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BEDROCK AQUIFERS IN THE NORTHERN SAN RAFAEL SWELL AREA, UTAH, WITH SPECIAL EMPHASIS ON THE NAVAJO SANDSTONE

by

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Prepared by
the United States Geological Survey
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Division of Water Rights

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[Plates are in pocket]

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CONVERSION FACTORS

Most values in this report are given in inch-pound units followed by metric units. The conversion factors are shown to four significant figures. In the text, however, the metric equivalents are shown only to the number of significant figures consistent with the accuracy of the value in inch-pound units.

Inch-pound Unit	Inch-pound Abbreviation		Metric Unit	Metric Abbreviation
(Multiply)		(by)	(to obtain)	
Acre	--	0.4047	Square hectometer	hm^2
		0.004047	Square kilometer	km^2
Acre-foot	acre-ft	0.001233	Cubic hectometer	hm^3
		1233	Cubic meter	m^3
Acre-foot per year	acre-ft/yr	0.001233	Cubic hectometer per year	hm^3/yr
Cubic foot per second	ft^3/s	0.02832	Cubic meter per second	m^3/s
Foot	ft	0.3048	Meter	m
Foot per day	ft/d	0.3048	Meter per day	m/d
Foot per mile	ft/mi	0.1894	Meter per kilometer	m/km
Foot squared per day	ft^2/d	0.09290	Meter squared per day	m^2/d
Gallon per day per foot	(gal/d)/ft	12.42	Liter per day per meter	(L/d)/m
Gallon per minute	gal/min	0.06309	Liter per second	L/s
Inch	in.	25.40	Millimeter	mm
		2.540	Centimeter	cm
Inch per hour	in./hr	25.40	Millimeter per hour	mm/hr
Mile	mi	1.609	Kilometer	km
Pound per square inch	lb/in^2	0.07031	Kilogram per square centimeter	k/cm^2
Square mile	mi^2	2.590	Square kilometer	km^2

Chemical concentration and water temperature are given only in metric units. Chemical concentration is given in milligrams per liter (mg/L) or micrograms per liter (μg/L). Milligrams per liter is a unit expressing the concentration of chemical constituents in solution as weight (milligrams) of solute per unit volume (liter) of water. One thousand micrograms per liter is equivalent to 1 milligram per liter. For concentrations less than 7,000 milligrams per liter, the numerical value is about the same as for concentrations in the inch-pound unit, parts per million (ppm).

Water temperature is given in degrees Celsius (°C), which can be converted to degrees Fahrenheit (°F) by the following equation: °F=1.8(°C)+32.

Altitudes in this report are referenced to "National Geodetic Vertical Datum of 1929 (NGVD of 1929)." The NGVD of 1929 is a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called "Mean Sea Level."

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UTAH, WITH SPECIAL EMPHASIS ON THE NAVAJO SANDSTONE

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ABSTRACT

The northern San Rafael Swell area in southeastern Utah includes about 2,880 square miles (7,460 square kilometers) and ranges in altitude from about 3,290 to 7,921 feet (1,195 to 2,414 meters). Precipitation, the main source of water in the area, ranges from slightly less than 6 inches (152 millimeters) to slightly more than 12 inches (305 millimeters).

Rocks that underlie the area range from Precambrian to Holocene in age. The thickness of sedimentary rocks ranges from 4,083 feet (1,244 meters) to about 30,000 feet (9,140 meters). The Entrada, Navajo, Wingate, and Coconino Sandstones and rocks of Mississippian age are considered major aquifers because of their large areal extent or thickness. Their water-yielding ability is affected mainly by faulting and folding which locally enhance ground-water circulation by fracturing, or impede circulation by offsetting the more permeable beds. Water in these aquifers ranges from fresh to briny.

The total hydrologic system in the northern San Rafael Swell area has an estimated average annual inflow and outflow of about 1.3 million acre-feet (1,600 cubic hectometers), of which about 1.15 million acre-feet (1,420 cubic hectometers) is derived from precipitation on the area. An estimated 99 percent of the water available to the area is consumed by evapotranspiration.

The estimated gross average annual ground-water recharge is 10,000 acre-feet (12 cubic hectometers) or less, of which 3,000 acre-feet (4 cubic hectometers) recharges the Navajo Sandstone. Recoverable water stored in the Navajo, Wingate, and Coconino Sandstones is estimated to be 160 million acre-feet (197,300 cubic hectometers), of which 42 million acre-feet (51,800 cubic hectometers) is in the Navajo alone.

Large, long-term withdrawals from the Navajo Sandstone are marginally feasible, but only west of the San Rafael Swell, and if the wells are widely spaced. Withdrawal of 20,000 acre-feet (25 cubic hectometers) per year for 30 years probably would reduce the amount of ground water in storage by about 1.4 percent. Withdrawals of this magnitude would have a negligible effect on the flow of the Colorado River.

INTRODUCTION

Purpose and scope

This report presents the results of a study of bedrock aquifers in the northern San Rafael Swell area, Utah (fig. 1), with special emphasis on the Navajo Sandstone of Triassic(?) and Jurassic age. The study was made by the U.S. Geological Survey in cooperation with the Utah Department of Natural Resources, Division of Water Rights. Fieldwork was done mainly during March 1979-July 1980, with supplemental testing and observations during August-December 1980.

The principal objectives of this study were to determine: (1) Well yields of the bedrock formations, (2) the capability of formations to yield, over the long term, water chemically suitable for presently (1980) known uses, and (3) effects of withdrawals from wells on the surface-water supply in the Colorado River Basin.

For the investigation, an area of 5,500 square miles (14,245 km^2) was initially considered. From this area, the approximate 3,640 square miles (9,430 km^2) shown on plate 1 was selected for further work. This latter area includes about 1,570 square miles (4,070 km^2) previously described by Hood and Danielson (1979b); re-evaluation consisted partly of revising the data base for about 710 square miles (1,970 km^2) in the southwestern part of the area shown on plate 1 for inclusion in a digital-computer model of the ground-water system. Most data collection and system evaluation was done in the remaining 2,880 square miles (7,460 km^2) of the area shown on plate 1.

Fieldwork included the collection of data on wells, springs, and the chemical quality of ground water, short-term aquifer testing, test drilling, and infiltration studies of the sandstone aquifers. Office work included digital-computer modeling of the Navajo Sandstone aquifer. Data used for the analysis given in this report are listed in tables 3, 4, 8, and 9-14.

General Features of the Area

The northern San Rafael Swell area is in parts of Carbon, Emery, and Grand Counties. It comprises approximately the northern two-thirds of the Swell and adjacent areas that extend from Castle Valley on the west to the Green River on the east, and from the vicinity of Wellington on the north to the drainage divide between the San Rafael River and Muddy Creek drainage basins on the south.

Altitudes in the area range from 3,920 feet (1,195 m) where the Wayne-Emery County line meets the Green River to 7,921 feet (2,414 m) at San Rafael Knob, near the center of the Swell (pl. 1). The Swell is a major geologic fold, or elongate dome, with a major axis about 70 miles (113 km) long, that trends northward and a minor axis about 30 miles (48 km) long. The Swell is mainly an area of barren rock that has been deeply dissected by streams that cross and are incised transversely into the folded rocks. Erosion has removed the upper rocks in the center of the Swell; an inward-facing cliff delineates the Jurassic sandstone aquifers in the north and south ends of the Swell (fig. 2), and the interior topography is extremely rugged. Throughout the Swell, ragged erosional remnants of rock are common, and deep canyons complicate overland travel.

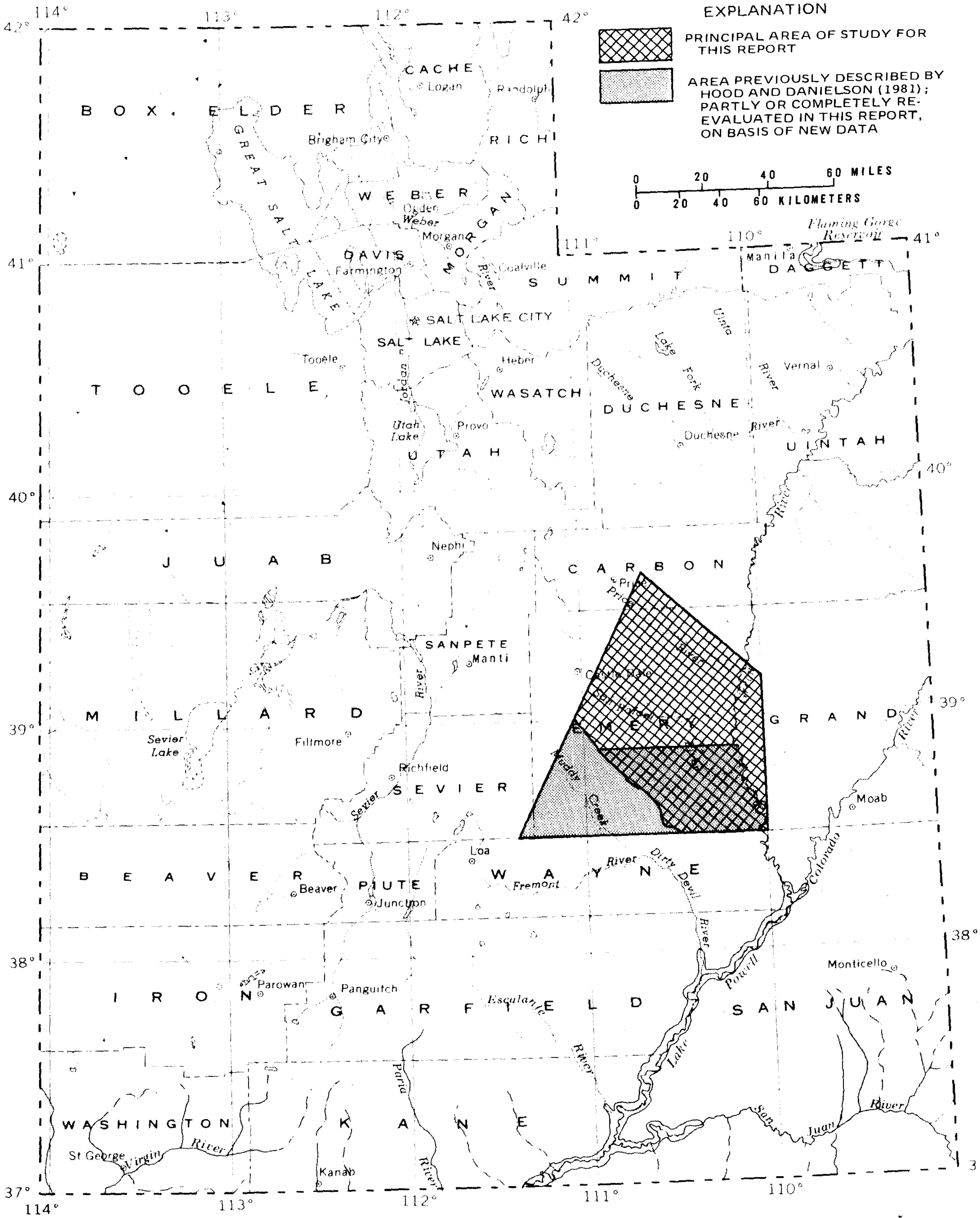
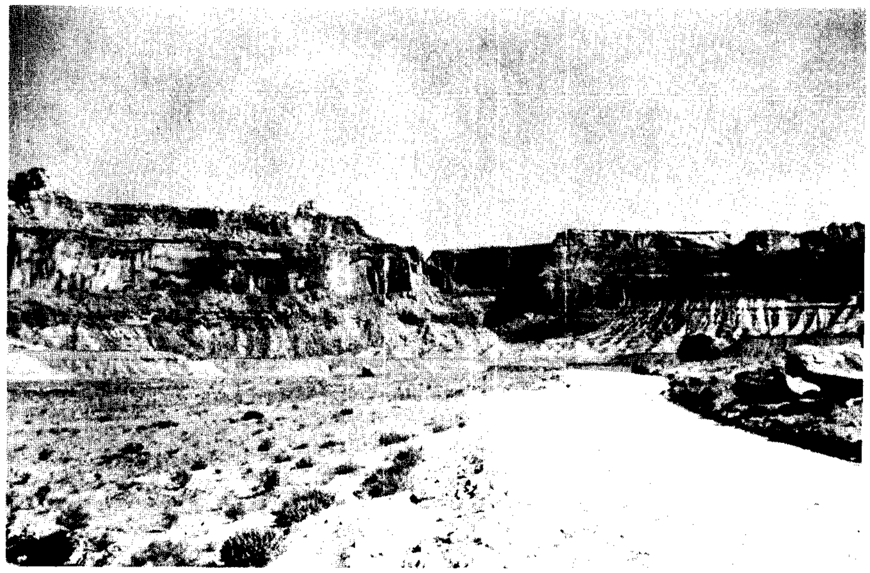
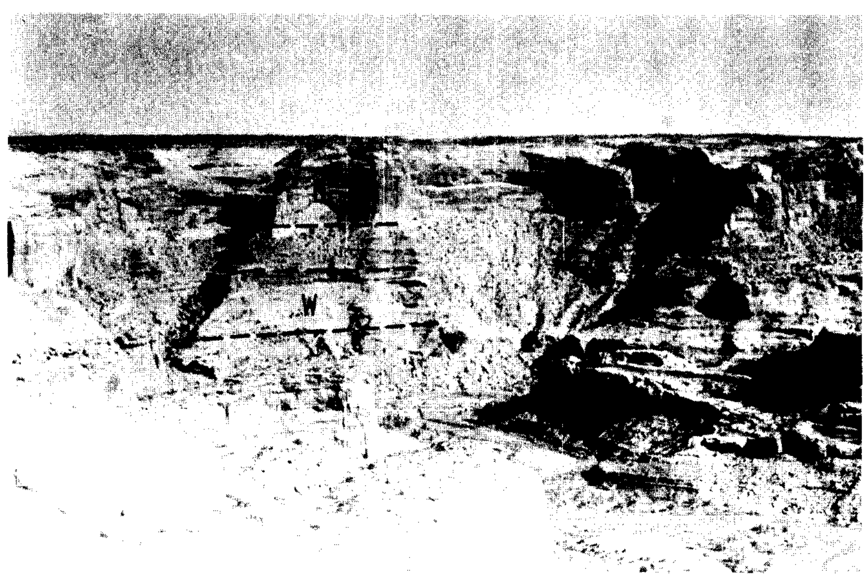


Figure 1.—Location and extent of the northern San Rafael Swell area.



A: View looking northward from location (D-21-11)4ab, toward mouth of Buckhorn Wash Canyon. Formations range from Carmel Formation at top of cliff to Chinle Formation at base in mouth of canyon. Foreground is part of rolling internal plain developed on limestone of the Moenkopi Formation.



B: View, looking southeastward, from top of cliff at location (D-20-11)8dc. Upper smooth surface is a rolling plain developed on limestone in the Carmel Formation. San Rafael River flood plain, below, is fringed with phreatophytes and saline residue.

Figure 2.—Erosional features in the San Rafael Swell. Erosion has removed the Navajo Sandstone (N) and Wingate Sandstone (W) from the inside of the San Rafael Swell, leaving inward-facing, deeply dissected cliffs. Little recharge occurs on the steep surfaces; exposure of the aquifers has allowed them to drain near the dissected parts.

Much of the Swell consists of barren rock, but locally a sparse cover of grass and juniper (*Juniperus* sp.) exists; the vegetative cover in the northern high part of the Swell is somewhat denser, including a juniper-pinyon (*Juniperus* sp.-*Pinus monophylla*[?]) community. (See Vallentine, no date, p. 2-5 and 24-25.)

The areas adjacent to the Swell consist of shale flats and partly dissected terraces to the west, north, and northeast. To the east, the area contains partly dissected pediments and deep canyons near the Green River. This area contains grasslands and salt-desert and black-brush plant communities.

Most of the area is uninhabited or seasonally occupied by ranchers and miners who reside elsewhere. The only population centers are Green River, Wellington, and the small community of Woodside. Cultivated crops are grown mainly around Green River, but there are small, isolated tracts of farmland along the lower Green, Price, and San Rafael Rivers.

Acknowledgments

The writers extend thanks to the well and spring owners, well drillers, and companies who provided hydrologic and geologic data. Special thanks are due to Mr. and Mrs. Lloyd Hatt of Green River, Utah, whose intimate knowledge of the eastern part of the study area aided in locating water sources and access to the area. Officials of the U.S. Department of Energy, Grand Junction, Colo., provided detailed information on deep core holes. The Utah Power & Light Co. gave permission for drilling on their lands along the San Rafael River.

Previous and Concurrent Studies

Published information on the geology of the study area is abundant. The area is in that part of Utah which experienced some of the earliest geological and mineral exploration. (For example, see Lupton, 1912.) The first test well for petroleum in Utah was drilled at Green River. As a result of several periods of petroleum and uranium exploration, there are many published reports on the geology, including brief articles such as that by Lupton (1911), detailed descriptions of formations as given in the guidebooks of the Intermountain Association of Petroleum Geologist (1954, 1956, and 1958), and detailed geologic mapping of Gilluly (1929). Other than the Geologic Map of Utah (Stokes, 1964), the principal sources of discussion and representation of geology in the area are Baker (1946), Gilluly (1929), and Stokes and Cohenour (1956). A report by Jobin (1962) relates hydrologic properties of the formations to the occurrence of uranium.

Published information on water in the study area is less abundant. Reports by Mundorff (1972) and by Mundorff and Thompson (1982) pertain to chemical quality of surface water and fluvial sediment in the Price and San Rafael River basins. Hood and Danielson (1979, 1981) discuss bedrock aquifers in the adjacent lower Dirty Devil River basin area. Lines and Morrissey (1983) discuss the Ferron Sandstone aquifer in Castle Valley which is on the west edge of the present study area.

Results of regional hydrologic studies that included all or parts of the northern San Rafael Swell area are given in the following reports: Thomas (1952); Iorns, Hembree, and Oakland (1965); Feltis (1966); Price and Arnow (1974); and Waddell, Contratto, Sumsion, and Butler (1981). Data collected during several of those studies and used in this study are given in the following reports: Iorns, Hembree, Phoenix, and Oakland (1964); Sumsion (1979); and Waddell, Vickers, Upton, and Contratto (1978).

Terminology

The term permeability is used in this report to denote the relative ease with which a water-bearing formation can transmit water. The specific measure of permeability is hydraulic conductivity (*K*)[1]. The following ranges of measured or estimated hydraulic conductivity are used in this report:

Range	K, in feet per day
Very low	Less than 0.5
Low	0.5 to 5
Moderate	5 to 50
High	50 to 500
Very high	More than 500

The terms used in this report to classify water according to the concentration of dissolved solids are as follows:

Classification		Concentration, in milligrams per liter
Fresh		Less than 1,000
	Slightly saline	1,000 to 3,000
Saline	Moderately saline	3,000 to 10,000
	Very saline	10,000 to 35,000
Briny		More than 35,000

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[1]The hydraulic conductivity (*K*) of a water-bearing material is the volume of water that will move through a unit cross section of the material in unit time under a unit hydraulic gradient. The units for *K* are cubic feet per day per square foot [$(ft^3/d)/ft^2$], which reduces to feet per day (ft/d). The term hydraulic conductivity replaces the term field coefficient of permeability, which was formerly used by the U.S. Geological Survey and which was reported in units of gallons per day per square foot. To convert a value for field coefficient of permeability to the equivalent value of hydraulic conductivity, divide by 7.48; to convert from hydraulic conductivity to coefficient of permeability, multiply by 7.48.

Well-, Spring-, and Miscellaneous-Site-Numbering System

The system of numbering wells and springs in Utah is based on the cadastral land-survey system of the U.S. Government. The number, in addition to designating the well or spring, describes its position in the land net. By the land-survey system, the State is divided into four quadrants by the Salt Lake base line and meridian, and these quadrants are designated by the uppercase letters A, B, C, and D, indicating the northeast, northwest, southwest, and southeast quadrants, respectively. Numbers designating the township and range (in that order) follow the quadrant letter, and all three are enclosed in parentheses. The number after the parentheses indicates the section, and is followed by three letters indicating the quarter section, the quarter-quarter section, and the quarter-quarter-quarter section--generally 10 acres (4 hm^2);[1] the letters a, b, c, and d indicate, respectively, the northeast, northwest, southwest, and southeast quarters of each subdivision. The number after the letters is the serial number of the well or spring with the 10-acre (4-hm2) tract; the letter "S" preceding the serial number denotes a spring. If a well or spring cannot be located within a 10-acre (4-hm^2) tract, one or two location letters are used and the serial number is omitted. Thus (D-19-13)12ddd-1 designates the first well constructed or visited in the SE$\frac{1}{4}$SE$\frac{1}{4}$SE$\frac{1}{4}$ sec. 12, T. 19 S., R. 13 E., and (D-23-10)9bbd-S1 designates a spring in the SE$\frac{1}{4}$NW$\frac{1}{4}$NW$\frac{1}{4}$ sec. 9, T. 23 S., R. 10 E. Other sites referenced in text are numbered in the same manner, but no serial number is used. The numbering system is illustrated in figure 3. In this report, the letter "W" that follows the serial number designates a petroleum-test well that has been left for use as a water well; the suffix letter "S" designates a well that has been plugged back; and the suffix letter "D" designates a well that has been deepened.

Surface-water gaging stations, where continuous records are available, are identified by an eight-digit downstream-order number adopted by the U.S. Geological Survey. (See U.S. Geological Survey, 1977, p. 9.) Thus, the station on the San Rafael River near Green River, Utah, is designated 09328500.

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[1]Although the basic land unit, the section, is theoretically 1 square mile (2.5 km^2), many sections are irregular. Such sections are subdivided into 10-acre (4-hm^2) tracts, generally beginning at the southeast corner, and the surplus or shortage is taken up in the tracts along the north and west sides of the section.

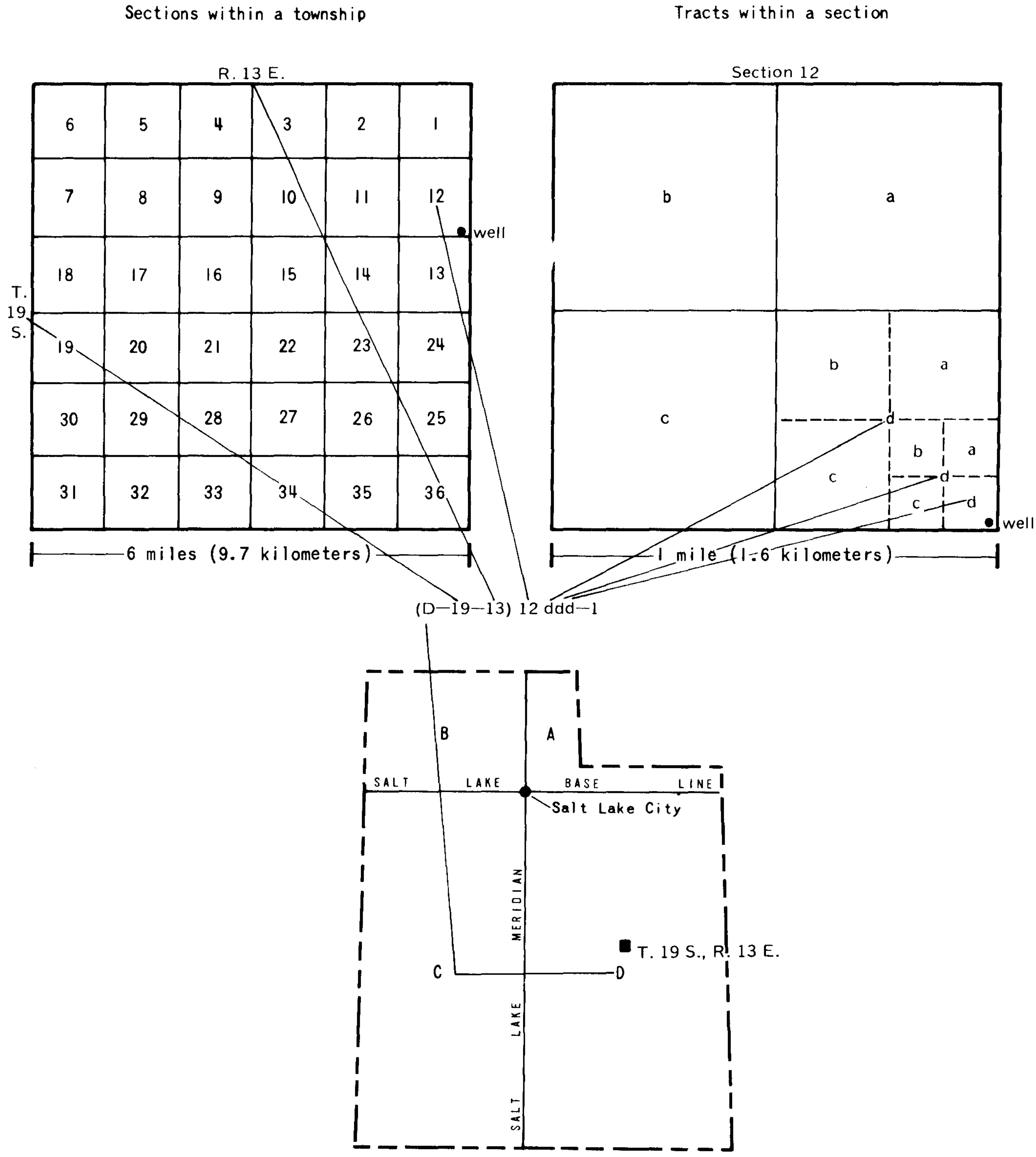


Figure 3.—Well- and spring-numbering system used in Utah.

GEOLOGIC SETTING

Formations and Their Hydrologic Characteristics

Rocks that underlie the northern San Rafael Swell area range in age from Precambrian to Holocene (pl. 2 and tables 1 and 2). Most of the sedimentary formations have substantial variations in lithology, mainly due to different depositional conditions, and in thickness, due partly to depositional conditions and partly to the events that followed deposition. The complete section of sedimentary rocks has a maximum thickness of about 30,000 feet (9,140 m) and a minimum thickness of about 12,000 feet (3,660 m). The minimum known thickness (where the section is not complete) is 4,083 feet (1,244 m) at well (D-22-12)5abd-1 (table 11).

All the formations in the geologic section contain some water, but much of the section from the practical standpoint of well yields is not considered to contain useful aquifers. Some of the hydrologic, structural, and physical characteristics of the aquifers are readily measurable or visible in outcrops. Other characteristics of both the exposed and unexposed formation can be evaluated only from well drilling, aquifer testing at wells, chemical analysis of water from wells and springs, and laboratory testing of rock samples from formations that are known to transmit water. A brief evaluation of each formation is given in table 2 and selected supplementary geologic data are given in table 11. Data from outcrop and core samples are given in tables 3 and 4, and the samples and sampling sites are described in table 13.

Of the geologic units listed in table 2, five are considered to be major aquifers because of their large areal extent or thickness or their potential for locally large yields to individual wells. These units are the Entrada, Navajo, and Wingate Sandstones, the Coconino Sandstone, including its lateral facies equivalents in the Cutler Formation, and rocks of Mississippian age. Several other geologic units also are aquifers, but they are restricted in potential development owing to their thinness, distribution of permeable zones, or chemical quality of water. They include older alluvium, the Salt Wash Sandstone Member of the Morrison Formation, the Curtis Sandstone, the Carmel Formation, and the Moss Back Member of the Chinle Formation.

The Carmel Formation has a special importance to the ground-water hydrology of the northern San Rafael Swell area. First, it is widely exposed in the area, both east and west of the Swell, and can receive recharge directly. Second, it overlies the Navajo Sandstone, and locally can supply water to or receive water from the Navajo. Third, the formation contains large amounts of evaporites (mainly gypsum, but also salt near the west edge of the area) which contribute to the deterioration of the chemical quality of both ground and surface waters in the area. The Carmel Formation is a good aquifer, locally, in the region, yielding several cubic feet per second of water to individual wells and springs (Hood and Danielson, 1979, table 11; 1981, table 7). However, most discharges from wells and springs in the Carmel Formation range from seepage to about 30 gallons per minute (2 L/s).

Navajo Sandstone

Navajo Sandstone was selected as the principal subject of study in this report because the sandstone, regionally, is the best aquifer of the three thick sandstone aquifers described. Of the three, the Navajo is the shallowest, apparently the most permeable, and contains the freshest water.

The Navajo Sandstone, for the most part, is a very fine to fine-grained quartzose sandstone (tables 3 and 13) that coarsens to medium grained at the top (figs. 4 and 5, table 3). In figure 4, the histograms for depths of 340 and 500 feet (104 and 152 m) are representative of most of the formation, but samples from test NSRT-2 show that the formation generally is coarser and better sorted near the top. Sample NSRT-2-100 (table 3) has the grain-size bimodality described by Hood and Danielson (1979, p. 13).

Colors in the Navajo Sandstone range from light red or orange through light brown and pale tan to gray and pure white; the color depends on the amount of iron as grain coating remaining after leaching by circulating ground water. Colors in the northern and northeastern parts of the San Rafael Swell tend toward shades of brown indicating somewhat lower permeability. On the whole, the Navajo tends to be more uniformly colored than such formations as the Entrada Sandstone in which only the most permeable beds or fracture zones (fig. 6) have colors that indicate leaching.

The Navajo Sandstone in the northern San Rafael Swell area ranges from loose, soft and friable to hard and well indurated. The degree of hardness depends on the type of exposure or lack of exposure to surface effects, length of time exposed, and the grain size; moisture content also seems to determine hardness where the sandstone is not saturated. In cliffs (fig. 7) where the sandstone is drained, as well as in some nearly horizontal exposed surfaces, the sandstone is very hard. At the site of rock sample UTSR-24, the sandstone is too hard to disaggregate for sieve analysis; yet at the site of UTSR-24, Engineering Research Associates (1953) reported that during tunneling operations, the sandstone was soft 6 to 30 feet (2 to 9 m) from the outer surface. In the soft sandstone, the available pore space was 50 percent saturated; the casehardened zone contained much less moisture and was dry at the surface. In drilling test holes into the sandstone aquifer, the drill penetrates the upper part rapidly; the penetration rate decreases with depth, presumably because of the smaller grain size. Where the sandstone is strongly shattered by faulting or folding, as at sampling site UTSR-16 (table 13), it is very loose, friable, and well-leached; this is because of mechanical disruption of the grain bonds.

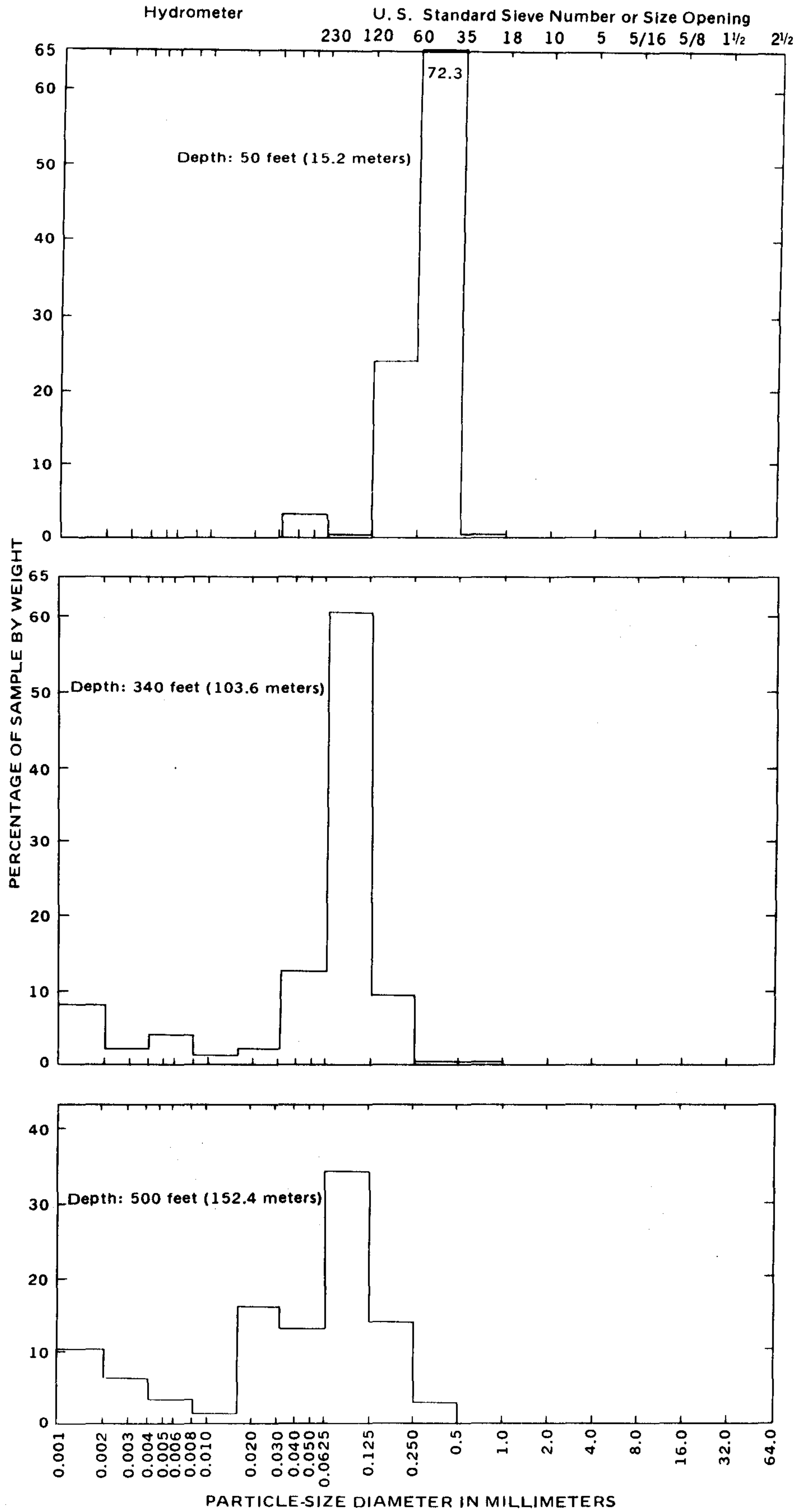
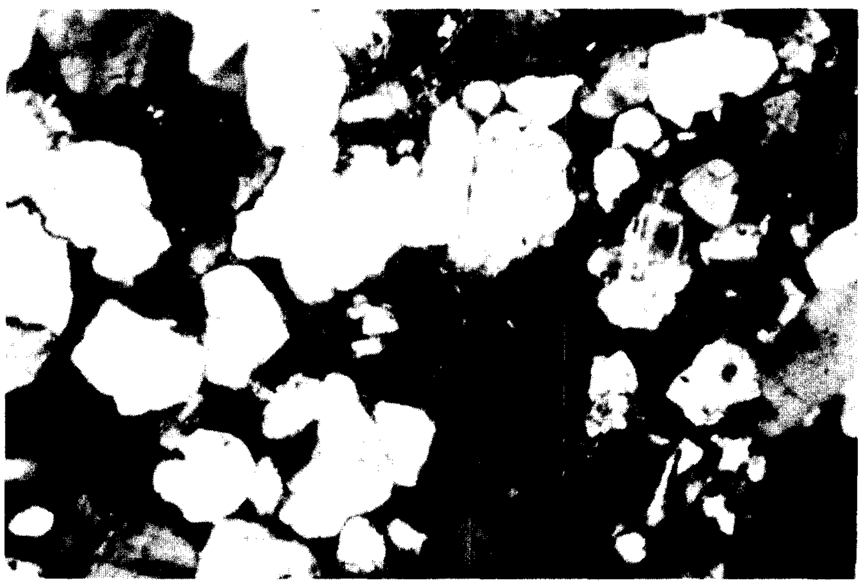


Figure 4.—Grain-size distribution in three samples of the Navajo Sandstone from test hole NSRT-2, (D-19-12)30bba-1. (See also table 3.)

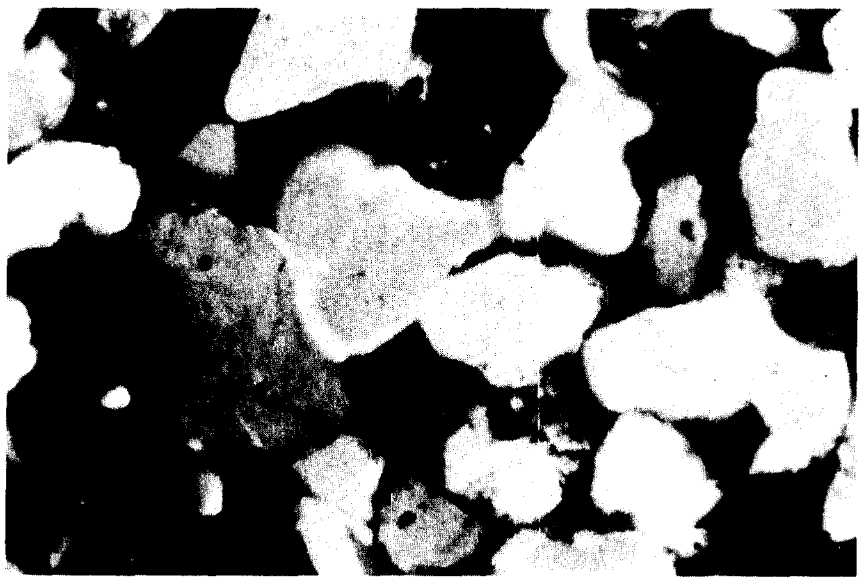
C: Sample UTSR-20 near bottom of Navajo Sandstone



D: Sample UTSR-11 near middle of Wingate Sandstone

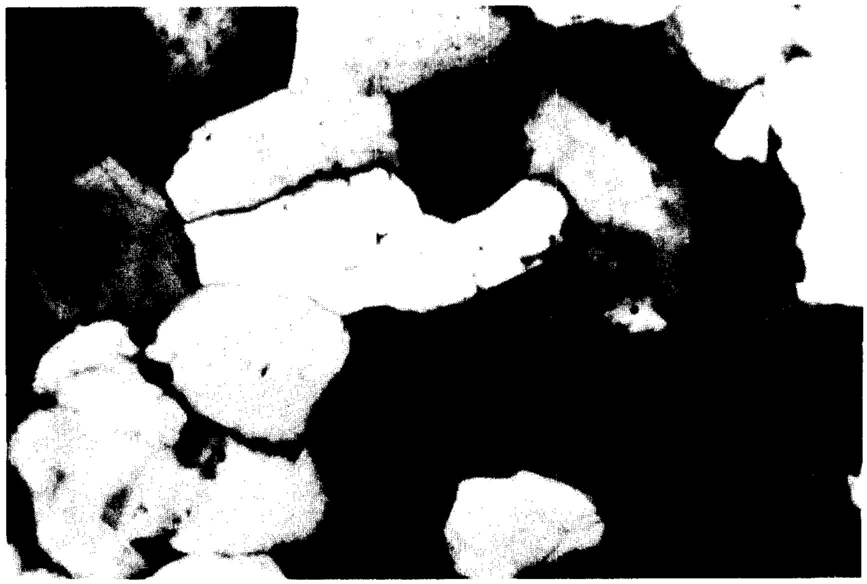
Figure 5.—Photomicrographs of sandstone specimens. All photos taken with polarized light at approximate magnification x 140. (See table 13 for description of samples.)—Continued

A: Sample UTSR-27-4 near top of Navajo Sandstone



B: Sample UTSR-8 near middle of Navajo Sandstone

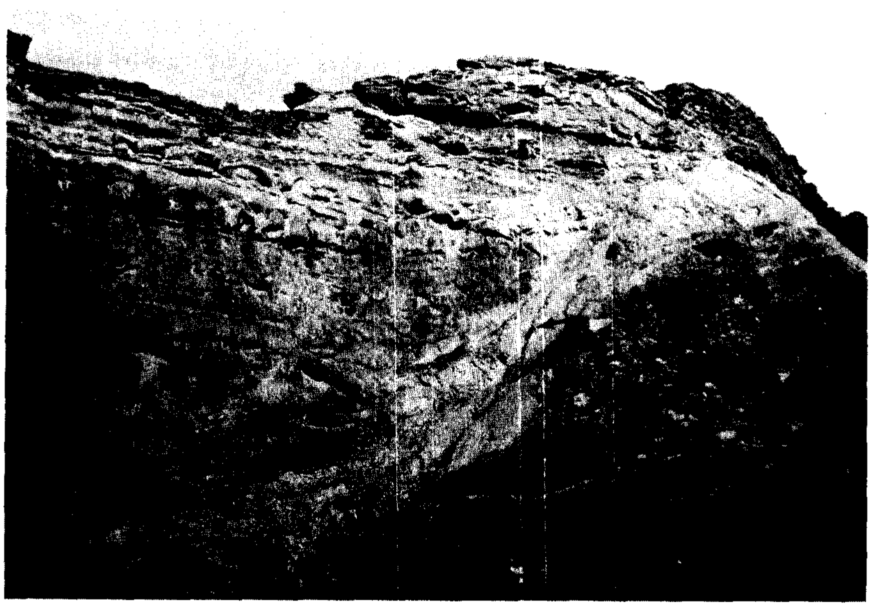
Figure 5.--Photomicrographs of sandstone specimens. All photos taken with polarized light at approximate magnification x 140. (See table 13 for description of samples.)



E. Sample UTSR 13A-5 near top of Coconino Sandstone.

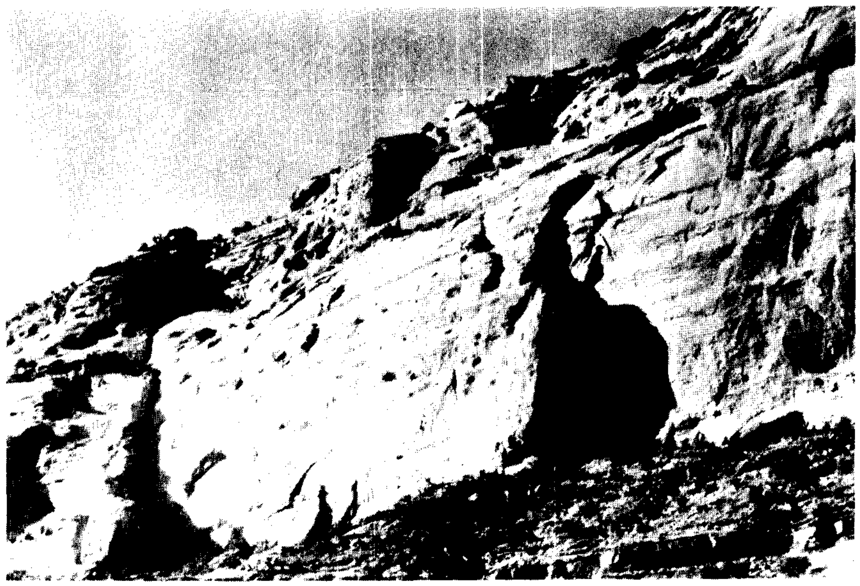
Figure 5.—Photomicrographs of sandstone specimens. All photos taken with polarized light at approximate magnification x 140. (See table 13 for description of samples.)—Continued

A: Fracture zone (arrow) in Navajo Sandstone at about location (D-22-13)12aba on Highway I-70. The fracture dips slightly eastward and contains some leached, loose white sand.



B: View, looking eastward, of thrust fault (arrow) in the Entrada Sandstone at site of spring (D-17-12)23aba-S1. Most of cliff is red, but along the fault, the rock has been bleached or leached by circulation of water.

Figure 6.—Fracturing at folds and near faults promotes recharge, discharge and interformational leakage of water.



A: View, looking southward from location (D-25-11)2cdd, of Navajo Sandstone cliff in wall of Temple Wash Canyon. Cliff weathers through spalling of large vertical slabs. Old surfaces are case-hardened, reportedly to depths of 6 to 30 feet, giving the impression that the sandstone is very hard.

B: View of Black Dragon Canyon, looking northeastward from location (D-21-13)34cad. Coconino Sandstone (C) underlies Kaibab Limestone (K) and, beyond, the Moenkopi Formation (M). Fracturing, relatively gentle slopes, and lithology contribute to a strongly weathered, hackly outcrop of the Coconino Sandstone.

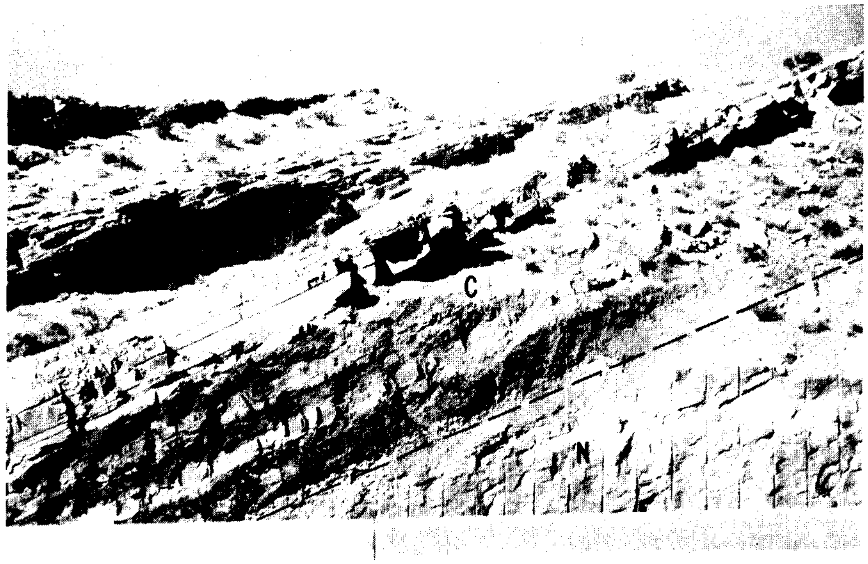
Figure 7.—Exposures of the Navajo Sandstone and other formations. Mode of exposure, in part, controls susceptibility to recharge and surficial character of sandstone aquifers. Steep or vertical slopes cannot be recharged.

The top of the Navajo Sandstone in the northern San Rafael Swell area generally is sharply defined and easy to identify in outcrops (fig. 8) and while drilling a well. In most areas, the base of the Carmel Formation consists of dense gray to black limestone, a thin bed of sandstone, and a bed of red siltstone that lies on the Navajo. The top of the Navajo is indicated by the appearance of cuttings from the red siltstone and a subsequent and abrupt increase in the drill-penetration rate (fig. 9). Cuttings from the sandstone--generally loose sand--are at first masked by cuttings from above or they are carried away in the drilling fluid, but the change in penetration rate is quite marked and can be seen if it is expected. As shown in figure 9, the top of the sandstone as picked from drilling time can be confirmed by geophysical logging, particularly when using the gamma-ray log. The natural radiation of the sandstone is relatively low and constant, whereas, the overlying beds of the Carmel Formation have relatively high radiation peaks. The configuration of the gamma-ray log shown in figure 9 is characteristic of that for the formational contact in all the study area.

