 336, 570, and 571), and the maximum contaminant level for fluoride ranges from 1.6 to 2.0 mg/L. Fluoride concentrations in water in the Coconino aquifer generally range from 0.0 to 0.6 mg/L.

ALLUVIUM AND VOLCANIC ROCKS

In the Canyon Diablo area, few wells have been completed in the alluvium or volcanic rocks. All wells that obtain their water from the alluvium are near the Little Colorado River. During 1978-79, the depth to water could be measured in only three wells in the alluvium; some wells had been abandoned and capped. The water levels in a well in sec. 20, T. 19 N., R. 16 E., a well in sec. 20, T. 20 N., R. 16 E., and well 5M-85 in the Navajo Indian Reservation were 7.8, 13.3, and 13.7 ft below the land surface, respectively. Water levels in the wells fluctuate seasonally, probably in response to the variation in flow of the Little Colorado River. Yield data are not available for the wells. A well in sec. 15, T. 21 N., R. 9 E., penetrates 75 ft of alluvium, is completed in volcanic rocks at a depth of 120 ft, and has been dry since 1957.

Few chemical-quality data are available for water from wells that penetrate the alluvium. During 1978-79, the specific conductance of water from the well in sec. 20, T. 19 N., R. 16 E., and well 5M-85 was 640 and 1,900 micromhos per centimeter at 25°C, respectively. In 1954 a chemical analysis of water from well 5M-85 indicated that the dissolved-solids to specific-conductance ratio was about 0.6, the dominant ions were sodium and chloride, and the fluoride concentration was 0.4 mg/L.

A few springs issue from the volcanic rocks in the western part of the area. In the summer of 1978, the discharges of four springs were 0.35 to 40 gal/min; several other spring sites were visited, but the springs were dry. Spring discharge probably fluctuates in response to snowmelt and runoff. Dissolved-solids concentrations in the water from three of the springs were 94, 267, and 404 mg/L, and the fluoride concentrations were 0.0, 0.2, and 0.4 mg/L. The specific conductance of the water from the fourth spring was 95 micromhos, which indicates that the dissolved-solids concentration was 57 mg/L.

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Sellers, W. D., and Hill, R. H., eds., 1974, Arizona climate 1931-1972: Tucson, University of Arizona Press, 616 p.

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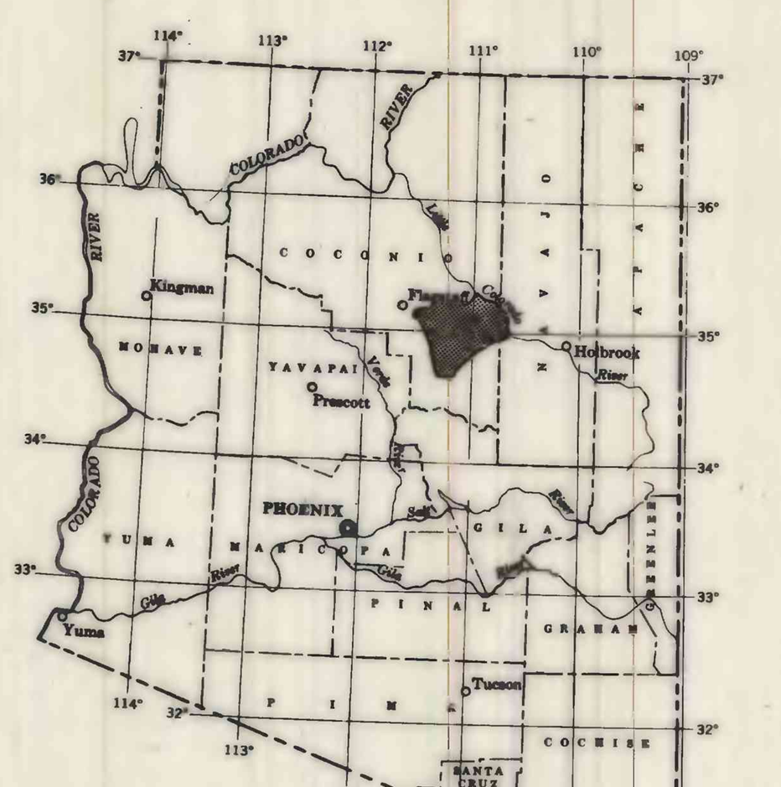
________1977b, National secondary drinking water regulations: Federal Register, v. 42, no. 62, March 31, 1977, p. 17143-17147.