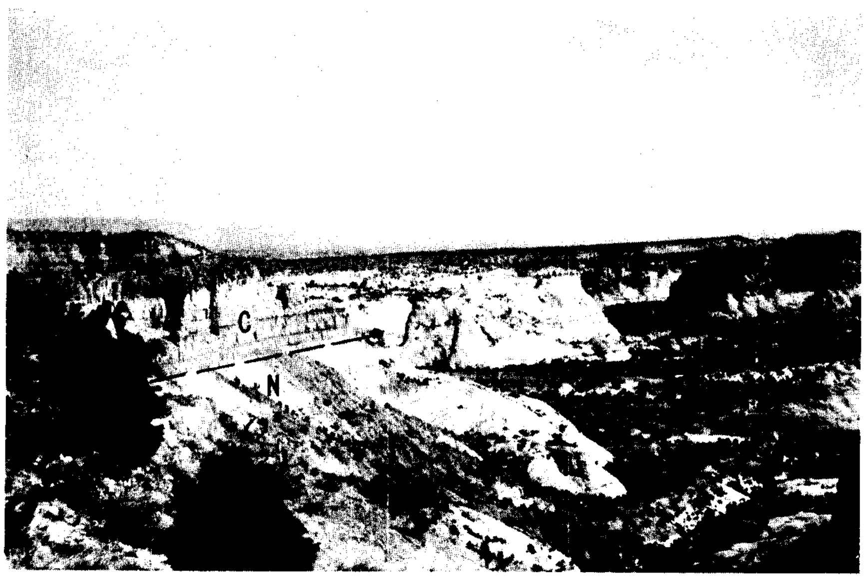
The base of the Navajo Sandstone is more difficult to identify than the top. The contact with the underlying Kayenta Formation reportedly is gradational, but at least locally, the lowermost Navajo can contain some locally derived debris reworked from the Kayenta. Because of this difficulty in identifying the contact, data reported from some of the wells in table 11 probably are somewhat in error. For the purpose of this report, the base of the Navajo is picked as the bottom of a continuous sandstone section where the underlying siltstone is more than a few inches thick. Except in an area of bleached rock (Hawley and others, 1968) near the middle of the Swell, the color of the siltstone generally is maroon or dark red to brick red.

The thickness of the Navajo Sandstone in the northern San Rafael Swell area ranges from less than 200 feet (60 m) at the northeast edge of the study area to about 750 feet (230 m) at the southwest corner (pl. 3). The thickening is not uniform. Because the top of the Navajo is sharply defined and fairly uniform, the variation of thickness probably is due to variations in the position of the Navajo-Kayenta contact. The lines showing equal thickness on plate 3 were plotted from individual well data; where the top or bottom of the Navajo was not reported in the well log, the contact was estimated from the thickness of the overlying and underlying formations. The resultant map shows a consistent variation in thickness of the Navajo, despite the probable erroneous reporting of its base in some well logs.

The variations in thickness of the Navajo Sandstone indicate that the formation probably was deposited on an uneven surface of the Kayenta Formation. The data indicate that this surface was a sequence of ridges and valleys trending southwestward in the direction the Navajo thickens. Data also indicate that the Navajo was deposited as dune sand on land (Stokes and Holmes, 1954), in shallow water (Freeman and Visher, 1975), or most probably a combination of both.



A: Contact between Carmel Formation (C) and Navajo Sandstone (N) in south wall of road cut on Highway I-70, at location (D-22-13)12aac, on east side of San Rafael Swell.



B: View, looking northward from an overlook on Highway I-70, at location (D-22-9)33bba, on west side of San Rafael Swell.

Figure 8.—The upper contact of the Navajo Sandstone is easy to identify in outcrops. As in A, above, limestone, sandstone, and a basal red siltstone of the Carmel Formation (C) overlies soft massive sandstone of the Navajo Sandstone (N). An exception occurs in the vicinity of area shown in photograph B, where limestone of the Carmel Formation lies directly on the Navajo Sandstone.

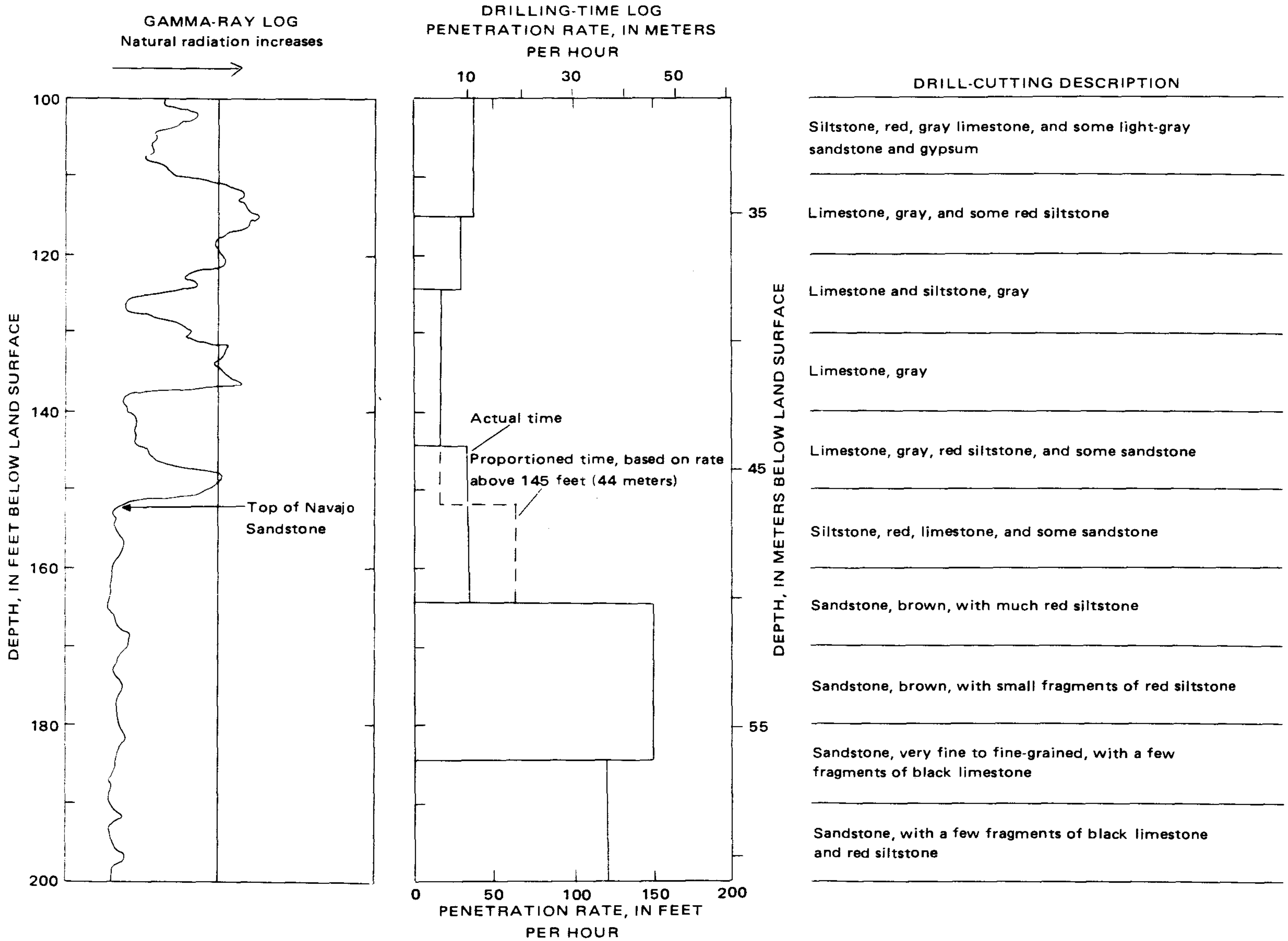


Figure 9.—Parts of gamma-ray and drilling-time logs and drill-cutting description for test hole NSRT-1, (D-20-10)6bdd-1.

The permeability of the Navajo Sandstone in the northern San Rafael Swell area ranges from very low to moderate, but locally it may be high. Measured $\underline{K}$ for outcrop and core samples range from 0.0037 to 5.1 feet per day (0.001 to 1.6 m/d). (See table 4.) Transmissivities[1] derived from low-discharge, short-term aquifer tests (table 5) at the only wells in the area available for testing ranged from 27 to 642 feet squared per day (2.5 to 60.1 m^2/d). Values of $\underline{K}$ calculated from these values for $\underline{T}$ and thickness of the sandstone at the respective wells were in the range for $\underline{K}$ cited above; this supports the conclusions of Johnson and Greenkorn (1960) that there can be quantitative agreement of formation coefficients derived from core analyses and discharging well tests.

The storage coefficient[2] ($\underline{S}$) of the Navajo Sandstone could not be determined using the available data in the northern San Rafael Swell area. Because of the regional hydrologic similarity of the formation, it is assumed that the generalized value of 0.001 for $\underline{S}$ used by Hood and Danielson (1979, p. 32) also applies to the Navajo in the northern San Rafael Swell area.

Hood and Danielson (1979, p. 34) also estimated the specific yield[3] of the Navajo Sandstone to be between 5 and 10 percent. This range is about the same as that measured in the bottoms of shallow core holes where soil moisture was measured with a neutron probe (fig. 10). In the bottoms of the core holes, the sandstone is drained but is least affected by near-surface evaporation or recharge. The (Boyles Law) porosity of the Navajo ranged from 3.6 to 26.8 percent (table 4); the average is 17.7 percent, and 50 percent of the average is about 9 percent; which indicates that the range also agrees with the report by Engineering Research Associates (1953) that the sandstone was 50 percent saturated.

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[1]Transmissivity ($\underline{T}$) is the rate at which water is transmitted through a unit width of the aquifer under a unit hydraulic gradient. The units for $\underline{T}$ are cubic feet per day per foot $(ft^3/d)/ft$, which reduces to feet squared per day (ft^2/d). The term transmissivity replaces the term coefficient of transmissibility, which was formerly used by the U.S. Geological Survey and which was reported units of gallons per day per foot. To convert a value for coefficient of transmissibility to the equivalent value of transmissivity, divide by 7.48; to convert from transmissivity to coefficient of transmissibility, multiply by 7.48.

[2]The storage coefficient ($\underline{S}$) of an aquifer is the volume of water it releases from or takes into storage per unit surface area of the aquifer per unit change in head. $\underline{S}$ is a dimensionless number. Under confined conditions, $\underline{S}$ is typically small, generally between 0.00001 and 0.001. Under unconfined conditions, $\underline{S}$ is much larger typically from 0.05 to 0.30.

[3]Specific yield of a rock or soil is the ratio of the volume of water it will yield by gravity after being saturated, to the volume of the rock or soil.

Structure and Other Factors That Affect Hydrology

Faulting and folding are the principal recognizable factors that alter the permeability of consolidated rocks in the northern San Rafael Swell area. Secondary factors include the removal of gypsum and limestone by solution.

The principal structural feature that distorts the rocks is the large anticlinal fold that comprises the San Rafael Swell. The Swell developed mainly as a result of horizontal compression from the west (Kelley, 1955, fig. 10). The axis of the Swell is gently arced, being convex to the east (pl. 4). The fold is asymmetric; rock along the east flank (fig. 11) dips most steeply; the Navajo Sandstone attains a maximum dip of about 85° in T. 23 S., R. 13 E. In that area, the Moenkopi Formation and probably older sedimentary rocks are overturned (Hawley and others, 1968, pl. 2) and may be thrust-faulted at depth. The dip of the Navajo decreases both northward and southward. Dips westward from the Swell are gentler. Associated with the larger fold are several lesser structures such as the Woodside Dome at the northeast side of the Swell and the anticline that underlies the town of Green River (pl. 4).

The effect of the folding of the Navajo Sandstone and other aquifers is twofold, fracturing and jointing of the competent beds (fig. 12) by flexing and shattering of those beds by associated faulting. Both of these effects can create greater permeability or reduce the original permeability. Any residual open fractures greatly enhance permeability. Craft and Hawkins (1959, p. 283) state that the permeability of an open fracture only 0.001 inch (0.0254 mm) wide is 54,000 millidarcies (md)[1], or 132 feet per day (40 m/d), about 26 times greater than the maximum hydraulic conductivity of the Navajo given in table 3. Many observed joints in the Navajo Sandstone, however, were filled with impermeable material. Near (D-21-9)15dda, the site of rock sample UTSR-29, a vertical fracture in the Navajo was about 6 inches (15 cm) wide and completely filled with coarsely crystalline gypsum. Near (D-20-13)15daa, a vertical fracture about 0.5 inch (1.3 cm) wide was completely filled with iron oxide.

The most significant find with regard to fracture filling was at (D-22-13)35bdc, the site of rock sample UTSR-8 (table 13) and test hole NSRT-5. There several large, high-angle open fractures are superimposed on a dense network of thin silica-filled joints that parallel the strike of the formation. (See description of sample UTSR-8, table 13.) From this occurrence, it can be inferred that the flexing of the Navajo Sandstone proceeded in stages, and that fully refilling the fractures has led to a decrease in sandstone permeability.

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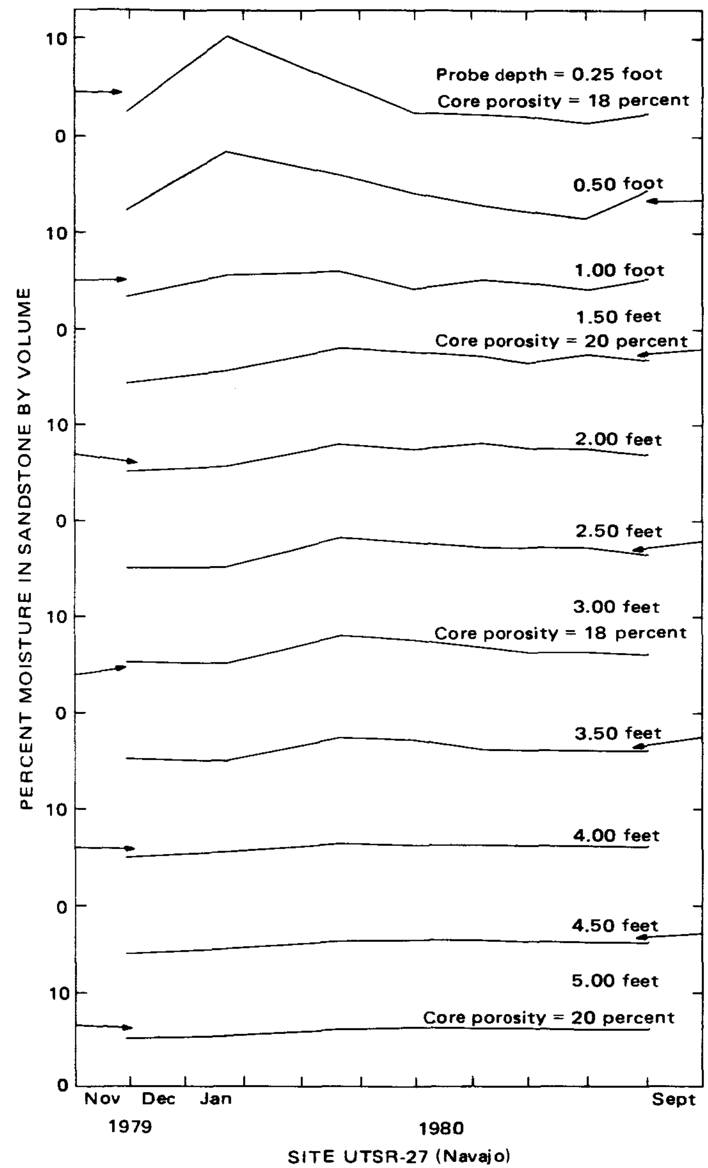
[1]Permeability determinations by oil-industry service companies are reported in millidarcies (or 0.001 Darcy). The Darcy has the dimensions of 0.987×10^{-8} square centimeters (at 20°C). For comparision with other results in this report, values in millidarcies were converted as follows:

hydraulic conductivity (at 60°F) = 2.439 x millidarcies/1,000



	SITE	LOCATION	REMARKS
Navajo Sandstone	UTSR-27	(D-20-12)3cab-1	On highland in San Rafael Swell. Water level far below zone measured
	UTSR-19A	(D-23-13)27bcc-1	On south bank of Straight Wash. Bottom may be in capillary fringe
	UTSR-22	(D-24-16)15dbb-1	At north edge of dry wash on bare sandstone. Water level far below zone measured
Coconino Sandstone	UTSR-13A	(D-21-11)25ddd-2	On east side of dry wash on bare sandstone. Water level estimated to be far below zone measured
	UTSR-23	(D-23-11)27bca-1	On weathered slope east of county road and southwest of old concrete foundation. Water level far below zone measured, but some moisture is perched on hard limestone (?) layer at 4.5 feet

Number given in feet is probe depth for individual curve. Value for core porosity positioned with relation to probe depth. For additional data on these sites, see tables 2, 3, and 13

Figure 10.—Graphs showing percentage of soil moisture in shallow core holes in the Navajo and Coconino Sandstones in the northern San Rafael Swell area, Utah. (From measurements after method of J. R. Peterson, U. S. Geological Survey written commun., 1977.)

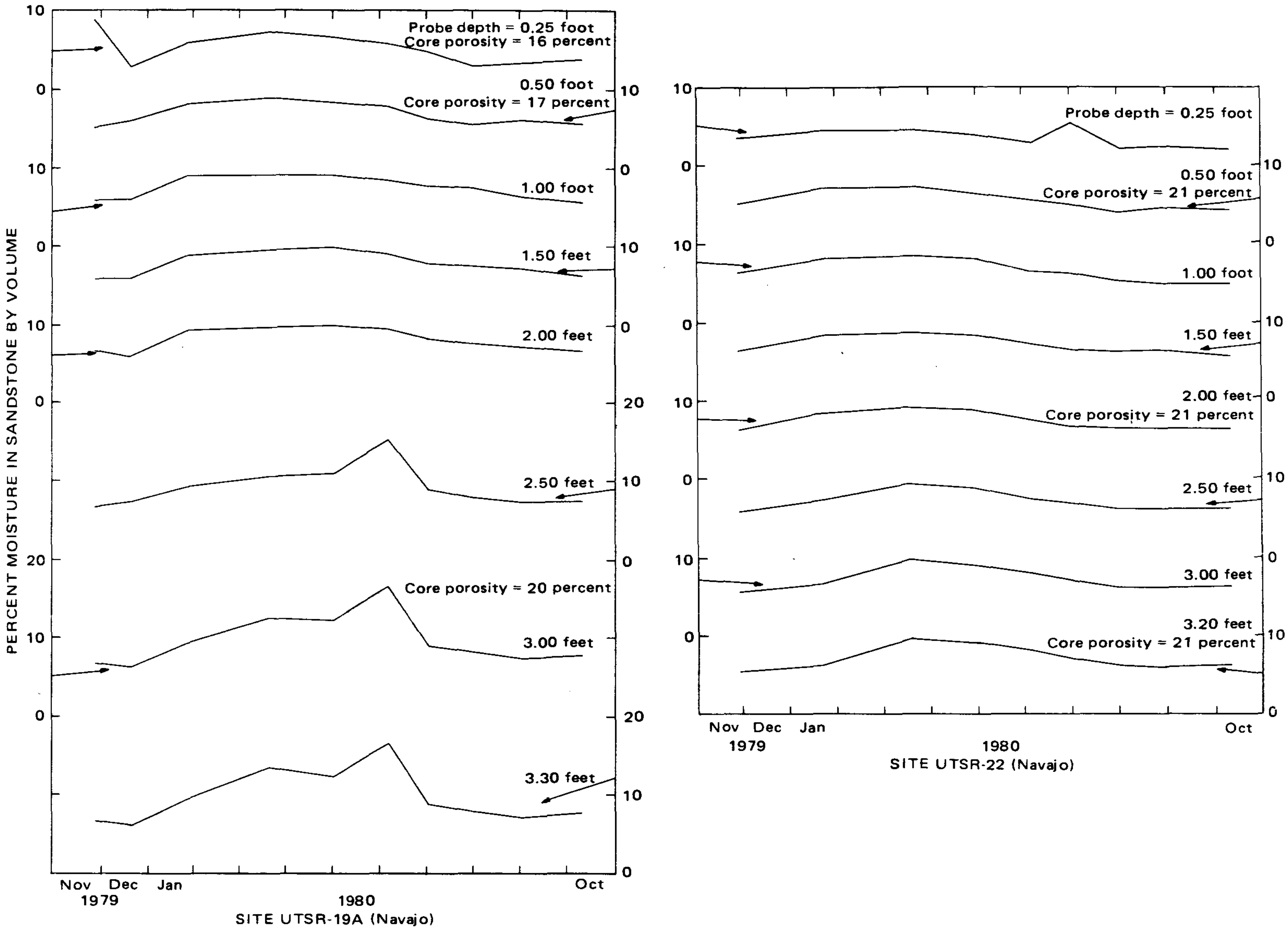


Figure 10.—Graphs showing percentage of soil moisture in shallow core holes in the Navajo and Coconino Sandstones in the northern San Rafael Swell area, Utah. (From measurements after method of J. R. Peterson, U. S. Geological Survey written commun., 1977.)—Continued

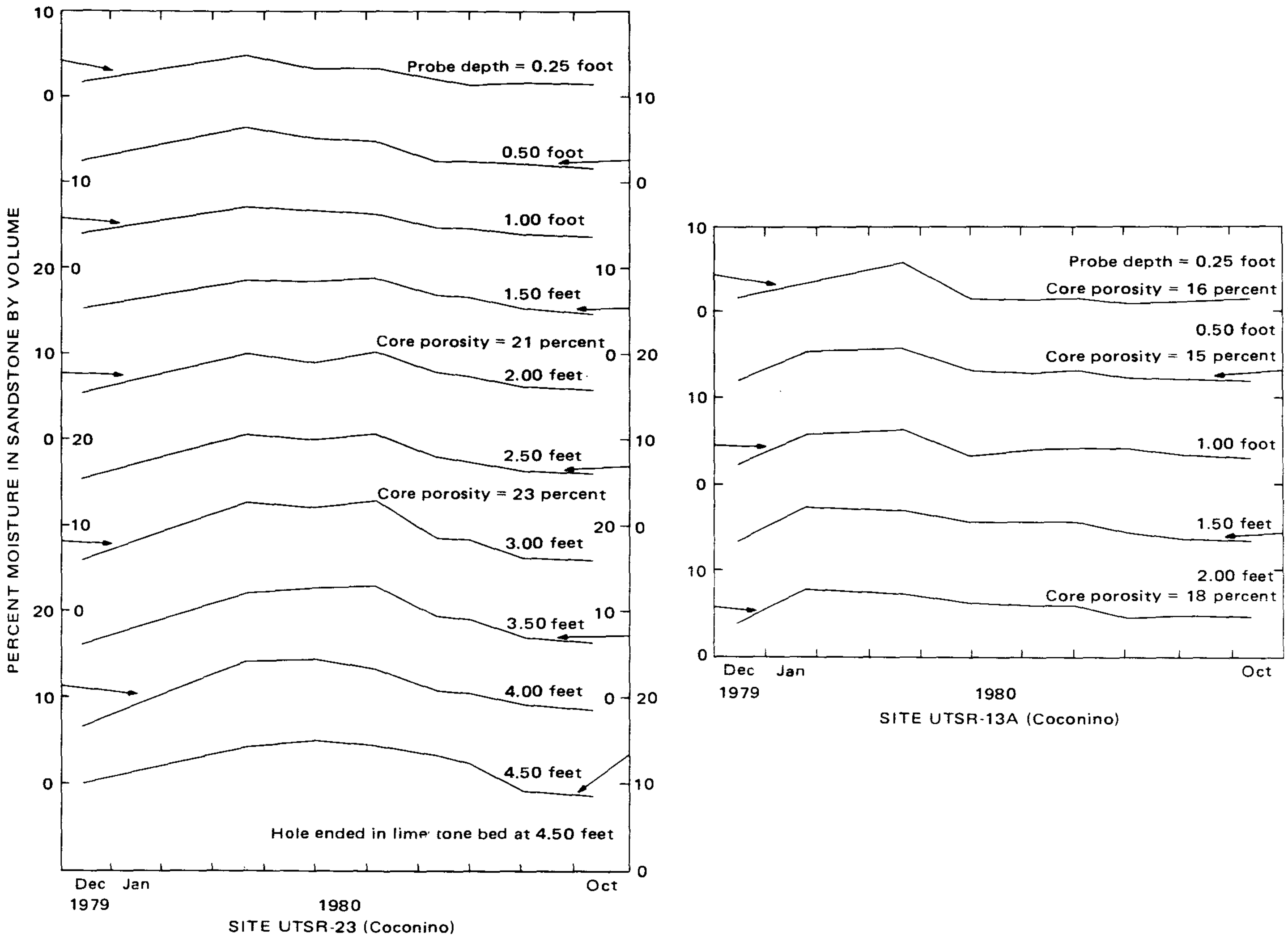


Figure 10.—Graphs showing percentage of soil moisture in shallow core holes in the Navajo and Coconino Sandstones in the northern San Rafael Swell area, Utah. (From measurements after method of J. R. Peterson, U. S. Geological Survey written commun., 1977.)—Continued

A: View, looking southward along east side of San Rafael Swell from location (D-22-14)7bb, showing steep dip of Navajo Sandstone (N) and flatirons of overlying Carmel Formation (C). Dip increases southward to nearly vertical.

B: View, looking eastward from location (D-21-9)15abd, into Coal Wash on west side of the swell. Carmel Formation (C) and Navajo Sandstone (N) dip about 4° toward viewer. Dry wash is typical of most drainage channels in the swell. The sandstone here probably is only partly saturated and can receive recharge during infrequent runoff.

Figure 11.—Dips of formations. The San Rafael Swell is asymmetric, with steep dips on the east side and gentler dips to the west. Structural distortion on the east side results in greater recharge per unit area, but steep dips reduce the area of intake.

Figure 12.—View downward to bottom of Black Dragon Canyon, from location (D-21-13)34cad, showing potholes (arrows) in strongly jointed, weathered Coconino Sandstone. Susceptibility of the sandstone to recharge (and similarly, the Navajo Sandstone) is diminished by the accumulation of silt and mud in the potholes and in joints. The pools of water may persist for days or weeks after rain or snowmelt.

Faulting in the study area takes two basic forms, nearly vertical faults with virtually straight traces and low-angle thrust faults such as in T. 15 S., R. 11 E., near Wellington (pl. 2). Commonly, faulting is thought to result in decreased transmissivity by moving permeable beds against less permeable beds; this condition may occur at some faults in the area. However, much faulting in the area is the result of adjustment to the horizontal stress that created the Swell; as such, some of the vertical faults are tension faults that may be open enough to allow appreciable leakage of water and petroleum (Lupton, 1912, p. 117-120; Rigby and Bauer, 1972). Even thrust faults that appear largely intraformational, such as depicted by Peterson (1954, fig. 2), and in figure 6B create paths for movement of water within the formation.

Permeability is lower in rocks in which porosity has decreased (Bredehoeft, 1964, fig. 1). Porosity and permeability data in table 4 show that the loading of core samples to simulate increased overburden pressure results in a 6-percent decrease in porosity, but a 20-percent or more decrease in permeability, with a sevenfold increase in pressure. Thus, the permeability of the Navajo Sandstone in the Book Cliffs, beneath 7,000 to 9,000 feet (2,130 to 2,740 m) of overburden, is significantly lower than the permeability of the sandstone where it crops out in the Swell. In like manner, the persistence of fractures is reduced with depth of burial (Nelson and Handin, 1977).

A given rock is more permeable to saline water than to fresh water. (For example, see Frick, 1962, table 23-5.) Thus, the saline water that commonly is associated with deeply buried formations partly offsets the effect of deep burial on the permeability. Moreover, the difference in permeability between a confined aquifer and the confining bed is somewhat reduced where the aquifer carries saline water; this probably occurs in the northern San Rafael Swell area.

Solution of rock materials also has significant effect on the permeability of certain geologic formations. Solution of gypsum results in partial collapse of the beds in the Carmel Formation and overlying formations and creep of the beds, as at (D-20-10)6bdd-1, the site of test hole NSRT-1. Solution of limestone and dolomite leads to cavernous, permeable zones in formations such as the Mississippian rocks; those rocks, where tested for petroleum, yielded much water to many of the petroleum-test wells (table 11).

In some instances large amounts of mill fiber or other materials have to be placed in wells during drilling to plug solution cavities and maintain circulation of the drilling fluid. An extreme example is well (D-23-11)22ccc-1W which was drilled to a depth of 2,285 feet (696 m) in 1936. The driller's record shows that significantly more plugging material was put into the hole than was drilled out of it; the hole was 2,270 feet (692 m) deep when measured in 1979 during the study.

Cavernous zones in limestone mainly are due to solution of the limestone by circulating recharge water that is laden with carbon dioxide from near-surface sources such as decaying organic material in soils. Active solution from that source probably does not reach depths of more than a few hundred feet. The sinkhole in (D-22-12)10bbb (pl. 1) is being actively stoped in limestone and siltstone of the base of the Moenkopi Formation; the formation overlies the Kaibab Limestone, and solution of limestone in both formations is due to solution by recharge water. Limestone solution does occur at relatively great depths, and the rate of solution is accelerated if the pH of the water is lowered by the presence of hydrogen sulfide and carbon dioxide. These two gases mainly are the products of sulfate reduction associated with hydrocarbon oxidation; in solution they produce weak acids. In the San Rafael Swell, hydrogen sulfide seems most prevalent in the Moenkopi Formation, but carbon dioxide is present in several formations from rocks of Mississippian age upward to the Curtis Formation (tables 9 and 11); several test wells produced carbon dioxide at rates of several million cubic feet per day. This continuous supply of the gas when migrating through limestone of the several formations aids in self-accelerating development of cavernous zones. Locally, the process probably leads to subsidence and collapse features such as that illustrated by Hawley, Robeck, and Dyer (1968, fig. 7).

HYDROLOGY

Summary Statement

Water available to the northern San Rafael Swell area is derived from precipitation on the area and surface-water inflow in the Price and San Rafael Rivers. The volume of ground water in storage is many times greater than the estimated average annual recharge. Discharge from the area mainly is by evapotranspiration, but also by surface-water outflow in the Green River and by ground-water outflow. The gross amounts of inflow and outflow are listed in table 6.

Precipitation

Most of the northern San Rafael Swell area is arid because of the area's position with respect to adjacent higher lands and because of its relatively low relief. Average annual precipitation (pl. 1) ranges from slightly less than 6 inches (150 mm) to slightly more than 12 inches (300 mm). Average monthly precipitation (pl. 1) is least in winter and greatest in summer and fall. Precipitation in winter is less because winter storms move downslope from the west where they have released most of their moisture in high mountains. In summer, the prevailing flow of air is from the south, and upslope flow of air toward the western mountains and the Book Cliffs, together with erratically distributed thunderstorms, increases the probability of precipitation. Nearly all precipitation is consumed within the area.

The average annual (1931-60) volume of precipitation on the study area is estimated to be 1.15 million acre-feet (1,420 hm^3), as determined from planimetry between lines of equal precipitation on plate 1. The average for the 2,880-square-mile (7,460-km^2) area is 7.4 inches (188 mm).

Surface Water

The northern San Rafael Swell area is drained by the Green River and two of its tributaries, the Price and San Rafael Rivers (pl. 1). Both tributaries head in mountains west and north of the study area. The Green River, upstream from gaging station 09315000 at Green River, Utah, has a drainage area of 44,850 square miles (116,200 km^2). The Price River, upstream from gaging station 09314500 at Woodside, has a drainage area of 1,540 square miles (3,990 km^2), and the San Rafael River, upstream from gaging station 09328500 near Green River, has a drainage area of 1,628 square miles (4,217 km^2). The combined average annual discharge at the two tributary gaging stations is 177,400 acre-feet (220 hm^3), or 3.9 percent of the 4,568,000 acre-feet (5,630 hm^3) at Green River. (See U.S. Geological Survey, 1978, for periods of record.) Most other streams in the study area are ephemeral; however, some may have perennial flow for short distances from springs such as Cottonwood Wash downstream from spring (D-20-13)15dad-S1. Monthly mean discharge at seven gaging stations is illustrated on plate 1 and listed in table 8. Detailed records and statistical data are given by the U.S. Geological Survey (1954, 1964, 1970, 1973, 1971-79). Additional discussion of drainage area, discharge at miscellaneous gaging sites, and effects of geology on surface-water quality is given by Mundorff (1972) and Mundorff and Thompson (1982).

The Green River at Green River, although it includes the discharge of the Price River, derives nearly all its water from northeastern Utah and adjacent parts of Wyoming and Colorado. Thus, flow of the Green River is little affected by hydrologic changes in the northern San Rafael Swell area. The river contributes little to ground water in the study area, except where water from the river is distributed by canal for irrigation on alluvium near the town of Green River. The Green River is the discharge area for much of the surface-water and residual ground-water outflow from the northern San Rafael Swell area.

The Price and San Rafael Rivers derive most of their flows from freshwater sources in mountains west and north of the Swell. During much of the year, their flows are entirely diverted for irrigation of long-established farmlands extending from Price southwestward through Castle Valley. As a result, their flows through the Swell consist mainly of irrigation-return flow that is slightly to moderately saline. As early as 1924, during his fieldwork, Gilluly (1929, p. 76) noted that

> "the water of both San Rafael and Muddy Rivers is sometimes so concentrated that even stock will not drink it, but this happens only during the hottest and driest periods."

The degradation of surface-water quality results not only from upstream irrigation, but also the flow of water over rocks of Late Cretaceous age and the effects of evapotranspiration along the stream channels (Thomas, 1952, p. 24).

The losses from evapotranspiration, though not quantified, must be large especially during the hot part of the year. The canyon of the San Rafael River, near the east side of the Swell is 800 feet (245 m) deep; air temperatures there often exceed 100°F (38°C) or more on sunny summer afternoons. High air temperatures together with low relative humidity cause high rates of evaporation, especially at low stages of the streams. Likewise, discharge from phreatophytic growth at stream edges and on flood plains (fig. 2B) even in deep canyons probably induces recharge to the alluvium from the rivers, thus further depleting the flow and increasing the salinity.

On the whole, there is little net gain to the streams that transect the San Rafael Swell except during infrequent heavy thunderstorms and rare years of thick snow cover in the Swell. There is little inflow of ground water even though the Price and San Rafael Rivers cut into several of the aquifers listed in table 2 and shown on plate 2. Conversely, the rivers seem to lose water at times (table 7), even during the cold months of winter as indicated in table 8. The average midwinter gain across the Swell for either of the main streams is less than 2 cubic feet per second (0.06 m^3/s). The indicated losses cannot be explained without extensive seepage studies. It seems improbable that the midwinter decreases are due to irrigation diversions or instream evaporation between the stations, nor can it be probable that the streams lose water to the aquifers they transect.

Ground Water

Ground water in the northern San Rafael Swell area is derived from precipitation on the area and from consequent flow in upland tributaries to the Price and San Rafael Rivers, mainly during winter. Much of the ground water is discharged locally within the area. Water can move from one aquifer to another; however, residual recharge water moves mainly to the principal drainage channels which are the most deeply incised into the aquifers. A small amount of ground water flows out of the area and into the lower Dirty Devil River basin, and a part ultimately reaches the Green River.

Recharge

Ground-water recharge in the study area is from precipitation on the area; this includes seepage from upland tributary flow resulting from the precipitation. No ground-water inflow is inferred to occur in the post-Paleozoic rocks. The principal streams, the Price and San Rafael Rivers, are ground-water discharge points, rather than sources of recharge, other than to stream-channel alluvium.

The gross annual volume of recharge from precipitation in the northern San Rafael Swell area is estimated to be about 10,000 acre-feet (12 hm^3). This is only about 1 percent of the total annual volume of precipitation on the area. The estimate was made by comparing the potential for infiltration of precipitation in the northern San Rafael Swell area with that in the adjacent lower Dirty Devil River basin (Hood and Danielson, 1981). The potential in the lower Dirty Devil River basin, where an estimated 2 percent of the annual precipitation goes to ground-water recharge, is greater than in the northern San Rafael Swell area. Where precipitation is greatest, the most recharge occurs in the unconsolidated rocks, but unlike the lower Dirty Devil River area, outcrops of such (pl. 2) are small and widely scattered in the northern San Rafael Swell area. The most permeable of the bedrock aquifers permit very low rates of recharge and the volume of recharge depends on surface area exposed. More water infiltrates the Navajo Sandstone than the Wingate Sandstone because the latter is exposed mainly in vertical cliffs that in most parts of the study area are capped with remnants of the Kayenta Formation which has a lower permeability.

Recharge to the bedrock aquifers occurs during prolonged wet surface conditions, which limits recharge mainly to periods of winter precipitation and snowmelt, when evaporation from the surface is at a minimum. Vertical hydraulic conductivities of the three major sandstone aquifers range from 0.0095 to 1.5 feet per day (0.0029 to 0.5 m/d) (table 4); this is 0.005 to 0.75 inch per hour (0.13 to 19 mm/hr). Short-term storms, such as summer thunderstorms, contribute little to recharge. For example, an intense storm may drop more than 1 inch (25 mm) of rain in 15 minutes, only to have most run off because of the low permeability of the bedrock. The chance for infiltration is lessened by the steep slopes common to much of the bedrock area that cause rapid runoff. Subsequent to such short storms, the water that does penetrate the bedrock returns to the surface due to capillary action and the water is evaporated.

Changes in moisture as a percentage by volume of the rock for November 1979-October 1980, measured in three holes in the Navajo Sandstone and two in the Coconino Sandstone are shown in figure 10. In general, the percentage of moisture content begins increasing in the shallowest part of each hole during late fall, reaches a peak during midwinter, and then decreases until about August. For each successively deeper level, the peaking of moisture content occurs later than that at the surface, thus indicating a wave of moisture draining downward. In the deepest parts of the holes, least affected by surface conditions, the range of moisture change is about 1 to 4 percent. Note the abrupt temporary rise at site UTSR-22 where a summer storm added moisture to the shallowest zone; the moisture did not penetrate deeper than about 0.25 foot (7.6 cm).

The Navajo Sandstone probably receives more of the ground-water recharge than any other bedrock aquifer in the study area. The estimated direct recharge to the sandstone aquifer in the study area is 3,000 acre-feet (3.7 hm^3) per year or an average rate of 4.1 cubic feet per second (0.12 m^3/s). This figure does not include possible recharge by interformational leakage; it does include recharge directly from precipitation on the sandstone outcrop throughout the study area and recharge from flow in upland drainage channels (pl. 1). The figure of 3,000 acre-feet (3.7 hm^3) is based on the amount of water needed--3.7 cubic feet per second (0.10 m^3/s) or 2,680 acre-feet (3.3 hm^3) per year--as input to the digital-computer model to achieve best fit for the sandstone aquifer system.

The estimated annual amount of recharge to the Navajo Sandstone, 3,000 acre-feet (3.7 hm^3) compares favorably with the observed change (fig. 10) in moisture content. The addition of moisture, as a percentage by volume, can be visualized as a depth of water; in a cubic foot of the sandstone, the 1 to 4 percent added moisture cited above would amount to a depth of 0.01 to 0.04 foot (3.0 to 12.2 mm) of water. If the estimated annual recharge, 3,000 acre-feet (3.7 hm^3), is divided by the area of outcrop of the Navajo Sandstone, about 93,000 acres (37,637 hm^2), the result is 0.03 foot, or 0.36 inch (9 mm) --within the range of moisture change described above.

Occurrence and Movement

Ground water in the northern San Rafael Swell area occurs under confined, perched, and unconfined conditions; each of these conditions occurs in several areas. Most water in the unconsolidated deposits is unconfined. In several areas, one or more of the major sandstone aquifers are partly or completely drained. Water in the consolidated rocks is unconfined in and near outcrops around the perimeter of the Swell and where the rocks are dissected by canyons near the Green River. Downgradient from outcrop areas, the water level intersects the bottoms of overlying confining beds, and beyond, the water becomes confined.

Confined conditions mainly occur off the flanks of the Swell where the major aquifers are buried. Locally in these areas confining artesian pressures are great enough to raise water levels in wells higher than the land surface. For example, the water level in the Navajo Sandstone at test hole (D-23-14)25bca-1 (table 9) was 105 feet (32 m) higher than the land surface.

The condition is representative of a broad area from the east side of the Swell to the Green River. More deeply buried aquifers probably have greater pressure, as at well (D-23-16)15dca-1 (table 11).

Water in several aquifers differs in occurrence at any given site due to differences in recharge and permeability. For example, the Navajo Sandstone is only partly saturated near the Green River because of its higher permeability relative to the Carmel Formation. In the same general area, water in the overlying Carmel Formation and Entrada Sandstone is perched. These formations yield water to springs such as (D-24-16)27cbb-S1 (table 10).

Perched conditions also occur in other formations in the study area. On Cedar Mountain, for example, recharge to the Salt Wash Sandstone Member of the Morrison Formation occurs during the spring and discharge to springs and seeps on the east face of the mountain occurs during early summer; this probably explains why well (D-17-11)27ccd-1 was dry (table 9). Other examples of perched conditions are at spring (D-20-9)35ccd-S1 (table 10), well (D-19-13)21cbd-1 (table 9), and well (D-22-11)23bdc-1 (table 11).

Ground water moves downgradient from recharge areas to discharge areas along paths of greatest transmissivity. The direction of movement generally is depicted by maps of the potentiometric surface. For most of the formations listed in table 2, there are insufficient data to construct potentiometric-surface or ground-water level maps. The study area, however, is part of the regional-study area described by Hanshaw and Hill (1969, p. 267-280) who used petroleum-test data to show the gross features of the potentiometric surfaces in Paleozoic aquifers. The maps they constructed (Hanshaw and Hill, 1969, figs. 2 and 6-8) indicate that ground water in the Paleozoic rocks west of the Green River moves from areas north and northwest of the San Rafael Swell southward past the Swell.

Of the younger aquifers, a potentiometric-surface map is provided only for the Navajo Sandstone as shown on plate 5 of this report. It can be assumed that the potentiometric surface for the Wingate Sandstone is similar because the two formations share common areas of general outcrop and similar lithology and structural distortion.

The potentiometric surface for the Navajo Sandstone (pl. 5) shows that ground water moves from the outcrop area of the sandstone, around the Swell, away from the Swell. On the west side of the Swell, ground water moves from the area of maximum precipitation around San Rafael Knob (pl. 1) westward and thence both southward into the lower Dirty Devil River basin area and north-northeastward. In moving northeastward, the ground water is augmented by a little recharge along the Swell; a part of the water is discharged to the San Rafael River. Most water in the sandstone at the north end of the Swell moves around a high, dry area of the sandstone and thence southeastward toward the Green River.

On the east side of the Swell, a ground-water divide exists near the surface divide southeast of Temple Mountain. In this southeastern area, water in the sandstone moves northeastward toward the confluence of the Green and San Rafael Rivers. Some water is intercepted by discharge points near the faults that intersect Cottonwood Springs, (D-24-14)32adb-S1 (table 10). In the highlands near Keg Knoll, a very small amount of recharge moves through the lower part of the westward-dipping sandstone (pl. 5) and thence northward toward the San Rafael River.

The potentiometric contours on plate 5 are based both on the sparse control shown and on the results of digital-computer modeling; contours are fitted to the existing data, but the direction and spacing of the contours are guided by the modeling results. A basic assumption that affects the direction of contours in the northern part of the study area is that no water enters the area from the north and northwest. This assumption is based on the relatively great depth of burial (pl. 6) and, therefore, the greatly reduced permeability of the sandstone, and the relative lack of outcrops of the Navajo Sandstone (Stokes, 1964; logs and other data in Hood, Mundorff, and Price, 1975) in those directions.

Fragmentary water-level data, indicated by both wells and springs, for aquifers younger than the Navajo Sandstone show that water movement in them is largely from their local outcrops to the nearest lower drainage that is cut into them. However, where the younger aquifers are deeply buried, the direction of movement probably is much the same as for the Navajo Sandstone.

Storage

Estimates of ground-water storage are made only for the Navajo and Wingate Sandstones and for the Coconino Sandstone (incuding its lateral facies equivalents). The estimate for the Navajo Sandstone probably has the best accuracy owing to the greater effort spent on data acquisition for that formation. Estimates are based on data in tables 2, 4, and 11, and on plate 3. The estimates for all three aquifers are as follows:

Aquifer	Average thickness (feet)	Area (square miles)	Estimated effective porosity (percent)	Volume of ground water in transient storage (millions of acre-feet)	Assumed specific yield (percent)	Recoverable water in transient storage, assuming complete drainage (millions of acre-feet)
Navajo Sandstone	[1]412	[1]2,300	[2]17.7	[3]94	[2]9	42
Wingate Sandstone	400	2,350	20	[4]100	5	27
Coconino Sandstone	700	2,880	20	[4]232	8	93
Totals (rounded)				440		160

[1]Based on planimetry of area containing full thickness of the formation.

[2]See page 20.

[3]An estimated 87 percent of the sandstone is saturated.

[4]An estimated 90 percent of the sandstone is saturated.

The three sandstone aquifers, thus, contain about 160 million acre-feet (197,300 hm^3) of water that could be recovered if the aquifers could be completely drained. This figure is an upper limit to development of the aquifers because complete drainage could never be achieved.

The volume of water stored in other aquifers in the study area cannot be estimated from the available data. It is probable that the total volume does not exceed that stored in the Navajo, Wingate, and Coconino Sandstones.

The ground-water system in the northern San Rafael Swell area is almost unaffected by development. There may be some interformational movement of ground water through uncased wells such as (D-25-14)26dba-1 (table 9), but this does not change the total volume of water stored in the bedrock. Wells completed in bedrock aquifers yield small quantities of water for a few widely scattered stock and mine-supply systems; several of these wells yield water from the Navajo Sandstone. They include such low-yield stock wells, as well (D-24-15)6caa-1S (table 9), that have been left flowing for years. Total annual withdrawal from such wells, however, is small. For example, withdrawal from the entire ground-water system in the bedrock aquifer system probably did not exceed 200 acre-feet (0.25 hm^3) during 1980. For practical purposes, therefore, the withdrawal did not change the volume of ground water in storage.

Water-level changes in wells in the study area are due to small natural changes in storage. Fluctuations of water levels in six observation wells in the northern San Rafael Swell area during parts of 1979 and 1980 are shown in figure 13, together with brief explanations of well conditions and the causes of fluctuations. (See also figure 14 for fluctuation of water level in a natural discharge area.)

Discharge

Annual ground-water discharge in the northern San Rafael Swell area equals the estimated ground-water recharge for that area--10,000 acre-feet (12 hm^3), or less. The discharge consists of discharge to streams, outflow in bedrock aquifers, evapotranspiration, and the small amount of well discharge noted in the section on storage. None of the means of discharge can be precisely quantified for all the aquifers, but evapotranspiration probably is the largest.