Wilson, E. D., Moore, R. T., and O'Haire, R. T., 1960, Geologic map of Navajo and Apache Counties, Arizona: Arizona Bureau of Mines map, scale 1:375,000.

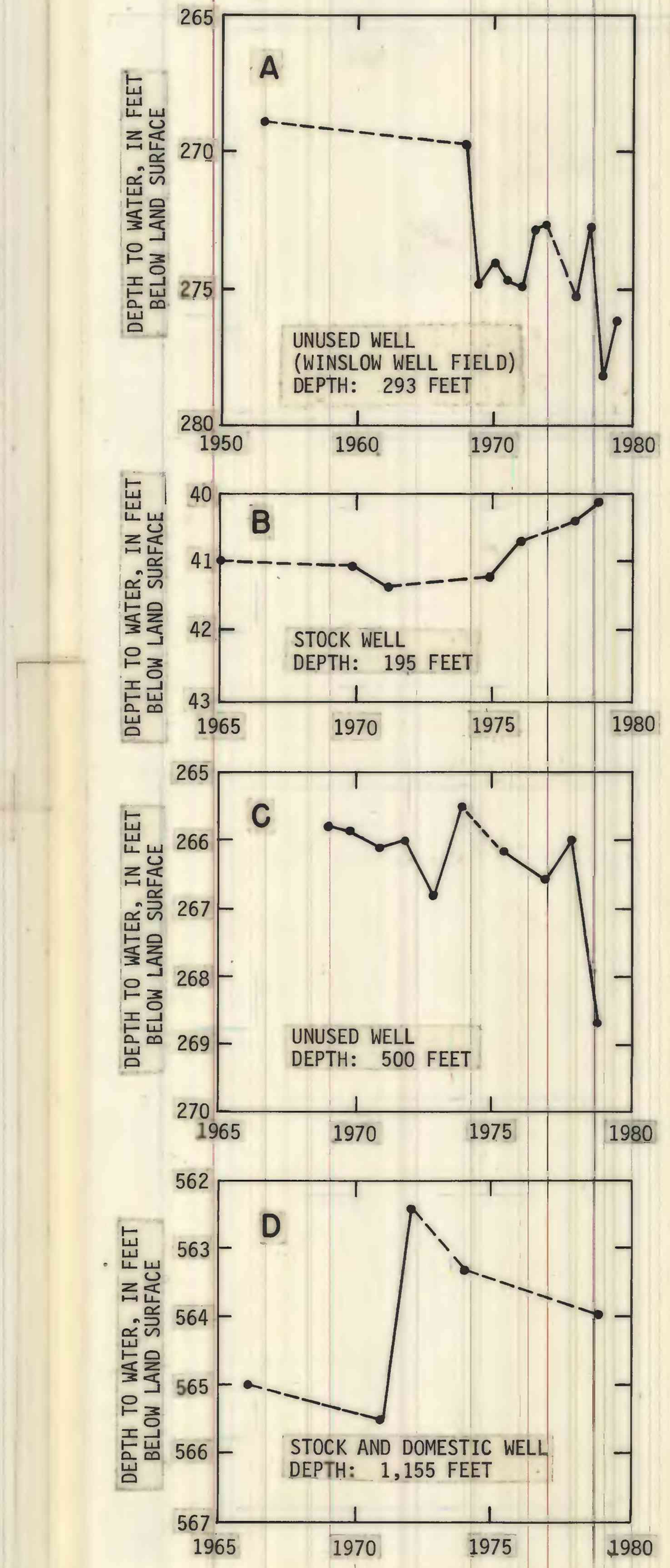
Composite stratigraphic column for the Canyon Diablo area

System	Formation or member
Quaternary	Alluvium
Quaternary and Tertiary	Volcanic rocks
Triassic	Chinle Formation Moenkopi Formation
Permian	Kaibab Limestone Coconino Sandstone Supai Formation Upper member



INDEX MAP SHOWING AREA OF REPORT (SHADED)

HYDROGRAPHS OF THE WATER LEVEL IN SELECTED WELLS SHOWN ON THE MAP
[Dashed line indicates an inferred water level]