Navajo Sandstone aquifer.--Discharge from the Navajo Sandstone occurs principally to the surface in the San Rafael River where the river has incised the sandstone on both the west and east sides of the Swell; lesser amounts of discharge occur in the channels of the lower San Rafael and Green Rivers, near their confluence. Discharge to the rivers is estimated to be 2,000 acre-feet (2.5 hm^3) annually or 67 percent of the estimated annual recharge to the sandstone. An estimated 300 acre-feet (0.4 hm^3) per year moves through the sandstone from the west side of the Swell southward into the drainage area of the lower Dirty Devil River. An additional estimated 300 acre-feet (0.4 hm^3) moves through the sandstone east-southeastward out of the northeast side of the study area (pl. 4). The remaining 400 acre-feet (0.5 hm^3) is discharged through springs and seeps and direct evaporation. Much of the spring flow and seepage is consumed by evapotranspiration near the point of discharge.

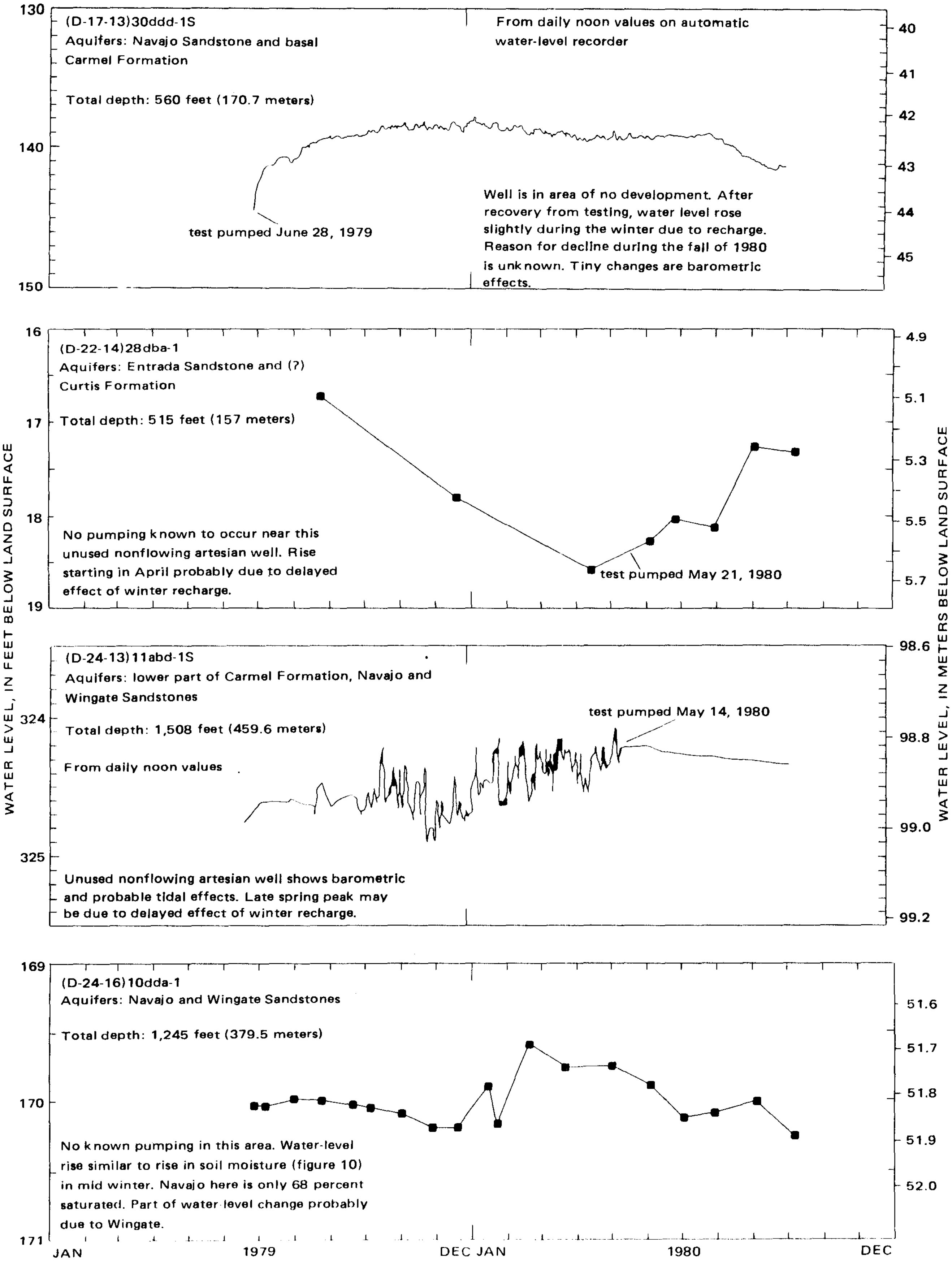


Figure 13.—Water levels in observation wells.

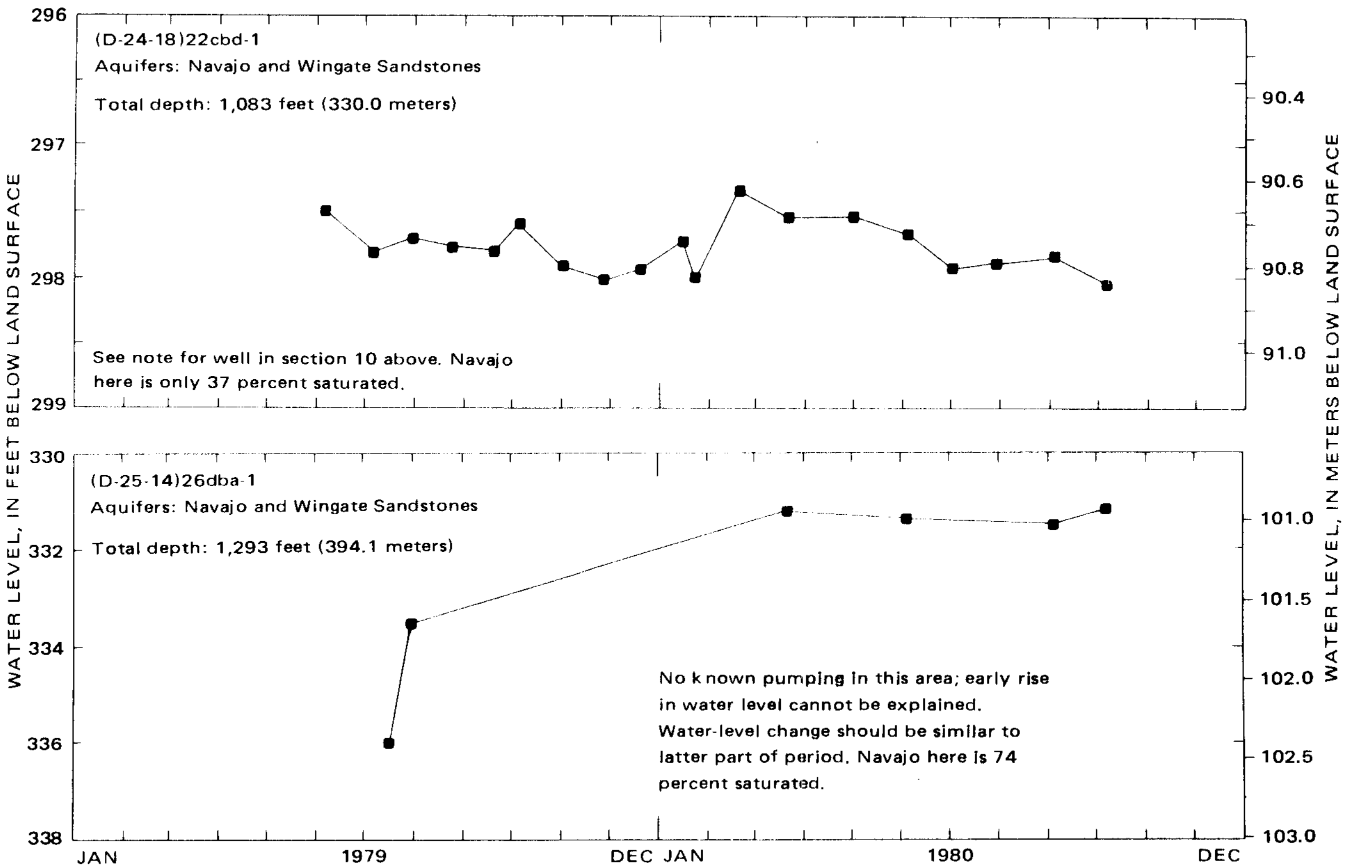


Figure 13.—Water levels in observation wells.—Continued

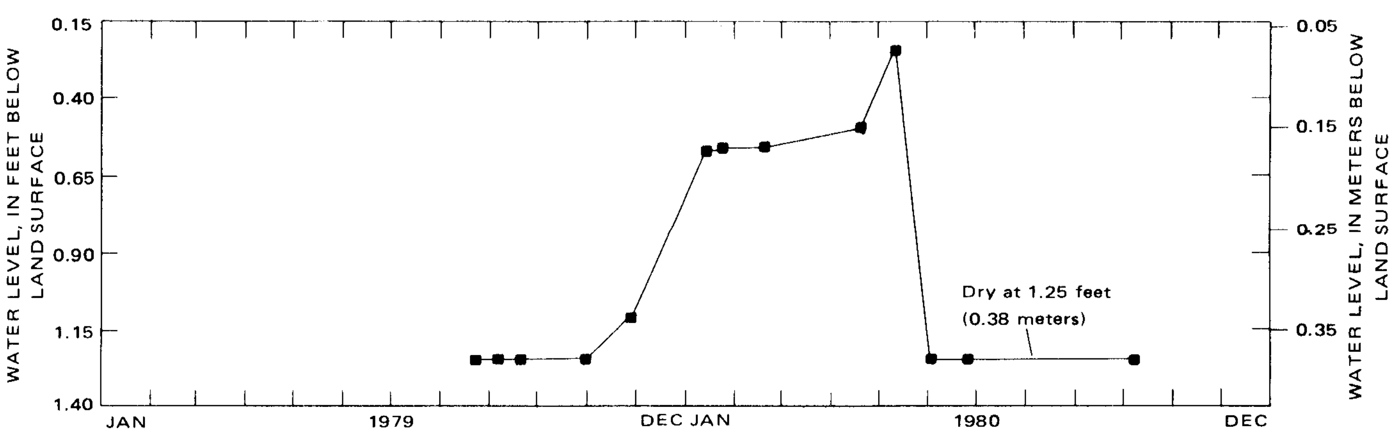


Figure 14.—Water level in shallow core hole (D-20-13)15daa-1. Core hole is on left (north) bank of Cottonwood Wash where the wash cuts through the Navajo Sandstone on east side of the San Rafael Swell. Sandstone is almost saturated most of the year and discharges water by evaporation. During late fall and winter, evaporation almost ceases and water level rises nearly to land surface.

Other consolidated aquifers.--Discharge of ground water from the other consolidated rocks could not be calculated for lack of data. However, some of the rocks, both younger and older than the Navajo Sandstone, discharge mainly in the study area, particularly where those rocks are strongly dissected; where they are deeply buried, they also transmit small quantities of water toward the Dirty Devil River basin and the Green River. For example, see well (D-23-16)15dca-1 (table 11), which shows a ground-water level higher than the nearby Green River.

Evapotranspiration.--The amount of ground water discharged by evapotranspiration was not calculated both because the absolute amount probably is small and because the maximum gross evapotranspiration occurs where a mixture of surface water and an unknown percentage of ground water is discharged.

Both field inspection and false-color satellite imagery show that the only dense vegetation in the study area is in irrigated areas near Green River, in Castle Valley, west of the San Rafael Swell, and in small tracts along the Price and San Rafael Rivers. Other than near the irrigated tracts, phreatophytic vegetation grows only as a fringe at stream edge and on the lowest terrace where flood inundation occurs during infrequent floods. At these locations the phreatophytes obtain most of their water from streamflow and stream-channel underflow.

Elsewhere, widely scattered moist areas and small springs, mostly intermittent, are marked by small patches of phreatophytes, such as Temple Spring (D-25-13)6aca-S1 or (D-17-12)23aba-S1 (table 10). Small damp areas are found throughout the study area, some in deep inaccessible canyon country such as that shown in figure 2B. The springs shown on plate 1 are only those found in the field or shown on available topographic maps; the springs shown probably amount to less than half the actual number.

Direct evaporation of water from consolidated aquifers occurs at some locations in the study area. In Eagle Canyon, at spring (D-22-9)8aca-S1 (table 10), wet sandstone in the canyon wall has a thick coating of white mineral residue that indicates evaporation. Likewise, water evaporates directly from the Navajo Sandstone in Cottonwood Canyon in the vicinity of spring (D-20-13)15dad-S1 (table 10). Shallow core hole UTSR-21, (D-20-13)15daa-1, was drilled nearby on a shelf of sandstone about 3 feet (1 m) above the streambed. The cliff next to the site was damp several feet above the shelf and was covered with mineral efflorescence. When the hole was drilled in the summer of 1979, the core was almost saturated yet, the adjacent streambed was dry; the head of streamflow was downstream. Later in the water year, as the head of streamflow (5 to 10 gal/min, or 0.3 to 0.6 L/s) again migrated upstream, water entered the core hole. By May 1980, the water level in the hole was near the surface of the shelf above the streambed. (See fig. 14.) This general condition occurs at several areas around the Swell.

Chemical Quality of Ground Water

The chemical quality of ground water in the northern San Rafael Swell area ranges from fresh to briny. Chemical analyses of water samples from formations that range from Mississippian to Holocene in age are listed in table 14. Supplemental data for the southern part of the area shown on plate 1 are in Hood and Danielson (1981, table 13). Brief descriptions of the chemical characteristics of water from the formations are in table 2.

The dissolved-solids concentration of ground water is controlled by a number of factors, including the depth of burial of the aquifer, the distance of the water source from the recharge area, the permeability of the rocks, and the amount of easily dissolved minerals in the rocks. Thus, springs or wells such as (D-22-14)6bbc-S1 and (D-19-13)21cbd-1 yield water with low dissolved-solids concentrations. This is because they discharge from shallow rocks in or near recharge areas that have been leached and contain mostly minerals of low solubility; conversely, some petroleum-test wells such as (D-15-10)26aaa-1 and (D-22-16)2bba-1, that penetrate deeply buried aquifers, produce brine or very saline water because of slow circulation over long distances from recharge areas, or because the formation contains much easily dissolved mineral such as halite (rock salt).

The Navajo Sandstone contains mostly water that ranges from fresh to moderately saline. Very saline water was obtained from one well that was converted from a petroleum-test hole; the water is of the sodium sulfate type (not characteristic of the Navajo) and may represent leakage into the well from another formation.

Most water in the Navajo Sandstone is fresh to moderately saline. The freshest water in the Navajo is of the calcium magnesium bicarbonate type. Locally magnesium is the predominant cation. Most samples from the sandstone, however, were mixed waters of the calcium magnesium sulfate chloride type, which indicates that water of the calcium bicarbonate type in the Navajo is mixed with water of the calcium sulfate chloride type from interformational leakage. In such areas as the San Rafael Desert, east of the Swell, such leakage must come from below the Navajo, because of the relatively high artesian pressures there. Around the flanks of the Swell, however, the source of calcium sulfate is gypsum in the overlying Carmel Formation; water in the Carmel leaks down into the Navajo.

Analyses for two water samples (table 14) are moderately saline water of the calcium bicarbonate and calcium magnesium bicarbonate chloride types. At the dissolved-solids concentrations found in samples from wells (D-15-11)12cda-1 and (D-18-14)9dca-1, bicarbonate as the dominant anion is due to the occurrence of carbon dioxide under pressure in the formation. (See tables 9 and 11.)

The analyses in table 14 indicate that the Navajo Sandstone contains water useful for stock and irrigation and, in parts of the area, for domestic purposes within a few miles of the aquifer outcrop both east and west of the Swell and in most of the San Rafael Desert, south of Green River.

EFFECTS OF LARGE-SCALE WITHDRAWAL OF GROUND WATER

Potential annual water requirements in the northern San Rafael Swell area, over the currently (1980) granted water rights, range from perhaps 5,000 acre-feet (6.2 hm^3) for small industry or coal-fired power generation plants to as much as 200,000 acre-feet (250 hm^3) for a proposed nuclear powerplant near Green River. For the latter amount, it is expected that ground water would be used conjunctively with a part of Utah's allocation of water in the Upper Colorado River Basin.

Well Yields and Drawdown

This study shows that aquifers, the Navajo Sandstone in particular, can supply 5,000 to 20,000 acre-feet (6.6 to 25 hm^3) of ground water for periods of 30 years, or more. However, the aquifers alone cannot supply 200,000 acre-feet (250 hm^3) per year.

The potential yield to wells in the Navajo is dependent on the hydraulic conductivity and thickness of the sandstone, and on well diameter. The effect of hydraulic conductivity and thickness, for an assumed storage coefficient of 0.001, are shown in the following table:

Aquifer thickness (feet)	Assumed hydraulic conductivity (ft/d)	Transmissivity (ft^2/d)	Assumed well discharge (gal/min)	Years of pumping	Drawdown, in feet, at distance of 1 foot	10 feet	100 feet	1,000 feet	10,000 feet	50,000 feet
200	0.2	40	450	10	3,370	2,580	1,790	995	232	0
				20	3,490	2,700	1,900	1,110	338	7
				30	3,560	2,770	1,980	1,180	403	19
				40	3,610	2,820	2,030	1,230	450	34
	1.0	200	450	10	729	571	413	252	97	10
				20	753	595	437	278	121	23
				30	767	609	451	292	134	32
				40	777	619	460	302	144	40
500	.2	100	900	10	2,820	2,190	1,560	923	299	10
				20	2,920	2,280	1,650	1,020	389	39
				30	2,970	2,340	1,710	1,070	443	66
				40	3,010	2,380	1,750	1,110	482	90
	1.0	500	900	10	609	482	355	228	102	22
				20	628	501	374	248	121	37
				30	639	512	386	259	132	47
				40	647	520	394	267	140	54

The table shows that it is unrealistic to expect large sustained well yields where the aquifer is thin, as northeast of the San Rafael Swell (pl. 3); it is also unrealistic to expect large yields where the hydraulic conductivity is low, as is the case where the formation is deeply buried. Digital-computer modeling of the aquifer shows that increasing the well diameter from 10 to 18 inches (25 to 46 cm) will decrease long-term drawdown in the pumped well by about 10 percent.

The simplistic calculations given in the table above do not take into account the effects of discharge points along rivers, boundaries such as the outcrop of the Navajo Sandstone around the San Rafael Swell, or variations in $\underline{T}$ due to both changes in $\underline{K}$ and the varying thickness of the sandstone. For this reason, the Navajo was modeled.

The model representing 4,640 square miles (12,020 km^2) was constructed using the methods of Trescott, Pinder, and Larson (1976). Simplifying assumptions included the use of uniform values for storage coefficient and specific yield and the restriction of the model to those parts of the aquifers where the Navajo Sandstone is fully saturated or nearly so. It also was assumed that the Navajo does not leak to or receive leakage from the bounding formations. Hydraulic conductivity was estimated from the permeability rock specimens, aquifer tests, and reported data from petroleum tests, and it was graduated across the area modeled according to the depth of burial of the aquifer. Several sets of assumed values were tested, and the effects of discharging wells and well diameter were tested for assumed periods of as much as 30 years. Few data are available and time for model development was limited, but the model is considered to be a reasonable representation of the hydrologic system. The model could not be calibrated because of a lack of water-level data both areally and with time. However, the model was useful in guiding the analysis of the aquifer by other methods, and it was useful as a general guide to delimit the rates and significant areas of recharge and discharge and to evaluate the general effect of well discharge on the stream system.

The modeling of the sandstone aquifer shows that: (1) A well northeast of the San Rafael Swell in the study area will have drawdown about 1,000 feet (305 m) when pumped continuously at 1 cubic foot per second (449 gal/min, or 0.28 m^3/s) up to 30 years; (2) a well west of the Swell could be pumped at 2 cubic feet per second (900 gal/min or 0.6 m^3/s), but large drawdown would occur after a year or more of continuous pumping; (3) to achieve a given yield multiwell arrays with well spacings of 1 mile (1.6 km) or more are preferable (despite locally high artesian pressures, the relatively low $\underline{T}$ of the Navajo Sandstone restricts the spread of the cone of depression due to pumping); (4) pumping near the San Rafael River would reverse discharge of the sandstone aquifer to the river only if the sandstone were completely dewatered at its outcrop on the river; and (5) the discharge to the Green River, which is less than 1 cubic foot per second (0.02832 m^3/s) would be little affected by 30 years of pumping at about 2 cubic feet per second (0.05664 m^3/s), if the withdrawal is made more than 10 miles (16 km) from the river.

The effects of pumping on the rates of interformational leakage cannot be assessed using the available data, although it recognized some leakage must occur. Whatever amount occurs as a result of lowering water levels in the Navajo Sandstone would offset a part of the amount removed from storage in the sandstone. The most important effect would be a degradation of ground-water quality in the sandstone aquifer; some leakage occurs naturally, as can be seen from the chemical characteristics of samples from the Navajo. Enhanced leakage would increase the naturally occurring degradation. Likewise, induced saline-water infiltration from the San Rafael River would degrade the chemical quality of water in the aquifer.

From the foregoing discussion, it is apparent that large-scale development of the Navajo Sandstone in the study area is only marginally feasible; the feasibility should be based on the cost of widely spaced, relatively low-yield wells and the attendant gathering and storage system. Moreover, the natural discharge from the sandstone aquifer would be little affected by pumping unless a large number of wells were installed close to the discharge areas--again, marginally feasible. Thus for example, nearly all the annual withdrawal of 20,000 acre-feet (25 hm^3) per year would come from storage. It should be noted that a withdrawal of 20,000 acre-feet (25 hm^3) per year for 30 years amounts to 600,000 acre-feet (740 hm^3) or about 1.4 percent of the ground water stored in the Navajo Sandstone in the study area.

Effect on Flow of the Colorado River

The effects of pumping ground water in the northern San Rafael Swell area would have a negligible effect on the flow of the Green River, a principal tributary of the Colorado River. Because of the small exposure of the Navajo Sandstone to the river, direct diversion from the river, by infiltration into the outcrop probably would be less than 1 cubic foot per second (0.028 m^3/s). The principal effect would be diversion of water from the tributaries which discharge to the Green River. Even if pumping diverted all the estimated natural ground-water recharge of 10,000 acre-feet (12 hm^3) and induced an equal amount, the resultant diversion would amount to 25 cubic feet per second (0.71 m^3/s) or less than 0.5 percent of the average flow of the Green River at Green River, Utah (U.S. Geological Survey, 1979, p. 241). Because the Green River is tributary to the Colorado River, the effect on the Colorado River would be even less.

FURTHER STUDIES NEEDED

In 1980, the amount of ground-water data available on the Navajo Sandstone in the study area was small. Even less information was available on the other principal aquifers. Prior to any firm planning for future large-scale ground-water development, the following studies are considered necessary for evaluating feasibility or planning the operation of well fields.

1. The flow system in the Navajo Sandstone and other aquifers needs to be better defined throughout the area, including more information on the potentiometric surface and hydraulic properties of both the sandstone and its confining beds.

2. Pressure relations among the several aquifers need to be defined, because of the potential for increased or induced interformational movement of water.

3. From the data aquired under items 1 and 2, a reliable calibrated digital-computed model of the Navajo Sandstone and associated aquifers needs to be constructed for predictive purposes.

4. The chemical quality of available ground water areally and with depth needs to be better known, particularly in the northern half of the study area.

SUMMARY AND CONCLUSIONS

Rocks that underlie the northern San Rafael Swell area range in age from Precambrian to Holocene. All the geologic units contain some water, but only five are considered to be major aquifers--the Entrada, Navajo, and Wingate Sandstones, the Coconino Sandstone including its equivalents in the Cutler Formation, and rocks of Mississippian age. Several other lithologic units--older alluvium, the Salt Wash Sandstone Member of the Morrison Formation, the Curtis Formation, the Carmel Formation, and the Moss Back Member of the Chinle Formation--are at least locally important.

The circulation of water in the consolidated aquifers is affected by faulting and folding which locally enhance water movement by fracturing, or impede the movement by offsetting permeable beds or sealing zones with rock of lower permeability. At least locally, fracturing also enhances interformational leakage. Other factors affecting circulation are the reduction of porosity due to depth of burial, the salinity of the circulating water, and the solution of carbonate rocks and evaporites.

The total hydrologic system in the northern San Rafael Swell area has an estimated average annual inflow and outflow of about 1.3 million acre-feet (1,600 hm^3), of which about 1.15 million acre-feet (1,420 hm^3) is derived from precipitation on the area and the remainder is inflow in the Price and San Rafael Rivers. An estimated 99 percent of the water is consumed by evapotranspiration and most of the remaining 1 percent leaves the area as surface flow.

The estimated long-term average annual ground-water recharge is 10,000 acre-feet (12 hm^3), or less; at least 30 percent of this amount recharges the consolidated rocks. At least 20 percent of the water is discharged to the streams and the remainder is consumed by evapotranspiration or moves out of the area as ground-water outflow.

The total amount of ground water in storage cannot be calculated. However, the Navajo, Wingate, and Coconino Sandstones contain an estimated 160 million acre-feet (197,300 hm^3) of recoverable fresh to moderately saline water.

The estimated average annual recharge to and discharge from the Navajo Sandstone in the northern San Rafael Swell area is about 3,000 acre-feet (3.7 hm^3). This is only 0.007 percent of the recoverable water in the sandstone aquifer.

On the basis of available data and a digital-model approximation, calculations show that an annual withdrawal of 20,000 acre-feet (25 hm^3) for 30 years would reduce the amount of recoverable water stored in the Navajo Sandstone by about 1.4 percent.

Although most wells inventoried during this study yield small quantities of water, yields of more than 1,000 gallons per minute (63 L/s) to individual wells are possible locally in the area. Large yields would be accompanied by large drawdowns--1,000 feet (305 m) or more--in and near well fields after several years of pumping.

Well yields from the Wingate and Coconino Sandstones probably could be equal to those from the Navajo Sandstone because the average saturated thicknesses of those formations are greater; the largest yields from all formations would be expected in fractured areas and those yields also would be accompanied by large drawdowns--especially if the aquifer is confined. The pumping effects in other aquifers in the area cannot be evaluated.

Ground water in much of the northern San Rafael Swell area is saline. Most unconsolidated deposits contain saline water because of evapotranspiration in uplands and saline streamflow, except in the Green River bottoms. Most consolidated rocks contain freshwater only near their outcrop areas. Known occurrences of freshwater in the Navajo Sandstone include not only outcrop areas both east and west of the Swell, but also at depth in a broad area extending from the east-central edge of the Swell to the Green River. In most areas, water in the Navajo shows some degradation by mixing with more saline water from other formations through interformational leakage.

Information obtained during this study indicates that:

1. Bedrock aquifers (the thick sandstone aquifers in particular) in the northern San Rafael Swell area can yield additional fresh to slightly saline water--perhaps as much as 5,000 acre-feet (6 hm^3) per year--with relatively little effect on the ground-water system.

2. Large withdrawals (as much as 20,000 acre-ft or 25 hm^3 per year from the bedrock aquifers, the Navajo Sandstone in particular) are feasible; however, this is possible only where the formations are thickest (as along the west side of the San Rafael Swell), and if widely spaced wells are used. Such large withdrawals require many wells because of the low permeability of the sandstone. The chemical quality of water probably would be degraded.

3. Large withdrawals would have some side effects, including reduction of artesian pressure at the few existing wells, cessation of some spring flow, and a small effect on the flow of the San Rafael River. However, the effect on the flow of the Colorado River would be very small.

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GEOHYDROLOGIC DATA

Table 1.—Codes used in identifying aquifers or geologic units in tables 9, 10, 11, and 14

[See also table 2.]

110PTOD	Pediment, terrace or other deposits of Quaternary age
111ALVM	Alluvium of Holocene age
112ALVM	Alluvium of Pleistocene age
200MNCS	Mancos Shale
200MSZC	Undivided rocks of Mesozoic age
210DKOT	Dakota Sandstone
217BCKR	Buckhorn Conglomerate Member of Cedar Mountain Formation
217CDRM	Cedar Mountain Formation
220GLNC	Glen Canyon Group, undivided
220JRSC	Undivided rocks of Jurassic age
220NVJO	Navajo Sandstone
221BRSB	Brushy Basin Shale Member of Morrison Formation
221CRML	Carmel Formation
221CRTS	Curtis Formation
221ENRD	Entrada Sandstone
221MRSN	Morrison Formation
221SLWS	Salt Wash Sandstone Member of Morrison Formation
221SMVL	Summerville Formation
230MNKP	Moenkopi Formation
231CCRK	Church Rock Member of Chinle Formation
231CHNL	Chinle Formation
231KYNT	Kayenta Formation
231MBCK	Moss Back Member of Chinle Formation
231SRMP	Moss Back Member of Chinle Formation where originally identified as the "Shinarump Conglomerate"
231WNGT	Wingate Sandstone
237SNBD	Sinbad Limestone Member of Moenkopi Formation
300PLZC	Undivided rocks of Paleozoic age
310CCNN	Coconino Sandstone
310CTLR	Cutler Formation
310KIBB	Kaibab Limestone
310OGRK	Organ Rock Tongue of Cutler Formation
310RICO	Rico Formation
310WTRM	White Rim Sandstone Member of Cutler Formation
319ELPC	Elephant Canyon Formation
320MNGC	Manning Canyon Shale
320MOLS	Molas Formation
320PSLV	Undivided rocks of Pennsylvanian age
321HKTL	Honaker Trail (upper member of Hermosa Formation)
324HRMS	Hermosa Formation
324PRDX	Paradox Member of Hermosa Formation
330DSRT	Deseret Limestone
330MDSN	Madison Limestone
330MSSP	Undivided rocks of Mississippian age
330RDLL	Redwall Limestone
331HMBG	Humbug Formation
340DVNN	Undivided rocks of Devonian age
341ELBR	Elbert Formation
341OURY	Ouray Limestone
370CMBR	Undivided rocks of Cambrian age
371LYNC	Lynch Dolomite
374BWMN	Bowman Limestone
374HRMN	Hartmann Limestone
374OPHR	Ophir Shale
374TNTC	Tintic Quartzite
400PCMB	Undivided rocks of Precambrian age

Note: Many of the formation identifications given in various tables, the petroleum-test wells in particular, are those of reporting companies; most reported identifications were not checked, or corrected, except where obvious errors had been made.

Table 2.--Description of geologic units known to underlie parts of the northern San Rafael Swell area

[See table 1 for codes used in identifying aquifers or geologic units in tables 9, 10, 11, and 14. Abbreviations: ft, feet; ft^3/s, cubic feet per second; gal/min, gallons per minute.]
Character of material and hydrologic characteristics: See text for description of data-site numbering system. Locations of sites are shown on plate 1.
Hydrologic characteristics: Ranges of permeability and salinity are given on page . Interpretations of chemical quality of water are based on analyses given in table 14, or for some aquifers, are inferred from the lithology or from geophysical logs. Ranges of permeability are partly based on hydraulic conductivity as given in table 4.

Erathem	System	Series		Geologic unit	Character of material	Hydrologic characteristics
Cenozoic	Quaternary	Holocene		Younger alluvium, gravel surfaces, and covering deposits of dune sand or other windblown deposits	Surficial deposits of clay, silt, sand, and gravel. Local areas of talus or colluvium too small to map. Along stream valleys, younger alluvium is well sorted, but generally is less than 20 ft thick. Gravel surfaces may be the upper parts of terrace deposits or the covering of pediments. Dune sand is a well-sorted veneer, as much as 20 ft thick, and it occurs mainly in the San Rafael Desert. Covering deposits otherwise include substantial amounts of clay and silt. In stream valleys, deposits presently are (1980) being incised.	Very low to high (?) permeability. In most areas these deposits are above the water table; in stream valleys they are part of the deposits that yield water to shallow wells; they are less permeable than the underlying older alluvium and more permeable than most consolidated rocks. Gravel surfaces and dune sand generally are above the water table, but locally may yield small amounts of water to springs, and both are good recharge media. In some areas, water from these deposits may be fresh, however, they generally yield saline water because they receive recharge from saline streamflow, they contain detritus from saline consolidated rocks, or because of evapotranspiration in areas where the water table is shallow. For example, see records of wells (D-20-16)17bab-1 and (D-21-16)9aac-1.
		Pleistocene		Older alluvium and older terrace deposits and pediment cover	Silt, sand, gravel and boulders. Crops out in river valley south of the town of Green River and underlies the channels of the Price and San Rafael Rivers. Underlies gravel surfaces, such as those along the Book Cliffs. Thickness, 10 to 100 ft.	Low to high permeability. In deeply incised drainages, is in direct contact with streams. In extensive deposits, as near Green River, well yields might be several hundred gallons per minute. In some areas, water in the deposits is fresh. In most places, however, it generally is saline, partly because of saline water discharge from underlying bedrock and partly because of recharge from saline streamflow.
Mesozoic and Cenozoic	Cretaceous and Tertiary	Upper Cretaceous and Paleocene		Tertiary and Upper Cretaceous rocks, undivided	Mostly black to gray, silty to fissile shale and very fine to fine-grained sandstone. Full section is several thousand feet thick, but only a residual section is present around the west and northeast flanks of the San Rafael Swell.	Shale has very low permeability and is a confining bed for both the interbedded sandstone and underlying formations. Upward leakage through the shale probably is nil. The sandstone, especially in the lower units, is a freshwater aquifer west of the Swell (see Waddell and others, 1978, 1981, and Lines and Morrissey, 1983). Water in this section in some areas is characteristically saline and of the sodium bicarbonate type. Debris from erosion of the shale degrades the chemical quality of water in streams carrying the debris and in alluvium containing the debris.
Mesozoic	Cretaceous	Lower Cretaceous	Cedar Mountain Formation	Shale member of the Cedar Mountain Formation	Nodular shale. Thickness ranges from less than 100 to about 600 ft.	Very low (?) permeability. Little known regarding the permeability or chemical quality of water.
				Buckhorn Conglomerate Member of the Cedar Mountain Formation	Conglomeratic sandstone and (?) shale. Discontinuous; thickness, 0 to 125 ft.	Very low to low (?) permeability. Probable source of springs such as (D-16-12)16cbd-S1. Yields range from seepage to an estimated 30 gal/min of fresh to slightly saline water, mainly of the sodium bicarbonate type. Where deeply buried, formation probably yields water of greater salinity.
	Jurassic	Upper Jurassic	Morrison Formation	Brushy Basin Shale Member	Variegated, bentonitic shale, with minor sandstone, conglomerate, and limestone. Thickness, generally 200 to 400 ft.	Very low permeability. Retards groundwater circulation; but near outcrop areas yields small quantities of fresh to moderately saline water to springs such as (D-19-9)1acd-S1. Debris from shale adds to sediment load carried by streams and reduces the permeability of the bottoms of alluvial channels.

Table 2.--Description of geologic units known to underlie parts of the northern San Rafael Swell area--Continued

Erathem	System	Series		Geologic unit	Character of material	Hydrologic characteristics
Mesozoic	Jurassic	Upper Jurassic	Morrison Formation	Salt Wash Sandstone Member	Conglomeratic, crossbedded sandstone with minor shale. Thickness about 130 to more than 500 ft; seems to thicken southwestward toward the central western side of study area.	Very low to low (?) permeability. Little known about formation, but may contain saline water in most places; exceptions are near outcrops, especially in Cedar Mountain area.
	Jurassic	Middle Jurassic	San Rafael Group	Summerville Formation	Red-brown, even-bedded, thin-bedded mudstone, siltstone, and sandstone. Local, small channel sandstone inclusions increase (?) southward. Thin beds and network of gypsum veinlets are common. Very uniform lithology in most of the area. Thickens westward from about 100 to 700 ft.	Very low permeability. Supplies water to a few seeps such as (D-19-9)26cab-S1 which yields a moderately saline water of the sodium sulfate type.
				Curtis Formation	Greenish-gray and brown fine- to coarse-grained glauconitic marine sandstone and siltstone with minor greenish-gray and red shale, and local thin lenses of conglomerate. Forms prominent marker between the darker Summerville Formation and Entrada Sandstone. Thickness, 31 to 223 ft; thins southward, though variable locally.	Very (?) low permeability. Most water is saline. Well (D-22-14)28ddd-1 yielded a moderately saline water in which bicarbonate was the dominant anion and which was charged with carbon dioxide. Spring water at (D-19-13)13bbd-S1 was very saline and of the sodium sulfate type.
				Entrada Sandstone	Mainly light reddish-brown to tan massive crossbedded sandstone and reddish-brown siltstone that thicken southwestward where the formation is more clayey and massive. In northeastern part of area, formation contains some lenses and beds of fine- to medium-grained sandstone (sample UTSR-28) that weathers to a golden yellow. Total thickness, about 200 to more than 700 ft.	Very low to moderate permeability. Clayey facies not known to be an aquifer. Water may be fresh in and near sources of fresh water recharge to the outcrop; chemical quality probably deteriorates with distance from outcrop and depth of burial. Fresh water probably of the sodium bicarbonate type. Saline water probably has sulfate as the dominant anion, except circumstances like that at well (D-22-14)28dba-1 which yielded a moderately saline water of the calcium bicarbonate type heavily charged with carbon dioxide.
				Carmel Formation	In general, formation consists of a basal red shale and a sandstone bed, overlain by a lower part of dense limestone and an upper part of shale with some sandstone and beds of massive gypsum. Near the Green River, the formation is about 100 ft thick and is quite sandy; the shale, gypsum, and limestone content increase westward. At the west side of the study area, the thickness is nearly 700 ft and is more than 1,000 ft west of the area. Salt occurs in the formation (Gilluly and Reeside, 1928, p. 74; Hood and Danielson, 1981, table 10; U.S. Department of Energy, oral commun., 1979); these occurrences are an eastward extension of the massive salt beds west of the project area (Stokes and Cohenour, 1956, p. 27). This salt is one source of the saline water found in the region. The formation underlies much of the upper dip slopes in the western San Rafael Swell, where considerable slumping of beds is due to solution, mainly of bedded gypsum, in the area south and east of Cedar Mountain, limestone in the lower Carmel caps and protects the Navajo Sandstone from erosion.	Very low to locally high (?) permeability. Formation in undisturbed state probably has very low permeability, but where the rocks have been fractured or exhumed, water percolating from the surface or leaking from below, under artesian pressure, has dissolved limestone and gypsum and has developed cavernous zones and slumping which accelerates the solution process. Hood and Danielson (1979, table 1) indicate yields of 2 ft^3/s from fractured parts of the formation. In the study area, few large yields were found. Sandstone in test hole NSR T-6 yielded an estimated 100 gal/min at 205 ft; spring (D-23-8)30bdb-S1, in the bottom of Kimball Draw canyon discharged an estimated 10 gal/min. Most other sites yielded 5 gal/min or less. The basal siltstone (including thin limestone laminae such as sample UTSR-25) impedes ground-water movement between the Carmel and the underlying Navajo. The condition leads to perched water occurrences in the Carmel where the underlying Navajo may be only partly saturated as at well (D-19-10)15bac-1 and springs (D-24-16)27cbb-S1 and (D-25-13)6aca-S1; the springs are representative of numerous sites in and near the San Rafael Desert. Elsewhere, the basal beds are fractured and leak, as at spring (D-21-14)5aab-S1, the water of which probably is derived from the Navajo. Water in the Carmel ranges from fresh to slightly

Erathem	System	Series		Geologic unit	Character of material	Hydrologic characteristics
Mesozoic	Jurassic	Middle Jurassic	San Rafael Group	Carmel Formation--Continued		saline of mixed type, such as that from spring (D-21-14)5aab-S1, to slightly to moderately saline water of the calcium sulfate type, such as that from spring (D-22-9)8aca-S1. Near the section of rock, the water may range from slightly saline to briny water of the sodium chloride type. In most areas, sulfate is the dominant anion.
	Triassic(?) and Jurassic	Upper Triassic(?) and Lower Jurassic		Navajo Sandstone	Gray, buff, and locally red sandstone; thickly and intricately crossbedded. See text.	Very low to moderate permeability. Very low permeability where undisturbed. Erratically distributed fracturing locally enhances or decreases permeability. See text. The sandstone yields fresh to moderately saline water of mixed type. Locally produces commercial carbon dioxide. See text.
	Triassic(?)	Upper Triassic(?)	Glen Canyon Group	Kayenta Formation	Irregularly bedded grayish-pink and maroon shale, siltstone, and fine- to coarse-grained sandstone, in part conglomeratic, with minor beds of limestone. Contact with overlying Navajo is transitional in some areas. In some areas reported thickness of Kayenta differs significantly from well to well, indicating possible erosion surface on top of the formation. Thickness, 50 (?) to 350 ft, increasing from north to southwest. Shaliness decreases southeastward.	Very low to low (?) permeability. Samples UTSR-14 and 14A indicate that siltstone in the formation is 1,000 to 2,000 times less permeable than sandstone in adjacent beds; the sandstone is about as permeable as that in the Navajo. Although the formation probably acts as a confining bed between the Navajo and Wingate Sandstones, because of lower relative permeability, the formation can leak water from one sandstone to the other, especially where the Kayenta is fractured or artesian pressure is present in the underlying Wingate. The siltstone beds create perched water areas in the base of the otherwise drained Navajo or in the top of the Kayenta, as indicated by test wells, (D-19-12)9dbc-1 and (D-19-12)30bba-1 and Keg Spring, (D-26-16)1cda-S1. Water from Keg Spring reportedly is fresh; elsewhere, water in the formation may be saline or similar in quality to that in the Navajo and Wingate Sandstones.
	Triassic	Upper Triassic	Glen Canyon Group	Wingate Sandstone	Reddish-brown to buff, very fine to medium-grained crossbedded sandstone. Calcareous, at least in outcrop; poorly to well indurated; contains several interbedded layers of siltstone in vicinity of sample UTSR-11. Almost as uniform in lithology as the Navajo, but contains more fine-grained constituents. Most outcrops are in vertical cliffs that have a cap of remnant Kayenta Formation and are strongly jointed. Thickness, 100 to 220 ft on west, and increasing to 500 to 600 ft on east side of study area.	Very low to moderate (?) permeability. Grain-size, porosity, and permeability analyses indicate that the sandstone has about the same <u>K</u> as the lower and middle parts of the Navajo, but overall permeability probably is somewhat lower because of the included siltstone beds. Low to moderate permeability can be inferred for the sandstone where it is strongly jointed or fractured. Yields small quantities of fresh to slightly saline water to springs such as (D-23-10)9bbd-S1, which yields less than 1 gal/min. Well yields are inferred to be smaller than those estimated for the Navajo (see text). Near recharge areas, water in the Wingate is of the calcium magnesium bicarbonate type. In slightly to moderately saline water, the dominant anion is sulfate. Where deeply buried, water in the Wingate probably is more saline than in the Navajo under similar conditions.
	Triassic	Upper Triassic	Chinle Formation	Chinle Formation (Upper part)	Regionally contains seven members, mostly of fluvial and lacustrine origin; not all members present at any given locality. (See Stewart, Poole, and Wilson, 1972) Mudstone, siltstone, sandstone, and some conglomerate in various shades of purple, red, and brown. Total thickness ranges from about 200 to almost 700 ft, increasing southward.	Chinle as a whole has very low to low (?) permeability. Most of formation is too fine grained to accept much recharge. Conversely, it enhances surface runoff and contributes much sediment to surface water. Yields small amounts of water to seeps. Well (D-24-9)5bcb-1 has a large drawdown (table 9) when pumping an estimated 10 gal/min of slightly saline water in which sulfate is the dominant ion. Two petroleum-test wells respectively yielded moderately saline water of the sodium bicarbonate type and very saline water in which chloride is the dominant anion.
	Triassic	Upper Triassic	Chinle Formation	Moss Back Member	Yellowish-gray, fine- to medium-grained, lenticular, conglomeratic sandstone; minor mudstone seams, limestone conglomerate, and coaly material. This is the member identified in early petroleum-test wells as the "Shinarump Conglomerate" which is absent in the northern and central San Rafael Swell.	

Table 2.--Description of geologic units known to underlie parts of the northern San Rafael Swell area--Continued

Erathem	System	Series		Geologic unit	Character of material	Hydrologic characteristics
Mesozoic	Triassic	Middle(?) Triassic	Moenkopi Formation	Moenkopi Formation (Upper part)	Reddish-brown, ripple-marked, even-bedded, fissile mudstone and siltstone, and fine-grained sandstone, with thin layers and veins of gypsum. Locally petroliferous. In part of study color changes from red to gray, probably as a result of reduction associated with carbonaceous materials. Thickness, 200 to 775 (?) ft.	Moenkopi, as a whole, has very low to low (?) permeability. In and near outcrops, particularly in the higher parts of the Swell, the formation yields small amounts of fresh to slightly saline water of the magnesium calcium sulfate type. Spring discharge points probably are related to fracturing. Largest yield found is at Sulfur Spring, one of a group of springs in the canyon of the San Rafael River (Hess, 1911). This spring discharges an estimated 200 gal/min of a moderately saline water of the calcium sulfate bicarbonate type; the water from the group contains a large amount of hydrogen sulfide and probably carbon dioxide. Water from well (D-23-10)12ddd-1 contains a measurable amount of hydrogen sulfide. Records of petroleum-test wells show that the formation, where deeply buried, contains moderately saline to briny water of mixed types.
		Lower Triassic		Sinbad Limestone Member	Yellowish-gray and tan, thin- to medium-bedded, oolitic dolomite and limestone, with minute amounts of siltstone and sandstone. Forms prominent benches where exposed in the central part of the Swell. Average thickness about 100 ft.	Core samples of the Sinbad Limestone Member indicates generally very low permeability for most areas; however, where the limestone is at the surface or has been strongly fractured, ground-water circulation probably has developed local cavernous zones. Samples from petroleum-test wells indicate the deeply buried limestone contains saline to briny water.
				Moenkopi Formation (Lower part)	Light reddish-brown, yellowish-gray and green or bluish-gray, even-bedded siltstone and sandstone containing gypsum veinlets; chert-pebble conglomerate at base. Thickness, 20 (?) to 140 ft. Total thickness of the Moenkopi Formation is 360 to 1,100 ft or more, increasing from east to west.	See discussion of Moenkopi, as a whole, under section on upper part, above.
Paleozoic	Permian	Lower Permian		Kaibab Limestone	Light-gray to brown, cherty, silty limestone; some dolomite; white, calcareous siltstone; thin beds of white, crossbedded, fine-grained sandstone. Caps terraces and edges of cliffs of the Coconino Sandstone in the east-central part of the Swell. Average thickness in the Swell is about 100 ft. Thickens southwestward from 0 ft near the northeastern side of the Swell.	Core samples generally indicate very low permeability for most areas, where undisturbed. Where the limestone is at or near surface or has been fractured, ground-water circulation probably has developed local cavernous zones. The sinkhole which is stoped up into the Moenkopi Formation in (D-22-12)10 (pl. 1) probably is due to solution of the underlying Kaibab. Water in the limestone may be fresh near outcrops in the Swell; where the formation is deeply buried, as in petroleum-test well (D-18-14)30ccb-1, the water is briny and of the sodium chloride type.
			Coconino Sandstone in most of study area / Cutler Formation to east and southeast	Coconino Sandstone	In much of study area, sandstone of Permian age is called the Coconino Sandstone (Stokes, 1964); near the east flank of the Swell, the Coconino interfingers with members of the Cutler Formation. The Coconino consists of light-gray to buff, friable to very hard, very fine to medium-grained, thickly crossbedded sandstone, with some grit and limestone (?) near base. Upper contact, where exhumed, weathers to a hackly, rough surface that has bright red iron-rich patches. Thickness averages about 700 ft.	Very low to low (?) permeability. Surface and shallow core samples indicate that the upper part of the Coconino has permeability and porosity in the same range as samples in the Navajo. Where deeply buried, unleached and unfractured, permeability may be lower. Wells (D-22-11)23bdc-1 and (D-23-11)22ccc-1S indicate the sandstone is partly to fully drained in the highest part of the Swell. J. A. Rice (petroleum geologist, written commun; Jan. 9, 1917), on the basis of 15 shallow test holes west of Temple Mountain found "abundant" water at depths of 12 to 350 ft; water was "invariably encountered." The water level trended roughly parallel to land surface. Water in the Coconino near outcrops probably is fresh to slightly saline and of mixed types, as in well (D-23-9)2ccb-1. Water from petroleum tests is moderately saline to briny and of the sodium chloride type.