EXPLANATION

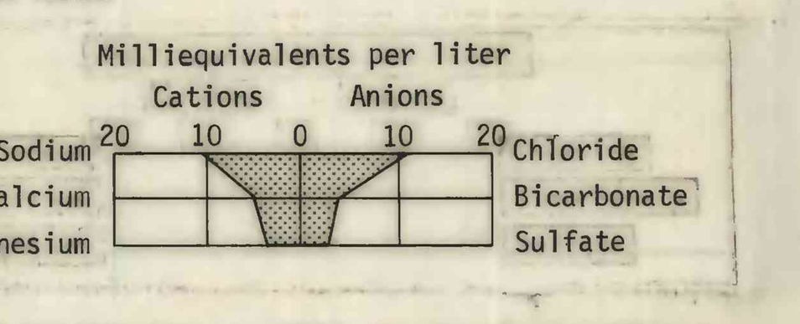
4800 — POTENTIOMETRIC CONTOUR—Shows altitude at which water level would have stood in tightly cased well that obtains water from the Coconino aquifer. Dashed where approximately located. Contour interval 100 feet. Datum is mean sea level

5T-319 / 216R(1955) / 4650 / 8620 / 0.5 — WELL THAT OBTAINS WATER FROM THE COCONINO AQUIFER—First entry, 5T-319, is well number assigned by the Navajo Tribe; well numbers are not shown for off-reservation wells. Second entry, 216R(1955), is depth to water in feet below land surface [M, depth to water measured; R, depth to water reported; (1955), year in which water level was determined]. Third entry, 4650, is altitude of the water level in feet above mean sea level. Fourth entry, 8620, is specific conductance in micromhos per centimeter at 25°C (specific conductance is an indication of the dissolved-solids concentration in water). Fifth entry, 0.5, is fluoride concentration in milligrams per liter

5M-85 / 13.7M(1978) / 4776 / 1900 — WELL THAT OBTAINS WATER FROM THE ALLUVIUM OR VOLCANIC ROCKS—First entry, 5M-85, is well number assigned by the Navajo Tribe; well numbers are not shown for off-reservation wells. Second entry, 13.7M(1978), is depth to water in feet below land surface [M, depth to water measured; R, depth to water reported; (1978), year in which water level was determined]. Third entry, 4776, is altitude of the water level in feet above mean sea level. Fourth entry, 1900, is specific conductance in micromhos per centimeter at 25°C (specific conductance is an indication of the dissolved-solids concentration in water)

40E(1978) / 7360 / 130 / 0.0 — SPRING THAT ISSUES FROM THE VOLCANIC ROCKS—First entry, 40E(1978), is discharge in gallons per minute [E, discharge estimated; M, discharge measured; (1978), year in which discharge was determined]. Second entry, 7360, is altitude of land surface in feet above mean sea level. Third entry, 130, is specific conductance in micromhos per centimeter at 25°C (specific conductance is an indication of the dissolved-solids concentration in water). Fourth entry, 0.0, is fluoride concentration in milligrams per liter

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



DS=5030 — DISSOLVED SOLIDS—Number, 5030, is dissolved solids in milligrams per liter

•A — WELL FOR WHICH A HYDROGRAPH IS SHOWN

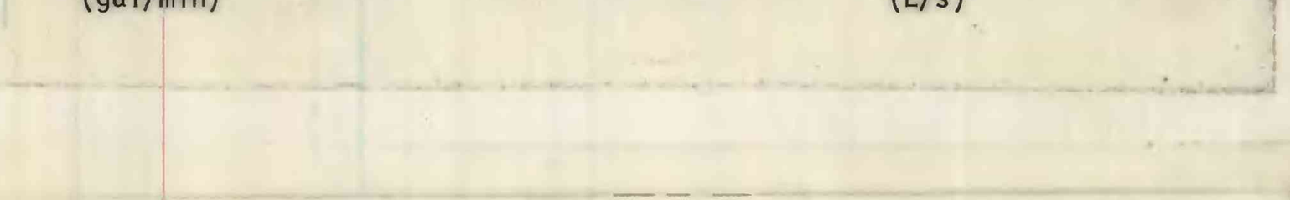
GENERALIZED DIRECTION OF GROUND-WATER FLOW

ARBITRARY BOUNDARY OF GROUND-WATER AREA

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	0.4047	hectare (ha)
acre-foot (acre-ft)	0.001233	cubic hectometer (hm^3)
gallon per minute (gal/min)	0.06309	liter per second (L/s)



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

BASE FROM U.S. GEOLOGICAL SURVEY
HOLBROOK 1:250,000, 1954-70 AND
FLAGSTAFF 1:250,000, 1954-70

MAP SHOWING GROUND-WATER CONDITIONS IN THE CANYON DIABLO AREA, COCONINO AND NAVAJO COUNTIES, ARIZONA 1979

BY
CYNTHIA L. APPEL AND DONALD J. BILLS