Erathem	System	Series	Geologic unit		Character of material	Hydrologic characteristics
Paleozoic	Permian	Lower Permian	Coconino Sandstone in most of study area; Cutler Formation to east and southeast	White Rim Sandstone Member of the Cutler Formation	See discussion of Coconino Sandstone. White, gray, and buff, fine- to medium-grained arkosic (?) sandstone.	See discussion of Coconino Sandstone. Petroleum-test wells in this unit south of study area generally yielded slightly to moderately saline water.
				Organ Rock Tongue or Member of the Cutler Formation	Reddish-brown siltstone and thin-bedded, fine-grained sandstone.	Very low (?) permeability. Characteristics not known.
				Cedar Mesa Sandstone Member of the Cutler Formation	Yellowish-gray, reddish-orange, and reddish-brown, friable, fine- to coarse-grained arkosic (?) sandstone, with minor beds of red sandy shale and gray cherty limestone. This unit is not exposed in study area, but underlies the eastern part of the area; the lithology changes radically both to the northwest and the southeast. Thickness, about 1,000 ft.	See discussion of Coconino Sandstone. No water samples, but water probably saline.
		Wolfcampian	Elephant Canyon Formation (of Barrs, 1962)	Rico Formation	Elephant Canyon is mainly (?) limestone and present mainly in and near the Swell. Interfingers (?) with Rico or decreases in thickness as Rico thickens. Rico Formation consists of sandstone, cherty limestone, siltstone, and shale. Thickens southeastward from about 300 to about 800 ft at east edge of study area.	Characteristics unknown. Permeability probably very low; water probably saline.
	Pennsylvanian	Middle and Upper Pennsylvanian	Oquirrh(?) Formation to northwest; Hermosa Formation (Hermosa Group of Wengerd and Matheny, 1958) to southeast	Upper member of Hermosa (includes Honaker Trail Formation of Wengerd and Matheny, 1958)	Limestone interbedded with cross-bedded arkosic (?) sandstone, siltstone, and shale. Thickens southeastward. A small exposure of this (?) unit is mapped by Stokes (1964) in Straight Wash, near the central east edge of the Swell.	Very low (?) permeability. Water samples from the Hermosa are mainly from the Paradox Member (see below). Those reported for other members are very saline to briny and are of the sodium chloride type.
		Middle Pennsylvanian		Paradox Member of the Hermosa Formation	Salt, gypsum, anhydrite, black shale, sandstone, and limestone. Occurs east of the Swell and wedges out westward; thickens southeastward; absent in the Swell.	Very low to moderate (?) permeability. Very low permeability, except where fracturing has allowed circulating ground water to dissolve salt, gypsum, and limestone. Near the fault system south of the town of Green River a petroleum-test well flowed 20 to 146 gal/min while being drilled in the Paradox. Water samples were very saline to briny and of the sodium chloride, sodium chloride sulfate, and calcium sodium chloride type.
				Lower member (Pinkerton Trail Member of Wengerd and Strickland 1954)	Mainly dark-gray limestone, dolomite, and shale. Total thickness of Hermosa Formation or its equivalents ranges from less than 2,000 ft north and west of the Swell to a minimum of about 200 (?) ft in the Swell and thickens southeastward to more than 5,000 ft near the Green River.	Characteristics not known. Permeability probably very low; water probably briny.
		Lower Pennsylvanian		Molas Formation	Variegated claystone, and shale, siltstone, and conglomerate; includes limestone and chert regolith in karst surface in upper 10 to 100 ft of underlying Mississippian rocks. Present only (?) where Mississippian was exposed at surface during deposition of Manning Canyon (?) Shale in northwestern part of area. Thickness, 20 to about 500 ft.	Characteristics not known. Permeability probably very low; but probably confines water of unknown quality in Mississippian rocks.

Table 2.--Description of geologic units known to underlie parts of the northern San Rafael Swell area--Continued

Erathem	System	Series	Geologic unit	Character of material	Hydrologic characteristics
Paleozoic	Mississippian and Pennsylvanian		Manning Canyon (?) Shale	Black to gray (?) marine shale, siltstone, claystone, and (?) limestone. Present only (?) in northwestern part of study area.	Characteristics not known. Permeability probably very low; but probably confines water of unknown quality in Mississippian rocks.
	Mississippian	Upper Mississippian	Humbug Formation	Mainly limestone and dolomite. Both upper surface and some zones internally are locally (?) cavernous. W. D. Quigley (written commun., August 30, 1969) described a reef-like zone within the upper 100 ft of the formation, that had a 2-ft open cavity, at (D-20-14)33baa-1. Note: the study area is in an area of transition among the lithologies and nomenclature used for the Colorado Plateau, Basin and Range and Wasatch Plateau areas. See Cooper (1955, p. 63, 65) and Rocky Mountain Assoc. Geologists (1972) for discussion of formation names, lithologies, and extent of geologic units. Total thickness of Mississippian rocks range from 0 (?) to about 1,800 ft. They are removed or perhaps faulted out at well (D-24-9)14dda-1.	Very low to high permeability. Cores from petroleum tests show that undisturbed carbonate section has very low permeability. Where faulted, fractured, or dissolved by ground water, the permeability is high. In the test described by Quigley, the bit dropped about 2 ft on entering the cavernous zone and the circulation of drilling fluid was lost abruptly. Many of the petroleum-test wells that were drilled to test these rocks yielded relatively large amounts of water; one or more of the wells flowed when tested. Most water samples from petroleum-test wells were very saline to briny and of the sodium chloride or sodium magnesium chloride type. However, in well (D-23-10) 28dbb-1, where the Mississippian is relatively shallow, the water recovered was slightly to moderately saline and of mixed types, indicating probable local recharge from downward leakage through the overlying rocks.
		Lower Mississippian	Redwall Limestone equivalent — Names used by various petroleum companies: Redwall Limestone "Leadville Limestone" Deseret Limestone "Madison Limestone or Group"		
	Cambrian and Devonian	Lower, Middle, Upper Cambrian, Upper Devonian	Undivided sedimentary rocks. [Includes Elbert Formation, Ouray Limestone, Lynch Dolomite, Bowman and Hartmann Limestones, Ophir Shale, and Tintic Quartzite]	Includes quartzite or quartzitic sandstone, sandstone, siltstone, conglomerate, shale, limestone, and dolomite. Thickness about 2,000 to 3,200 ft.	Characteristics not known. Permeability probably very low.
Pre-Cambrian			Undivided rocks of Precambrian age	Granitic and metamorphic rocks. Depths and altitudes vary widely; depths 10,840 ft in well (D-17-10) 1dbb-1, and 4,083 ft in well (D-22-12)5abd-1.	Characteristics not known. Permeability probably very low.

Table 3.--Results of laboratory analyses of rock samples from

[See table 13 for sample descriptions. Abbreviations:

Location: See description of well- and spring-numbering system.
Median size: Median = d_{50} = diameter of 50 percentile.
Sorting coefficient: Geometric quartile deviation, $\sqrt{Q_3/Q_1}$, taken from cumulative curves representing frequency data of sediments. Q_3 = 25-percent quartile, Q_1 = 75-percent quartile.
Skewness: $(Q_1 \times Q_3)/(\text{median})^2$.
Kurtosis: $(Q_3 - Q_1)/2\ (P_{90} - P_{10})$ taken from cumulative curves. P_{90} = 90 percentile, P_{10} = 10 percentile.
Uniformity coefficient: Uniformity coefficient sorting index = d_{60}/d_{10}.
Carbonate content: Calcium carbonate equivalent by carbon dioxide absorption method.

Location	Sample No.	Grain size (millimeters) in percent by weight							
					Sand				
		Clay <0.004	Silt 0.004-0.0625		Very fine 0.0625-0.125	Fine 0.125-0.25	Medium 0.25-0.50	Coarse 0.5-1.0	Very coarse 1.0-2.0
									Entrada
(D-23-13)24add-1	UTSR-28	-	6.1	-	5.7	40.0	44.2	3.2	0.0
									Navajo
(D-18-12)25aac-1	UTSR-4	-	2.2	-	16.3	47.9	31.6	2.0	0.0
(D-19-10)13dbd-1	UTSR-5	-	2.2	-	27.4	69.4	1.0	.0	.0
(D-19-11)17bba-1	UTSR-26	-	5.2	-	34.2	52.5	7.8	.3	.0
20bca-1 [1]	UTSR-24	-	-	-	-	-	-	-	-
(D-19-12)30bba-1 [2]	NSRT-2-50	-	2.8	-	.6	24.1	72.3	.2	.0
	NSRT-2-60	-	6.4	-	29.1	37.0	26.3	1.2	.0
	NSRT-2-100	8.0	-	10.9	27.3	18.2	35.3	.3	.0
	NSRT-2-140	11.9	-	14.6	33.3	19.9	17.9	2.4	.0
	NSRT-2-180	-	6.9	-	41.1	41.9	9.5	.3	.0
	NSRT-2-210	11.9	-	20.0	37.8	26.0	4.2	.1	.0
	NSRT-2-220	-	8.8	-	40.8	41.4	8.5	.5	.0
	NSRT-2-260	7.0	-	22.8	33.5	29.5	6.9	.3	.0
	NSRT-2-300	8.0	-	25.4	45.7	17.7	3.1	.1	.0
	NSRT-2-340	10.0	-	19.6	60.5	9.3	.3	.3	.0
	NSRT-2-380	7.0	-	24.3	39.3	28.4	1.0	.0	.0
	NSRT-2-420	6.0	-	22.6	53.5	17.0	.9	.0	.0
	NSRT-2-450	12.0	-	27.4	42.1	17.4	1.1	.0	.0
	NSRT-2-500	16.0	-	32.9	34.3	13.9	2.7	.2	.0
(D-20-12)3dab-1	UTSR-27-2	-	.7	-	4.8	17.8	74.4	2.3	.0
	UTSR-27-6	-	1.3	-	17.7	28.0	51.6	1.4	.0
	UTSR-27-9	-	1.5	-	6.7	37.6	53.2	1.0	.0
	UTSR-27-13	-	1.9	-	15.9	27.6	49.5	5.1	.0
(D-20-13)15cad-1	UTSR-20	-	7.9	-	44.7	37.6	9.8	.0	.0
15daa-1	UTSR-21-2	-	2.5	-	18.3	73.5	5.7	.0	.0
	UTSR-21-4	-	2.6	-	10.4	77.9	9.0	.1	.0
(D-21-9)15add-1	UTSR-30	-	6.2	-	44.8	39.0	9.0	1.0	.0
15dda-1	UTSR-29	-	3.5	-	44.5	51.0	1.0	.0	.0
(D-22-13)12aab-1	UTSR-3	5.4	-	1.0	18.5	41.7	33.2	.2	.0
12aba-1	UTSR-2	-	9.7	-	30.2	59.7	.3	.1	.0
12abb-1	UTSR-1	9.6	-	34.7	49.3	6.2	.2	.0	.0
		-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-
12abb-2	UTSR-1A	-	12.7	-	26.0	43.4	17.9	.0	.0
35bdc-1	UTSR-8	-	2.4	-	22.2	63.8	11.6	.0	.0
(D-23-9)3bda-1	UTSR-16	-	6.9	-	51.8	40.2	1.1	.0	.0
3bdb-1	UTSR-15	-	1.1	-	19.3	38.0	41.5	.1	.0
(D-23-13)27bcc-1	UTSR-19A-2	7.4	-	11.5	59.1	19.8	3.3	.1	.0
	UTSR-19A-6	-	4.4	-	30.3	59.2	6.1	.0	.0
28add-1	UTSR-19	-	7.0	-	32.1	42.7	17.6	.6	.0
(D-24-12)35bcd-1	TQUT-5	-	4.5	-	80.0	.5	15.0	.0	.0
35bcd-2	TQUT-4	-	4.0	-	17.0	43.0	35.0	.2	.0
35cbd-2	NS-7A	-	7.2	-	68.8	24.0	.0	.0	.0
(D-24-14)32aac-1	UTSR-18	-	3.4	-	10.2	41.8	42.5	2.1	.0
(D-24-16)12bcb-1	UTSR-7	-	4.0	-	31.3	60.9	3.8	.0	.0
15dbb-1	UTSR-22-2	-	4.6	-	42.8	46.1	6.3	.2	.0
	UTSR-22-9	7.9	-	3.2	41.4	39.8	8.4	.3	.0
									Kayenta
(D-22-10)33bca-1	UTSR-14	-	6.4	-	16.6	71.8	5.2	0.0	0.0
33bca-2	UTSR-14A	19.4	-	26.6	52.9	4.0	.0	.0	.0
									Wingate
(D-19-11)33bbd-1	UTSR-6	-	3.3	-	28.6	47.9	20.2	0.0	0.0
(D-22-13)1dcd-1	UTSR-11	9.0	-	8.1	65.0	18.8	.1	.0	.0
35bcc-1	UTSR-9	6.9	-	33.5	47.0	12.4	.1	.0	.0
(D-23-10)9bbd-2	UTSR-17	12.3	-	6.5	69.4	13.8	1.0	.0	.0

outcrops, test-well drill cuttings, and shallow core holes

mm, millimeters; gm/cm^3, grams per cubic centimeter.]

Median size (mm)	Sorting coefficient	Skewness	Kurtosis	Uniformity coefficient	Dry unit weight (gm/cm^3)	Specific gravity of solids (gm/cm^3)	Carbonate content (percent)
Sandstone							
0.239	1.51	0.971	0.285	2.80	2.01	2.73	-
Sandstone							
0.197	1.48	1.07	0.248	2.62	2.26	2.62	2.4
.153	1.33	.932	.280	2.22	2.24	2.65	.00
.144	1.46	.903	.305	2.38	2.28	2.63	.67
-	-	-	-	-	2.31	2.64	.00
.310	1.30	.953	.266	2.26	-	-	-
.164	1.66	.966	.258	2.90	-	-	-
.144	2.05	1.08	.290	26.4	-	2.67	-
.102	2.00	1.09	.215	41.2	-	2.68	-
.129	1.52	1.00	.299	2.30	-	-	-
.0871	2.37	.486	.279	36.4	-	2.69	-
.126	1.52	.994	.299	2.33	-	-	-
.0949	2.52	.473	.303	22.5	-	2.65	-
.0804	1.82	.645	.220	19.2	-	2.64	-
.0790	1.47	.816	.235	22.1	-	2.66	-
.0869	1.81	.779	.249	17.1	-	2.66	-
.0825	1.56	.781	.205	11.7	-	2.67	-
.0744	2.39	.399	.267	43.9	-	2.65	-
.0639	2.32	.510	.249	39.1	-	2.64	-
.321	1.26	1.00	.238	2.36	1.91	2.66	.08
.260	1.58	.780	.306	3.39	2.17	2.65	.00
.264	1.47	.893	.310	2.33	2.04	2.64	.00
.267	1.59	.797	.303	3.45	2.14	2.64	.00
.120	1.52	1.07	.291	2.22	2.05	2.65	.25
.165	1.27	1.00	.249	2.18	2.10	2.66	.00
.174	1.25	1.00	.268	1.86	-	-	.00
.123	1.51	1.06	.294	2.21	-	2.65	2.3
.128	1.44	.955	.306	2.13	-	2.66	.17
.190	1.54	1.04	.257	3.13	2.21	2.69	1.5
.141	1.45	.845	.308	2.51	2.55	2.65	.17
.0677	1.55	.845	.248	13.1	2.45	2.74	35.8
-	-	-	-	-	-	-	[3]70.7
-	-	-	-	-	-	-	[3]48.8
-	-	-	-	-	-	-	[4]39
.150	1.60	.864	.240	3.21	2.15	2.68	.40
.165	1.31	1.00	.231	2.32	2.12	2.69	.08
.111	1.44	1.06	.288	1.96	1.93	2.66	1.8
.214	1.56	.975	.287	2.98	-	-	-
.0913	1.34	1.00	.157	4.01	2.20	2.67	.00
.150	1.41	.897	.299	2.37	2.09	2.68	.33
.149	1.56	.927	.236	2.63	2.13	2.66	2.7
.0927	1.24	1.00	.0811	1.54	2.02	2.67	.00
.197	1.52	1.04	.262	2.93	2.16	2.73	.00
.0962	1.29	1.00	.199	1.65	-	2.66	.00
.229	1.51	.995	.283	2.75	-	-	-
.148	1.40	.895	.300	2.32	2.32	2.68	.92
.130	1.48	.974	.303	2.21	2.04	2.65	.50
.122	1.53	1.02	.294	2.38	2.10	2.65	.00
Formation							
0.162	1.27	1.00	0.238	2.46	2.00	2.68	2.3
.0685	1.55	.802	.242	81.5	2.20	2.65	1.4
Sandstone							
0.162	1.48	0.934	0.227	2.55	2.16	2.68	0.50
.0897	1.31	1.00	.162	4.16	2.12	2.65	1.6
.0719	1.57	.850	.227	10.5	2.26	2.66	9.6
.0880	1.28	1.00	.145	15.0	1.89	2.69	3.6

Table 3.--Results of laboratory analyses of rock samples from out

Location	Sample No.	Grain size (millimeters) in percent by weight							
		Clay	Silt		Sand				
		<0.004	0.004-0.0625		Very fine 0.0625-0.125	Fine 0.125-0.25	Medium 0.25-0.50	Coarse 0.5-1.0	Very coarse 1.0-2.0
								Moss Back	Sandstone
(D-22-13)35bcc-2	UTSR-10	-	1.7	-	11.2	63.4	23.7	0.0	0.0
									Coconino
(D-21-11)25ddd-1	UTSR-13	-	1.3	-	15.6	60.9	20.3	1.9	0.0
25ddd-2	UTSR-13A-1	-	3.1	-	14.7	48.2	27.1	6.9	.0
	UTSR-13A-3	-	1.5	-	10.1	52.2	31.1	5.1	.0
	UTSR-13A-5 [5]	-	1.3	-	22.7	70.1	5.9	.0	.0
	UTSR-13A-6 [1]	-	-	-	-	-	-	-	-
(D-23-11)27bca-1	UTSR-23-1	-	-	-	-	-	-	-	-
	UTSR-23-5	-	2.9	-	21.0	58.8	13.8	3.4	.1
	UTSR-23-9	-	7.9	-	22.7	53.5	13.7	2.1	.1
(D-23-13)8cbc-1	UTSR-12	-	.5	-	.6	49.6	47.5	1.8	.0

[1] Sample was too hard to disaggregate for sieve analysis.
[2] Last segment of sample number designates depth to bottom of 10-foot sample. All samples from air-rotary drilling in dry formation.
[3] Rerun of carbonate content.
[4] From point count during thin-section analysis by Core Laboratories, Inc. Does not include 8 percent organic material which also is a cementing agent.
[5] Sieve analysis by Core Laboratories, Inc., converted to units and ranges used by the U.S. Geological Survey.

Median size (mm)	Sorting coefficient	Skewness	Kurtosis	Uniformity coefficient	Dry unit weight (gm/cm ^{3})	Specific gravity of solids (gm/cm ^{3})	Carbonate content (percent)
Member of the Chinle Formation							
0.188	1.31	1.00	0.193	2.00	2.28	2.66	0.08
Sandstone							
0.182	1.33	1.00	0.183	2.22	2.14	2.66	0.33
.200	1.51	1.11	.235	2.65	-	-	1.2
.208	1.47	1.11	.255	2.12	1.66	2.65	.08
.162	1.28	1.00	.255	2.19	-	-	-
-	-	-	-	-	2.26	2.64	2.3
-	-	-	-	-	-	-	3.6
.170	1.34	1.00	.180	2.42	2.02	2.66	.17
.161	1.45	.906	.216	2.75	2.10	2.66	.17
.248	1.43	1.02	.301	2.02	2.05	2.64	.00

[Determinations, except as noted, by Core Laboratories, Inc., Dallas, Tex.[1] Abbreviations: ft/d, feet per day; lbs/in^2, pounds per square inch.]
Location: See description of well- and spring-numbering system.
Sample No.: See table 13 for description of samples and sample sites.
Air permeability: See Weeks (1978, p. 3-6) for discussion of relation of air permeability and hydraulic conductivity. See sections on definition of terms and relation of units; a, average of values for two or more samples.
Boyle's Law porosity: See Katz (1959, p. 36-40) for discussion. Determination made with helium; a, average of values for two or more samples.
Overburden pressure: Simulated in laboratory loading chamber.
Calculated porosity: Determined by the U.S. Geological Survey from the ratio of dry unit weight (apparent specific gravity) to the specific gravity of solids (grain density).
Permeability ratios: H/V, horizontal to vertical values; A, air; W, water; W/A, water to air values; H, horizontal; V, vertical.

Location	Sample No.	Horizontal				Overburden pressure (lbs/in^2)
		Permeability (millidarcies)		Hydraulic conductivity (ft/d)	Boyle's Law porosity (percent)	
		Air	Water			
						Entrada
(D-23-13)24add-1	UTSR-28	-	-	-	-	-
						Carmel
(D-19-11)17bba-2	UTSR-25	-	-	-	-	200
						Navajo
(D-18-12)25aac-1	UTSR-4	-	-	-	-	-
(D-19-10)13dbd-1	UTSR-5	-	-	-	-	-
(D-19-11)17bba-1	UTSR-26	-	-	-	-	200
20bca-1	UTSR-24	26	14	0.034	11.5	200
		26	12	.029	11.4	500
(D-20-12)3cab-1	UTSR-27-1	-	-	-	-	200
			-	-	-	500
	UTSR-27-2	-	-	-	-	-
	UTSR-27-4	1,420	1,030	2.5	19.4	200
		-	640	1.6	-	500
	UTSR-27-6	-	-	-	-	-
	UTSR-27-7	1,920	-	-	18.5	200
	UTSR-27-9	-	-	-	-	-
	UTSR-27-12	3,930	2,110	5.1	19.6	200
	UTSR-27-13	-	-	-	-	-
(D-20-13)15cad-1	UTSR-20	500	69	.17	20.6	200
15daa-1	UTSR-21-1	-	-	-	-	200
	UTSR-21-2	-	-	-	-	-
	UTSR-21-3	1,270	200	.49	22.1	200
(D-21-9)15add-1	UTSR-30	-	-	-	-	-
15daa-1	UTSR-29	-	-	-	-	-
(D-22-13)12aab-1	UTSR-3	-	-	-	-	200
12aba-1	UTSR-2	14	4.6	.011	14.1	200
		13	3.6	.0089	13.8	500
12abb-1	UTSR-1	.03	<.01	<.00002	6.7	200
		.02	<.01	<.00002	6.7	500
	UTSR-1A	-	-	-	-	-
35bdc-1	UTSR-8	590	330	.80	20.7	200
(D-23-9)3bda-1	UTSR-16	1,150	660	1.6	26.3	200
		-	600	1.5	-	500
(D-23-13)27bcc-1	UTSR-19A-1	-	-	-	-	200
	UTSR-19A-2	-	-	-	-	-
	UTSR-19A-3	175	-	-	17.5	200
	UTSR-19A-6	-	-	-	-	-
	UTSR-19A-7	1,530	560	1.4	21.2	200
28add-1	UTSR-19	-	-	-	-	-
(D-24-12)35bcd-1	TQUT-5[2]	-	-	-	-	-
	DAN-15	-	-	-	-	200
	DAN-18	-	-	-	-	200
	DAN-19	-	-	-	-	200
35bcd-2	TQUT-4[2]	-	-	-	-	-
	DAN-21	-	-	-	-	200
	DAN-22	-	-	-	-	200
	DAN-23	-	-	-	-	200
35cbd-2	76UT-39-1[2]	-	-	-	-	-
	76UT-39-2[2]	-	-	.30	-	-
	NS-7A	264	-	-	24.3	200
		256	-	-	24.1	500
		224	-	-	23.1	1,000
		215	-	-	22.8	1,500
(D-24-16)12bcb-1	UTSR-7	-	-	-	-	200
15bdd-1	UTSR-22-1	-	-	-	-	200
	UTSR-22-2	-	-	-	-	-
	UTSR-22-5	550	190	.46	21.4	200
	UTSR-22-9	-	-	-	-	-
						Kayenta
(D-22-10)33bca-1	UTSR-14	1,200	500	1.2	23.4	200
33bca-2	UTSR-14A	1.7	.3	.00073	14.1	200

of outcrop and core samples

Permeability (millidarcies) Air	Permeability (millidarcies) Water	Vertical Hydraulic conductivity (ft/d)	Boyle's Law porosity (percent)	Calculated porosity (percent)	Permeability ratios H/V A	Permeability ratios H/V W	Permeability ratios W/A H	Permeability ratios W/A V
Sandstone								
-	-	-	-	26.4	-	-	-	-
Formation								
0.02	-	-	2.3	-	-	-	-	-
Sandstone								
-	-	-	-	13.7	-	-	-	-
-	-	-	-	15.5	-	-	-	-
22	3.9	0.0095	13	13.3	-	-	-	0.18
16	8.5	.021	11.6	12.5	1.63	1.65	0.54	.54
-	6.5	.016	-	-	-	1.85	.46	-
1,110	340	.83	18	-	-	-	-	.31
-	290	.71	-	-	-	-	-	-
-	-	-	-	28.6	-	-	-	-
1,930	-	-	20.7	-	.74	-	.73	-
-	-	-	-	-	-	-	-	-
-	-	-	-	18.1	-	-	-	-
975	-	-	17.9	-	.51	-	-	-
-	-	-	-	23.1	-	-	-	-
3,430	-	-	20.9	-	1.15	-	.54	-
-	-	-	-	18.9	-	-	-	-
-	-	-	-	22.6	-	-	.14	-
340	79	.19	19.2	-	-	-	-	.23
-	-	-	-	21	-	-	-	-
325	-	-	20.8	-	3.91	-	.16	-
-	-	-	-	21.1	-	-	-	-
-	-	-	-	23.3	-	-	-	-
1,280	460	1.1	19.1	15.6	-	-	-	.36
13	1.5	.0037	14.5	3.8	1.08	3.07	.33	.12
-	-	-	-	-	-	-	.28	-
<.01	<.01	<.00002	3.6	10.6	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	19.8	-	-	-	-
-	-	-	-	21.2	-	-	.56	-
860	430	1.0	26.8	27.4	1.34	1.54	.57	.50
-	-	-	-	-	-	-	-	-
42	2.6	.0063	15.8	-	-	-	-	.062
-	-	-	-	17.6	-	-	-	-
120	-	-	17	-	1.46	-	-	-
-	-	-	-	22	-	-	-	-
285	-	-	19	-	5.37	-	.37	-
-	-	-	-	19.9	-	-	-	-
-	-	1.5	-	24.3	-	-	-	-
311	-	-	16.5	-	-	-	-	-
983	-	-	16.4	-	-	-	-	-
688	-	-	15.9	-	-	-	-	-
-	-	-	-	20.9	-	-	-	-
1,000	-	-	12.7	-	-	-	-	-
946	-	-	14.1	-	-	-	-	-
385	-	-	14.6	-	-	-	-	-
-	-	1.3	-	25.2	-	-	-	-
-	-	.24	-	24.1	-	1.25	-	-
220	-	-	23	24.8	1.20	-	-	-
196	-	-	22.9	-	1.31	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
43	7.1	.017	14.3	13.4	-	-	-	.17
480	275	.67	21.3	-	-	-	-	.57
-	-	-	-	23	-	-	-	-
500	-	-	208	-	1.10	-	.35	-
-	-	-	-	20.7	-	-	-	-
Formation								
580	170	.41	24	25.3	2.07	2.94	.42	.29
1.2	.3	.00073	16.7	16.9	1.42	1[illegible]	.18	.25

Table 4.--Permeability and porosity

Location	Sample No.	Permeability (millidarcies) Air	Permeability (millidarcies) Water	Horizontal Hydraulic conductivity (ft/d)	Boyle's Law porosity (percent)	Overburden pressure (lbs/in^2)
						Wingate
(D-19-11)33bbd-1	UTSR-6	-	-	-	-	-
(D-22-13)1cdd-1	UTSR-11	560	340	0.83	24.8	200
35bcc-1	UTSR-9	-	-	-	-	-
(D-23-10)9bbd-2	UTSR-17	-	-	-	-	-
						Moss Back Sandstone
(D-22-13)35bcc-2	UTSR-10	-	-	-	-	-
						Sinbad Limestone Member
(D-17-12)1bba-1[3,4]	-	-	.0a	.0a	6.7a	-
(D-24-13)23cdc-1[3]	1	48	-	-	20.4	200
	2	16	-	-	17.3	200
	3	.13	-	-	4.4	200
	1-6	23a	-	-	14.3a	200
	7	6.4	-	-	11.1	200
	8-23	.46a	-	-	7.4a	200
	24-28	.076a	-	-	3.1a	200
	29	.03	-	-	3	200
(D-25-13)12bcc-1[3]	1-6	.07a	-	-	4.2a	200
	7	.03	-	-	.8	200
	8-12	.05a	-	-	3.1a	200
	13-15	.03a	-	-	2.4a	200
	16-19	1.08a	-	-	5.5a	200
	20-21	1.04a	-	-	10.5a	200
	22-23	.93a	-	-	10.5a	200
	24-26	.037a	-	-	1.5	200
	27	10	-	-	19.2	200
	28-33	.27a	-	-	7.2	200
	34	7.1	-	-	8.9	200
	36	-	-	-	11.2	200
						Kaibab
(D-24-13)23cdc-1[3]	30-51	.05a	-	-	1.9a	200
	52	2.7	-	-	13.5	200
	53-59	108a	-	-	6.8a	200
	60	2.8	-	-	12	200
	61	.78	-	-	10.5	200
	62-65	.58a	-	-	8.5a	200
						Coconino
(D-21-11)25ddd-1	UTSR-13	-	-	-	-	-
25ddd-2	UTSR-13B-1	-	-	-	-	200
	UTSR-13B-2	375	190	.46	15.1	200
	UTSR-13A-3	-	-	-	-	-
	UTSR-13A-5	970	650	1.6	18.8	200
	UTSR-13A-6	-	-	-	-	-
(D-23-11)27bca-1	UTSR-23-4	1,390	-	-	21.7	200
	UTSR-23-5	-	-	-	-	-
	UTSR-23-6	3,080	1,850	4.5	24.6	200
	UTSR-23-9	-	-	-	-	-
(D-23-13)8cbc-1	UTSR-12	-	-	-	-	-
						Mississippian
(D-25-13)12bac-1[3]	37-41	.46a	-	-	10.1a	200
	42	2.6	-	-	20.2	200
	43-47	1.2a	-	-	19.4a	200
	48	6	-	-	21.6	200
	49	7	-	-	15.8	200
	50	5.1	-	-	20.1	200
	51-53	.31a	-	-	12a	200
	54-56	.53a	-	-	2.63a	200
	57-58	.18a	-	-	8.2a	200
	59-60	.045a	-	-	7.4a	200
	61-62	.14a	-	-	9.7a	200
	63-67	.029a	-	-	6.3a	200
	69-72	-	-	-	-	-

1 In samples submitted by the U.S. Geological Survey, horizontal or vertical 1 1/2-inch plugs were drilled, using water as the coolant and lubricant. Plug samples were leached of salts with methyl alcohol and then thoroughly dried. Air permeability and Boyle's Law (helium) porosity were determined for these dry cores. Selected samples were evacuated and pressure saturated with filtered, degassed Dallas tap water. Specific water permeability was determined using that water.

2 From Hood and Danielson (1981, tables 11 and 12).

3 Data from petroleum-test wells (table 11), filed with the U.S. Geological Survey by the lease operator.

4 Determinations by Rocky Mountain Engineering Co., Denver, Colo.

of outcrop and core samples

Permeability (millidarcies) Air	Permeability (millidarcies) Water	Vertical Hydraulic conductivity (ft/d)	Boyle's Law porosity (percent)	Calculated porosity (percent)	Permeability ratios H/V A	Permeability ratios H/V W	Permeability ratios W/A H	Permeability ratios W/A V
Sandstone								
-	-	-	-	19.4	-	-	-	-
290	150	0.37	23.1	20	1.93	2.27	0.61	0.52
-	-	-	-	15	-	-	-	-
-	-	-	-	29.7	-	-	-	-
Member of Chinle Formation								
-	-	-	-	14.3	-	-	-	-
of Moenkopi Formation								
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
Limestone								
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
Sandstone								
-	-	-	-	19.5	-	-	-	-
200	130	.32	16.2	-	-	-	-	.65
-	-	-	-	-	-	-	.51	-
-	-	-	-	37.3	-	-	-	-
550	-	-	16.3	-	1.76	-	.67	-
-	-	-	-	14.8	-	-	-	-
430	-	-	21.2	-	3.23	-	-	-
-	-	-	-	24	-	-	-	-
625	-	-	22.1	-	4.95	-	.60	-
-	-	-	-	21.1	-	-	-	-
-	-	-	-	22.3	-	-	-	-
rocks								
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-

Table 5.--Summary of short aquifer tests
[See text for definitions of terms and relation of units. Abbreviations: gal/min, gallons per minute; ft, feet; ft^2/d, feet squared per day; ft/d, feet per day; hrs, hours.]

Discharge: E, estimated; F, flowed. Value is weighted average where not estimated.
Transmissivity from straight-line methods: Each analytical plot contains two or three straight-line segments. Values are listed in order of increasing time since recovery began.
Remarks: Temperature and specific conductance measured at well. Temperature is in degrees Celsius (°C). Specific conductance is in micromhos per centimeter at 25°C (umhos), as determined by conductivity meter.

Well number	Date	Pumping period (hrs)	Discharge (gal/min)	Maximum observed drawdown (ft)	Transmissivity (ft^2/d): From straight-line methods	Transmissivity (ft^2/d): Estimated from specific capacity	Hydraulic conductivity (ft/d)	Remarks
(D-17-13)30ddd-1S	6-28-79	4.00	11.8	[1]40.4	61 455 150	67	0.3 2 .7	Petroleum-test well plugged back and left for water well; never used. May have been somewhat cleaned out by test pumping. Water level 1 year later was about 20 ft lower than pre-pumping level. Final temperature, 16.0 °C; specific conductance, 11,600 umhos.
(D-20-10)6bdd-1	7-14-80	>12	10 E,F	([2])	642 256	-	2 .8	U.S. Geological Survey test hole NSRT-1. Navajo Sandstone isolated with borehole packer set at 142 ft. Artesian-pressure recovery measured for 1.2 hrs. Final temperature, 13.0°C; specific conductance, 968 umhos.
(D-23-14)25bca-1	7-23-80	>17	14 F	([2])	27 37	-	.1 .2	U.S. Geological Survey test hole NSRT-6A. Navajo Sandstone isolated with borehole packer set at 445 ft. Artesian-pressure recovery measued for 1.73 hrs. Final temperature, 16.5°C; specific conductance, 842 umhos.
(D-24-13)11adb-1S	5-14-80	3.17	10.2	[3]>10	53 171	-	.1 .4	Petroleum-test well plugged back and left for water well; never used. Open hole from Entrada Sandstone to Chinle Formation. Final temperature, 17°C; specific conductance, 1,068 umhos.
(D-24-13)36dba-1	5-13-80	2.0	13.3	25.9	-- 36 260	100	.2 .09 .6	Unused well. Open hole from Navajo Sandstone to Chinle Formation. Final temperature 15.0°C; specific conductance, 2,530 umhos.

1 Actual measurement. Neglects probable effect of surface inflow that would have made pre-pumping water level abnormally high.
2 Initial shut-in head unknown. Water levels affected by drilling procedures; hole flowed for hours prior to test.
3 No pumping level measured because of depth to water and size of hole.

Table 6.—Summary of hydrologic estimates

[Abbreviations: acre-ft/yr, acre-feet per year.]

Complete hydrologic system	Long-term average (acre-ft/yr)
Inflow	
Precipitation (p. 28)	1,150,000
Price River; stations 09314250 plus 09314280 (table 7)	68,857
San Rafael River at station 09328000	56,071
Ground-water inflow	none
Total (rounded)	1,300,000
Outflow	
Price River at station 09314500 (table 7)	70,606
San Rafael River at station 09328500	61,251
Estimated yield of ungaged areas (table 7)	3,000
Discharge by wells, probable maximum (p. 34)	200
Ground-water outflow, minimum (from below)	600
Evapotranspiration, gross	[1] 1,139,000
Total (rounded)	1,300,000
Ground-water system[2]	
Navajo Sandstone[3]	
Recharge	
From precipitation (p. 30)	3,000
From ground-water inflow	none
Total	3,000
Discharge (p. 34)	
To San Rafael and Green Rivers	2,000
Ground-water outflow	600
Evapotranspiration	400
Total	3,000
Complete ground-water system	
Recharge (p. 30)[4]	10,000
	Acre-ft
Storage in three major consolidated aquifers (p. 33)	440,000,000
Recoverable fresh to moderately saline water	[5] 160,000,000

[1] Amount calculated by difference between other individual items of inflow and outflow.
[2] Incomplete budget because of unknowns.
[3] Rounded amount for each item as used or inferred from steady-state digital model for best fit of potentiometric surface.
[4] Assumed to equal long-term discharge.
[5] Assumes complete drainage of Navajo, Wingate, and Coconino Sandstones.

Table 7.—Stream gains or losses, in acre-feet, across San Rafael Swell, 1973-79

[See pl. 1 for locations of stations. Abbreviations: ft^3/s, cubic feet per second.]

Station	Water year							
	1973	1974	1975	1976	1977	1978	1979	Average
				Price River				
09314250	106,900	29,900	72,960	30,250	15,740	31,760	87,700	53,601
09314280	21,700	11,830	22,990	14,980	6,010	7,440	21,840	15,256
Subtotal	128,600	41,730	95,950	45,230	21,750	39,200	109,540	68,857
09314500	139,000	39,120	97,550	42,650	22,670	42,950	110,300	70,606
Net gain or (loss)	10,400	(2,610)	1,600	(2,580)	920	3,750	760	1,749
								or 2.4 ft^3/s
				San Rafael River				
09328000	109,100	41,740	89,940	32,390	12,160	37,770	69,400	56,071
09328100	–	–	–	32,260	14,430	35,340	70,240	–
For reach	–	–	–	(130)	2,270	(2,430)	840	–
09328500	138,600	36,910	91,580	24,920	15,170	42,530	79,050	61,251
For reach	–	–	–	(7,340)	740	7,190	8,810	–
Net gain or (loss)	29,500	(4,830)	1,640	(7,470)	3,010	4,760	9,650	5,180
								or 7.2 ft^3/s
					Total for gaged reaches			6,930
					Estimated yield of ungaged area			3,000
					Total (rounded)			10,000
								or 13.8 ft^3/s

Table 8.--Monthly mean discharge at streamflow-gaging stations

[Discharge is in cubic feet per second; from files of U.S. Geological Survey, Salt Lake City, Utah.

Asterisk *, no value for month because 1 or more days of record is missing.]

Station 09314250 Price River below Miller Creek, near Wellington

Year	October	November	December	January	February	March	April	May	June	July	August	September
1972	*	*	*	*	*	*	44.10	43.61	48.53	26.03	33.55	27.57
1973	146.10	38.33	37.68	35.00	43.18	116.19	259.23	676.13	158.33	110.77	94.13	43.00
1974	45.71	30.07	40.03	40.00	40.00	54.39	40.57	62.94	48.43	57.10	17.10	18.20
1975	63.90	42.83	29.68	32.74	46.07	62.39	101.70	171.48	462.77	90.74	47.61	60.70
1976	36.61	45.77	25.42	32.55	47.90	45.52	47.70	49.68	44.77	40.52	34.74	50.00
1977	28.13	21.00	16.94	10.00	12.89	16.71	11.22	23.97	8.11	81.53	18.47	9.90
1978	15.44	14.76	9.42	8.39	10.00	46.84	157.60	140.23	42.47	43.29	23.79	12.57
1979	23.00	185.23	24.19	19.13	22.79	271.16	300.97	390.55	82.33	46.13	56.55	25.70
1980	22.71	25.47	21.52	26.71	103.34	107.97	369.80	811.29	595.40	71.77	65.74	215.47
1981	791.57	*	*	*	*	*	*	*	*	*	*	*
Average	68.12	50.43	25.61	25.56	41.08	90.15	148.10	263.32	165.68	63.10	43.52	51.46

Station 09314280 Desert Seep Wash near Wellington

Year	October	November	December	January	February	March	April	May	June	July	August	September
1972	*	*	*	*	*	*	*	21.38	14.49	11.30	11.03	22.11
1973	47.61	23.77	13.39	7.74	8.05	20.16	27.73	36.10	60.43	40.45	28.00	29.53
1974	27.65	24.87	13.77	8.32	8.00	12.35	16.95	19.19	21.47	21.65	11.82	9.45
1975	36.06	29.03	10.85	6.13	5.71	27.52	16.30	27.26	53.33	67.16	36.42	50.97
1976	45.84	30.87	13.00	10.45	12.11	16.15	26.73	28.61	16.54	12.87	13.82	20.49
1977	18.03	15.47	9.45	2.00	3.71	5.77	4.38	6.82	1.83	20.98	7.44	2.96
1978	2.76	4.24	3.25	4.14	5.21	22.22	11.08	20.06	24.70	10.62	7.15	7.55
1979	9.20	35.00	7.84	6.85	7.16	169.94	22.30	25.00	23.20	18.29	20.65	13.56
1980	17.55	19.17	13.03	14.06	61.07	30.48	24.23	103.26	40.07	35.16	26.45	67.77
Average	25.59	22.80	10.57	7.46	14.08	38.07	18.71	32.36	28.45	26.50	18.09	24.93

Station 09314500 Price River at Woodside

Year	October	November	December	January	February	March	April	May	June	July	August	September
1947	67.74	42.57	34.77	18.48	52.07	76.35	79.10	106.06	55.10	35.48	238.29	37.43
1948	51.68	37.33	41.35	28.29	49.59	69.00	74.07	47.87	43.07	42.87	94.95	10.22
1949	31.81	27.20	28.48	28.19	46.75	162.84	225.63	213.13	246.33	211.71	76.58	92.63
1950	95.10	47.97	35.58	28.00	103.39	102.32	222.90	132.13	71.67	164.19	52.23	69.43
1951	48.94	51.30	48.16	33.55	51.96	81.71	51.03	84.16	100.40	70.03	314.45	54.67
1952	90.61	52.43	30.06	31.13	48.10	152.00	645.63	1762.26	888.37	145.35	150.68	89.90
1953	75.61	71.03	59.23	56.00	63.21	85.29	69.80	75.45	85.17	101.03	175.68	55.03
1954	87.39	63.30	36.71	40.65	78.46	76.77	59.93	62.23	52.90	63.97	50.32	199.80
1955	133.55	48.60	24.19	20.00	23.04	173.74	101.37	53.00	33.90	25.51	78.45	15.85
1956	22.13	28.03	43.97	34.26	38.83	56.84	38.73	39.84	25.57	48.06	22.10	8.33
1957	19.35	18.63	14.00	16.71	41.00	43.61	36.30	197.48	171.77	104.10	477.71	82.60
1958	97.58	337.00	51.03	50.00	81.93	90.94	356.33	643.16	221.37	70.81	78.77	109.30
1959	46.32	44.30	48.45	40.23	45.39	45.35	29.13	26.42	21.90	9.95	105.63	71.46
1960	33.10	32.83	26.23	26.13	30.00	103.74	37.37	20.42	14.81	4.21	17.56	40.60
1961	190.15	23.80	19.57	10.70	22.57	25.58	14.99	5.26	1.51	8.63	99.64	457.17
1962	18.52	26.23	21.49	15.16	134.61	133.55	473.57	198.10	47.07	162.35	10.81	250.72
1963	95.84	27.97	23.36	13.58	45.68	108.28	25.65	21.61	25.51	24.61	251.20	199.89
1964	22.45	23.17	15.23	11.32	17.97	31.00	54.07	94.16	47.30	31.52	166.84	31.97
1965	18.29	25.90	25.71	39.58	52.57	52.03	162.27	460.87	308.60	271.48	137.03	99.67
1966	80.26	90.77	88.77	54.58	59.32	188.35	168.83	88.19	54.77	61.84	50.55	116.90
1967	38.74	34.33	100.68	24.84	53.36	77.74	61.03	92.52	425.17	157.77	96.35	107.90
1968	45.35	38.77	46.87	33.00	45.86	71.84	109.47	298.61	509.53	105.32	295.23	71.20
1969	95.13	59.90	31.61	32.26	36.00	348.77	534.73	682.48	324.23	128.10	213.97	193.57
1970	78.81	63.43	41.65	35.39	65.75	75.65	58.93	78.10	263.60	98.74	100.23	98.67
1971	58.61	66.47	45.68	27.58	55.43	84.42	93.87	127.23	117.03	57.77	84.13	53.50
1972	103.52	80.93	36.68	34.10	36.21	125.16	66.33	64.68	73.73	40.87	46.84	42.63
1973	365.06	67.80	48.55	40.00	50.43	173.87	259.57	735.29	226.37	164.55	93.48	60.37
1974	69.90	54.03	61.74	60.61	60.64	60.74	51.00	74.87	60.83	58.48	18.84	16.23
1975	94.87	68.37	41.61	42.74	58.61	93.39	125.37	174.74	492.40	235.39	77.87	112.50
1976	81.65	89.50	35.42	41.52	63.79	62.55	71.17	70.90	48.43	39.26	35.00	67.47

Table 8.--Monthly mean discharge at streamflow-gaging stations--Continued

Station 09314500 Price River at Woodside--Continued

Year	October	November	December	January	February	March	April	May	June	July	August	September
1977	39.42	31.70	34.19	20.00	20.00	26.77	16.77	21.60	3.85	120.23	29.60	8.42
1978	31.48	18.66	12.24	13.06	22.14	124.42	172.93	168.84	53.13	48.68	25.82	17.66
1979	20.29	179.47	25.06	22.52	39.93	375.03	367.70	533.58	104.10	52.65	69.13	30.03
1980	34.35	38.83	34.06	44.58	176.59	134.77	383.67	929.74	671.10	102.90	104.65	450.80
1981	6.00	*	*	*	*	*	*	*	*	*	*	*
Average	72.48	59.19	38.60	31.43	55.05	108.66	155.86	246.62	173.25	90.25	115.90	100.72

Station 09315000 Green River at Green River

Year	October	November	December	January	February	March	April	May	June	July	August	September
1895	3250.00	2934.33	2236.77	2168.39	2136.07	3776.45	8276.00	21406.45	14613.33	9434.84	3343.23	1771.33
1896	2023.87	1585.83	1304.52	1331.61	1385.17	2461.61	4843.33	12639.35	26336.67	6720.97	3236.77	3062.00
1897	2109.35	1725.00	1300.00	1000.00	1200.00	2000.00	6434.33	40990.32	24796.67	6126.45	3255.81	3232.00
1898	5261.93	2940.67	1398.39	1000.00	1050.00	2576.13	7699.33	13393.55	17016.67	8030.32	2250.97	1744.67
1899	1504.52	1376.33	1297.42	1597.42	1721.43	2797.42	5618.33	15481.29	32440.00	20978.06	8185.16	2857.67
1905	*	*	*	*	*	2988.06	4072.67	12942.26	24293.33	7640.96	2726.77	2506.67
1906	2479.03	2053.33	1318.06	1400.00	1616.43	6106.45	9578.67	24777.42	28500.00	13432.90	6172.90	5079.33
1907	3023.55	3258.00	2429.68	2440.00	3793.93	6755.16	13983.33	24670.96	38836.67	31625.81	11221.94	4821.67
1908	3671.29	2564.67	1468.06	1300.00	1533.79	3572.90	6579.67	11641.61	18066.67	10258.06	6813.87	3381.33
1909	3584.52	2159.00	801.45	1978.71	1716.79	8124.19	9292.00	22409.68	46310.00	25229.03	10275.16	9959.67
1910	3932.58	2981.33	1291.13	1000.00	2500.71	11434.52	12523.33	21232.26	13659.00	3228.06	2158.39	2035.67
1911	3274.52	2273.67	1515.81	2330.97	3441.07	6282.90	5481.00	11729.35	19383.33	8456.45	2925.81	1975.00
1912	3802.58	2244.67	1642.58	1720.97	1798.28	3688.71	6551.33	16086.13	37630.00	16270.97	6864.19	3624.33
1913	3655.48	3505.67	1523.87	2303.23	2228.57	4156.45	12813.33	16498.71	19426.67	14726.45	4330.00	3831.33
1914	3564.52	3253.00	1679.03	1950.00	2640.36	6431.94	12588.67	28522.58	35683.33	13631.61	4617.10	2624.67
1915	3958.06	2723.00	1531.29	1500.00	1766.43	3034.52	7439.00	10988.06	15606.67	6159.03	2075.16	3118.33
1916	3937.42	2834.00	1878.71	1715.48	2237.93	9075.48	10524.33	20958.06	22996.67	10341.61	5748.06	2570.67
1917	4994.19	2565.00	2054.84	1293.55	2089.29	3350.65	11930.33	26222.58	46303.33	27993.55	6655.48	4010.67
1918	3256.45	3096.33	2723.23	2351.61	2450.00	4081.94	6474.67	13772.90	29046.67	11480.97	3276.13	2572.00
1919	3684.84	3013.00	2116.13	1420.32	1750.00	4495.81	7974.67	14854.84	9286.33	1754.68	1203.19	1787.80
1920	1993.87	2101.67	1472.90	1748.39	2431.38	3965.16	6533.67	26723.55	34056.67	10220.00	4533.55	2537.33
1921	2607.10	3313.00	1896.13	1970.97	3042.14	7669.03	7449.67	25160.32	46653.33	10753.22	5501.61	3434.67
1922	2346.13	2463.33	2179.03	1753.71	2474.29	6420.65	6045.67	26770.97	37423.33	8595.16	4071.29	2885.33
1923	2061.61	2587.00	2131.94	2198.06	2118.57	3672.58	11468.33	25832.26	30850.00	12942.90	5782.58	3302.67
1924	3887.42	3382.33	2066.45	1444.19	2868.28	3305.81	11311.33	15880.00	12590.00	3627.42	1473.23	1499.33
1925	1708.06	2052.33	1178.84	1451.61	2332.14	4475.16	7887.00	13688.39	14100.00	9267.74	4371.94	4529.00
1926	4846.77	3222.00	2372.58	1897.10	2274.64	5601.61	10269.00	18235.81	13120.67	5766.45	3228.39	1575.33
1927	1923.87	1728.67	1685.32	1656.13	1996.07	3545.48	6466.33	20748.39	22066.67	12333.23	3754.84	8514.67
1928	4935.48	4320.33	2334.84	2801.94	2724.83	6432.26	6636.67	30561.29	21156.67	7240.32	3692.90	2095.33
1929	3567.10	2849.00	1585.94	2007.42	1971.43	7857.74	12236.33	25058.06	26273.33	10400.00	4769.35	6346.00
1930	4156.77	2792.33	2136.90	1252.90	4163.57	3981.61	10254.67	11827.74	17476.67	5512.90	8228.39	3795.00
1931	3926.13	2481.33	1863.23	1531.94	1943.21	3506.45	4982.67	7782.90	7447.33	1692.65	1488.71	943.20
1932	1484.84	1498.43	869.35	1288.39	1588.62	4127.42	8254.67	22529.68	20930.00	10906.13	3863.55	2254.33
1933	1898.39	2275.00	1264.55	1454.84	1677.50	3094.52	4504.67	10772.90	23033.33	5426.45	1742.26	1345.00
1934	1231.94	1485.67	1392.00	1625.48	2149.29	2155.16	2927.33	4632.26	2128.00	645.03	711.81	603.07
1935	717.68	934.83	927.68	1112.16	1508.93	1892.90	2891.67	7430.97	21240.00	5393.55	2019.68	1272.60
1936	958.84	1393.33	986.71	1083.87	1575.86	2288.39	7519.67	21374.19	17664.67	6180.65	5160.00	2291.00
1937	1921.61	2194.00	1317.29	1000.00	1700.00	4575.48	7583.00	18813.55	15103.33	8994.84	2593.87	2474.67
1938	1986.77	2089.67	1953.35	1643.23	2253.93	4277.42	7862.00	18248.71	22603.33	7910.32	2820.65	4982.00
1939	3809.35	2875.00	2498.71	2082.58	1863.93	6342.58	7499.33	14347.42	8804.33	2638.71	1609.35	2119.63
1940	2051.94	1650.00	1442.10	1327.48	1678.97	3231.61	4260.33	11436.13	8271.67	1736.32	804.61	1361.47
1941	2464.19	1902.67	1556.06	1629.68	2269.64	3513.87	5268.33	19061.61	19263.33	5829.68	4350.32	3057.00
1942	5169.35	4028.67	2736.13	1823.29	2206.43	4298.71	14412.33	15932.26	21353.33	6743.55	2473.23	1524.33
1943	1912.90	2077.33	1894.84	1816.45	2336.07	3834.52	9568.33	12409.35	18050.00	9954.52	4880.00	1951.00
1944	2015.48	2451.67	1823.23	1367.42	1935.52	4104.52	8884.67	15032.90	23380.00	9617.10	2322.58	1224.33
1945	1867.10	2001.33	1438.39	1770.32	2302.50	3013.55	4888.67	14783.22	17073.33	11396.45	5455.16	2734.33
1946	2620.00	2503.67	1834.84	2000.00	2105.36	3833.23	8876.33	12606.77	12543.00	4288.06	2471.94	1758.67
1947	2420.00	2862.33	2503.87	1487.1	2717.86	6686.77	7090.00	22767.42	22646.67	10667.10	5941.94	2786.67
1948	2943.23	3006.33	2478.39	2290.65	2373.45	5097.42	9374.33	17250.32	16000.66	4357.74	2230.32	1159.00
1949	1499.68	1739.67	1577.10	1633.23	1976.79	4495.48	7963.33	19861.29	25993.33	9629.68	2798.39	1871.67
1950	3361.61	3200.67	2078.61	2290.32	2637.14	5794.84	10419.00	16690.65	26330.00	11940.65	3997.74	2503.00
1951	2492.26	2792.00	2779.35	1842.90	3010.36	3326.45	6247.00	14345.81	22000.00	10200.32	6158.39	2986.00
1952	3421.29	2754.67	2140.65	2187.10	2440.00	2601.29	16597.00	34096.77	30396.67	8365.16	5124.52	3095.67
1953	2096.13	2059.33	2096.45	2271.61	2542.14	3525.48	3712.33	7381.94	19610.00	6120.32	3441.61	1467.67
1954	1403.23	2106.67	1742.58	1744.52	2486.79	2751.61	4537.00	10402.58	6316.33	5623.22	1946.13	2253.33

Station 09315000 Green River at Green River--Continued

Year	October	November	December	January	February	March	April	May	June	July	August	September
1955	2253.87	2015.00	1295.48	1296.45	1555.71	3861.94	5226.33	11020.32	11000.00	3620.00	2616.45	1187.87
1956	1255.48	1449.73	2064.84	2513.87	1735.66	5110.00	7731.33	16180.65	20290.00	4776.77	2750.32	1217.00
1957	1243.48	1666.00	1291.61	1354.19	1801.43	3846.13	4878.00	14842.90	31436.67	18927.42	6282.90	3390.67
1958	3006.13	3834.00	2421.61	2076.45	3306.43	4004.84	7263.00	21318.39	19726.33	3643.23	1791.94	1609.33
1959	1481.29	1713.67	1857.74	1579.03	2043.57	2379.03	3678.33	7812.26	12817.33	5627.42	2919.68	1742.67
1960	2898.06	2552.00	1728.39	1546.77	1768.62	5209.68	8968.33	8961.93	11469.67	2768.39	1121.23	986.93
1961	1564.87	1767.67	1306.77	1291.94	1692.86	2220.65	3097.67	5554.84	9110.33	1815.39	1292.90	2946.33
1962	3809.35	2700.33	2043.55	1861.29	7258.21	6520.97	18366.67	21948.39	18053.33	9725.48	2871.29	1647.00
1963	2044.52	1586.67	1178.26	1157.65	2151.43	1617.42	2590.67	6485.16	5205.00	824.77	1170.29	1594.03
1964	772.06	1242.50	1369.74	1767.42	1976.55	2087.10	3191.33	10306.45	12181.33	5590.00	3194.84	2345.00
1965	3184.84	3364.67	4340.00	4883.22	5452.14	5877.74	8707.33	13314.52	20286.67	6879.03	3710.65	3172.67
1966	4108.06	4023.33	4033.87	2948.71	2983.57	6397.74	6550.33	9197.42	5467.67	2380.97	2382.26	2645.00
1967	3077.10	2672.33	2378.39	3190.32	3042.86	4159.35	4375.67	8194.52	19060.00	8254.52	4020.32	3882.00
1968	4061.94	4087.00	3730.00	4045.16	3406.55	3927.42	4618.00	11523.23	20966.67	6922.26	5618.06	4043.33
1969	3750.00	3715.00	3396.45	4589.03	5632.50	5763.55	11048.33	17812.90	11497.00	5812.26	4396.13	4133.33
1970	4151.61	3972.00	4404.52	3106.13	3155.00	3148.39	4176.33	14093.87	17123.33	6835.16	3447.74	3014.33
1971	2836.45	2675.00	2354.19	2511.61	2968.93	3279.68	8052.66	11617.74	17820.00	6456.13	3203.55	3521.00
1972	3432.90	4412.67	4343.55	4425.81	5264.48	5245.81	5439.33	10332.90	14010.33	4008.71	3277.42	2076.00
1973	4919.35	5721.67	4508.06	4296.77	4778.57	5562.26	5092.33	18990.00	17970.00	8469.03	4932.58	3908.00
1974	3755.16	4291.67	3880.97	3756.77	2706.43	4880.97	5991.33	19174.19	14992.00	4370.00	3128.71	2909.00
1975	3720.00	3916.00	3330.97	4231.29	4653.93	4056.13	3768.00	10605.8	21056.66	14613.55	5173.22	2872.00
1976	2608.71	3438.00	4748.06	4205.81	4331.38	4774.19	5205.33	12443.55	11051.00	4574.84	3356.45	3109.67
1977	3485.48	3684.33	3671.29	3849.68	3592.14	4665.48	4474.33	5650.32	4409.67	2978.06	2759.68	2358.33
1978	1898.06	1951.67	1924.84	2049.35	2246.79	4035.16	6287.33	11157.42	18053.33	7855.16	2815.48	2332.00
1979	2289.68	3089.00	2881.61	2970.97	3003.57	5619.68	8700.67	15448.06	15826.67	6554.52	3474.84	2519.00
1980	2453.23	3035.67	2713.23	3356.13	5300.69	4358.06	5884.67	16919.35	17005.00	5070.32	2319.35	3074.67
1981	2947.83	*	*	*	*	*	*	*	*	*	*	*
Average	2860.05	2660.51	2111.82	2089.39	2581.23	4433.30	7489.74	16324.31	20045.74	8365.87	3792.34	2781.95

Station 09328000 San Rafael River near Castle Dale

Year	October	November	December	January	February	March	April	May	June	July	August	September
1948	26.71	58.73	58.77	45.00	98.14	88.10	59.93	320.74	222.27	29.19	16.52	5.50
1949	19.26	30.80	30.71	27.74	37.93	119.97	180.93	499.77	748.63	143.10	71.39	22.60
1950	37.00	49.53	35.42	34.84	87.50	68.84	51.43	170.45	179.37	88.97	19.61	23.63
1951	22.19	37.77	48.19	35.00	36.79	31.26	23.63	252.19	386.80	55.06	143.16	31.17
1952	61.39	50.67	41.29	40.45	79.83	167.97	352.53	1600.32	2116.03	303.45	100.81	70.57
1953	57.52	61.07	62.39	84.19	94.89	83.42	48.73	51.16	538.03	89.26	111.03	30.83
1954	53.03	60.77	44.06	49.68	84.89	52.32	52.70	139.71	31.30	14.38	8.79	29.95
1955	21.42	29.07	34.55	29.97	31.36	107.74	39.70	68.06	95.53	12.79	54.84	5.61
1956	11.57	17.30	32.61	44.42	43.69	39.26	22.13	225.06	126.40	18.72	7.12	2.87
1957	9.67	15.97	15.03	22.10	58.79	29.97	24.53	137.55	1450.07	315.87	147.65	58.13
1958	119.58	189.33	63.87	61.94	127.40	96.10	243.43	1126.74	929.17	38.16	28.29	41.50
1959	24.97	40.13	55.10	41.43	65.36	41.42	28.10	24.61	45.57	6.08	8.23	10.82
1960	12.23	23.00	22.00	21.97	28.62	103.61	53.13	146.77	164.70	7.56	1.94	10.34
1961	71.17	31.93	22.68	22.58	26.50	31.90	30.20	57.36	35.38	5.76	50.46	167.56
1962	43.00	56.37	40.55	39.84	101.25	81.48	211.97	447.00	635.17	115.06	26.06	25.37
1963	48.48	39.67	31.77	30.16	63.89	26.55	14.67	127.9	166.87	13.10	68.06	72.37
1964	22.10	25.93	23.87	20.23	36.55	44.74	20.47	252.65	312.80	48.39	43.61	7.37
1972	*	*	*	*	*	*	*	*	*	*	33.90	33.40
1973	62.45	53.17	37.32	26.00	26.00	120.65	82.77	474.45	644.60	134.77	79.65	61.60
1974	73.48	47.63	38.94	32.65	33.61	52.42	35.03	77.23	98.43	95.32	55.77	49.07
1975	71.00	65.80	27.26	23.23	39.86	45.23	32.37	48.55	517.50	422.42	94.58	101.87
1976	85.55	53.10	36.32	26.00	56.83	33.13	26.90	56.71	53.80	45.61	26.97	34.90
1977	35.52	28.23	23.45	20.00	22.57	25.29	9.92	10.18	4.64	15.32	3.70	2.59
1978	7.85	9.69	13.26	17.06	23.43	44.48	20.93	21.52	328.83	86.81	28.97	26.17
1979	32.32	53.53	30.00	28.94	23.82	161.10	55.20	146.52	425.30	85.84	64.84	42.13
1980	55.64	47.40	83.29	121.64	139.96	69.13	59.10	220.10	1178.67	258.25	54.79	118.97
1981	72.29	*	*	*	*	*	*	*	*	*	*	*
Average	43.66	47.06	38.11	35.66	58.19	70.64	71.23	268.26	457.43	96.63	51.91	41.80

Table 8.--Monthly mean discharge at streamflow-gaging stations--Continued

Station 09328100 San Rafael River at San Rafael Bridge Campground, near Castle Dale

Year	October	November	December	January	February	March	April	May	June	July	August	September
1975	*	*	*	*	*	*	*	*	*	*	61.75	64.50
1976	82.23	55.77	34.03	25.00	53.83	25.71	20.44	79.00	49.53	43.39	26.86	37.63
1977	34.19	28.43	20.87	19.00	20.11	26.94	11.31	8.63	2.04	26.97	22.73	17.28
1978	11.85	9.28	13.15	18.26	25.39	58.87	24.03	20.94	284.87	60.97	30.97	29.93
1979	35.16	105.50	31.00	27.29	27.00	147.77	64.77	127.16	400.13	93.87	68.29	36.50
1980	46.97	37.63	58.71	72.61	152.22	94.06	56.86	218.69	1231.00	246.55	66.23	96.88
1981	73.86	*	*	*	*	*	*	*	*	*	*	*
Average	42.59	47.32	31.55	32.43	52.15	68.16	35.19	89.21	286.47	94.35	44.77	41.90

Station 09328500 San Rafael River near Green River

Year	October	November	December	January	February	March	April	May	June	July	August	September
1910	127.58	162.00	125.00	150.00	200.00	728.74	748.07	1196.13	306.93	110.16	44.26	234.77
1911	222.16	98.83	100.90	224.42	196.25	164.16	163.43	491.52	607.63	98.81	88.03	152.43
1912	355.77	64.17	60.00	50.00	70.00	100.00	95.73	405.97	1570.43	222.65	74.74	59.73
1913	384.39	199.17	46.65	40.00	50.00	136.06	338.37	1075.00	464.00	136.26	45.61	236.93
1914	72.55	124.57	65.13	55.00	65.00	90.00	251.27	1625.58	1650.33	293.55	45.10	25.17
1915	158.71	41.20	60.90	48.00	47.00	207.94	196.83	379.58	448.77	38.03	1.20	34.11
1916	7.52	119.97	68.61	58.00	80.93	379.48	207.20	541.52	931.70	196.48	343.77	71.33
1917	848.26	81.10	87.19	20.00	99.96	130.61	194.23	854.74	2245.07	369.68	109.16	219.13
1918	64.77	78.97	63.87	55.97	73.68	109.16	107.27	140.90	588.03	552.48	125.42	129.33
1946	48.71	48.10	33.35	29.26	70.54	97.03	182.73	321.39	133.47	17.45	112.92	6.36
1947	41.83	78.33	57.87	37.55	96.11	66.55	55.57	536.39	435.27	76.06	317.32	48.90
1948	32.19	58.63	64.68	50.00	110.52	115.94	64.27	269.16	222.90	29.86	88.89	0.13
1949	13.96	28.90	34.45	31.26	43.57	144.45	166.87	492.00	871.00	219.81	78.35	42.72
1950	47.03	53.40	40.39	39.19	111.75	86.65	55.87	141.10	176.27	138.58	9.85	17.27
1951	17.16	36.67	45.48	40.00	51.32	36.65	20.33	237.43	387.93	44.19	193.35	19.77
1952	91.81	62.43	47.42	46.00	88.34	221.29	405.00	1505.84	2150.33	317.42	192.00	81.67
1953	56.23	59.20	66.77	92.45	119.14	92.85	56.97	36.03	521.77	82.13	139.68	25.73
1954	58.19	69.03	49.81	58.65	96.39	57.84	49.00	125.39	22.05	19.24	10.70	63.53
1955	36.94	28.63	37.81	33.97	36.32	104.77	42.47	57.39	93.07	4.96	48.38	0.74
1956	2.55	17.07	36.39	48.71	48.76	44.03	21.77	187.88	131.93	14.66	11.40	0.11
1957	0.85	12.68	16.16	26.45	65.68	41.06	23.30	141.58	1588.07	387.84	208.48	70.10
1958	162.97	357.83	79.68	72.9	135.5	94.97	222.50	1067.65	959.17	34.23	71.67	70.68
1959	22.29	41.30	60.48	42.71	69.79	47.68	27.43	16.65	36.54	1.84	10.46	18.82
1960	11.18	29.57	23.94	22.9	33.48	123.97	51.67	123.45	187.90	2.35	0.38	20.00
1961	123.88	34.80	29.71	31.71	46.11	40.19	32.00	48.61	32.17	0.31	116.69	308.73
1962	50.06	61.47	33.71	39.42	138.61	90.00	192.43	464.74	619.87	119.74	13.13	57.54
1963	67.32	38.60	35.97	33.23	71.93	35.13	15.54	96.13	170.77	8.80	150.68	108.50
1964	19.16	26.80	27.97	23.19	39.93	49.97	23.17	248.54	334.57	62.88	100.93	23.95
1965	2.28	20.33	50.48	57.81	55.93	52.35	92.77	291.29	1296.90	620.84	256.74	85.47
1966	65.10	77.93	83.42	48.35	62.86	136.52	74.97	70.10	28.09	28.05	8.99	29.06
1967	23.87	22.10	39.16	18.94	35.57	34.55	11.90	86.21	373.47	108.77	48.25	84.87
1968	34.94	36.57	29.94	26.61	42.55	42.13	40.17	98.71	426.17	97.58	179.48	65.13
1969	87.71	45.43	38.26	52.26	52.43	140.13	211.23	612.81	541.53	125.26	146.16	107.90
1970	68.48	61.23	59.61	32.26	68.21	39.42	32.20	220.13	805.50	143.35	60.68	63.53
1971	53.90	51.00	46.39	25.81	36.54	53.03	46.20	66.90	87.10	88.68	68.03	39.97
1972	87.00	68.37	30.65	33.00	52.69	51.26	26.60	34.68	53.10	23.03	16.26	13.13
1973	143.71	62.23	30.61	25.97	45.00	287.19	75.50	464.26	861.93	159.55	70.00	67.10
1974	76.81	55.33	40.55	32.68	33.61	49.81	34.20	56.29	73.27	78.06	41.61	37.80
1975	74.00	72.63	29.29	25.16	42.57	49.58	28.67	46.81	525.33	451.35	80.97	90.33
1976	64.23	55.27	29.90	23.00	47.72	23.29	15.20	37.35	37.40	29.94	22.10	27.36
1977	31.26	28.57	22.58	19.00	20.89	24.52	6.84	3.72	1.09	41.63	35.31	15.04
1978	4.95	5.68	11.83	14.65	22.18	79.32	16.77	23.26	369.17	137.68	13.96	7.24
1979	79.65	200.37	24.23	18.90	35.93	232.16	90.83	85.68	411.33	65.32	45.39	22.67
1980	41.33	41.57	76.23	95.77	148.90	107.45	55.70	209.35	1516.80	850.35	111.37	99.70
1981	40.75	*	*	*	*	*	*	*	*	*	*	*
Average	92.80	68.59	48.72	46.62	71.80	114.54	110.70	346.27	574.91	151.13	89.95	68.28

[Abbreviations: ft, feet; in., inches; gal/min, gallons per minute; °C, degrees Celsius, µmhos, micromhos per centimeter at 25°C]
Location: See text for description of well- and spring-numbering system. S, well plugged back in year shown as year constructed.
Owner: Owner at time well was visited by U.S. Geological Survey or listed by driller in State Well Driller's Report or given in other State or Federal records.
Depth: All depths reported, except for test holes drilled or logged by U.S. Geological Survey.
Finish: P, pipe perforated; X, open hole below unperforated pipe.
Principal aquifer: See table 1 for explanation of code; see table 2 for description of lithology.
Altitude: Altitude of land surface at well, in feet above National Geodetic Vertical Datum of 1929. Most altitudes are interpolated from topographic maps.
Water level: In feet below or above (+) land surface at well. Accuracy--G, measured with pressure gage; L, estimated from geophysical logs or measured with such logging device; R, reported; S, measured with steel tape; T, measured with electric tape. Site status (second column)--D, dry; F, flowing, but head not measured; R, pumped or flowed recently.
Type of lift: A, air; P, piston, generally pump jack and cylinder pump; N, none; S, submersible pump (electric); T, turbine. Flowing wells are not equipped.
Discharge: B, bailer measurement by driller; E, estimated; F, discharge is by natural flow; R, reported; V, volumetric, generally with bucket and stopwatch.
Use of water: H, domestic; N, industrial; S, stock; U, unused; Z, not used because well plugged or destroyed.
Remarks: Data available--A, aquifer test; C, chemical analysis in table 14; D, driller's log (see table 12 for selected logs); G, geologist's log of drill cuttings in table 12; J, geophysical logs in files of U.S. Geological Survey; W, water-level observations (see fig. 14 for selected hydrographs).

Location	Owner	Year constructed	Depth of well (ft)	Casing diameter (in)	Depth cased (ft)	Depth to first opening (ft)	Finish	Principal aquifer	Depth to aquifer (ft)	Altitude (ft)	Water level (ft)	
(D-16-13)8ddc-1S	U.S. Bureau of Land Management	1974	700	10.75	128	128	X	210DKOT	550	5,328	109.0	S
(D-17-11)27ccd-1	M. D. Mills	1961	72	4	72	-	-	221SLWS	46	5,758	20	R
											-	R,D
(D-17-13)30ddd-1S	U.S. Bureau of Land Management	1974	560	10.75	104	104	X	220NVJO	353	5,147	141.2	S
(D-18-14)9dca-1	R. W. Cook	1910	3,180	14	-	-	-	220NVJO	-	4,630	-	F
(D-19-10)15bac-1	U.S. Bureau of Land Management	1946	476	7.88	37	37	X	221CRML	310	5,615	157	R
(D-19-12)14bbb-1	State of Utah	1946	57	8	-	-	-	221CRML	0	5,740	-	S,D
(D-19-13)12ddd-1	U.S. Bureau of Land Management	1969	3,269	10.75	3,268	1,274	P	220NVJO	1,052	5,489	572.0	T
(D-19-13)21cbd-1	do.	1980	310	-	-	-	X	220NVJO	120	5,190	96.9	T
(D-20-10)6bdd-1	Utah Power & Light Co.	1980	475	-	-	-	X	220NVJO	152	5,260	+16.0	G
(D-20-14)11cba-1	U.S. Bureau of Land Management	1903	1,335	10	1,335	1,145	P?	220NVJO	1,055	4,498	+74	R
31cbd-1	L. G. Smith	1958	150	4	-	-	-	221CRML	0	4,560	-	-,F

water wells and test holes
petroleum-test and other test holes]

Date measured	Type of lift	Date discharge measured	Discharge (gal/min)		Draw-down (ft)	Use of water	Temperature (°C)	Remarks
5-05-77	N	-	-		-	U	-	Petroleum-test well plugged back and left for use as water well.
4- -61	T	4- -61	22	V	20	S	-	State inspector found well unused. Slightly alkaline water at 14 ft.
9-09-69	N	-	-		-	U	-	Data: D
10-06-80	N	6-28-79	12	V	39	N	16.0	Petroleum-test well plugged back and left for use as water well. Perched (?) water in Carmel Formation. Data: A, C, J, W.
10-21-46	N	10-21-46	200	E,F	-	Z	27.5	Known as the "Roadside Geyser," at Woodside. Would erupt about every 30 minutes, by carbon-dioxide drive. Aquifer estimated from reported depth of hole. See Intermountain Assoc. Petroleum Geologists, 1956, p. 207. Well plugged because of saline water. Data: C.
1-25-46	P	1-25-46	20	R	4	S	14.0	Known as Buckhorn Well. Data: C, D.
4-26-78	N	-	-		-	U	-	Driller reported drilling fluid lost through fissure in limestone.
11-10-80	N	-	-		-	U	-	Petroleum-test well plugged back and left, unperforated, for use as water well. Opened by U.S. Geological Survey. Fluid in hole very saline; measurements showed that plug did not leak. Jet-perforated by Welex Co. with one shot per foot from 1,274 to 1,294 ft. Water level rose to that shown and stabilized. Attempt to pump well abandoned after repetitive pump failure. During last pumping period, fluid specific conductance decreased from 11,300 to 9,400 µmhos showing that sandstone was yielding fresher water to well. Data: J, W.
7-31-80	N	6-27-80	30	E	-	U	15.5	U.S. Geological Survey test hole NSR T-3. Water perched in Carmel Formation at 59 ft; heard dripping. Yield estimated while cleaning out hole with air. Data: C, G, J.
7-14-80	N	7-14-80	10 2.8	E,F F,V	16 -	Z -	13.0 -	U.S. Geological Survey test hole NSR T-1. Drilled with air, then mud, and finally river water. Head increased as hole deepened; began flowing estimated 10 gal/min when completed. Set packer 141-146 ft. Second (smaller) discharge measured through 0.75-in. faucet. Data: A, C, G, J.
1903	N	8- -03 5- -55	11 2	F,R F,R	- -	S -	19.0 -	Known as Rio Grande well. Location originally reported as in section 15 (unsurveyed). Found caved, but still seeping in May 1977. Data: D.
4-26-78	N	4-26-78 6-08-79	20 50	E,F E,F	- -	U -	15.0 15.0	Uncontrolled flow to nearby dry wash. Has flowed long enough to establish water cress (*Nasturtium officinale*) and other vegetation and looks like a natural spring. Casing below surface of small pond. Local rancher reported that a spring in Navajo Sandstone in adjacent canyon ceased flowing when this well was drilled. Data: C.

Location	Owner	Year con- struct- ed	Depth of well (ft)	Casing diam- eter (in.)	Depth cased (ft)	Depth to first open- ing (ft)	Finish	Principal aquifer	Depth to aqui- fer (ft)	Altitude (ft)	Water level (ft)	
(D-20-16)17bab-1	Howard Hastings	-	30	-	-	-	-	112ALVM	0	4,110	-	-
(D-21-14)4cbd-1	U.S. Bureau of Land Management	-	-	-	-	-	-	221CRML	0	4,500	-	
(D-21-16)9aac-1	E. C. Gerhart	1960	16	4	16	12	P	111ALVM	0	4,070	6	R
(D-22-8)11ccb-1S	U.S. Bureau of Land Management	1961	1,937	2.38	1,937	1,416	P	231KYNT	1,300	5,940	285	R
(D-22-10)23cbc-1	Utah Department of Transportation	1971	84	7.88	-	-	-	231WNGT	0	7,035	33.1	S
33abc-	do.	1963	475	-	-	-	-	-	-	7,120	-	R,D
(D-22-11)23bdc-1	do.	1963	290	-	-	-	-	237SNBD	56	6,520	-	
(D-22-13)35bcd-2	U.S. Bureau of Land Management	1980	310	-	-	-	X	220NVJO	0	4,510	137.5	S
(D-22-14)15acc-1	Energy Fuels Inc.	1979	180	5	120	120	P	221MRSN	0	4,275	-	-
(D-22-14)28dba-1	Hatt Ranch	1979	515	4	-	-	P?	221ENRD	250	4,235	16.7	S
28ddd-1	do.	1952	265	8	70	70	X	221CRTS	100	4,200	6	S
31ddb-1	U.S. Bureau of Land Management	1935	350	6.25	320	70	P	221CRML	130	4,290	40	R
(D-23-8)3bab-1	Utah Department of Transportation	1963	300	-	-	-	-	221CRML	0	5,800	-	
7dbd-1	do.	1963	40	-	-	-	-	-	-	5,515	-	R,D
(D-23-9)2ccb-1	W. R. Snow	1966	690	5	690	-	-	310CCNN	560	7,030	576	L
(D-23-10)12DDD-1	U.S. Bureau of Land Management	1936	196	6.62	217	193	P	230MNKP	40	6,850	160 25.6	R S
(D-23-11)22ccc-1S	do.	1936	2,270	8.62	-	-	X	330MSSSP	1,270	6,710	1,730	T
(D-23-14)25bca-1	Utah Power & Light Co.	1980	700	-	-	-	-	220NVJO	460	4,160	+105	G,R
25bcd-1	do.	-	-	5	-	-	-	-	-	4,150	9.7	S
36bba-1	do.	-	57	3.25	-	-	-	221ERND	-	4,150	17.1	S

Date measured	Type of lift	Date discharge measured	Discharge (gal/min)	Draw-down (ft)	Use of water	Tem pera-ture (°C)	Remarks
-	S	-	-	-	-	-	Alluvium from Green River overlies Mancos Shale. Data: C.
-	N	-	-	-	U	-	Mine shaft; uranium test by B. J. Allers. Data: C.
9- -60	-	-	-	-	-	-	Formerly used for lawn irrigation; abandoned after filled with sand; alluvium overlies Mancos Shale. Data : C.
6- -61	N	-	-	-	Z	-	Core hole plugged back; casing perforated 1,416-1,418, 1,420-1,442, and 1,459-1,467 ft. Found unused and casing filled in 1978.
10-21-77	N	-	-	-	Z	-	Test hole for construction water for Interstate Highway 70. Found filled with rocks in 1978. Data: C.
-	-	-	-	-	-	-	Test hole for construction water for Interstate Highway 70. Data: D.
-	-	10-29-63	1.5 R	-	-	-	Do.
7-17-80	N	7-17-80	20 E	-	Z	17.5	U.S. Geological Survey test hole NSR T-5. Drilled with air. Discharge estimated while cleaning hole with air. Drilled into sandstone outcrop where dip is about 60°. Samples from about 100 to 170 ft appeared damp. At 170 ft, after connecting drill stem, drilled about 0.2 ft and hole started producing water; may have been result of an open fracture. Data: C, G, J.
-	S	10-30-79	7 R	160	H	-	At mine on State Highway 24.
8-24-79	N	5-21-80	5 V	180	U	17.0	Well drilled by mineral exploration company and left for water well. Gas can be heard bubbling and an unpleasant odor comes from between surface pipe and casing. When test pumped, water was heavily charged with carbon dioxide which, after water level was pumped down and pump stopped, caused well to continue to flow by gas lift. Data: C, J, W.
10-28-58	N	-	-	-	U	16.0	Never used because of poor water quality. Produced non-flammable gas from 125-225 ft that caused well to flow "like a geyser" only when well was bailed. Data: C, D.
1-07-36	N	1-07-36	10 B	160	Z	-	Known as San Rafael Well. Abandoned before 1952. Old report notes the well produced brackish water ample for sheep. Data: C, D.
-	N	9-15-63	0.5 R	-	-	-	Test hole for construction water for Interstate Highway 70. Data: D.
9-13-63	-	-	-	-	-	-	Do.
1-5-66	N	-	-	-	-	-	Found abandoned in 1979. Data: C, J.
12-18-39 7-15-61	P	7-28-36 12-18-39 10-31-58 7-19-80	17 R 12 R 4 E 7.2 V	- 37 - -	- - - -	- - 11.0 12.5	Known both as Sinbad Well and Georges Draw Well. One of eight wells reportedly drilled by Standard Oil Co. of California for supply of drilling and domestic water. Drilled to 217 ft. Depth and water level measured in 1961 by R. F. Hadley, U.S. Geological Survey. When sampled in 1979, water pumped was milky blue in color, and had strong odor of hydrogen sulfide.
7-30-79	N	11-20-36	53 R	-	U	17.2	Petroleum-test well converted to drilling water-supply well and left for use as stock-supply well. Never used. Found open to depth shown on date of water-level measurement. Water level measured with geophysical logging equipment. Specific conductance of water in hole at 1,750 ft was 1,150 μmhos, measured with logging equipment.
7-23-80	N	7-22-80 7-23-80	20 E 14 F,V	-	Z	17.5 16.5	U.S. Geological Survey test hole NSR T-6A. Drilled with air to 20 ft where hole produced a little water. Drilled hole with mud which was thinned when Navajo Sandstone was entered. Head increased with depth, and well was flowing at 550 ft. Set packer for testing at 445-450 ft. Measured discharge through 0.75-in. faucet. Pressure required use of commercial well-cementing company to plug hole. Data: A, C, G, J.
3-20-80	N	-	-	-	-	-	Near north side of old ranch house. Depth more than 30 ft. Well full of black muck, with odor of hydrogen sulfide. Mineral residue on old casing head indicates probable saline water quality.
3-20-80	N	-	-	-	-	-	Old test hole (?) on west side of county road. Aquifer designation based on field observations.

Location	Owner	Year constructed	Depth of well (ft)	Casing diameter (in.)	Depth cased (ft)	Depth to first opening (ft)	Finish	Principal aquifer	Depth to aquifer (ft)	Altitude (ft)	Water level (ft)
(D-23-14)36bdd-1	Utah Power & Light Co.	1980	215	-	-	-	-	221CRML	40	4,120	9.5 S
(D-24-9)5bcb-1	Lucky Strike Mine	-	-	6	-	-	-	231CHNL	0	5,900	19.8 S,R
(D-24-13)11adb-1S	U.S. Bureau of Land Management	1974	1,508	8.62	169	169	X	220NVJO	486	4,740	324.8 S
32bbd-1S	State of Utah	1967	1,263	7	1,263	-	-	220NVJO	74	4,844	20.4 S
36dba-1	do.	1979	1,184	7	-	-	X	220NVJO	155	4,660	151.7 S
(D-24-14)21adb-1	U.S. Bureau of Land Management	-	-	6	-	-	-	220NVJO	-	4,310	- -,F
(D-24-15)6caa-1S	Utah Power & Light Co.	1954	-	-	-	-	-	220NVJO	230	4,110	-,F
7aca-1	U.S. Bureau of Land Management	-	-	-	-	-	-	-	-	4,122	- -,F
(D-24-16)10dda-1	do.	1976?	1,245	6.63	-	-	X	220NVJO	8	4,235	170.0 S
22cbd-1	do.	1976?	1,083	7	-	-	X	220NVJO	16	4,450	297.5 S
(D-25-14)26dba-1	do.	-	1,293	6	-	-	X	220NVJO	190	4,910	336 L
(D-25-15)23bdb-1	do.	1935	350	8.25	330	330	X	220NVJO	193	4,795	290 R
32cac-1	State of Utah	1956	720	10	720	680	P	220NVJO	255	5,080	650 R
(D-26-7)17bca-1S	U.S. Bureau of Land Management	1947	1,134	13.38	1,134	-	-	220NVJO	204	6,125	-
(D-26-8)6aab-1	do.	1969	767	6.63	767	715	P	220NVJO	220	5,960	686 R
(D-26-11)9bbb-1	State of Utah	1980	844	8	802	802	X	220NVJO	818	5,070	454.5 T

Date measured	Type of lift	Date discharge measured	Discharge (gal/min)		Draw-down (ft)	Use of water	Temperature (°C)	Remarks
7-20-80	N	7-19-80	30	E,F	-	Z	15.0	U.S. Geological Survey test hole NSR T-6. Drilled at first with air; changed to mud. First water noted at 35-40 ft. Lost circulation at 205 ft and drilled without cutting returns to 215 ft. Lost circulation of drilling fluid at 50 ft in second hole at site. Data: C.
7-19-79	S	7-19-79	10	E	-	N,H	14.5	On north side of canyon above mine buildings. Mine superintendent reports that water is used for all purposes but drinking, and that well has a large drawdown. Data: C.
6-20-79	N	5-14-80	10	V	-	U	17.0	Petroleum-test well plugged back and left for use as water well, but never used. Data: A, C, J, W.
6-4-80	N	-	-		-	U	-	Petroleum-test well plugged back and left, unperforated, for use as water well. Opened by U.S. Geological Survey for perforating and testing. Preliminary tests showed that plug leaks and that water level represents that in formations below the Wingate Sandstone. This condition seemed to be confirmed by fresh blobs of oil appearing on the water surface in the well after preliminary testing. Well was resealed without further work.
4-15-80	N	5-13-80	13	V	26	U	15.0	Data: A, C, J.
-	N	6-7-79	8.0	F,V	-	S	15.0	Flows uncontrolled into stock pond rimmed by salt cedars (*Tamarix gallica*) on west side of Cottonwood Creek. Reportedly drilled by exploration company. Aquifer identification based on water quality. Data: C.
-	N	6-7-79	10	E,F	-	S	15.5	Petroleum-test well left for use as water well; on north bank of San Rafael River in grove of cottonwood trees (*Populus fremonti*) and salt cedar. Control valves, in 4 x 4 ft pit have rusted away; well flows uncontrolled to small stock pond. Water has odor of hydrogen sulfide. Data: C.
-	N	-	-		-	U	-	In relatively inaccessible area on south bank of San Rafael River. Local ranchers report well has flowed for many years and that water is potable.
6-27-79	N	-	-		-	U	-	Mineral (?) core hole between county road and small dry wash. Geophysical logging shows that water in hole is saline and of nearly uniform specific conductance, indicating that water probably is moving up the hole and out into the Navajo Sandstone. Data: J, W.
6-6-79	N	-	-		-	U	-	Mineral (?) core hole at east edge of county road. Remarks same as for preceding site.
7-17-79	N	-	-		-	U	-	Mineral (?) core hole on south side of county road. Geophysical logging shows that water in the hole is slightly saline and of nearly uniform specific conductance, indicating that water probably is moving out of the Navajo Sandstone, down the hole, and out into the Wingate Sandstone. Data: J, W.
9-3-35	P	10-1-35	8	R	-	S	-	Known as SaucerBasin Well. Water quality reported to be good. Data: D.
6-29-56	P	6-29-56	30	R	50	U	-	Known as Moonshine Well. Inspection in 1979 showed well had not been used for long period. Data: C.
-	-	-	5	R	-	U	-	Petroleum-test well plugged back and left for use as water well. Not known to have been used.
6-25-69	P	6-25-69	11	B	40	S	18.1	Known as Last Chance Well. Drilled in midst of swarm of igneous dikes and near fault. Casing perforated with machine-cut slots, 3 x 3/8 in., from 715 to 767 ft. Data: C, D.
4-15-80	N	3-8-80	30	R	-	U	-	Water-supply test well at Goblin Valley State Reserve. On top of bluff overlooking reserve and next to water tank that stores water hauled from town of Green River. Data: C, D, J.

Table 10.--Records of selected springs

[Abbreviations: ft, feet; gal/min, gallons per minute; °C, degrees Celsius; μmhos, micromhos per centimeter at 25°C; mi, mile.]
Location: See text for description of well- and spring-numbering system.
Name or owner: Name given on maps of U.S. Geological Survey or U.S. Bureau of Land Management, or name used by local residents; otherwise, landowner is given. Alternative name, if any, is given in remarks.
Altitude: Altitude of land surface at spring orifice(s) in feet above National Geodetic Vertical Datum of 1929, interpolated from topographic maps.
Aquifer code: See table 1 for explanation of code and table 2 for description of lithology of geologic unit.
Discharge: Method of measurement--C, current meter; E, estimated; V, volumetric (method unspecified, but generally with bucket and stopwatch).
Remarks: C, chemical-quality data in table 14. Citations are from Baker (1946, p. 12-14).

Location	Name or owner	Altitude (ft)	Aquifer code	Date measured	Discharge (gal/min)	Water quality: Temperature (°C)	Water quality: Specific conductance (μmhos)	Remarks
(D-15-13)18caa-S1	Big Spring	5,700	111ALVM	9-17-75	168C	13.0	1,500	Discharges from alluvium that overlies the Mancos Shale. C.
(D-16-12)16cbd-S1	U.S. Bureau of Land Management	5,600	217CDRM	7-18-79	4E	15.0	1,700	C.
(D-16-13)20dab-S1	do.	5,150	217CDRM	7-18-79	30E	-	3,200	C.
(D-17-12)23aba-S1	Stove Gulch Spring area	5,190	221ENRD	5-18-79 6-28-79 10-26-79	20V 1.5V Dry	20.0 - -	6,360 - -	Seepage rises in bed of gulch where gulch cuts Entrada Sandstone that is shattered by faulting. C.
(D-17-13)3abd-S1	Coon Spring	5,105	111ALVM	7-18-79	0.1V	21.0	4,050	Source is alluvium (?) on or near fault trace. C.
(D-18-10)13aab-S1	Staker Spring	6,365	217CDRM	7-10-79	4E	17.5	703	Spring box with pipe to trough. C.
(D-18-11)33acd-S1	U.S. Bureau of Land Management	6,970	221BRSB	7-10-79	-	-	3,930	Seepage in canyon. Small discharge (less than 1 gal/min) affects water temperature measurement. C.
(D-18-13)29dda-S1	North Summerville Seep	5,170	221CRML	5-8-79 10-26-79	2E 1E	10.0 -	4,820 -	Seepage from bed of conglomerate at top of formation. C.
(D-19-9)1acd-S1	Red Seep	5,635	221BRSB	10-31-58	1E	-	-	C.
26cab-S1	U.S. Bureau of Land Management	5,400	221SMVL	9-11-75	0.5E	15.5	5,240	C.
(D-19-13)13bbd-S1	do.	5,280	221CRTS	5-20-79 10-27-79 6-25-80	1E Dry Dry	18.5 - -	14,300 - -	On west side of Woodside anticline. Site sampled is composite flow from several seepage areas that discharge from jointed, dark gray, limy sandstone and overlying veneer of sand. Much mineral residue along edge of stream bed. C.
(D-20-9)33dda-S1	do.	5,560	111ALVM	10-25-79	5E	-	-	Streamflow originated in this reach of Coal Wash in 1979. This spring is fairly typical of several reaches of Coal and North Salt Washes where water may discharge from underlying bedrock or may be underflow brought to surface. Water is saline and sustains patches of salt cedar (*Tamarix gallica*), willow (?)(*Salix sp.*), and cottonwood (*Populus fremontii*) even where there is no visible flow.
35ccd-S1	Yellow Seep	5,700	221CRML	5-9-79	3E	11.0	2,860	Seepage accumulates along small strike valley. Piped to stock trough. C.
(D-20-10)23bdb-S1	U.S. Bureau of Land Management	5,390	231WNGT	-	-	-	-	Water reported fresh. Seepage issues from sandstone just above base of formation. In June 1980, creek upstream from spring reportedly was flowing.

Table 10.--Record of selected springs--Continued

Location	Name or owner	Altitude (ft)	Aquifer code	Date measured	Discharge (gal/min)	Water quality: Temperature (°C)	Water quality: Specific conductance (µmhos)	Remarks
(D-20-11)3cab-S1	U.S. Bureau of Land Management	5,260	111ALVM	5-3-78 6-8-78	- -	- -	2,480 3,190	In bed of Buckhorn Wash. Alluvium overlies Chinle Formation. C.
4aab-S1	do.	5,310	231CHNL	10-31-58 5-3-78 6-8-78	20E - -	- - -	2,550 2,710 6,590	May be from alluvium over Chinle Formation. C.
11bcc-S1	do.	5,155	111ALVM	5-3-78 6-8-78	- -	- -	3,770 5,200	Alluvium overlies Moenkopi Formation. C.
(D-20-13)15dad-S1	Cottonwood Canyon Spring	4,860	220NVJO	6-8-79	5E	13.5	1,340	Seepage issues from joints in sandstone and from overlying canyon fill. Many cottonwood trees in canyon bed. Sampling site is head of perennial in this reach; head of flow migrates downstream during summer and early fall. See text. C.
(D-20-14)34ccd-S1	Trail Spring	4,400	111ALVM	6-7-79	0	-	-	Stagnant pond at head of small channel on west side of Cottonwood Wash. Many phreatophytes in vicinity. No visible flow, but creek bed and banks are damp and covered with white mineral deposit.
(D-21-9)25baa-S1	U.S. Bureau of Land Management	5,870	220GLNC	-	-	-	-	Personnel of U.S. Bureau of Land Management report that this spring and that downstream, as well as others in this area, dry up in summer and in dry years.
25dda-S1	do.	5,910	220GLNC	-	-	-	-	See above.
(D-21-13)24cbb-S1	Sulphur Spring	4,320	230MNKP	1911	200E	-	-	One of a group of springs on both banks of San Rafael River in lower Black Box Canyon. Has strong odor of hydrogen sulfide. See Lupton (1911, p. 347-349). C.
(D-21-14)5aab-S1	Smith Cabin Spring	4,565	221CRML	6-8-79	5E	13.5	992	In deep cut below old cabin. Issues from jointed, steeply dipping limestone. Baker's report of a large amount of good water may have referred to higher spring that reportedly dried up. C.
(D-22-8)23aad-S1	Jensen Spring	6,075	221CRML	4-23-59	5E	-	-	Also called South Salt Wash Spring. South of trail in bed of South Salt Wash. C.
(D-22-9)8aca-S1	U.S. Bureau of Land Management	6,040	221CRML	10-25-79	10E	17.0	3,660	Seepage issues from sandstone beds, which accumulates in pools in deeply incised meanders in Eagle Canyon. Seep area thickly coated with white mineral deposits. Flow sinks into canyon fill downstream. C.
(D-22-13)35bcd-S1	do.	4,500	111ALVM	6-7-79 7-15-80	5E Dry	18.0 -	2,200 -	Estimated discharge probably is maximum. Underflow (?) in canyon fill does reach across Navajo outcrop. Abundant water life and some green algae. C.
(D-22-14)6bbc-S1	Spring Canyon Spring	4,500	220NVJO	10-28-58	5E	7.0	-	Baker called aquifer the basal Carmel; D. A. Phoenix (U.S. Geological Survey, written commun., 1962) called aquifer alluvium overlying Navajo, and could not find orifice. C.

Table 10.--Records of selected springs--Continued

Location	Name or owner	Altitude (ft)	Aquifer code	Date measured	Discharge (gal/min)	Water quality: Temperature (°C)	Water quality: Specific conductance (µmhos)	Remarks
(D-22-16)25ad-S	North Salt Wash Spring	4,160	221ENRD	-	-	-	-	In north fork of Salt Wash, near area of much faulting. C.
25dc-S	Salt Wash Seepage	4,140	221BRSB	-	-	-	-	General area of seepage in graben. C.
(D-23-7)24bca-S1	U.S. Bureau of Land Management	5,400	221CRML	-	-	-	-	Seepage issues from bed of South Salt Wash. Bed of wash is damp from here down to confluence with Muddy Creek. Thick growth of phreatophytes along banks.
(D-23-8)21bdc-S1	do.	5,840	221CRML	7-18-79	5E	-	3,000	Pond behind low banks against strongly deformed gypsum in north wall of Kimball Draw canyon. Outflow immediately sinks into canyon fill. Large salt cedar in damp areas.
30bdb-S1	do.	5,555	221CRML	7-18-79	10E	-	6,000	Rises in bottom of Kimball Draw, near top of Carmel. Numerous large phreatophytes in spring area. Piped to trough 0.3 mi downstream.
(D-23-10)9bbd-S1	Cliff Dweller Spring	7,120	231WNGT	10-31-58	1E	-	-	In notch in cliff, near base of sandstone. Collector piped to trough. Pipe was only dripping 7-19-79. C.
(D-23-13)34dbd-S1	Iron Wash Spring	4,380	111ALVM	10-28-58	15E	16.0	-	Underflow (?) in Iron Wash. Alluvium overlies Carmel. C.
(D-24-9)5bcb-S1	Lucky Strike Mine	5,840	231CHNL	7-19-79	1E	-	-	On right bank, up canyon from mine buildings. Unused; mine uses nearby well.
(D-24-10)3bba-S1	Tan Seep	6,700	230MNKP	10-27-44	5E	18.0	-	Developed spring; in Rods Valley. May issue from fault zone. C.
(D-24-13)4ddb-S1	Seep	4,470	221CRML	-	-	-	-	Seepage area in bottom of Iron Wash.
9acb-S1	Seep	4,510	220NVJO	-	-	-	-	Do.
20ccs-S1	Lost Spring	4,790	221CRML	10-28-58	2E	16.5	-	Also known as Red Rock Spring. Sample from pipe below cribbed rock wall.
24dcd-S1	Crows Nest Spring	4,520	220NVJO	-	-	-	-	Rises in channel where Navajo is faulted up against Entrada. Baker said spring yields a small amount of good water.
31daa-S1	Old Woman Spring	4,810	221CRML	-	-	-	-	Seepage area in basal sandstone of Carmel. Baker said yield was very small amount of alkaline water from a covered excavation.
(D-24-14)30bca-S1	Hawks Nest Spring	4,500	221CRML	-	-	-	-	Baker said yield was a very small amount of good water at Carmel-Navajo contact.
32adb-S1	Cottonwood Spring	4,375	220NVJO	-	-	-	-	Rises in canyon bottom above fault and at least 100 ft below top of Navajo. No visible flow in 1976. In June 1979 damp sand extended about 0.25 mi across fault and pool of stagnant water stood at fault. Dense phreatophytes and hydrophytes in canyon bottom.

Table 10.--Records of selected springs--Continued

Location	Name or owner	Altitude (ft)	Aquifer code	Date measured	Discharge (gal/min)	Water quality: Temperature (°C)	Water quality: Specific conductance (µmhos)	Remarks
(D-24-15)15aad-S1	Spring Canyon Spring	4,120	221CRML	-	-	-	-	Baker said yield was a small amount of alkaline water.
17acc-S1	U.S. Bureau of Land Management	4,165	221CRML	-	-	-	-	Baker called this site Lower Dugout Spring; relatively large discharge of gypsum-bearing water.
(D-24-16)19ddd-S1	Moonshine Spring	4,530	221CRML	-	-	-	-	Baker said yield was a small amount of slightly alkaline water. Orifice on north-trending structural feature.
27cbb-S1	U.S. Bureau of Land Management	4,515	221CRML	6-6-79	2E	-	3,300	Seepage in streambed where basal sandstone overlies red siltstone. Much mineral residue on streambed and adjacent banks. Found dry later in year and in 1980.
(D-24-17)27bad-S1	Arch Spring	4,280	220NVJO	-	-	-	-	Issues near contact with Kayenta.
(D-25-12)4aac-S1	Swazy Seep	5,020	221CRML	-	-	-	-	Issues from base of formation. Reported dry in summer 1977.
(D-25-13)2cab-S1	State of Utah	4,525	220NVJO	-	-	-	-	Seepage in channel of Cottonwood Wash where it cuts into the sandstone.
6aca-S1	Temple Spring	4,800	221CRML	-	-	-	-	Seepage area in bottom of wash; flow accumulated behind low dam. Dense phreatophytes in seepage area.
(D-25-14)28ada-S1	Dugout Spring	4,780	221CRML	6-6-79	Dry	-	-	Baker called this site Dugout Troughs. Poor quality water piped to troughs. In 1979 site marked only by patch of salt cedar in creek bed and broken pipe.
(D-26-14)10acd-S1	Upper Dugout Spring	4,965	221CRML	-	-	-	-	Baker reported small amount of poor quality water piped to troughs.
28bac-S1	Sweetwater Spring	5,380	221ENRD	-	-	-	-	Baker reported small amount of good water in excavated spring area.
(D-26-16)1cda-S1	Keg Spring	4,560	220NVJO	-	-	-	-	One of a group of springs that issue along Navajo-Kayenta contact in Keg Spring Canyon. Water reported good quality.

Table 11.--Records of selected petroleum-test wells and other test holes

[Abbreviations: ft, feet; gal/min, gallons per minute; ppm, parts per million; in., inch]

Location: See text for description of well- and spring-numbering system. D, well deepened in year shown as year constructed; S, well plugged back or otherwise tested in year shown as year constructed; W, test well left for use as or converted to water well. (See table 9.)
Name: Shows company that drilled well, followed by the number of the well drilled in individual lease area, followed by landowner or other lease holder.
Altitude: Altitude of land surface at well, in feet above National Geodetic Vertical Datum of 1929. Many altitudes are those reported by company drilling well, but all have been checked against topographic maps and have been modified where reported value seems seriously in error.
Selected geologic data: Formation code--See table 1 for explanation of code. See table 2 for description of lithology. Depths all have been adjusted, where possible, to depth below land surface. Some are company's reference datum, but difference generally is less than 15 ft.
Interval tested: Most intervals were isolated with packers and sampled through or in the drill stem; see remarks. Depths have been adjusted, where possible, as noted under selected geologic data.
Other data available: C, chemical analysis in table 14. J, geophysical logs run for this project, in files of U.S. Geological Survey. Note that most companies make geophysical logs of petroleum and mineral test holes; copies of such logs for some of the listed wells are in the files of State or Federal regulatory agencies.
Remarks: Term, MCF is 1,000 cubic feet of gas. Reference to amount of fluid recovered, in feet, means the linear distance above the packer that drill stem was filled with fluid which entered the empty drill stem when the packer was opened to test the formation. Term, "sulfur water" means water with an odor of dissolved hydrogen sulfide. Terms of water quality reported by petroleum-test drillers are not exact. "Fresh water" is any that is not recognizably salty, and may be fresh to moderately saline (see definitions in the introduction); "brackish water" is recognizable salty, but not a brine; salt water may range from very saline to briny.

Location	Name	Year constructed	Altitude (ft)	Depth drilled (ft)	Selected geologic data: Aquifer code	Selected geologic data: Depth to top (ft)	Selected geologic data: Depth to bottom (ft)	Interval tested: Depth to top (ft)	Interval tested: Depth to bottom (ft)	Other data available	Remarks
(D-14-12)19cbb-1	Pacific Transmission Supply No. 1 13-19 Federal	1974	5,808	1,643	210DKOT	880	925	-	-	-	-
					217CDRM	925	1,576	-	-		
					217BCKR	1,391	1,576	-	-		
					221MRSN	1,576	-	-	-		
22bdd-1	Oil Securities & Uranium No. 1 Marakis	1955	5,798	2,335	210DKOT	1,676	1,706	-	-	-	-
					217CDRM	1,706	2,235	-	-		
					217BCKR	2,206	2,235	-	-		
					221MRSN	2,235	-	-	-		
(D-15-10)26aaa-1	Shell No. 1 Federal	1958	5,500	10,854	221CRTS	2,540	2,700	-	-	C	Company called the sampled zone the Humbug Formation.
					221ENRD	2,700	3,308	-	-		
					221CRML	3,308	3,914	-	-		
					220NVJO	3,914	4,260	-	-		
					231KYNT	4,260	4,390	-	-		
					231WNGT	4,390	4,793	-	-		
					310KIBB	6,266	6,450	-	-		
					310CCNN	6,450	7,108	-	-		
					330MSSP	8,950	10,763	10,058	10,165		
(D-15-11)12cda-1	Carbon Dioxide & Chemical No. 2 Farnham Dome	1930	5,735	3,114	220NVJO	3,100	-	3,095	3,114	C	Water sample bailed from well by using temperature logging equipment at 2,320 ft. Well produced 2,780 MCF per day of carbon dioxide.
12dbc-1	Utah Oil Refining No. 1 Farnham Dome	1924	5,765	3,235	220NVJO	3,090	-	-	-	-	Replugged in 1944 to shut off water in sand at 1,332 to 1,392 ft. Well produced 12 MCF per day of carbon dioxide.
(D-15-12)7ccc-1	Pan American No. 1 Farnham Dome	1963	5,780	8,509	210DKOT	472	-	-	-	C	-
					217BCKR	1,050	-	-	-		
					221CRTS	2,005	2,164	-	-		
					220NVJO	3,008	3,280	-	-		
					231KYNT	3,280	3,580	-	-		
					231WNGT	3,580	3,775	-	-		
					310KIBB	4,896	5,012	-	-		
					310CCNN	5,012	5,282	-	-		
					330MSSP	7,042	8,154	7,433	7,986		Recovered very cloudy water with dark brown organic filtrate.
					340DVNN	8,154	8,284	-	-		
					370CMBR	8,254	8,492	-	-		
					400PCMB	8,492	-	-	-		

Table 11.--Records of selected petroleum-test wells and other test holes--Continued

Location	Name	Year constructed	Altitude (ft)	Depth drilled (ft)	Selected geologic data: Aquifer code	Selected geologic data: Depth to top (ft)	Selected geologic data: Depth to bottom (ft)	Interval tested: Depth to top (ft)	Interval tested: Depth to bottom (ft)	Other data available	Remarks
(D-15-12)8ccd-1	Equity No. 1 Federal	1959	5,687	9,174	210DKOT	400	410	-	-	C	Drilled to 1,141 ft by Shell Oil Co. Completed as a carbon-dioxide well.
					217CDRM	410	1,002	-	-		
					217BCKR	970	1,002	-	-		
					221CRTS	1,873	2,030	-	-		
					221ENRD	2,030	2,465	-	-		
					221CRML	2,465	2,787	-	-		
					220NVJO	2,787	3,118	-	-		
					231KYNT	3,118	3,230	-	-		
					231WNGT	3,230	3,617	-	-		
					230MNKP	3,915	4,877	-	-		
					237SNBD	4,490	-	4,495	4,501		Produced 2,750 MCF per day of carbon dioxide.
					310KIBB	4,877	5,072	-	-		
					331HMBG	7,546	7,970	-	-		
					330RDLL	7,970	9,130	8,323	9,174		Recovered 6,750 ft slightly gassy, slightly muddy salt water with a trace of oil.
					341ELBR	9,130	-	-	-		
17ddd-1	Equity No. 2 Federal	1962	5,598	4,572	217BCKR	905	950	-	-	-	-
					221ENRD	1,960	-	-	-		
					220NVJO	2,715	-	-	-		
					231WNGT	-	3,525	-	-		
18acd-1	Equity No. 3 Weber	1953	5,745	5,241	210DKOT	403	-	-	-	-	-
					221BRSB	971	1,325	-	-		
					221CRTS	1,816	2,003	-	-		
					221ENRD	2,003	2,467	-	-		
					221CRML	2,467	2,793	-	-		
					220NVJO	2,793	3,095	2,817	2,903		Zone produced 18,000 MCF per day of carbon dioxide. Some "sulfur" water.
					231KYNT	3,095	3,155	-	-		
					231WNGT	3,155	3,592	-	-		
					310KIBB	4,749	4,890	4,775	4,875		Recovered 2,048 MCF per day of carbon dioxide; 90 ft of "sulfur" water.
					310CCNN	4,890	-	4,935	5,112		Recovered 225 ft of carbon-dioxide-cut mud.
								5,091	5,241		Recovered 3,052 ft of water.
33aca-1	Equity No. 1 Weber	1952	5,440	9,360	210DKOT	430	471	-	-	-	-
					217BCKR	798	829	-	-		
					221CRTS	1,651	1,815	-	-		
					221ENRD	1,815	2,181	-	-		
					221CRML	2,181	2,487	-	-		
					220NVJO	2,487	2,853	-	-		
					231KYNT	2,853	2,912	-	-		
					231WNGT	2,912	3,354	-	-		
					230MNKP	3,611	4,626	4,119	4,617		Recovered only carbon dioxide.
					310KIBB	4,626	4,678	-	-		
					310CCNN	4,678	-	4,652	4,781		Recovered 1,547 ft of mud and 1,773 ft of gas-cut water.
					330MSSP	6,453	-	-	-		
					330MDSN	8,674	-	8,741	8,779		Recovered 450 ft of mud and 440 ft of water.
					370CMBR	9,211	-	9,272	9,360		Recovered only mud.
(D-15-12)36caa-1	McAdams No. 3 State	1962	5,454	4,110	221CRTS	1,753	1,876	-	-	-	Drilled by Cities Service Oil Co. Produced oil from Moenkopi Formation.
					220NVJO	2,474	-	-	-		
					231WNGT	2,894	3,319	-	-		

Location	Name	Year con-structed	Alti-tude (ft)	Depth drilled (ft)	Selected geologic data: Aquifer code	Selected geologic data: Depth to top (ft)	Selected geologic data: Depth to bottom (ft)	Interval tested: Depth to top (ft)	Interval tested: Depth to bottom (ft)	Other data avail-able	Remarks
(D-15-13)17dbc-1	Mountain Fuel Supply No. 1 Federal	1971	5,850	9,158	210DKOT	1,726	1,746	-	-	C	-
					217BCKR	2,015	2,050	-	-		
					221MRSN	2,050	2,546	-	-		
					221SMVL	2,546	2,808	-	-		
					221CRTS	2,808	2,930	-	-		
					221ENRD	2,930	3,270	-	-		
					221CRML	3,270	3,565	-	-		
					220NVJO	3,565	3,866	-	-		
					231KYNT	3,866	3,950	-	-		
					231WNGT	3,950	4,350	-	-		
					231CHNL	4,350	4,573	-	-		
					231SRMP	4,526	-	-	-		
					230MNKP	4,573	5,504	-	-		
					237SNBD	5,135	5,200	-	-		
					310KIBB	5,504	5,640	-	-		
					310CCNN	5,640	-	-	-		
					324HRMS	6,956	-	-	-		
					320MNGC	7,390	-	-	-		
					330DSRT	7,820	8,480	7,990	8,080		Recovered 300 ft slightly gas-and water-cut mud and 6,050 ft of slightly gas-cut salt water.
					330MDSN	8,480	8,880	-	-		
					340DVNN	8,880	8,950	-	-		
					370CMBR	8,950	9,090	-	-		
					400PCMB	9,090	-	-	-		
(D-16-10)28cdb-1	Chevron No. 1 Willson	1967	5,375	10,000	220NVJO	3,962	-	-	-	-	-
					231WNGT	-	4,900	-	-		
					310WTRM	6,534	7,200	-	-		
					330MSSP	9,350	-	-	-		
(D-16-11)11cba-1	Pan American No. 1 Federal	1965	5,375	9,425	221CRTS	1,465	1,595	-	-	-	-
					221ENRD	1,595	2,202	-	-		
					221CRML	2,202	2,484	-	-		
					220NVJO	2,484	2,848	-	-		
					231KYNT	2,848	2,987	-	-		
					231WNGT	2,987	3,377	-	-		
					310KIBB	4,725	4,858	-	-		
					310CCNN	4,858	5,530	-	-		
					331HMBG	7,612	8,016	-	-		
					330DSRT	8,016	8,760	8,150	8,275		2,500 MCF per day nonflammable gas by flow.
								8,276	8,369		1,500 to 2,000 MCF per day nonflamma-ble gas by flow.
								8,369	8,520		1,720 MCF per day nonflammable, by flow.
								8,520	8,620		Recovered 44 MCF nonflammable gas and 2,000 ft of water.
					330RDLL	8,760	-	-	-		
					370CMBR	9,382	-	-	-		
(D-16-12)1aab-1	Cities Service No. 4 Federal	1962	5,380	4,020	221CRTS	1,530	1,620	-	-	-	-
					220NVJO	2,280	-	-	-		
					231WNGT	2,770	3,156	-	-		
					230MNKP	3,420	-	3,890	3,903		Produced oil.
1bbd-1	McAdams No. 1 Federal	1953	5,425	7,930	221CRTS	1,512	1,650	-	-	C	Drilled by Cities Service Oil Co. Re-entered in 1961.
					221ENRD	1,650	1,983	-	-		
					221CRML	1,983	2,270	-	-		
					220NVJO	2,270	2,693	-	-		
					231WNGT	2,750	3,169	-	-		
					237SNBD	4,017	-	4,014	4,083		Recovered 80 ft of "sulfur gas"-cut mud, 90 ft mud-cut water and 450 ft water.
					310CCNN	4,550	5,177	-	-		
					331HMBG	7,350	7,733	-	-		
					330MDSN	7,733	-	7,831	7,930		Recovered 270 ft carbon dioxide and water-cut mud and 1,910 ft of carbon dioxide-cut salt water.

Table 11.--Records of selected petroleum-test wells and other test holes--Continued

Location	Name	Year constructed	Altitude (ft)	Depth drilled (ft)	Selected geologic data: Aquifer code	Selected geologic data: Depth to top (ft)	Selected geologic data: Depth to bottom (ft)	Interval tested: Depth to top (ft)	Interval tested: Depth to bottom (ft)	Other data available	Remarks
(D-16-12)1caa-1	McAdams No. 5 Federal	1962	5,504	4,110	221CRTS	1,503	1,645	-	-	-	Drilled by Cities Service Oil Co. Produced oil from Moenkopi Formation.
					221ENRD	1,645	2,070	-	-		
					221CRML	2,070	2,280	-	-		
					220NVJO	2,280	-	-	-		
					231WNGT	2,737	3,205	-	-		
2aab-1	McAdams No. 2 State	1961	5,432	4,020	220NVJO	2,278	-	-	-	-	Do.
					231WNGT	2,756	3,146	-	-		
2bab-1	Skyline No. 2-21 State	1972	5,515	4,145	221ENRD	1,600	-	-	-	-	Drilled with air.
					220NVJO	-	-	2,330	2,800		Produced 175 gal/min brackish water.
					231KYNT	-	2,800	-	-		
					231WNGT	2,800	-	2,800	3,180		Produced 70 gal/min brackish water.
4bad-1	Equity No. 2 Weber	1953	5,430	4,678	221CRTS	1,503	1,668	-	-	C	Tested nine zones between 3,975 and 4,452 ft, which produced a little water from the Moenkopi Formation.
					221ENRD	1,668	2,029	-	-		
					221CRML	2,029	2,339	-	-		
					220NVJO	2,339	-	-	-		
					231WNGT	2,794	3,228	-	-		
					230MNKP	3,490	4,611	Multiple tests			
4cda-1	Equity No. 4 Weber	1953	5,443	4,671	221CRTS	1,365	1,532	-	-	-	-
					221ENRD	1,532	1,902	-	-		
					221CRML	1,902	2,180	-	-		
					220NVJO	2,180	-	-	-		
					231WNGT	2,673	3,121	-	-		
					310CCNN	4,620	-	-	-		
12bac-1	McAdams No. 1 Federal	1962	5,341	4,322	221ENRD	1,362	1,712	-	-	-	Drilled by Cities Service Oil Co.
					220NVJO	2,004	2,458	-	-		
					231WNGT	2,522	2,912	-	-		
					230MNKP	3,151	4,170	3,655	3,761		Produced 3 barrels (126 gallons) of water per day with oil.
					310CCNN	4,304	-	-	-		
16dad-1	Equity No. 1 State	1961	5,557	3,820	217BCKR	170	196	-	-	-	-
					221SLWS	520	653	-	-		
					221ENRD	1,170	1,530	-	-		
					220NVJO	1,830	2,260	-	-		
					231WNGT	2,310	2,708	-	-		
					237SNBD	3,618	-	3,625	3,820		Recovered 1,300 ft slightly salty "sulfur" water.
23cbb-1	Globe Minerals No. 1 Garman and Fees	1969	5,700	3,616	221ENRD	999	1,428	-	-	-	-
					220NVJO	1,722	2,030	1,782	-		Reported yield (by air lift?) was 170 gal/min.
					231WNGT	2,140	2,604	-	2,604		
27abb-1	Carter No. 1 Federal	1957	5,815	7,132	221CRTS	980	1,135	-	-	C	-
					221ENRD	1,135	1,440	-	-		
					220NVJO	1,755	2,120	-	-		
					231WNGT	2,222	2,634	-	-		
					230MNKP	2,960	3,846	-	-		
					237SNBD	2,960	-	3,501	3,573		Produced 1,604 MCF per day of nonflammable gas with hydrogen sulfide odor.
					310CCNN	3,975	4,435	-	-		
					324HRMS	4,435	-	4,442	4,458		Recovered 30 ft of mud and 360 ft of water.
					331HMBG	6,140	6,410	-	-		
					330DSRT	6,410	6,585	-	-		
					330MDSN	6,585	-	6,998	7,132		Recovered 140 ft of mud and 840 ft of salt water.
(D-16-13)8ddc-1W	True No. 44-8 Hamill	1974	5,328	4,390	217BCKR	585	710	-	-	-	Plugged back and left for use as water well.
					221SLWS	1,000	1,270	-	-		
					221CRTS	1,451	1,625	-	-		
					221ENRD	1,625	1,985	-	-		
					220NVJO	2,220	2,560	-	-		
					231WNGT	2,650	3,070	-	-		
					310KIBB	4,300	-	-	-		

Table 11.--Records of selected petroleum-test wells and other test holes--Continued

Location	Name	Year con- structed	Alti- tude (ft)	Depth drilled (ft)	Selected geologic data: Aquifer code	Depth to top (ft)	Depth to bottom (ft)	Interval tested: Depth to top (ft)	Depth to bottom (ft)	Other data avail- able	Remarks
(D-16-13)21ccd-1	Reserve No. 1 Socony Mobil	1963	5,287	6,506	221CRTS	1,016	1,163	-	-	C	-
					221ENRD	1,163	1,485	-	-		
					220NVJO	1,777	2,099	1,784	-		Sampled while drilling with air in Navajo-Wingate section. At 2,400 ft yield reported as 50 gal/min of water containing 10,000 ppm of sodium chloride.
					231WNGT	2,205	2,644	-	2,400		
					230MNKP	2,912	3,896	3,494	-		
					237SNBD	3,516	3,574	-	3,550		Recovered 60 ft mud and 403 ft of muddy "sulfur" water.
					310CCNN	4,045	4,535	-	-		
					330MSSP	6,150	-	-	-		
(D-17-10)1dbb-1	Pure Oil No. 1 State	1961	5,569	10,915	221CRTS	1,637	1,800	-	-	-	-
					221ENRD	1,800	2,555	-	-		
					220NVJO	2,770	3,190	-	-		
					231WNGT	3,375	3,730	-	-		
					310CCNN	5,415	6,075	-	-		
					330MSSP	9,210	-	-	-		
					374OPHR	10,453	10,630	-	-		
					374TNTC	10,630	-	-	-		
					400PCMB	10,840	-	-	-		
(D-17-12)1bba-1	Read No. 1 Quintana	1963	5,632	3,312	221ENRD	846	1,236	-	-	-	-
					220NVJO	1,451	1,841	-	-		
					231WNGT	1,945	2,339	-	-		
(D-17-13)30ddd-1W	True No. 44-30 Hamill	1974	5,147	2,704	221CRML	0	353	-	-	-	Plugged back and left for use as water well. Drilled with mud, 391-1,728 ft because of water in Navajo and (?) Wingate.
					220NVJO	353	722	-	-		
					231WNGT	805	1,280	-	-		
					230MNKP	1,568	2,663	-	2,600		Brackish water with hydrogen sulfide. Reverse fault between 1,568 and 1,690 ft.
32bdc-1	U.S. Dept. of Energy No. SR-25	1979	5,157	1,625	221CRML	0	315	-	-	C	Test hole for coring Chinle Formation. Drilled with air and detergent. Navajo drilled hard and slowly. Water level estimated at 105 ft below land surface, from geophysical logs.
					220NVJO	315	745	312	400		
					231WNGT	890	1,245	312	700		
(D-17-14)29acd-1	Placid No. 1 Tidewater-Southern Union	1965	4,751	8,517	200MNCS	0	518	-	-	-	See table 4 for permeability data.
					210DKOT	518	653	-	-		
					217CDRM	653	970	-	-		
					217BCKR	970	998	-	-		
					221MRSN	998	1,470	-	-		
					221SMVL	1,470	1,690	-	-		
					221CRTS	1,690	1,879	-	-		
					221ENRD	1,879	2,190	-	-		
					221CRML	2,190	2,610	-	-		
					220NVJO	2,610	2,870	2,735	2,737		Recovered fresh water with odor of hydrogen sulfide.
								2,743	2,745		Recovered fresh water.
					231KYNT	2,870	3,100	-	-		
					231WNGT	3,100	3,430	-	-		
					231CHNL	3,430	3,935	-	-		
					230MNKP	3,935	4,812	-	-		
					237SNBD	4,400	4,527	-	-		
					310KIBB	4,812	4,933	-	-		
					310WTRM	4,933	5,220	-	-		
					310OGRK	5,220	5,393	-	-		
					319ELPC	5,393	6,175	-	-		
					324HRMS	6,175	-	-	-		
					324PRDX	6,358	7,265	-	-		
					330MSSP	8,160	-	8,340	8,507		Recovered 360 ft of water-cut mud, 540 ft muddy water, and 5,321 ft salt water.

Table 11.--Records of selected petroleum-test wells and other test holes--Continued

Location	Name	Year constructed	Altitude (ft)	Depth drilled (ft)	Selected geologic data: Aquifer code	Selected geologic data: Depth to top (ft)	Selected geologic data: Depth to bottom (ft)	Interval tested: Depth to top (ft)	Interval tested: Depth to bottom (ft)	Other data available	Remarks
(D-18-9)31dda-1	Kralik No. 1 State	1948	5,840	3,600	220NVJO	3,540	-	-	-	-	-
(D-18-10)18dab-1	Hamon No. 1 AMOCO	1973	5,767	4,530	221CRTS	1,262	1,424	-	-	-	-
					221ENRD	1,424	1,955	-	-		
					220NVJO	2,458	-	-	-		
					310KIBB	4,430	-	-	-		
(D-18-11)27aca-1	Austral No. 1-27 Amerada	1966	7,082	6,861	217CDRM	0	-	-	-	-	Driller reported 6-8 barrels (252-335 gallons) of water per hour, with 900 ppm of sodium chloride.
					220NVJO	1,682	-	1,682	1,900		Water zone indicated by geophysical logs.
					231WNGT	-	-	2,300	2,400		Do.
					310CCNN	3,940	4,416	-	-		
					330MSSP	5,206	-	5,590	5,610		Driller reported water.
					371LYNC	6,402	-	6,550	6,710		Do.
(D-18-12)12ada-1	El Paso Natural Gas No. 1 Harman	1953	5,291	6,806	221CRML	0	100	-	-	-	-
					220NVJO	100	400	-	-		
					231WNGT	524	970	-	-		
					310CCNN	2,330	-	-	-		
					320PSLV	2,859	4,566	-	-		
					330MSSP	4,566	-	5,050	5,150		Recovered 3,970 ft of salt water.
					374TNTC	6,580	6,720	-	-		
					400PCMB	6,720	-	-	-		
25aab-1	Modern Menerals No. 1 Skyline	1969	5,681	2,339	221CRML	0	50	-	-	-	-
					220NVJO	50	444	-	-		
					231WNGT	-	1,012	-	-		
					310KIBB	2,267	-	-	-		
(D-18-14)8ccd-1	Lemm-Maiatico No. 1 Federal	1960	4,830	7,920	217BCKR	240	275	-	-	-	-
					221SLWS	521	781	-	-		
					221CRTS	1,150	1,307	-	-		
					221ENRD	1,307	1,486	-	-		
					220NVJO	1,785	1,960	-	-		
					231WNGT	2,091	2,732	-	-		
					310CCNN	4,217	4,587	-	-		
					324HRMS	5,113	7,186	-	-		
					324PRDX	5,447	-	5,950	6,020		Recovered 300 ft of mud and 1,500 ft of slightly mud-cut water.
					320MOLS	7,168	7,270	-	-		
					320MNGC	7,270	7,472	-	-		
					330MSSP	7,472	-	7,640	7,920		Recovered 810 ft of mud, 450 ft of slightly water-cut mud, and 5,790 ft of brackish water.
30ccb-1	Humble Oil No. 2 Federal	1962	5,090	7,083	221CRTS	445	635	-	-	C	-
					221ENRD	635	995	-	-		
					220NVJO	1,294	-	-	-		
					231WNGT	-	2,246	-	-		
					310KIBB	3,606	3,710	3,605	3,673		Recovered 300 ft of mud, 720 ft of slightly mud-cut and heavily gas-cut "sulfur" water, and 1,620 ft of heavily gas-cut "sulfur" water.
					310CCNN	3,710	4,159	3,717	3,868		Recovered 160 ft of mud, 450 ft of slightly salty water, and 270 ft of gas-cut and slightly mud-cut water.
					330MSSP	6,872	-	6,963	7,083		Recovered 90 ft of mud and 3,366 ft of salt water.
(D-18-15)19abd-1	Shamrock No. 1 Federal	1966	4,584	9,896	220NVJO	4,920	5,300	-	-	-	-
					231WNGT	5,515	5,860	-	-		
					310CCNN	7,260	7,818	-	-		

Location	Name	Year constructed	Altitude (ft)	Depth drilled (ft)	Selected geologic data: Aquifer code	Selected geologic data: Depth to top (ft)	Selected geologic data: Depth to bottom (ft)	Interval tested: Depth to top (ft)	Interval tested: Depth to bottom (ft)	Other data available	Remarks
(D-19-9)8bdd-1	Hamon No. 1 Gulf Oil	1975	5,495	6,215	221SLWS	755	1,200	-	-	-	-
					221CRTS	1,460	1,620	-	-		
					221ENRD	1,620	2,270	-	-		
					220NVJO	2,900	-	-	-		
					231WNGT	3,580	3,850	-	-		
					310CCNN	5,115	-	-	-		
					330MSSP	5,790	-	-	-		
(D-19-10)23dbb-1	Bush No. 1 Phillips	1977	5,685	1,578	221CRML	0	180	-	-	-	-
					220NVJO	180	610	-	-		
					231WNGT	735	1,175	-	-		
(D-19-11)11bda-1	True No. 22-11 Hamill	1975	7,448	2,384	217CDRM	0	100	-	-	-	-
					221SLWS	400	600	-	-		
					221CRTS	765	950	-	-		
					221ENRD	950	1,313	-	-		
					220NVJO	1,605	2,045	-	-		
					231WNGT	2,130	-	-	-		
(D-19-12)9cca-1	Hancock Utah Devel. No. 1 Federal	1954	6,089	4,930	221CRML	0	16	-	-	-	Witness post at site shows that at 1,583 ft hole contains a lost geophysical survey tool containing a neutron source.
					220NVJO	16	546	-	-		
					231WNGT	686	1,094	-	-		
					310CCNN	2,376	-	-	-		
					330MSSP	4,158	-	4,251	4,366		Recovered 210 ft of slightly water-cut mud.
								4,788	4,839		Recovered 630 ft of mud-cut fresh water.
9dbc-1	Modern Minerals No. 1 Skyline-State	1969	6,070	2,376	221CRML	0	68	-	-	-	-
					220NVJO	68	556	-	-		Zone found dry in 1980.
	Re-entry by U.S. Geological Survey				231KYNT	556	713	-	-		Zone found slightly damp in 1980.
		1980		610	231WNGT	713	1,114	-	-		
					231SRMP	1,358	-	1,340	1,410		Driller reported about 1.5 gal/min of fresh water.
					310CCNN	2,355	-	-	-		
29caa-1	Reynolds Mining No. 1 Federal	1955	6,167	6,031	221CRML	0	30	-	-	-	-
					220NVJO	30	536	-	-		
					231KYNT	686	1,090	-	-		
					231CHNL	1,090	1,402	-	-		
					231SRMP	1,362	-	-	-		
					230MNKP	1,402	2,256	-	-		
					237SNBD	1,980	-	-	-		
					310KIBB	2,256	2,369	-	-		
					310CCNN	2,369	-	-	-		
					320PSLV	2,865	4,106	-	-		
					330MSSP	4,106	4,922	-	-		
					341OURY	4,922	5,052	-	-		
					341ELBR	5,052	5,302	-	-		
					371LYNC	5,302	5,695	-	-		
					374OPHR	5,695	-	-	-		
30bba-1	U.S. Geological Survey test hole No. NSR T-2	1980	6,182	550	221CRML	0	42	-	-	J	Dry to 550 ft, but siltstone in bottom seemed damp in last 20-30 ft. Selected samples from Navajo sent for sieve analysis.
					220NVJO	42	503	-	-		
					231KYNT	503	-	-	-		
(D-19-13)12dcb-1	Utah Oil Refining No. 1 Fitzhugh	1924	5,345	3,375	221CRTS	0	190	-	-	-	Discovery well for helium in Woodside anticline. (See Gilluly, 1929.) Zone yielded 6,000 to 9,000 MCF per day of inert gas with 1.31 percent helium.
					221ENRD	190	680	-	-		
					220NVJO	835	1,215	-	-		
					231WNGT	1,475	1,830	-	-		
					310CCNN	3,215	-	-	-		

Table 11.--Records of selected petroleum-test wells and other test holes--Continued

Location	Name	Year constructed	Altitude (ft)	Depth drilled (ft)	Selected geologic data: Aquifer code	Selected geologic data: Depth to top (ft)	Selected geologic data: Depth to bottom (ft)	Interval tested: Depth to top (ft)	Interval tested: Depth to bottom (ft)	Other data available	Remarks
(D-19-13)12ddd-1W	Humble Oil No. 1 Federal	1962	5,489	8,431	221CRTS	180	395	-	-	C	Composite record of petroleum testing operations. Plugged back and left, unperforated, for use as water well.
					221ENRD	395	894	-	-		
1S	Re-entry by Holly Resources	1969			220NVJO	1,052	1,439	-	-		
					231WNGT	1,664	2,022	-	-		
					310KIBB	3,306	3,424	3,341	3,373		Produced 5,000 MCF per day of nonflammable gas with spray of salt water that leaked from below bridge plug at 3,400 ft.
					310CCNN	3,424	3,884	3,671	3,702		Swabbed about 3 gal/min from three perforated intervals. Water was salty.
					324PRDX	5,301	-	5,518	5,608		Recovered 180 ft of mud and 5,120 ft of slightly salty water.
					330MSSP	6,391	7,226	6,736	6,915		Recovered 300 ft of mud and 5,160 ft of slightly mud-cut salt water.
21cbd-1	U.S. Geological Survey test hole NSR T-3	1980	5,190	310	111ALVM	0	8	-	-	C,J	Drilled with air and detergent.
					221CRML	8	120	-	-		Small amount of perched water in Carmel at 59 ft; later heard dripping to water level at 95 ft.
					220NVJO	120	-	120	310		See table 9 for hydrologic data.
(D-19-14)8cbd-1	Skyline No. 1 Federal	1970	5,033	6,528	220NVJO	1,640	-	-	-	-	-
					231WNGT	-	2,560	-	-		
					310WTRM	3,980	-	-	-		
11dcb-1	California-Time No. 1 Federal	1968	5,005	8,795	217BCKR	2,301	2,370	-	-	-	-
					221SLWS	2,557	2,825	-	-		
					221CRTS	2,994	3,110	-	-		
					221ENRD	3,110	3,501	-	-		
					220NVJO	3,812	3,995	-	-		
					231WNGT	4,180	4,770	4,440	4,575		Recovered 1,340 ft of mud-cut water.
					310WTRM	6,080	-	-	-		
					324PRDX	8,121	-	-	-		
35bcd-2	Carter No. 1-A Federal	1957	4,642	8,737	210DKOT	953	989	-	-	-	-
					217BCKR	1,170	1,207	-	-		
					221SLWS	1,388	1,675	-	-		
					221ENRD	2,187	2,422	-	-		
					220NVJO	2,652	-	-	-		
					231WNGT	-	3,612	-	-		
					310CCNN	4,865	5,263	-	-		
					330MSSP	8,587	-	-	-		
(D-19-15)14ddc-1	Clinton No. 1 Walsh	1975	6,060	10,798	210DKOT	4,364	-	-	-	-	-
					221ENRD	5,715	-	-	-		
					220NVJO	6,218	-	-	-		
					231WNGT	6,920	7,150	-	-		
					310CCNN	8,550	-	-	-		
(D-20-8)35bbd-1	True No. 11-35 Federal	1975	5,713	4,457	221CRML	1,530	2,150	-	-	-	-
					220NVJO	2,150	2,790	-	-		
					231WNGT	3,130	3,250	-	-		
					310KIBB	4,350	-	-	-		
(D-20-9)27bac-1	U.S. Dept. of Energy No. SR-204	1979	5,586	1,902	221CRML	0	472	-	-	-	Test hole for coring Chinle Formation. Water level estimated at 132 ft below land surface, from geophysical logs.
					220NVJO	472	1,012	-	-		
					231WNGT	1,220	1,550	-	-		
33aab-1	U.S. Dept. of Energy No. SR-203	1979	5,657	1,913	220NVJO	520	1,044	-	-	-	Water level estimated at 152 ft below land surface, from geophysical logs.
					231WNGT	1,264	1,601	-	-		
					231CCRK	1,601	1,737	-	-		
					231MBCK	1,737	-	-	-		
33daa-1	U.S. Dept. of Energy No. SR-202	1979	5,636	1,970	220NVJO	510	1,122	-	-	-	-
					231WNGT	1,298	1,628	-	-		

Table 11.--Records of selected petroleum-test wells and other test holes--Continued

Location	Name	Year constructed	Altitude (ft)	Depth drilled (ft)	Selected geologic data: Aquifer code	Depth to top (ft)	Depth to bottom (ft)	Interval tested: Depth to top (ft)	Depth to bottom (ft)	Other data available	Remarks
(D-20-10)6bdd-1	U.S. Geological Survey test hole NSR T-1	1980	5,260	475	111ALVM	0	30	-	-	C,J	Drilled with river water.
					221CRML	30	152	-	-		
					220NVJO	152	-	146	475		Flowed through packer and drill stem. Shut in for 1 hour 20 minutes. See table 9 for hydrologic data.
7dcb-1	True Oil No. 34-7 Federal	1975	5,558	2,440	220NVJO	182	725	-	-	-	-
					231WNGT	820	1,255	-	-		
					310CCNN	2,432	-	-	-		
(D-20-14)33bba-1	Toledo Mining No. 1 Skyline	1969	4,610	7,558						-	Detailed geologist log and test data in files of U.S. Geological Survey. Drilled with air to 2,269 ft where drilling mud had to be used to control water.
					221MRSN	0	430	230	240		Airlifting a "1-in. stream".
					221CRTS	695	865	-	-		
					221ENRD	865	1,180	865	880		Airlifting a "2-in. stream" of fresh water.
								960	990		Do.
					220NVJO	1,435	1,950	-	-		
					231WNGT	1,005	2,450	2,130	2,260		Do. Estimated discharge was more than 2,000 barrels per day (58 gal/min). Water reportedly analyzed by Green River Town.
					310CCNN	3,700	4,135	-	-		
					330MSSP	7,330	-	7,388	-		Drill pipe dropped about 2 ft and mud disappeared down hole.
								7,530	7,558		Recovered 180 ft of mud, 1,000 ft water-cut mud, and 2,230 ft of water containing 81,000 ppm of chloride.
(D-21-9)2bbb-1	U.S. Dept. of Energy No. SR-24	1979	5,770	1,772	221CRML	0	342	-	-	C	Water level estimated at 200 ft below land surface, from geophysical logs.
					220NVJO	342	940	342	520		Airlifting produced flow estimated at 100 gal/min.
								342	640		Water production increased.
								342	860		Do.
					231WNGT	1,115	1,452	342	1,450		Airlifting produced flow estimated at 200 gal/min.
(D-21-13)1dba-1	Wainoco No. 33-1 Skyline	1975	4,494	4,060	310WTRM	620	1,180	-	-	-	Driller reported zone yielded water.
					330MSSP	3,580	-	-	-		Do.
32dad-1	American Metal Climax No. 1 Putnam	1961	5,754	4,640	310KIBB	0	63	-	-	-	-
					310CCNN	63	740	-	-		
					319ELPC	740	1,236	-	-		
					324HRMS	1,236	2,170	-	-		
					324PRDX	1,754	1,868	-	-		Evaporite section.
					330MSSP	2,170	2,810	-	-		
					341OURY	2,810	2,930	-	-		
					341ELBR	2,930	3,179	-	-		
					371LYNC	3,179	3,876	-	-		
					374BWMN	3,876	-	-	-		
					374HRMN	-	4,215	-	-		
					374OPHR	4,215	4,414	-	-		
					374TNTC	4,414	4,580	-	-		
					400PCMB	4,580	-	-	-		

Table 11.--Records of selected petroleum-test wells and other test holes--Continued

Location	Name	Year constructed	Altitude (ft)	Depth drilled (ft)	Selected geologic data: Aquifer code	Selected geologic data: Depth to top (ft)	Selected geologic data: Depth to bottom (ft)	Interval tested: Depth to top (ft)	Interval tested: Depth to bottom (ft)	Other data available	Remarks
(D-21-14)5aad-1	Dennison Mines No. 5-1 Skyline	1974	4,563	6,000	310WTRM	2,425	2,990	-	-	-	-
					324HRMS	-	5,700	4,295	4,335		Recovered 1,800 ft of brackish water.
					330MSSP	5,824	-	-	-		
(D-21-15)24cca-1	Superior No. 14-24 Bamberger Estate	1961	4,215	10,606	221ENRD	1,538	1,922	-	-	C	-
					220NVJO	-	2,340	-	-		
					231WNGT	2,740	3,065	-	-		
					310CCNN	4,105	4,841	-	-		
					330MSSP	9,533	10,205	9,555	9,652		Recovered 173 ft of mud, 81 ft of water-cut mud, and 118 ft of muddy water.
								9,705	9,753		Recovered 600 ft of water-cut mud, and 5,700 ft of salt water.
(D-21-16)33bac-1	Skyline No. 1 Federal	1966	4,267	9,261	221ENRD	-	1,068	-	-	-	-
					220NVJO	1,225	-	-	-		
					231WNGT	-	2,180	-	-		
					310CCNN	3,265	3,642	-	-		
					310CTLR	3,642	3,856	-	-		
34dda-1	Ruby et al, No. 1 State	1936	4,056	2,627	221ENRD	-	487	-	-	C	Known as Crystal Geyser.
					220NVJO	695	1,065	-	-		
					231WNGT	-	1,614	-	-		
					310CCNN	2,622	-	-	-		
35dbc-1	Marland No. 1 Federal	1925	4,410	3,820	220NVJO	1,130	1,500	-	-	-	-
					231WNGT	-	2,055	-	-		
					310CCNN	3,055	3,400	-	-		
					310CTLR	3,400	3,570	-	-		
(D-21-17)26adc-1	Shell No. 1-26 Federal	1969	4,470	11,895	220NVJO	3,025	-	-	-	C	-
					310WTRM	5,028	5,463	-	-		
					324HRMS	6,260	-	6,465	6,615		Recovered 2,100 ft of salt water.
					324PRDX	7,916	-	-	-		
(D-22-8)10ccb-1	True No. 14-10 Federal	1975	6,057	3,690	221ENRD	0	685	-	-	-	-
					220NVJO	1,185	1,885	-	-		
					231WNGT	-	2,425	-	-		
					310KIBB	3,627	3,657	-	-		
					310CCNN	3,657	-	-	-		
11ccb-1W	Utah Plateau Uranium No. 1X Sterge	1961	5,940	2,246	221ENRD	0	120	-	-	C	Plugged back and left for use as a water well.
					220NVJO	735	1,300	-	-		
					231KYNT	1,300	1,550	1,416	1,467		Zone finished for water supply.
					231WNGT	1,550	1,924	-	-		
					231CHNL	1,924	2,195	-	-		
					230MNKP	2,195	-	1,400	2,246		Swabbed water sample. Water level 285 ft below land surface.
(D-22-10)30aca-1	Cities Service	1966	6,550	1,200	230MNKP	-	-			C	Core hole sampled while drilling.
								-	704		
								-	1,080		Water level recovered to 680 ft after 14 hours.
								-	1,200		Water level recovered to 580 ft after 28 hours.
33abc-1	Utah Dept. of Transportation	1963	7,120	475	231KYNT	0	68	-	-	-	Water test hole for contruction of Interstate Highway 70. See table 9.
					231WNGT	68	370	-	-		
					231CHNL	370	-	-	-		
(D-22-11)23bdc-1	do.	1963	6,520	290	230MNKP	0	39	-	-	-	Do.
					237SNBD	39	61	-	-		
					230MNKP	61	163	-	-		
					310KIBB	163	268	-	-		
					310CCNN	268	-	-	-		Water in basal Sinbad Limestone Member of the Moenkopi Formation was lost when hole was drilled into Coconino Sandstone.

Table 11.--Records of selected petroleum-test wells and other test holes--Continued

Location	Name	Year constructed	Altitude (ft)	Depth drilled (ft)	Selected geologic data: Aquifer code	Selected geologic data: Depth to top (ft)	Selected geologic data: Depth to bottom (ft)	Interval tested: Depth to top (ft)	Interval tested: Depth to bottom (ft)	Other data available	Remarks
(D-22-12)5abd-1	Three States Natural Gas No. 1 Federal	1954	6,230	4,183	310CCNN	0	-	-	-	-	-
					320PSLV	730	1,310	-	-		
					330MSSP	1,310	2,180	-	-		
					340DVNN	2,180	-	-	-		
					341ELBR	2,310	-	-	-		
					371LYNC	2,636	-	-	-		
					374OPHR	3,160	-	-	-		
					374TNTC	3,863	-	-	-		
					400PCMB	4,083	-	-	-		Granite wash at 4,083 ft; granite at 4,170 ft.
26abc-1	Reynolds Mining No. 1 Three States Natural Gas	1955	6,691	5,105	310KIBB	223	305	-	-	-	-
					310CCNN	305	-	-	-		
					320PSLV	1,105	2,404	-	-		
					330MSSP	2,404	3,118	-	-		
					400PCMB	5,066	-	-	-		
(D-22-13)24aad-1	AMAX No. 1 McCulloch	1964	4,730	6,755	221ENRD	480	933	-	-	-	-
					220NVJO	1,187	1,678	-	-		Driller reported water in Navajo to be saline.
					231WNGT	1,971	2,260	-	-		
					310CCNN	3,389	4,000	-	-		
					310OGRK	4,000	4,070	-	-		
					330MSSP	6,411	-	6,615	6,640		Recovered 200 ft of water-cut mud and 447 ft of muddy fresh water.
								6,645	6,755		Recovered 636 ft of muddy fresh water and 3,400 ft of fresh water.
(D-22-15)5ddb-1	California-Utah No. 1 Politano	1899	4,400	1,600	200MNCS	0	800	-	-	-	Reportedly ended in Morrison Formation. Water level 15 ft below land surface.
9abc-1	AMAX No. 9-7 Monsanto Chemical	1964	4,427	8,991	217CDRM	354	510	-	-	-	-
					221SLWS	802	1,146	-	-		
					221ENRD	1,537	1,873	-	-		
					220NVJO	2,063	2,494	-	-		
					231WNGT	2,664	3,067	-	-		
					310CCNN	4,092	4,848	-	-		
					330RDLL	8,560	-	8,637	8,747		Recovered 550 ft of water-cut mud and 7,200 ft of salt water.
26caa-1	Texas Eastern Transmission No. 1 Federal	1957	4,344	8,490	221ENRD	1,035	1,302	-	-	-	-
					220NVJO	1,530	2,015	-	-		
					231WNGT	-	2,256	-	-		
					310CCNN	3,543	4,110	-	-		
					310OGRK	4,110	-	-	-		
					330MSSP	8,330	-	8,388	8,490		Recovered 630 ft of mud, 380 ft of muddy salt water, and 6,640 ft of salt water.
28bda-1	Equity No. 1 Weber	1952	4,395	8,134	220NVJO	1,565	-	-	-	-	-
					231WNGT	-	2,530	-	-		
					310CCNN	3,559	-	-	-		
					330MSSP	7,860	-	7,999	8,131		Recovered 7,360 ft of salt water.
29bbd-1	American Metal Climax No. 29-4B Sinclair	1961	4,405	6,201	221SLWS	297	549	-	-	-	-
					221CRTS	718	941	-	-		
					221ENRD	941	1,378	-	-		
					220NVJO	1,597	2,058	-	-		
					231WNGT	2,251	2,615	-	-		
					310CCNN	3,624	-	-	-		
					319ELPC	4,343	-	-	-		
					324PRDX	6,190	-	-	-		Evaporite section.
(D-22-16)2bba-1	Amerada No. 1 State	1948	4,080	5,645	221CRTS	755	790	-	-	C	-
					221ENRD	790	1,327	-	-		
					220NVJO	1,495	-	-	-		
					230MNKP	2,025	2,608	-	-		Salt water at 2,003 ft. Fault at 2,025 ft.
					310CCNN	2,665	2,905	-	-		
					310CTLR	2,905	-	-	-		
					324PRDX	5,105	-	5,250	-		Well flowed brine from salt section while cleaning out hole. During 31-day test well produced 1.59 million gallons of brine, with oil and gas.

Table 11.--Records of selected petroleum-test wells and other test holes--Continued

Location	Name	Year constructed	Altitude (ft)	Depth drilled (ft)	Selected geologic data: Aquifer code	Selected geologic data: Depth to top (ft)	Selected geologic data: Depth to bottom (ft)	Interval tested: Depth to top (ft)	Interval tested: Depth to bottom (ft)	Other data available	Remarks
(D-22-16)2bbd-1	Amerada No. 2 State	1949	4,067	5,896	220NVJO	1,475	-	-	-	C	-
					231WNGT	1,960	2,405	-	-		
					231CHNL	2,405	-	-	-		
					230MNKP	-	2,880	-	-		Fault zone 2,640 to 3,180 ft.
					310CCNN	2,880	3,110	-	-		
					310CTLR	3,110	-	3,199	-		
					310RICO	-	3,195	-	-		
					324HRMS	3,195	3,750	-	3,405		Recovered 2,355 ft of mud, muddy water and water.
					324PRDX	3,750	-	5,792	5,896		Well flowed brine while drilling; produced 30 to 150 gal/min.
14bac-1	Ferguson No. 1 Ruby	1971	4,408	6,765	220NVJO	1,218	1,610	-	-	-	-
					231WNGT	1,727	2,155	-	-		
					310CCNN	3,100	-	-	-		
					324HRMS	4,445	-	4,765	4,847		Recovered 1,087 ft of slightly gas-cut salt water and mud.
25bbc-1	Mountain Fuel Supply No. 1 Skyline	1973	4,120	9,508	221ENRD	505	665	-	-	C	Numerous packer tests made.
					220NVJO	820	1,275	-	-		
					231WNGT	1,412	1,600	-	-		
					310CCNN	2,550	2,848	2,585	2,605		
					310CTLR	2,848	3,130	-	-		
					319ELPC	3,130	-	3,442	3,480		
					324HRMS	3,963	9,120	4,175	4,232		
					330MSSP	9,157	-	9,225	9,280		Recovered 8,600 ft of salt water.
(D-22-17)32aaa-1	Pacific Western No. 1 Sharp	1949	4,470	5,046	221ENRD	19	360	-	-	-	-
					220NVJO	485	700	-	-		
					231WNGT	905	1,385	-	-		
					310CCNN	2,323	2,725	-	-		
					310CTLR	2,725	2,843	-	-		
					310RICO	2,843	2,928	-	-		
					324PRDX	4,761	-	-	-		
34bda-1	Superior No. 22-34 Federal	1958	4,320	10,293	231WNGT	-	1,720	-	-	C	-
					310CCNN	2,690	-	-	-		
					330MSSP	10,020	-	10,053	10,173		Recovered 500 ft of muddy water and 2,670 ft of salt water.
(D-23-7)16bbd-1	U.S. Dept. of Energy No. SR-12B	1979	5,839	3,700	221BRSB	0	60	-	-	-	Formation tops estimated from geophysical logs.
					221SLWS	60	210	-	-		
					221SMVL	210	605	-	-		
					221CRTS	605	670	-	-		
					221ENRD	670	1,430	-	-		
					221CRML	1,430	2,092	-	-		
					220NVJO	2,092	2,850	-	-		
					231WNGT	2,964	3,340	-	-		
(D-23-8)32bba-1	U.S. Dept. of Energy No. SR-111	1979	5,821	2,014	221CRML	0	420	-	-	-	Hole left for earth-temperature gradient measurements by University of Utah. Water level reported at 344 ft below land surface.
					220NVJO	420	1,234	-	-		
					231KYNT	1,234	1,338	-	-		
					231WNGT	1,338	1,680	-	-		
					231CCRK	1,680	1,858	-	-		
					231MBCK	1,858	1,880	-	-		
					230MNKP	2,014	-	-	-		
(D-23-9)2ccb-1	Snow No. 1 State	1966	7,030	690	231WNGT	0	112	-	-	C	Water test hole near Interstate Highway 70.
					231CHNL	112	264	-	-		
					230MNKP	264	468	-	-		
					310KIBB	468	560	-	-		
					310CCNN	560	-	-	-		
17cbd-1	Amerada No. 1 Federal	1962	7,046	3,665	220NVJO	0	587	-	-	-	-
					231WNGT	914	1,219	-	-		
					231CHNL	1,219	1,483	-	1,248		Produced 4 to 6 gal/min of water.
					310KIBB	2,299	2,322	-	-		
					310CCNN	2,322	3,004	-	-		
					319ELPC						
(D-23-10)24dcc-1	Pan American No. 1 Anderson	1958	6,840	2,000	310KIBB	265	320	-	-	-	-
					310CCNN	320	1,090	-	-		
					324HRMS	1,090	-	-	-		
					330MSSP	1,600	-	-	-		
28dbb-1	Amerada No. 1-354 Federal	1961	6,817	3,144	330MSSP	-	-	-	2,197	C	Drilled with air.
								-	2,265		

Table 11.--Records of selected petroleum-test wells and other test holes--Continued

Location	Name	Year constructed	Altitude (ft)	Depth drilled (ft)	Selected geologic data: Aquifer code	Selected geologic data: Depth to top (ft)	Selected geologic data: Depth to bottom (ft)	Interval tested: Depth to top (ft)	Interval tested: Depth to bottom (ft)	Other data available	Remarks
(D-23-11)22ccc-1W	Standard Oil of California No. 1 Federal	1936	6,710	2,285	310KIBB	0	-	-	-	-	See composite sample log for this and well in sec. 28 in Baker, 1946. Company converted well to water-supply well after massive loss of drilling fluid circulation. See table 9.
					330MSSP	-	-	-	-		
27bbd-1	Standard Oil of California No. 2 Federal	1937	6,690	4,900	310CCNN	0	-	-	-	-	See preceding note for well 22ccc-1W.
					400PCMB	4,885	-	-	-		
34cab-1	Carter Oil No. 1 Federal	1922	6,605	3,035	-	-	-	-	-	-	See log in Gilluly (1929, p. 129).
(D-23-13)7dcc-1	Kerr-McGee No. 1 Texas Pacific	1957	6,520	2,218	310CCNN	0	-	-	-	-	-
					320PSLV	765	-	-	-		Water at about 900 ft. Fault zone at 1,000 ft.
					330MSSP	1,012	1,680	1,073	1,103		No water found.
								1,308	1,461		Do.
(D-23-14)9ddb-1	Cabot No. 1-9 Federal	1978	4,224	5,446	310WTRM	2,930	3,550	-	-		Produced water from two zones perforated in Moenkopi Formation.
11aaa-1	Forest No. 1 Federal	1963	4,371	7,250	310CCNN	3,195	-	-	-	-	-
					324PRDX	5,522	6,584	5,534	5,624		Recovered 315 ft of mud and 5,133 ft of black "sulfur" water containing 20,000 ppm of chloride.
					330MSSP	6,922	-	-	-		
19ddb-1	Monsanto No. 1 Federal	1958	4,378	6,060	220NVJO	-	1,018	-	-	-	-
25bca-1	U.S. Geological Survey test hole NSR T-6A	1980	4,160	700	111ALVM	0	20	-	-	C,J	See table 9.
					221ENRD	20	280	-	-		
					221CRML	280	460	-	-		
					220NVJO	460	-	450	700		Flowed through packer and drill stem.
36bdd-1	U.S. Geological Survey test hole NSR T-6	1980	4,120	215	221ENRD	0	40	-	-	C	Flowed at 110 ft. Appeared to contain more gas than air used for drilling. Lost circulation of clear water at 205 ft. Lost circulation at 50 ft in hole 30 ft south of first hole.
					221CRML	40	-	-	-		
(D-23-15)21bab-1	Shell No. 1 Federal	1959	4,679	7,702	220NVJO	1,190	1,640	-	-	C	Well drilled with salt mud.
					330MSSP	7,452	-	7,500	7,702		Recovered 3,240 ft of salt water.
(D-23-16)3bca-1	Mobil No. 12-3 Skyline	1961	4,038	9,450	220NVJO	-	1,280	-	-	C	-
					330MSSP	8,355	9,042	8,530	8,715		Recovered 1,150 ft of mud-cut salt water and 2,000 ft of salt water.
15dca-1	Mobil No. 34-15 Hancock	1961	4,050	8,440	220NVJO	539	948	-	-	C	Slight flow at 800 ft.
					310WTRM	2,540	2,860	2,530	2,570		Producing 3.3 gal/min.
					319ELPC	3,113	-	-	3,115		Producing 150 gal/min.
									3,240		Producing 146 gal/min.
					330MSSP	8,028	-	8,210	8,440		Recovered 651 ft of mud and 6,929 ft of salt water.

Table 11.--Records of selected petroleum-test wells and other test holes--Continued

Location	Name	Year constructed	Altitude (ft)	Depth drilled (ft)	Selected geologic data: Aquifer code	Selected geologic data: Depth to top (ft)	Selected geologic data: Depth to bottom (ft)	Interval tested: Depth to top (ft)	Interval tested: Depth to bottom (ft)	Other data available	Remarks
(D-23-17)9cac-1	Reserve No. 1 Colorado Fuel and Iron	1976	4,443	9,069	221ENRD	-	653	-	-	-	-
					220NVJO	802	-	-	-		
					231WNGT	1,331	1,685	-	-		
					310CCNN	2,705	3,056	-	-		
					310CTLR	3,056	-	-	-		
					330MSSP	8,846	-	-	-		
15cba-1	Pan American No. 1 Federal	1961	4,280	9,523	220NVJO	462	-	-	-	C	Producing oil well. Initially produced 9 barrels (378 gallons) of water with the oil.
					231WNGT	890	1,408	-	-		
					310CCNN	2,423	2,570	-	-		
					310CTLR	2,570	2,965	-	-		
					330MSSP	8,422	8,988	8,678	8,768		Recovered gas, oil, mud, and 610 ft of salt water.
					341OURY	8,988	9,100	-	-		
					341ELBR	9,100	9,493	-	-		
					371LYNC	9,493	-	-	-		
17ada-1	Texaco No. 1 Federal	1962	4,340	8,876	220NVJO	592	-	-	-	C	Producing oil well.
					231WNGT	-	1,568	-	-		
					310CCNN	2,550	-	-	-		
					330MSSP	8,458	-	8,732	8,738		Zone initially produced only oil. Water obtained later.
17dbc-1	Texaco No. 2 Federal	1963	4,280	8,764	220NVJO	540	-	-	-	C	Producing oil well. Initially produced 15 gal/min of water with the oil. Fault in the Hermosa Formation at 6,050 ft.
					231WNGT	-	1,524	-	-		
					310CCNN	2,473	-	-	-		
					330MSSP	8,445	-	8,709	8,716		
20aaa-1	Rosenblatt No. 1 Morich	1964	4,361	2,402	221CRTS	0	85	-	-	-	-
					221ENRD	85	445	-	-		
					220NVJO	540	765	-	-		
					231WNGT	1,000	1,540	-	-		
(D-24-9)14dda-1	Amerada No. 1 Elliot	1961	6,670	3,253	110PTOD	0	30	-	-	-	-
					230MNKP	30	200	-	-		
					310KIBB	200	244	-	-		
					310CCNN	244	938	-	-		
					341OURY	938	1,166	-	-		Mississippian rocks are missing.
					341ELBR	1,166	1,690	-	-		
					371LYNC	1,690	2,447	-	-		
					374BWMN	2,447	-	-	-		
					374HRMN	-	2,816	-	-		
					374OPHR	2,816	3,071	-	-		
					374TNTC	3,071	-	-	-		
(D-24-10)28cad-1	Blackwood & Nichols No. 1-28 General Hydrocarbons	1954	6,732	4,182	230MNKP	0	180	-	-	-	-
					310KIBB	180	240	-	-		
					310CCNN	240	-	-	-		
					324HRMS	1,104	-	-	-		
					330MSSP	1,557	-	-	-		
					341ELBR	2,299	-	-	-		
					371LYNC	2,984	3,529	-	-		
					374BWMN	3,529	-	-	-		
					374HRMN	-	4,070	-	-		
					374OPHR	4,070	-	-	-		
(D-24-13)2ccd-1	Iron Wash No. 1 State	1952	4,760	2,381	220NVJO	333	860	-	-	-	-
3dbb-1	Security No. 1 Federal	1970	4,510	3,800	220NVJO	88	500	300	500	-	Water reported.
11adb-1W	Texas Gas Exploration No. 1 Federal	1974	4,740	4,224	221ENRD	0	218	-	-	-	Plugged back and left for use as water well. Formation tops corrected from gamma-ray log.
					220NVJO	486	922	-	-		
					231KYNT	922	1,232	-	-		
23cdc-1	Columbia Gas No. 1-23 Paradox	1979	4,760	2,275	220NVJO	214	-	-	-	-	-
					231WNGT	-	1,306	-	-		
					237SNBD	2,066	-	-	-		See table 4 for permeability.
					310KIBB	2,235	-	-	-		Do.

Table 11.--Records of selected petroleum-test wells and other test holes--Continued

Location	Name	Year constructed	Altitude (ft)	Depth drilled (ft)	Selected geologic data: Aquifer code	Selected geologic data: Depth to top (ft)	Selected geologic data: Depth to bottom (ft)	Interval tested: Depth to top (ft)	Interval tested: Depth to bottom (ft)	Other data available	Remarks
(D-24-13)32bbd-1W	Union No. 1 State	1967	4,844	2,355	220NVJO 231WNGT 310CCNN	74 877 2,265	705 1,225 -	- - -	- - -	-	Plugged back, unperforated, and left for use as water well. Formation tops corrected from gamma-ray log.
36dba-1	State of Utah	1979?	4,660	1,184	221CRML 220NVJO 231WNGT	0 155 840	155 570 1,165	- - -	- - -	C	Left for water well by exploration company. Formation tops from gamma-ray log. See table 9.
(D-24-14)10aac-1	Union Texas No. 1 Allied Chemical	1972	4,308	7,284	220NVJO	280	-	-	-	-	-
21dab-1	Carter No. 1 Monsanto Chemical	1958	4,321	7,655	220NVJO	220	-	-	-	-	-
(D-24-15)5caa-1	General Petroleum No. 45-5-G Federal	1951	4,260	7,161	220NVJO	360	880	-	-	-	Fresh water reported to be in Navajo and Wingate. Water in Coconino reported salty.
6caa-1	English No. 1 Moore	1954	4,110	2,370	220NVJO 231WNGT	230 950	740 1,320	- -	- -	C	Left as a flowing water well.
(D-24-16)10dda-1	U.S. Bureau of Land Management	1976?	4,235	1,245	221CRML 220NVJO 231WNGT	0 8 693	8 495 1,056	- - -	- - -	J	Probable uranium core-test hole left for use as a water well. Formation tops from gamma-ray log.
15acd-1	Pledger No. 1 U-TEX	1965	4,272	5,370	220NVJO	-	440	-	-	-	-
19bda-1	Shell No. 1 Federal	1958	4,758	8,677	220NVJO	488	-	-	-	-	-
22cbd-1	U.S. Bureau of Land Management	1976?	4,450	1,083	221CRML 220NVJO 231WNGT	0 16 464	16 464 1,042	- - -	- - -	J	Probable uranium core-test hole left for use as a water well. Formation tops from gamma-ray log.
(D-25-8)32cad-1	U.S. Dept. of Energy SR-112	1979	6,300	1,974	221CRML 220NVJO 231WNGT 231CCRK 231MBCK	0 178 1,308 1,574 1,784	178 1,144 1,574 1,784 1,817	- - - - -	- - - - -	-	Hole left for earth-temperature gradient measurements by University of Utah. Water level reported 902 ft below land surface.
(D-25-11)33dbd-1	U.S. Bureau of Land Management	1975	4,900	2,090	221ENRD 221CRML 220NVJO	0 40 370	40 370 -	- - 380	- - 400	C	Drilled by mineral exploration company. Formation tops from partial geophysical log. Sampled during drilling with air.
(D-25-12)1dcc-1	Union No. 019-1 Federal	1967	4,880	2,355	220NVJO	177	797	-	-	-	-
24bbb-1	Pan American No. 1 American Petrofina	1959	5,025	5,929	220NVJO	319	926	-	-	-	-
34ccc-1	Delhi No. 1 Russell	1953	5,157	6,008	220NVJO	694	1,145	-	-	-	-
(D-25-13)11bbb-1	Union No. 1 (998-A) Federal	1967	4,743	5,175	220NVJO	85	563	-	-	-	-
12bac-1	Columbia Gas No. 1-12 Paradox	1979	4,759	4,926	220NVJO 231WNGT 237SNBD 330MSSP	101 - 1,910 3,706	- 1,188 - -	- - - -	- - - -	-	- See table 4 for permeability data. Do.

Table 11.--Records of selected petroleum-test wells and other test holes--Continued

Location	Name	Year constructed	Altitude (ft)	Depth drilled (ft)	Selected geologic data: Aquifer code	Selected geologic data: Depth to top (ft)	Selected geologic data: Depth to bottom (ft)	Interval tested: Depth to top (ft)	Interval tested: Depth to bottom (ft)	Other data available	Remarks
(D-25-14)21bdb-1	Reynolds & Carver No. 1 Federal	1969	4,750	5,144	220NVJO	90	-	-	-	-	-
26dba-1	U.S. Bureau of Land Management	1976?	4,910	1,293	221ENRD 221CRML 220NVJO 231WNGT	0 42 190 847	42 190 736 1,284	- - - -	- - - -	-	Probable uranium core-test hole left for use as a water well. Formation tops from gamma-ray log.
(D-25-15)15abd-1	Superior No. 31-15 Socony Mobil	1963	4,960	6,470	220NVJO	353	764	-	-	-	-
22aca-1	Conoco No. 2 Lloyd	1958	4,840	6,396	220NVJO	320	840	-	-	-	-
32cad-1	Standard Oil of California No. 1 State	1956	5,075	5,843	220NVJO	250	810	-	-	-	-
(D-25-16)10bac-1	Shell No. 2 Federal	1959	4,738	7,393	220NVJO	40	484	-	-	-	-
29cdb-1	Standard Oil of California No. 1 Harrington	1957	4,853	6,701	220NVJO	117	610	-	-	-	-
R(D-25-17)20daa-1	Superior No. 43-20 Federal	1961	4,611	7,225	231WNGT 310WTRM 330MSSP	- 1,364 6,050	410 - 6,604	- 1,365 6,361	- 1,515 6,386	C	Salty water reported. Recovered 50 ft of mud, 450 ft of muddy water, and 5,130 ft of salt water.
(D-26-6)11aad-1	Energetics No. 41X-11 Federal	1973	5,861	3,405	220NVJO	425	1,475	-	-	-	Drilled with air. Water reported in Navajo.
(D-26-7)7cad-1	Colorado Energetics No. 23X-7 Reserve	1973	6,017	3,230	220NVJO	214	-	-	-	-	-
17bca-1W	Mountain Fuel Supply No. 1 Senior	1947	6,125	3,485	220NVJO	204	1,270	1,040	1,128	-	Plugged back and left for use as a fresh water well. Produced about 5 gal/min.
17bdb-1	Mountain Fuel Supply No. 1-A Senior	1948	6,124	8,518	220NVJO	204	1,250	-	-	-	-
17cba-1	Ramsey No. 1-X Senior	1934	6,122	3,168	220NVJO	215	1,195	-	-	-	Water level reported at about 740 ft below land surface when well was 1,745 ft deep.
17cda-1	Byrd-Frost No. 1-X English	1953	6,118	2,753	220NVJO	220	1,240	-	-	-	-
18aab-1	Coleman No. 1-A English	1953	6,084	2,875	220NVJO	230	1,309	852 860 946	855 870 968	-	Bailed 1.4 gal/min. Bailed 3.5 gal/min. Volume of water increased.
19bbd-1	Shell No. 1 English et al	1960	5,955	6,704	220NVJO	390	1,384	-	-	-	-
20dab-1	Shumway Uranium Mining No. 1 Parker	1957	5,200	2,620	220NVJO	38	1,050	-	-	-	-
(D-26-11)9bbb-1	State of Utah	1980	5,070	855	221CRTS 221ENRD 221CRML 220NVJO	0 30 492 818	30 492 818 -	- - - 802	- - - 855	C,J	Water test well Goblin Valley State Reserve. See table 9.
(D-26-13)17cdb-1	LaRue No. 1 Kerr-McGee	1962	5,262	5,780	220NVJO	-	1,150	-	-	-	-

Table 11.--Records of selected petroleum-test wells and other test holes--Continued

Location	Name	Year constructed	Altitude (ft)	Depth drilled (ft)	Selected geologic data: Aquifer code	Selected geologic data: Depth to top (ft)	Selected geologic data: Depth to bottom (ft)	Interval tested: Depth to top (ft)	Interval tested: Depth to bottom (ft)	Other data available	Remarks
(D-26-13)25cbd-2D	Pan American No. 9 Humble	1962	5,402	6,380	220NVJO	540	1,000	-	-	-	-
35aca-1	Pan American No. 10 Humble	1963	5,652	6,040	220NVJO	740	1,238	-	-	-	-
(D-26-14)7bbc-1	Odessa No. 1 Shannon	1959	5,155	5,750	220NVJO	490	-	-	-	-	-
30cdb-1	Humble No. 7 Federal	1961	5,330	6,007	220NVJO	557	-	-	-	-	-
(D-26-16)31ccd-1	Hunt No. 1 Federal	1972	5,210	5,000	220NVJO	-	630	-	-	-	-

Table 12.--Selected lithologic logs of wells and test holes

[Abbreviations: ft^3/d, cubic feet per day; $^{\circ}C$, degrees Celsius; ft, feet; gal/hr, gallons per hour; gal/min, gallons per minute; in., inches; umhos, micromhos per second at $25^{\circ}C$; lbs/in^2, pounds per square inch, lbs/in^2]

Location: See text for description of well- and spring-numbering system.
Altitudes: Given for land surface at well or test hole, in feet above National Geodetic Vertical Datum of 1929.
Thickness: Given in feet.
Depth: Given to base of unit, in feet below land surface.
For sample logs by J. W. Hood, U.S. Geological Survey: Samples were collected at 10-foot intervals. Descriptions are not adjusted for sample-return lag. Tops of formations, as given in table 11, were picked mainly from geophysical logs and do not always match cutting descriptions. (See discussion in text.) Remarks regarding drilling conditions, water levels, and chemical quality were taken from records of observations while drilling of the holes.

Material	Thickness	Depth
(D-15-11)12cda-1. Log by Carbon Dioxide and Chemical Co. Altitude 5,735.		
Shale, gray	12	12
Limestone, thin layers, and hard rock	88	100
Limestone, hard	12	112
Sand, hard, red	28	140
Shale, yellow	5	145
Rock, sandy, red	10	155
Rock, red, with gray shale	40	195
Shale, gray	5	200
Sand, gray	10	210
Shale, gray	15	225
Rock, red	45	270
Shale, hard, gray	15	285
Rock, red	5	290
Shale, gray	20	310
Limestone, white	80	390
Limestone, hard, white	30	420
Limestone, white	30	450
Shale, sandy, gray	80	530
Shale, gray, and thin, hard limestone	90	620
Shale, brown, and thin, hard layers	30	650
Shale, sandy, gray, and thin, hard layers	50	700
Limestone, hard	10	710
Shale, gray, and thin, hard layers	40	750
Sand	10	760
Shale, gray	10	770
Rock, red	10	780
Sand, hard, red, and thin, hard layers	25	805
Shale, sandy	10	815
Sand, hard, sharp	20	835
Shale, brown	35	870
Rock, red	15	885
Shale, brown	15	900
Rock, hard, red	30	930
Shale, sandy, hard, red	30	960
Rock, red; caving	25	985
Shale, brown	30	1,015
Rock, red	30	1,045
Shale, brown	30	1,075
Shale, gray	20	1,095
Limestone, hard, gray	15	1,110
Sand, hard; show of water	10	1,120
Limestone, hard, blue	35	1,155
Limestone with thin layers of sand; hole filled with 200 ft of water from 1,165-1,170 ft	15	1,170
Sand; water to within 400 ft of surface	5	1,175
Limestone, hard, blue; caving	17	1,192
Shale, gray	18	1,210
Sand, fine, hard	5	1,215
Shale, gray; caving	37	1,252
Limestone, thin, hard	10	1,262
Rock, hard, red	18	1,280
Rock, thin, hard	4	1,284
Shale, red	7	1,291
Rock, thin, hard	5	1,296
Shale, red	9	1,305
Rock, thin, hard	5	1,310
Rock, red	8	1,318
Sand	7	1,325
Rock, hard, red	7	1,332
Rock, red, and thin, hard layers	23	1,355
Rock, red	22	1,377
Shale, brown	7	1,384
Rock, red	12	1,396
Sand, reddish; water	6	1,402
Rock, sandy, thin, hard	5	1,407
Sand; water rose to 1,426 ft	42	1,449
Limestone, thin, hard, with brown shale	8	1,457
Limestone	3	1,460
Limestone; bailing water from hole	1	1,461
Rock, red; bailing water from hole	4	1,465
Limestone, red; bailing water from hole	5	1,470
(D-15-11)12cda-1.--Continued		
Limestone, thin, hard; bailing water from hole	3	1,473
Rock, hard, red	9	1,482
Shale, sandy, brown	15	1,497
Rock, sandy, red; show of water from 1,500-1,505 ft	8	1,505
Shale, sandy, brown, thin hard layers; water at 70 ft above former level	10	1,515
Rock, hard, red	6	1,521
Shale, brown, with thin gypsum layers	10	1,531
Sand, hard	9	1,540
Shale, sandy, red, thin, hard layers	10	1,550
Rock, red	20	1,570
Limestone	10	1,580
Limestone, sandy	10	1,590
Shale, sandy, hard	12	1,602
Limestone	24	1,626
Limestone, brown	12	1,638
Limestone, red	12	1,650
Limestone, sandy, hard	12	1,662
Limestone, hard	12	1,674
Limestone, sandy, hard	12	1,686
Sandstone and limestone	12	1,698
Limestone, sandy, hard	12	1,710
Limestone	10	1,720
Limestone, sandy, hard, red	10	1,730
Limestone, sandy, hard	10	1,740
Shale, red, thin, hard layers	10	1,750
Limestone, hard, red	10	1,760
Limestone, red, thin, hard layers	10	1,770
Limestone, hard, red	5	1,775
Limestone, red, thin, hard layers	10	1,785
Limestone, red	10	1,795
Limestone, hard, red	2	1,797
Rock, thin, hard; light show of heavy oil	3	1,800
Shale, sandy, red	5	1,805
Limestone, red	10	1,815
Shale, brown, thin, hard layers; caving	10	1,825
Shale and thin, hard layers; caving	10	1,835
Shale, brown, thin, hard layers; caving	10	1,845
Shale, brown; caving	17	1,862
Shale, brown, and thin, hard layers; caving	28	1,890
Limestone, thin, hard	5	1,895
Limestone, brown	5	1,900
Limestone, gray	15	1,915
Limestone, brown	5	1,920
Shale, red, and thin, hard layers	10	1,930
Shale, brown; bailed water	15	1,945
Limestone, thin, hard, and shale;, bailed water to 1,950 ft	10	1,955
Limestone, gray, shale and thin, hard layers	15	1,970
Limestone, blue, hard	15	1,985
Sand, gray	10	1,995
Sand, hard, sharp, gray	20	2,015
Sand, gray	20	2,035
Sand, hard, gray	15	2,050
Sand, sharp, gray	50	2,100
Sand, hard, green	10	2,110
Sand, hard, sharp, gray	25	2,135
Shale, gray, and thin, hard layers	15	2,150
Shale, gray and red banded	7	2,157
Rock, red	8	2,165
Limestone, hard, brown	15	2,180
Limestone, red and gray	15	2,195
Limestone, thin, hard	10	2,205
Rock, hard, red	10	2,215
Sand, hard, red	30	2,245
Sand, hard, brown	10	2,255
Sand, hard, red	10	2,265
Sand, very fine, hard, brown	10	2,275
Sand, red	20	2,295
(D-15-11)12cda-1.--Continued		
Sand, yellow	10	2,305
Rock, red	20	2,325
Sand, red	60	2,385
Shale, dark red	80	2,465
Shale, red, and thin, hard layers	20	2,485
Shale, dark brown, and thin, hard layers	20	2,505
Shale, red, and thin, hard layers	20	2,525
Shale, brown, and thin, hard layers	20	2,545
Shale, red, and thin, hard layers	20	2,565
Shale, sandy, dark, and thin, hard layers	20	2,585
Shale, dark red, and thin, hard layers	20	2,605
Shale, sandy, dark brown	15	2,620
Shale, dark red, and thin, hard layers	20	2,640
Shale, sandy, dark	20	2,660
Rock, red, and thin, hard layers	25	2,685
Rock, soft, red	10	2,695
Shale, gray	75	2,770
Limestone, hard, gray	20	2,790
Shale, gray, and thin, hard gypsum layers	10	2,800
Shale, gray, and thin, hard layers	25	2,825
Limestone, blue	20	2,845
Shale, gray, and thin, hard gypsum layers	15	2,860
Shale, gray	25	2,885
Shale, blue	10	2,895
Shale, gray	25	2,920
Shale, gray and gypsum	15	2,935
Shale, gray and brown	10	2,945
Limestone, hard, thin, gray	30	2,975
Limestone, hard	25	3,000
Limestone, gray	20	3,020
Limestone, sandy, hard, dark	20	3,040
Limestone, hard	27	3,067
Limestone, hard, gray	15	3,082
Sand, red, sharp	4	3,086
Sand, very fine, hard, dark gray; first show of carbon dioxide at 3,093 ft	10	3,096
Sand, hard, gray, and limestone; slight increase in gas	7	3,103
Limestone, sandy, gray with yellow bands, some sand	5	3,108
Sand; gas tested at 2,780,000 ft^3/d, shut-in pressure to 750 lbs/in^2	6	3,114
(D-15-11)12dbc-1. Log by Utah Oil Refining Co. Altitude 5,765.		
Shale, red	120	120
Sand, coarse	5	125
Sand, coarse, mixed	5	130
Sand, gray, sharp	20	150
Shale, soft, gray	15	165
Sand and shale, mixed	15	180
Shale, hard, gray	6	186
Shale, red	14	200
Rock, thin, hard	3	203
Shale, sandy, red	42	245
Shale, red, and thin, hard layers	20	265
Shale, gray	85	350
Shale, sandy, gray	105	455
Sand, hard, gray	10	465
Sand, hard, and thin, hard layers	35	500
Shale, dark, and thin, hard layers	110	610
Shale, gray and red, and thin, hard layers	40	650
Shale, hard, red	20	670
Shale, sandy, gray	40	710
Limestone, sandy, hard	15	725
Shale, sandy, hard, gray and red	75	800

Material	Thickness	Depth
(D-15-11)12dbc-1.--Continued		
Shale, sandy, red	175	975
Shale, red, and thin, hard layers	120	1,095
Sand	5	1,100
Sand, hard; fresh water, 1 barrel (42 gal/hr)	45	1,145
Sand	40	1,185
Sand, hard	20	1,205
Sand, fine, hard	20	1,225
Sand, coarse	23	1,248
Shale, sandy, red	7	1,255
Rock, thin, hard	4	1,259
Sand, hard, red	59	1,318
Sand, fine, hard, red	14	1,332
Sand, hard, red; brackish water 400 ft below drilling floor	60	1,392
Shale, sandy, hard, brown	18	1,410
Shale, sandy, red and brown	18	1,428
Sand, red, and thin, hard layers	12	1,440
Limestone, sandy, red	30	1,470
Shale, hard, and gypsum	10	1,480
Sand, hard, red	10	1,490
Limestone, sandy, hard	5	1,495
Shale, sandy, hard	9	1,504
Sand, hard, red	6	1,510
Shale, sandy, hard	25	1,535
Sand, soft	7	1,542
Sand, hard, red	7	1,549
Limestone, sandy, hard	5	1,554
Sand, hard, red	6	1,560
Limestone, sandy, hard	7	1,567
Limestone, hard, red	8	1,575
Limestone, sandy, red	10	1,585
Sand, hard, red	17	1,602
Shale, sandy, hard	8	1,610
Sand, red, and limestone	8	1,618
Limestone, hard, pink	12	1,630
Limestone, crystalline, pink	2	1,632
Shale, limy, red	6	1,638
Rock, thin, hard, red	6	1,644
Shale, red, and flint	6	1,650
Rock, thin, hard	2	1,652
Shale, sandy, white	3	1,655
Conglomerate; show of oil	14	1,669
Sand, shaly, hard	10	1,679
Rock, shaly, thin, hard	5	1,684
Shale, and thin, hard layers	25	1,709
Shale, hard, and thin, hard layers	4	1,713
Shale, red	5	1,718
Shale, pink, and thin, hard layers	4	1,722
Shale, red, and thin, hard layers	21	1,743
Sand, hard, and shale	7	1,750
Shale, red, and thin, hard layers	25	1,775
Shale, sandy, hard	7	1,782
Shale, red, and thin, hard layers	44	1,826
Shale, hard, red, and thin, hard layers	49	1,875
Shale, red	40	1,915
Shale, sandy, red	35	1,950
Shale, sandy, red and green	40	1,990
Shale, sandy, gray	20	2,010
Sand, gray	10	2,020
Limestone, sandy, hard, gray	20	2,040
Sand, gray	30	2,070
Sand, yellow	10	2,080
Sand, hard, gray and yellow	40	2,120
Sand, shaly, green	20	2,140
Rock, thin, hard, and shale	13	2,153
Sand, hard, red, and thin, hard layers	457	2,610
Sand, reddish brown	40	2,650
Shale, sandy, red	20	2,670
Shale, soft, red, and thin, hard layers	50	2,720
Shale, sandy, gray	55	2,775
Shale, sandy, pinkish gray	20	2,795
Limestone, hard, gray	15	2,810
Shale, sandy, gray	20	2,830
Shale, hard, gray	15	2,845
Gypsum, shaly, gray	37	2,882
Shale, hard, gray	18	2,900
Gypsum, shaly, hard, gray	20	2,920
Shale, gray and pink	35	2,955
Sand, hard, red, and thin, hard layers	10	2,965
Sand, hard, brown	5	2,970
Sand, gray, and limestone	9	2,979
Sand, white	5	2,984
Limestone, sandy, hard, gray	30	3,014
Sand, very hard, dark gray	20	3,034
Limestone, sandy, brown	33	3,067
Sand, hard, reddish	19	3,086
(D-15-11)12dbc-1.--Continued		
Sand, hard, gray and yellow banded; gas encountered at estimated 20,000,000 ft^3/d; filled hole with water to control gas	19	3,105
Sand, hard, dark gray	6	3,111
Sand blue; show of heavy black oil	4	3,115
Sand, hard, dark	5	3,120
Sand, hard, light gray	30	3,150
Shale, blue, very sticky	4	3,154
Sand and shale, very hard gray	3	3,157
Sand, gray, and thin, hard layers	58	3,215
Sand, light gray	20	3,235
Sand, white at total depth ..		

Note: Hole abandoned due to loss of drilling tools.

Material	Thickness	Depth
(D-17-11)27ccd-1. Log by owner. Altitude 5,758.		
Sand, dry	2	2
Sandstone, soft	7	9
Shale, hard, blue	23	32
Conglomerate, hard	8	40
Clay, hard, white	6	46
Sandstone, porous	12	58
Gravel and coarse sand	14	72
(D-19-10)15bac-1. Log by Conway Brothers. Altitude 5,615.		
Soil, brown	8	8
Sand, muddy red	32	40
Shale, red	60	100
Shale, red, sandy	110	210
Shale, light to dark red	50	260
Shale, red, medium to hard	38	298
Sandstone, light, hard	7	305
Sandstone, medium hard, brown	5	310
Shale, limy, alternating medium to hard	30	340
Limestone, very hard, light	10	350
Shale, limy, gray	10	360
Shale, blue-gray	25	385
Shale, brown	15	400
Shale, limy, gray	10	410
Shale, brown	25	435
Sandstone, soft, dark gray; water	10	445
Sandstone, limy, light	5	450
Sandstone, light	15	465
Shale, hard, light blue	11	476
(D-19-12)30bba-1. Sample log by J. W. Hood. Altitude 6,182.		
Limestone, gray, and pale gray siltstone, with about 3 in. of soil on top	10	10
Siltstone, bright red, and some limestone	10	20
Siltstone, pale yellow	10	30
Sandstone, light brown and tan, very fine to fine-grained	10	40
Sandstone, pale ocherous yellow, very fine to fine-grained, well-sorted	20	60
Sandstone, tan, very fine to fine-grained, silty	110	170
Sandstone, light brown to light yellow-brown, very fine to fine-grained	30	200
Sandstone, pale gray-tan, very fine grained	10	210
Sandstone, pale brown, very fine to fine-grained	20	230
Sandstone, light orange-brown, very fine to fine-grained	10	240
Sandstone, pale gray-tan, very fine to fine-grained	100	340
Sandstone, pale yellow-brown, very fine to fine-grained	10	350
Sandstone, tan, very fine to fine-grained	10	360
Sandstone, pale gray, very fine to fine-grained	20	380
Sandstone, tan, very fine to fine-grained	10	390
Sandstone, pale brown, very fine to fine-grained	10	400
Sandstone, tan	10	410
Sandstone, pale brown, very fine to fine-grained	30	440
Sandstone, tan, very fine to fine-grained	10	450
Sandstone, pale tan-gray, very fine to fine-grained	50	500
(D-19-12)30bba-1.--Continued		
Siltstone, sandy, maroon, and sandstone, very fine to medium-grained	10	510
Sandstone, maroon, very fine to fine-grained; cuttings slightly damp at 520 ft	10	520
Sandstone, pale brown, and many very small fragments of maroon siltstone	10	530
Sandstone, pale orange-brown, very fine to fine-grained; cuttings damp when recovered	10	540
Sandstone, pale maroon, very fine to fine-grained and maroon siltstone; cuttings damp; few drops of water ejected with cuttings at 545 ft	10	550

Note: This hole, drilled with air, was dry through the entire Navajo section. The air blew away a substantial amount of fines as dust. This megascopic examination indicates a monotonous lithology altered mainly by color changes. Little was seen in the way of radical grain-size changes or secondary minerals such as iron, quartz, calcite, and gypsum. Consequently, the cuttings were considered an ideal set to test the indefinite conclusion that the Navajo Sandstone has a consistent grain-size change with depth in the formation. Samples were selected at seeming lithologic changes to represent the entire suite of samples; 14 samples were split and sieving. See table 3 for results of sieve analysis.

Material	Thickness	Depth
(D-19-13)21cbd-1. Sample log by J. W. Hood. Altitude 5,190.		
Soil, brown, bit-cut tan siltstone, and fine gravel	10	10
Siltstone, red, bit-cut tan siltstone and fine gravel	10	20
Siltstone, gray, with thin layers of red color	10	30
Siltstone, gray	10	40
Sandstone, tan, fine-grained, very silty	10	50
Siltstone, finely bit-cut, grayish tan; cuttings damp at 57 feet; small amount of water at 59 ft; changed from air to foam	10	60
Limestone, gray, and interbedded gray siltstone	30	90
Limestone, dark gray	20	110
Limestone, red and light gray, and red siltstone	10	120
Siltstone, red, and hard, light brown, very fine to medium-grained bit-cut sandstone fragments	10	130
Sandstone, tan, and (cavings of ?), gray limestone, and red siltstone	10	140
Sandstone, light brown, very fine to medium-grained, and (cavings of ?) limestone	20	160
Sandstone, light brown, very fine to medium-grained, and (cavings of ?) limestone; sandstone more friable; test hole definitely producing water at 170 ft	20	180
Sandstone, light orange-brown, very fine to medium-grained, friable, with limestone fragments; amount of water produced gradually increased	10	190
Sandstone, light brown, very fine to fine-grained, well-sorted, friable, with fragments of limestone and red siltstone	10	200
Sandstone, pale brown, very fine to fine-grained, well-sorted	20	220
Sandstone, tan, very fine to fine-grained, with some red siltstone and limestone cavings	20	240
Sandstone, tan, very fine to fine-grained, with some red siltstone and limestone cavings with specks of white precipitates	10	250

Material	Thickness	Depth
(D-19-13)21cbd-1. Continued		
Sandstone, tan, very fine to fine-grained, with some red silstone and limestone cavings, with specks of white precipitates and with thin layer of well-cemented very fine grained sandstone; specific conductance of water was 690 umhos	10	260
Sandstone, tan, very fine to fine-grained, with some red siltstone and limestone fragments	30	290
Sandstone, tan, very fine to fine-grained, silty, with white precipitates	10	300
Sandstone, tan, very fine to fine grained, silty, with white precipitates, red siltstone, and thin layers of well-cemented very fine grained sandstone; at 310 ft, discharge estimated to be 30 gal/min; temperature 15.5°C; pH 7.8; specific conductance 960 umhos; water level 97 ft below land surface	10	310
(D-20-10)6bdd-1. Sample log by J. W. Hood. Altitude 5,260.		
Clay, silty, brownish gray, and fine to medium gravel	10	10
Gravel, fine to coarse, bit-cut, surficial material caved and made the setting of surface pipe difficult; water at 22-23 ft; drilled with thick mud	10	20
Siltstone, gray, clayey, and gray limestone	10	30
Limestone, gray, and some gray, sandy siltstone	60	90
Siltstone, red, gray limestone, and some light gray sandstone	10	100
Siltstone, red, gray limestone and some light gray sandstone, generally paler color than above, with gypsum	10	110
Limestone, gray and some red siltstone; drilling fluid subsided to 8 ft overnight; changed to air drilling; ..	10	120
Limestone and gray siltstone	10	130
Limestone, gray	10	140
Limestone, gray, red siltstone, and some sandstone; hole producing water; temperature 16.7°C; specific conductance 5,220 umhos	10	150
Siltstone, red, limestone and some sandstone	10	160
Sandstone, brown, with much red siltstone	10	170
Sandstone, brown, with small fragments of red siltstone	10	180
Sandstone, brown, very fine to fine-grained with a few fragments of black limestone	10	190
Sandstone, brown, very fine to fine-grained, with a few fragments of limestone and red siltstone (cavings ?) at approximately 200 ft; specific conductance was about 4,000 umhos	20	210
Sandstone, muddy, grayish brown, with fewer cavings; water increasing and nearly clear	30	240
Sandstone, pale orange-brown, very fine to medium-grained, with small fragments of red siltstone; water level 4.4 ft below land surface or about 2 ft above river level	20	260
Sandstone, grayish brown, very fine to fine-grained, with very fine fragments of red siltstone; estimated 30 gal/min from hole with airlift; specific conductance 1,417 umhos at 16.9°C ...	30	290
(D-20-10)6bdd-1.--Continued		
Sandstone, pale brown, very fine to medium-grained, with very fine fragments of red siltstone	30	320
Sandstone, gray-brown, very fine to fine-grained; changed to drilling with clear river water	10	330
Sandstone, pale grayish tan, very fine to fine-grained, with specks of white precipitates	10	340
Sandstone, pale brown, very fine to fine-grained, with specks of white precipitates	40	380
Sandstone, very pale brown to tan, very fine to fine-grained	40	420
Sandstone, pale brown, very fine to fine-grained, with very fine fragments of red siltstone	40	460
Sandstone, pale brown, very fine to fine-grained, with very fine fragments of red siltstone and many white flakes of white precipitates--probably gypsum or calcite	10	470
Sample missing	5	475
Note: After completion of hole, water flowed at estimated 10 gal/min overnight, until packer set for test. Temperature 13.0°C; specific conductance 870 umhos.		
(D-20-10)7dcb-1. Log summarized from sample descriptions by K. Reavens. Altitude 5,558.		
No sample	140	140
Shale, very calcareous, variegated, and dense limestone; no porosity or permeability	30	170
Sandstone, slightly calcareous, fine- to medium-grained; subrounded, moderately sorted, orange to white, thin clay interbeds, and brick red shale; fair to good porosity and permeability; no sample from 260-290 ft ...	180	350
Siltstone, very sandy, gray-green, and slightly calcareous, fine- to medium-grained, subrounded, moderately sorted, orange to white; fair to good porosity and permeability.	30	380
Sandstone, slightly calcareous, fine- to medim-grained, subrounded, moderately to poorly sorted, friable, orange to white; fair to good porosity and permeability.	120	500
Sandstone, slightly calcareous, fine- to medium-grained, subrounded, moderately to poorly sorted, friable, orange to white; fair to good porosity and permeability: and very shaly, slightly calcareous, variegated sandstone, very fine to medium-grained, poorly sorted; poor porosity and permeability	30	530
Sandstone, fine-grained, moderately sorted, subanguiar to subrounded, white, some orange chalky sand with anhydrite; fair porosity and permeability	60	590
Sandstone, fine-grained, moderately sorted, subangular to subrounded, white; fair porosity and permeability; with reddish brown, very fine grained, very argillaceous sandstone; poor porosity and permeability	120	710
Siltstone, reddish brown, with white, fine-grained, moderately sorted, subangular to subrounded sandstone and interbedded white, chalky anhydrite	120	830
(D-20-10)7dcb-1.--Continued		
Sandstone, silty, reddish, fine- to medium-grained, subrounded, well-cemented, with white anhydrite	30	860
Sandstone, silty, pale red, fine- to medium-grained, subrounded, well-cemented, with some pale grayish green clay and gray shale.	30	890
Sandstone, white to pale yellow, medium- to fine-grained, poorly sorted; fair porosity and permeability	90	980
Sandstone, fine- to medium-grained, white to reddish, shaly to silty, some clay	30	1,010
Sandstone, fine- to medium-grained, white to pale reddish, shaly to slightly silty, some clay	120	1,130
Sandstone, pale pink to red, fine-grained, subangular to subrounded, some brick red shale	70	1,200
Sandstone, pale pink to red, fine-grained, subangular to subrounded, with white, chalky anhydrite	50	1,250
Sandstone, fine-grained, pale green, with green interbedded clay, and white to pale pink, fine-grained, subangular to subrounded sandstone, green to grayish green sand, and brick red shale and siltstone	10	1,260
Shale, green to grayish green and reddish brown to brick red, red siltstone, some fine-grained, pale green sandstone	10	1,270
Shale, red to brick red, siltstone, and some pale green shale	30	1,300
Shale and siltstone, red to brick red	30	1,330
Shale and siltstone, red to brick red, green to pale green shale, and dense, buff to gray dolomite	20	1,350
Shale and siltstone, red to brick red	50	1,400
Shale and siltstone, red to brick red, and white to pale pink, well-cemented, subangular to subrounded, fine- to medium-grained sandstone; no porosity or permeability; some pale grayish green shale and white anhydrite from 1,420-1,430 ft	30	1,430
Sandstone, fine to coarse, white to gray, subrounded hard, black dead hydrocarbon residue on and between some grains, and red to brick red and pale green shale and siltstone; fair to poor porosity and permeability	60	1,490
Sandstone, fine to coarse, hard, white to gray, subrounded, well-cemented, slightly calcareous, infilled with anhydrite, with red and greenish gray shale	50	1,540
Sandstone, fine to coarse, slightly conglomeratic, hard, white to gray, subrounded, well-cemented, slightly calcareous, infilled with anhydrite, and gray to white, dense limestone; no porosity or permeability	10	1,550
Shale, variegated, dense, pyritic, white to gray limestone, and fine to coarse, slightly conglomeratic, hard, white to gray, subrounded, well-cemented, slightly calcareous sandstone	10	1,560
Siltstone, brown, and variegated shale	10	1,570

Material	Thickness	Depth
(D-20-10)7dcb-1.--Continued		
Siltstone, green to reddish brown, variegated shale, some buff, dense, sandy dolomite, some anhydrite; no porosity or permeability	10	1,580
Dolomite, hard, dense, buff, some anhydrite; green to reddish brown siltstone, variegated shale; no porosity or permeability	20	1,600
Siltstone and shale, reddish brown, hard, dense, buff, sandy dolomite, variegated shale, some anhydrite; no porosity or permeability	10	1,610
Siltstone, reddish brown	20	1,630
Siltstone, reddish brown, variegated shale, and dense, buff, silty dolomite	10	1,640
Dolomite, silty, gray, dense and reddish brown siltstone	10	1,650
Siltstone, red to reddish brown, some buff to light gray, silty dolomite	10	1,660
Shale, gray, soft, very pyritic dolomite, with red shale and red to reddish brown siltstone	10	1,670
Siltstone, dark brown to black, interbedded with anhydrite	10	1,680
Shale, light gray to grayish green, very pyritic, and dark brown to black siltstone	10	1,690
Shale, light gray to grayish green, very pyritic	10	1,700
Shale, light gray to grayish green, and brown to black anhydritic siltstone	10	1,710
Shale, light gray to grayish green, very pyritic	70	1,780
Shale, variegated, pyritic	10	1,790
Shale, light gray to grayish green, pyritic, with nodules	10	1,800
Shale, light gray to grayish green, pyritic, slightly micaceous	10	1,810
Shale, light gray to grayish green, pyritic, slightly micaceous, and brown mottled, slightly to very calcareous, very pyritic, fine-grained sandstone; poor to no porosity and permeability	10	1,820
Shale, light gray to grayish green, very pyritic, slightly micaceous, slightly calcareous, some brown mottled, slightly to very calcareous, very pyritic, fine-grained sandstone; no porosity or permeability; 50 percent shale, 50 percent sandstone, from 1,830-1,840 ft	20	1,840
Shale, light grayish green, very pyritic, micaceous, some brown mottled, slightly to very calcareous, very pyritic, fine-grained sandstone. 80 percent shale, 20 percent sandstone from 1,850-1,860 ft, 90 percent shale, 10 percent sandstone from 1,860-1,870 ft	30	1,870
Shale, light gray to grayish green, very pyritic with pyrite nodules, slightly micaceous, slightly calcareous	20	1,890
Shale, light gray to grayish green, very pyritic, slightly micaceous	40	1,930
(D-20-10)7dcb-1.--Continued		
Shale, light gray to grayish green, very pyritic, slightly micaceous, and subangular, well-cemented, poorly sorted, fine-grained, white to blue mottled, calcareous sandstone to sandy limestone; poor porosity and permeability; 50 percent shale, 50 percent sandstone from 1,940-1,950 ft, slightly less sandstone from 1,950-1,960 ft	40	1,970
Sandstone, subangular, white to blue mottled, argillaceous, well-cemented, fine-grained, poorly sorted, slightly calcareous; very poor porosity and permeability	10	1,980
Shale and siltstone, light gray to grayish green, pyritic; no sample from 2,000-2,020 ft	40	2,020
Shale and siltstone, light 2,000-2,020 ft	40	2,020
Shale and siltstone, light gray to grayish green, pyritic, some sandstone or sandy dolomite; no porosity or permeability	40	2,060
Shale and siltstone, grayish green, mottled brown dolomitic sandstone with interbedded pyrite; no porosity or permeability	10	2,070
Limestone, white, dense, pelleted to oolitic, black, dead oil residue between pellets and oolites	10	2,080
Limestone, white, dense, less pelleted and oolitic; abundant light gray, dense, chalky limestone	10	2,090
Limestone, gray to light gray, dense, 25 percent white pelleted oolitic limestone	10	2,100
Limestone, gray to light gray, dense, some dense, pelleted, oolitic, dark gray, argillaceous limestone	10	2,110
Limestone, gray to dark gray, dense, pyritic, some oolitic and pelletal dark gray, dense, argillaceous limestone	50	2,160
Limestone, gray to light gray, pelleted to dense; fair porosity and permeability	10	2,170
Limestone and dolomite, light gray to white, dense; no porosity or permeability	10	2,180
Shale, light gray, very pyritic, interbedded with brown micaceous shale	10	2,190
Shale, light gray to white, very pyritic, contains pyrite nodules, micaceous	20	2,210
Shale, light gray to white, very pyritic, contains pyrite nodules, micaceous, and brown, micaceous, very pyritic siltstone	30	2,240
Shale, pale gray, very pyritic	20	2,260
Siltstone, very pyritic, very micaceous	10	2,270
Shale, pale gray, very pyritic, and very micaceous, very pyritic siltstone	40	2,310
Shale, light gray, calcareous, pyritic, micaceous, interbedded with calcareous, shaly, light brown to brown, oolitic, pelletal, fine-grained, well-cemented siltstone and sandstone; poor porosity and permeability	10	2,320
(D-20-17)7dcb-1.--Continued		
Shale, light gray, very pyritic, contains pyrite crystals and nodules, grades to siltstone; poor porosity and permeability	10	2,330
Siltstone, brown oil-stained, light gray, very pyritic shale	10	2,340
Shale, light gray, very pyritic, brown oil-stained siltstone	10	2,350
Limestone, gray to dark brown, oolitic, abundant chert, some light gray, pyritic shale; no porosity or permeability	10	2,360
Limestone, dolomitic, oolitic, fragmental, pelletal, black stain between fragments, pinpoint vugular porosity, white to bluish white chert; very poor porosity and permeability	50	2,410
Limestone and dolomite, white to gray, dense, fragmental, some dead oil stain, some clear bluish white chert; no porosity or permeability	10	2,420
Limestone, white to gray, dense, fragmental, some dead oil stain, fine-grained, calcareous sandstone	10	2,430
Sandstone, fine-grained, very calcareous, pelletal and oolitic limestone	10	2,440
(D-20-14)11cba-1. Log by W. F. Burns Co. Altitude 4,498.		
Sand, gray	5	5
Conglomerate	58	63
Sand, gray; first water	5	68
Slate, blue; caves slowly but does not prevent drilling; set 10-in. casing	182	250
Talc	40	290
Sand, white; second water	6	296
Slate, blue	10	306
Rock, red	14	320
Sand, white; water	12	332
Slate	8	340
Sand, white; water	5	345
Conglomerate	5	350
Slate, green	10	360
Sand, gray	10	370
Slate, green	12	382
Sand, green; water	45	427
Rock, red	8	435
Sand, gray	55	490
Rock, red; caves	10	500
Sand, gray	90	590
Gypsum	18	608
Slate, white	10	618
Sand, red	85	703
Slate, red; set 8.25-in. casing	5	708
Sand, gray; slight show of water	162	870
Sand, white; slight show of oil	10	880
Sand, hard, gray; water filled 150 ft of hole	5	885
Rock, red	20	905
Sand, red	5	910
Sand, gray	10	920
Sand, red and white	25	945
Sand, red	20	965
Sand, hard, white; more water	35	1,000
Sand, soft, gray; more water	20	1,020
Sand, soft, white; well flowing	15	1,035
Sand, hard, gray	35	1,070
Shale, red	15	1,085
Sand, white; flow increased	5	1,090
Sand, hard, red	25	1,115
Sand, red	18	1,133
Rock, red; set 6.25-in. casing	12	1,145
Sand, soft, white	10	1,155
Sand, hard, white	25	1,180
Sand, soft, white	45	1,225
Sand, hard, red	10	1,235
Sand, soft, sharp, red	50	1,285
Sand, sharp, gray	10	1,295

Material	Thickness	Depth
(D-20-14)11cba-1.--Continued		
Sand, hard, black	8	1,303
Alabaster	4	1,307
Sand, hard, red	8	1,315
Sand, soft, red	10	1,325
Shale, purple	10	1,335
(D-22-10)33abc-1. Log by Utah Department of Transportation. Altitude 7,120.		
Sandstone, gray to buff	40	40
Sandstone, gray with thin beds of shale	28	68
Sandstone, homogeneous, fine- to medium-grained	302	370
Sandstone, fine-grained	7	377
Shale, sandy	5	382
Sandstone, very fine grained	6	388
Shale, limy	2	390
Sandstone	5	395
Sandstone, shaly and thin-bedded shale	11	406
Shale	5	411
Sandstone	7	418
Shale	11	429
Sandstone	6	435
Shale, and thin-bedded sandstone	40	475
(D-22-11)23bdc-1. Log by Utah Department of Transportation. Altitude 6,520.		
Shale and thin sandstone	3.5	3.5
Sandstone, silty and thin-bedded shale	4.5	8
Sandstone, limy and sandy shale	28	36
Sandstone, silty and some shale	3	39
Limestone, light gray	17	56
Limestone, fossiliferous, and shale	5	61
Shale, thin-bedded limy and shaly sandstone	102	163
Limestone, and sandy limestone with geodes	105	268
Sandstone, medium- to coarse-grained	22	290
(D-22-13)35bcd-2. Sample log by J. W. Hood. Altitude 4,510.		
Sandstone, ocherous yellow, very fine to fine-grained; small amount of road fill at top	20	20
Sandstone, white, very fine to fine-grained	10	30
Sandstone, white, very fine to fine-grained and very fine to medium-grained, pale yellow with iron inclusions	20	50
Sandstone, pale gray, very fine to fine-grained	10	60
Sandstone, pale tan, very fine to fine-grained	10	70
Sandstone, pale tan, very fine to fine-grained and light brown, very fine to fine-grained	10	80
Sandstone, pale gray, very fine grained	10	90
Sandstone, light yellow-brown, very fine to fine-grained	20	110
Sandstone, gray, very fine to fine-grained, with fine white fragments of vein filling; cuttings seem damp at 115 ft	10	120
Sandstone, tan, very fine to fine-grained, silty	10	130
Sandstone, pale grayish tan, very fine to fine-grained	10	140
Sandstone, pale grayish tan, and ocherous yellow, very fine to fine-grained	10	150
Sandstone, pale grayish tan, very fine to fine-grained; at 170 ft, after adding drill stem, driller reported drilling only "an inch or so" when hole started producing water, which apparently came from an open fracture	20	170
(D-22-13)35bcd-2.--Continued		
Sandstone, pale brown, very fine to fine-grained with a few fragments of red siltstone	20	190
Sandstone, light brown to brown, very fine to fine-grained; some road-fill cavings; specific conductance 1,310 umhos	10	200
Sandstone, light brown to brown, very fine to fine-grained; some road-fill cavings and some small fragments of white vein filling; specific conductance 1,280 umhos; water level, after overnight recovery, 137 ft below land surface	10	210
Sandstone, pale brown, very fine to fine-grained, with a few very small iron-stained sandstone aggregates and some ocherous yellow fragments	40	250
Sandstone, pale brown, very fine to fine-grained with some ocherous yellow fragments and a larger number of iron-stained aggregates than above	10	260
Sandstone, gray with fine mottling of iron-stained spots	10	270
Sandstone, gray and tan, very fine to fine-grained, with a few small fragments of red siltstone and white vein filling	10	280
Sandstone, gray and tan, very fine to fine-grained, with a few small fragments of red siltstone and white vein filling, and a few angular fragments of dense silica-cemented sandstone	10	290
Sandstone, pale brown, very fine to fine-grained, with many very small iron-stained sandstone aggregates	20	310

Note: Drilled in mouth of canyon where access trail enters canyon. Because of space restrictions, drilled in edge of trail track, where road fill may be as much as 2 ft thick. From about 100 ft down, sand ejected from hole was damp, but no free water apparent until 170 ft where level later was 137 ft below land surface. Apparently hole penetrated an open fracture. Final water sample at 310 ft; temperatue 17.5°C; pH 7.3; specific conductance 1,290 umhos.

Material	Thickness	Depth
(D-22-14)15aac-1. Log by H. & H. Drilling, Inc. Altitude 4,275.		
Sandstone, white	5	5
Mudstone, brown	25	30
Mudstone, gray	10	40
Sandstone, gray	15	55
Mudstone, brown	20	75
Sandstone, gray	30	105
Mudstone, brown	3	108
Sandstone, white	7	115
Mudstone, brown	3	118
Sandstone, gray	22	140
Mudstone, brown	20	160
Sandstone, brown	20	180
(D-22-14)28ddd-1. Log by H. R. Phillips. Altitude 4,200.		
Sand and gravel; shallow water	70	70
Shale, red and gray	30	100
Sand and gray shale; water and increasing amount of nonflammable gas	125	225
Shale, red	40	265

Note: Well would flow like a geyser for a few minutes only when well was bailed.

Material	Thickness	Depth
(D-22-14)31ddb-1. Log by O. R. Anderson. Altitude 4,290.		
Gravel, coarse	29	29
Gravel and quicksand	14	43
Shale, sandy, red	32	75
Sand, red, coarse; water	15	90
Sandstone, red, fine-grained.	40	130
(D-22-14)31ddb-1.--Continued		
Sand, soft, red; water	48	178
Shale, red	82	260
Sandstone, white; water	45	305
Shale and sandstone, interbedded; ample brackish water	45	350
(D-23-8)3bab-1. Log by Utah Department of Transportation. Altitude 5,800.		
Gypsum and shale, weathered	8	8
Gypsum, gray, and thin-bedded shale	16	24
Shale, hard, gray	9.5	33.5
Gypsum, sandy, gray	23.5	57
Gypsum, white, pure	2.5	59.5
Shale, gray	2	61.5
Gypsum, white, pure	3.5	65
Shale, gray	7.5	72.5
Gypsum, gray, with thin-bedded shale	7	79.5
Shale, with thin gypsum beds	12.5	92
Shale, red and siltstone	1.5	93.5
Shale, and some gypsum beds	13	106.5
Shale, hard, brown-gray	5	111.5
Gypsum, white	3	114.5
Shale, with some gypsum beds	20.5	135
Gypsum, white	3.5	138.5
Sample missing	10	148.5
Shale, soft, red, and mudstone	1.5	150
Shale, gray	4	154
Shale, soft red	2	156
Shale, gray	9	165
Shale, red	8.5	173.5
Shale, gray, limy	52	225.5
Shale, hard, gray and shaly limestone	69.5	295
Limestone, sandy	5	300
(D-23-8)7dbd-1. Log by Utah Department of Transportation. Altitude 5,515.		
Sand, silty	9	9
Sand and gravel	6	15
Sand and gravel, coarse-grained and a small boulder	18	33
Siltstone and mudstone with gypsum	7	40
(D-23-10)12ddd-1. Log by C. A. McKinnon. Altitude 6,850.		
Soil, red	40	40
Limestone and shale, red; small amount of water	25	65
Shale, gray, limy	25	90
Shale, brown, limy	10	100
Shale, gray, limy	75	175
Shale, brown	20	195
Sand, gray, fine; water	19	214
Shale, gray	3	217
(D-23-14)25bca-1. Sample log by J. W. Hood. Altitude 4,160.		
Sand, loose, red, silty; hole produced water near 20 ft; started drilling with mud	20	20
Siltstone, red, sandy	10	30
Sandstone, cream-colored, very fined grained, silty	10	40
Sandstone, cream-colored, very fine grained, silty, and red, very fined grained, silty sandstone	10	50
Sandstone, white, very fine to fine-grained, silty	10	60
Sandstone, white and red, very fine to fine-grained, with siltstone	10	70
Sandstone, white, very fine to medium-grained, with red siltstone	10	80
Sandstone, white, very fine to medium-grained, with red siltstone, sandstone is mainly fine to medium-grained and better sorted than at 70-80 ft	30	110

Material	Thickness	Depth
(D-23-14)25bca-1.--Continued		
Sandstone, white, very fine to medium-grained, with red siltstone, sandstone is mainly fine to slightly coarse grained, drilling mud alternates in color from chocolate-brown to brownish tan	10	120
Sandstone, white to grayish tan, fine to slightly coarse grained, with red siltstone	10	130
Sandstone, pale brown to gray, fine to slightly coarse grained, wiht red siltstone	10	140
Sandstone, light reddish brown, very fine to medium-grained	20	160
Sandstone, light reddish brown, silty	10	170
Sandstone, pale brown to gray, very-fine to medium-grained, with many specks of red siltstone	10	180
Sandstone, pale tan, very fine to fine-grained, well-sorted, with a few fragments of red siltstone	10	190
Sandstone, pale brown, very fine to medium-grained, well-sorted; lost some drilling mud to formation	20	210
Sandstone, light brown, very fine to medium-grained, well-sorted, with a few small fragments of dark siltstone	20	230
Sandstone, pale tan, very fine to medium-grained, with a few fragments of dark siltstone	10	240
Sandstone, pale tan, very fine to fine-grained, with a few small fragments of red siltstone	10	250
Sandstone, light brown, very fine to medium-grained, with a few small fragments of red siltstone; had to add material to mud to decrease loss of drilling fluid	20	270
Sandstone, pale tan, very fine to medium-grained	10	280
Siltstone, cream-colored, sandy, with much evaporitic mineral fragments	10	290
Sandstone, dark brown, with small fragments of dark siltstone and gypsum	10	300
Siltstone, red-brown, with small fragments of gypsum and some sand	20	320
Gypsum, finely cut up, with red-brown siltstone, and some sand	20	340
Gypsum, finely cut up, with red-brown siltstone, sandier than at 320-340 ft	10	350
Siltstone, dark reddish brown, sand, and finely-cut gypsum; section from 300-360 ft hard; changed to button bit	10	360
Sandstone, brown, fine- to medium-grained, with some brown siltstone and finely-cut gypsum	10	370
Sandstone, brown, very fine to medium-grained, with traces of brown siltstone and gypsum	10	380
Sandstone, brown, very fine to fine-grained, with traces of brown siltstone and gypsum	10	390
Sandstone, brownish gray, very fine to fine-grained, with traces of brown siltstone and gypsum	20	410
Sandstone, gray limy, and gray limestone	10	420
Limestone, gray, finely cut, with some tan, very fine to fine sand	10	430
(D-23-14)12ddd-1.--Continued		
Limestone, gray, finely cut, some very fine to fine brown sand and red siltstone; siltstone diminishes at 440-450 ft	20	450
Siltstone, red, and very fine to fine-grained sandstone (sample lag about 10-20 ft?); at 460 ft penetration rate increased rapidly	20	470
Sandstone, white, very fine to medium-grained, with many small fragments of dark red siltstone	10	480
Sandstone, tan, very fine to fine-grained, with many specks of white evaporites, well-sorted, some fragments of red siltstone at 490-500 ft; at 490 ft, mud level in hole did not subside while adding drill stem; mud is thinning	20	500
Sandstone, pale tan, very fine to fine-grained with fine specks of red siltstone at 500-520 ft, increasing to about 40 percent of sample at 520-530 ft, again decreasing to less than 5 percent at 540-560 ft and about 10 percent at 560-570 ft, with some flakes of white evaporite; mud level rose during change of drill stem at 510 ft; at 550 ft, hole was definitely flowing	70	570
Sandstone, very pale brown, very fine to fine-grained with little red siltstone	10	580
Sandstone, pale tan, very fine to medium-grained, with about 10 percent red siltstone and white evaporite at 580-590 ft and less than 5 percent at 590-610 ft; drilling fluid now is almost plain water	30	610
Sandstone, pale brown, very fine to fine-grained	10	620
Sandstone, pale brown, very fine to medium-grained, with less than 10 percent red siltstone and white flakes of evaporite	10	630
Sandstone, pale brown, very fine to fine-grained, with a few fragments of red siltstone	20	650
Sandstone, pale yellowish brown, very fine to fine-grained	10	660
Sandstone, pale tan, very fine to medium-grained, with white flakes of evaporite at 650-670 ft, about 10 percent red siltstone; little red siltstone at 670-680 ft; about 10 percent at 680-690 ft; red siltstone diminished to less than 5 percent at 700-710 ft; hole flowing; temperature 17.5°C; specific conductance 908 umhos	50	710
(D-23-14)36bdd-1. Sample log by J. W. Hood. Altitude 4,120.		
Soil, thin red, over fine- to medium-grained silty red sandstone and very fine to fine-grained pale yellow sandstone	10	10
Sandstone, pale yellow, very fine to medium-grained, very friable sandstone	10	20
Sandstone, pale yellow, very fine to medium-grained, very friable sandstone, with some ocherous yellow to pale red friable sandstone	10	30
Sandstone, light reddish brown, fine- to medium-grained, with a few fragments of pale grayish green shale; water at about 35 ft	10	40
(D-23-14)36bdd-1.--Continued		
Sandstone, light reddish to dark brown, fine- to medium-grained, with fragments of red sandy siltstone	20	60
Sandstone, medium brownish red, very fine to fine-grained, a few fragments of gray shale	10	70
Sandstone, pale reddish tan, very fine to fine-grained	10	80
Sandstone, pale reddish brown to light brown, with a few fragments of dark red siltstone	10	90
Sandstone, light yellow to tan, very fine to fine-grained, with a few fragments of red siltstone and dark yellow sandstone	10	100
Sandstone, light yellow to tan, very fine to fine-grained, with a few fragments of red siltstone and dark yellow sandstone, slightly darker than at 90-100 ft, with more fragments of dark red, very friable siltstone and very small fragments of gray shale; hole flowing; temperature 15.0°C; specific conductance 3,230 umhos; pH 6.7	10	110
Sandstone, light yellow to tan, very fine to fine-grained, with a few fragments of red siltstone and dark yellow sandstone, contains more red siltstone and gray shale than at 90-100 ft; fragment of crystalline gypsum	10	120
Sandstone, pale tannish brown, very fine to fine-grained; very few other fragments in sample	10	130
Sandstone, tannish brown, very fine to medium-grained; many large (as much as 1 in.) fragments of dark red siltstone at 130-170 ft; red siltstone fragments smaller at 170-180 ft; red siltstone fragments up to 3/4-in. diameter at 180-190 ft; fragments of iron-oxide cavity filling	60	190
Sandstone, pale brown, fine- to medium-grained, many small fragments of red siltstone and some small fragments of white amorphous gypsum; hole producing 100-200 gal/min; water and air flowing from joint about 6 ft east of rig; temperature 17.9°C; specific conductance 2,650 umhos; changed to water for drilling	10	200
No samples; drilled blind after circulation lost; water level 10 ft below land surface	15	215

Note: Well partly drilled with air which eroded walls of hole and probably contaminated cuttings with cavings of wall above drilled interval shown, by violently ejecting water along hole's bore; well flowed from depth of about 110-205 ft; at 205 ft, flowing water appeared to be gas-lifted long after drilling air should have dissipated. Circulation lost immediately after 205 ft reached. Circulation lost in second hole, 30 south, at depth of 50 ft.

Material	Thickness	Depth
(D-25-15)23bdb-1. Log by O. R. Anderson. Altitude 4,795.		
Soil, sandy	4	4
Sandstone, red	66	70
Sandstone, white	20	90
Shale, sandy, red	15	105
Sandstone	45	150
Shale, sandy red	14	164
Shale, blue	6	170
Shale, hard blue	12	182
Shale, hard red	11	193
Sandstone, soft; water at		

Table 13.--Descriptions of rock samples analyzed for hydrologic properties and grain-size distribution, and of sampling sites.

[Abbreviations: ft, feet; in., inch; mm, millimeter; md, millidarcy.]

Location: See descriptions of well- and spring-numbering system.
Samples of several formations in the northern San Rafael Swell area were obtained, mainly from outcrops, and submitted to Core Laboratories, Inc., Dallas, Texas or to the Central Laboratory of the U.S. Geological Survey, Denver, Colorado. In addition, analyses of cores from three petroleum-test wells were obtained from the files of the U.S. Geological Survey. The description of the sources and the general nature of the samples follow. Thin-section descriptions are by Core Laboratories, Inc.; percentages cited for the thin sections are from point counts. Hydrologic characteristics, grain-size analyses, and permeability are given in tables 2, 3, and 4.

Location	Sample No.	Description
Sample from the Entrada Sandstone		
(D-23-13)24add-1	UTSR-28	Hand specimen from outcrop near top of hill 200 ft east of State Highway 24. Yellow, very friable sandstone. This sandstone contrasts with the usual red silty sandstone and siltstone in the Entrada Sandstone.
Sample from the Carmel Formation		
(D-19-11)17bba-2	UTSR-25	Hand specimen from outcrop in slope between east edge of Furniture Draw and county road, near head of Buckhorn Wash. Very dense, red-brown to lavender, finely crystalline, fossiliferous limestone. Interbed in red siltstone at base of formation.
Samples from the Navajo Sandstone		
(D-18-12)25aac-1	UTSR-4	Weathered hand specimen from slope north of dry wash; near top of formation. Light gray friable sandstone.
(D-19-10)13dbd-1	UTSR-5	Hand specimen from low road cut on north edge of county road in head of Buckhorn Wash. Firm tan sandstone.
(D-19-11)17bba-1	UTSR-26	Core hole at east edge of stream channel in Furniture Draw. (See UTSR-25, above.) Cut 2.25-in. core to depth of 0.5 ft in the top of the formation. Upper 0.3 ft used for grain-size analysis; last 0.2 ft used for permeability sample. Took 2 hours to cut sample. Very hard, light brown sandstone; almost limonitic in color.
(D-19-11)20bca-1	UTSR-24	Hand specimen broken from 2 ft calyx core near bottom of dry wash above box canyon near head of Buckhorn Wash. Core was cut as part of a 1949 explosion test on the sandstone. Sample is from a depth of 2-4 ft below land surface and from near top of formation. Very hard white to pale tan sandstone. Sample was too hard to disaggregate for grain-size analysis.
(D-19-12)30bba-1	NSR T-2	U.S. Geological Survey test hole drilled at southwest side of intersection of county road and trail to Big Flat. Hole was drilled with air and penetrated full thickness of Navajo Sandstone which was found to be dry to bottom. From set of 10-foot samples, suite of 14 samples chosen to represent zones apparently uniform in megascopic lithology and color.
(D-20-12)3cab-1	UTSR-27	Core hole in bare bottom of small stream channel at north side of ranch trail. Cut 2.25-in. core to depth of 5 ft near top of the formation. Top 0.9 ft was very soft. Remainder moderately indurated. Tan sandstone. Core hole cased with sealed aluminum tubing for soil moisture measurements.
	UTSR-27-1	Depth 0.0-0.2 ft.
	UTSR-27-2	Depth 0.2-0.45 ft.
	UTSR-27-4	Depth 0.9-1.7 ft. Thin-section description: medium sandstone: quartzarenite. This sample is homogeneous, poorly sorted sandstone consisting of 97 percent quartz, 1 percent feldspar, 1 percent chert, and 1 percent kaolinite. Grain size ranges from 0.02 to 0.4 mm, and the grains are generally equant and rounded to well-rounded. The moderately packed grains are in tangential or planar contact. Monocrystalline quartz with straight or slightly undulose extinction constitutes the bulk of the sample. Rutile needles, mica, and amphibole are present as inclusions. Well-rounded chert grains are scattered throughout the sample. Minor amounts of polycrystalline quartz also are present. Secondary quartz overgrowths are delineated by faint dust rims and are the primary cementing agent. This cementation is incomplete, however, and 22 percent intergranular porosity remains. Microcline and plagioclase feldspars are dispersed throughout the sample. Kaolinite is present as an alteration product which completely masks the original grains. Traces of finely crystalline siderite, muscovite, hornblende, and zircon also are present in the sample.
	UTSR-27-6	Depth 2.05-2.45 ft.
	UTSR-27-7	Depth 2.45-2.85 ft.
	UTSR-27-9	Depth 3.5-3.8 ft.
	UTSR-27-12	Depth 4.4-4.7 ft.
	UTSR-27-13	Depth 4.7-5.0 ft.

Table 13.--Descriptions of rock samples analyzed for hydrologic properties and grain-size distribution, and of sampling sites--Continued.

Location	Sample No.	Description
Samples from the Navajo Sandstone.--Continued		
(D-20-13)15cad-1	UTSR-20	Hand specimen from base of cliff on north side of Cottonwood Wash at bend in canyon. Sample from near base of formation. Slightly friable sandstone with red and tan laminae.
		Thin-section description: subarkosic quartzarenite.
		This sample is a homogeneous, poorly sorted sandstone consisting of 92 percent quartz, 6 percent feldspar, 1 percent kaolinite, and 1 percent organic material. Grain size ranges from 0.01-0.28 mm, and the grains are equant to subelongate and subrounded to subangular. The moderately packed grains are in planar or concavo-convex contact.
		Monocrystalline quartz with straight or undulose extinction is the primary mineral constituent. Rutile needles, zircon, and tourmaline are present as inclusions. Traces of rounded chert also are present.
		Microcline, orthoclase, and plagioclase feldspars are scattered throughout the sample. Alteration to clay and dissolution of these feldspars is common. The orthoclase appears to be more elongate than the quartz and fresher than the other feldspars.
		The sample is cemented with an early stage of secondary quartz overgrowths and a fine siliceous matrix. The cementation is incomplete and remaining intergranular pore space accounts for 14 percent of the sample. Kaolinite occurs as an alteration product which completely masks the original grains. Traces of organics, muscovite, hornblende, and zircon also were found.
(D-20-13)15daa-1	UTSR-21	Core hole at base of cliff on north side of Cottonwood Wash; on sandstone shelf, about 3 ft above bottom of stream channel. Core consists of brown, moderately indurated sandstone. Lower part of cliff and the shelf is damp and covered with mineral efflorescence. Core was saturated, and air used for coring would not clear cuttings from hole; air bubbled up from joints 1-2 ft from hole. No water standing in hole after coring stopped. Cased with open-ended aluminum tubing for water-level measurement.
	UTSR-21-1	Depth 0.0-0.2 ft.
	UTSR-21-2	Depth 0.2-0.5 ft.
	UTSR-21-3	Depth 0.5-0.9 ft.
	UTSR-21-4	Depth 0.9-1.1 ft.
(D-21-9)15add-1	UTSR-30	Weathered hand specimen from outcrop in bed of Coal Wash. Sample from near top of formation.
(D-21-9)15dda-1	UTSR-29	Weathered hand specimen from base of bluff at northeast side of the junction of North and South Forks, Coal Wash. Light yellow-brown, thin-bedded sandstone. Weathering causes sandstone to split into layers 0.75 to 1 in. thick.
(D-22-13)12aab-1	UTSR-3	Hand specimen from road cut at south side of Interstate Highway 70, at mouth of Spotted Wolf Canyon. Brown to tan friable sandstone about 30 ft below top of formation.
(D-22-13)12aba-1	UTSR-2	Hand specimen from road cut at south side of Interstate Highway 70 in Spotted Wolf Canyon. Brown friable sandstone near middle of formation.
		Thin-section description: fine sandstone; quartzarenite.
		This sample is a homogeneous, moderately sorted sandstone consisting of 97 percent quartz, 2 percent feldspar, and 1 percent calcite. The grains are generally subrounded to subangular and equant in shape. Grain size ranges from 0.01 to 0.20 mm. The grains are moderately packed and are in concavo-convex or planar contact.
		Monocrystalline quartz with straight or slightly undulose extinction is the primary mineral constituent. Rutile and muscovite are present as inclusions. Traces of chert and polycrystalline quartz also are present. Microcline and plagioclase feldspar are present in minor amounts and appear as fresh unaltered grains. Traces of zircon and hornblende are present.
		Secondary quartz overgrowths are the most important cementing agents. Minor patches of calcite also are present. Remnant porosity is very high due to the poorly consolidated nature of the sample, but an accurate estimate is not possible because of extensive plucking (of the thin section).
(D-22-13)12abb-1	UTSR-1	Hand specimen from outcrop at south side of Interstate Highway 70 in Spotted Wolf Canyon and at base of formation. Very hard brown calcareous sandstone or sandy limestone; contains healed fractures.
		Thin-section description: fine sandstone; calcareous quartzarenite.
		This sample is a homogeneous, moderately sorted sandstone consisting of 52 percent quartz, 39 percent calcite, 8 percent organics, and 1 percent feldspar. Grain size ranges from 0.02-0.20 mm, with grains averaging 0.12 mm. A few large grains are as large as 0.34 mm. The grains generally are equant and subangular to angular. Loosely packed grains are in tangential or planar contact.
		Monocrystalline quartz with straight or slightly undulose extinction is the primary mineral constituent. Rutile needles are common inclusions. Minor amounts of chert and polycrystalline quartz are also present. The most important cementing agent is calcite which is often encroaching on framework grains. Some iron staining is evident within the calcite. Organic material is associated with this calcite and also is a cementing agent. Remaining pore space is limited to 1-2 percent.

Table 13.--Descriptions of rock samples analyzed for hydrologic properties and grain-size distribution, and of sampling sites--Continued.

Location	Sample No.	Description
Sample from the Navajo Sandstone.--Continued		
		Microcline and plagioclase feldspars are present in minor amounts. These appear as fresh, unaltered grains, although several grains are fractured. Trace minerals include hornblende, zircon, and muscovite. Some grain plucking occurred during thin section preparation.
(D-22-13)12abb-2	UTSR-1A	Hand specimen from bed overlying source bed of sample UTSR-1. Soft, gray friable sandstone.
(D-22-13)35bdc-1	UTSR-8	Hand specimen from cut in unused mine access road in mouth of canyon. Sample from near middle of formation. Light brown friable sandstone that contains numerous thin fractures which are healed with a non-carbonate mineral.
		Thin-section description: medium sandstone; quartzarenite.
		This sample is a moderately to tightly packed sandstone consisting of 96 percent quartz, 3 percent feldspar, and 1 percent chert. The grains generally are equant and subrounded. Grain size ranges from 0.03 to 0.35 mm, except for a vein of medium silt-sized grains that occur throughout the length of the sample. Grain contacts are planar, concavo-convex, or slightly sutured. The primary mineral constituent is monocrystalline quartz with straight or undulose extinction. Rutile needles are common inclusions. Polycrystalline quartz and chert are present in minor amounts.
		Microcline and plagioclase feldspars are randomly scattered throughout the sample. Alteration to clay and dissolution of these feldspars is common and has resulted in minor secondary porosity.
		The sample is cemented with an early stage of secondary quartz overgrowths, as well as a minor amount of organic material. The vein of silt-sized material is tightly cemented by a fine siliceous matrix and no porosity is present here. However, in the rest of the sample as much as 22 percent intergranular pore space was observed. Trace amounts of hornblende and muscovite are present.
(D-23-9)3bda-1	UTSR-16	Hand specimen from cut on north side of local access road, south of Interstate Highway 70. Rock in the cut shows intense shattering and a small thrust zone; rock in the shattered zone is bleached. Sample is from the darker rock. Light yellow to tan, friable sandstone. Outer part of sample weathered.
(D-23-9)3bdb-1	UTSR-15	Hand specimen from cut on north side of local access road, south of Interstate Highway 70. Sample is from top of formation. Light tan to yellowish white sandstone; locally ocherous. Induration so poor that sandstone will shatter into bits when hit with a hammer.
(D-23-13)27bcc-1	UTSR-19A	Core hole in bare bottom of gulley about 5 ft above south edge of Straight Wash and south of trail that goes up canyon. Cut 2.25-in. core to 3.4 ft. Hole seemed to be damp near bottom. Hole cased with sealed aluminum tubing for soil moisture measurements. Tan to brown sandstone.
	UTSR-19A-1	Depth 0.0-0.20 ft.
	UTSR-19A-2	Depth 0.2-0.45 ft.
	UTSR-19A-3	Depth 0.45-0.90 ft.
	UTSR-19A-6	Depth 2.7-3.0 ft.
	UTSR-19A-7	Depth 3.0-3.4 ft.
(D-23-13)28add-1	UTSR-19	Hand specimen from south wall of Straight Wash Canyon, 50-100 ft below top of formation. Tan to yellowish gray mottled sandstone. Weathered.
(D-24-12)35bcd-1		Core hole in bare slope of San Rafael Reef, where precipitation can drain from site. Cut 1.375-in. core to depth of 3.5 ft. See Hood and Danielson, 1981, table 11. Tan friable sandstone.
	TQUT-5	Depth 0.0-1.0 ft.
	DAN-15	Depth approximately 1 ft.
	DAN-18	Depth approximately 3 ft.
	DAN-19	Depth approximately 3.4 ft.
(D-24-12)35bcd-2		Core hole in bare slope of San Rafael Reef, where precipitation can accumulate in depression. Cut 1.375-in. core to depth of 3.9 ft. See Hood and Danielson, 1981, table 11. Tan friable sandstone.
	TQUT-4	Depth 0.0-1.0 ft.
	DAN-21	Depth approximately 1 ft.
	DAN-22	Depth approximately 2 ft.
	DAN-23	Depth approximately 3 ft.

Table 13.--Descriptions of rock samples analyzed for hydrologic properties and grain-size distribution, and of sampling sites--Continued.

Location	Sample No.	Description
Sample from the Navajo Sandstone.--Continued		
(D-24-12)35cbd-2		Core hole in bare bottom of Old Woman Wash. Cut 2.25-in. core to approximately 4 ft. See Hood and Danielson, 1981, table 11. Tan friable sandstone.
	76UT-39-1	Depth 0.0-0.10 ft.
	76UT-39-2	Depth 0.10-1.0 ft.
	NS-7A	Depth 1.0-2.0 ft.
(D-24-14)32aac-1	UTSR-18	Weathered hand specimen from base of bluff west of Cottonwood Wash and south of fault scarp that exposes Navajo Sandstone near Cottonwood Spring. Very friable sandstone with red and tan laminae. Weathering causes sandstone to split into thin sheets. Sample from about 100 ft below top of formation.
(D-24-16)12bcb-1	UTSR-7	Weathered hand specimen from edge of canyon west of Green River and south of ranch trail. Sample from near top of formation. Pale orange well-indurated sandstone.
(D-24-16)15dbb-1	UTSR-22	Core hole in bare sandstone at north side of dry stream channel and east of county road where it skirts around shallow canyon. Cut 2.25-in. core to depth of 3.5 ft. Hole cased with sealed aluminum tubing for soil moisture measurements. Hole is in top of formation. Brown, moderately indurated sandstone.
	UTSR-22-1	Depth 0.0-0.40 ft.
	UTSR-22-2	Depth 0.40-0.90 ft.
	UTSR-22-5	Depth 1.5-1.9 ft.
	UTSR-22-9	Depth 2.8-3.3 ft.
Samples from the Kayenta Formation		
(D-22-10)33bca-1	UTSR-14	Hand specimen from road cut on north side of Interstate Highway 70 and west of Ghost Rocks rest area. Sample is from point about 10 ft below natural land surface. Tan to light pink, cross-bedded sandstone with streaks of red along bedding planes and included pellets of green shale.
(D-22-10)33bca-2	UTSR-14A	Hand specimen from same site as UTSR-14, but from about 4 ft below natural land surface. Light tan to greenish-white, even-bedded, very fine-grained sandstone with green streaks along bedding planes.
Samples from the Wingate Sandstone		
(D-19-11)33bbd-1	UTSR-6	Hand specimen from road cut on east side of road in Buckhorn Wash Canyon. Pinkish-tan firm sandstone.
(D-22-13)1dcd-1	UTSR-11	Hand specimen from road cut at south side of Interstate Highway 70 in Spotted Wolf Canyon. Sample from near middle of formation. Pink to tan or orange massive sandstone with thin laminae. Moderately indurated.
		Thin-section description: fine sandstone; quartzarenite.
		This sample is well-sorted, loosely packed sandstone consisting of 95 percent quartz, 4 percent feldspar, and 1 percent chert. Grain size ranges from 0.02-0.20 mm, and the grains are subrounded and equant to subelongate. Grain contacts are primarily planar and tangential. The major clastic constituent is monocrystalline quartz with straight or slightly undulose extinction. Rutile and zircon are present as inclusions. Minor amounts of polycrystalline quartz and chert also are present.
		Plagioclase feldspar and microcline are evenly dispersed throughout the sample. Clay alteration and dissolution of these feldspars is common.
		The sample is cemented by an early stage of secondary quartz overgrowths. A trace amount of calcite also is present. The sample is very poorly consolidated and contains 31 percent pore space. Trace amounts of organic material and hornblende are present in the sample.
(D-22-13)35bcc-1	UTSR-9	Weathered hand specimen from south wall of canyon, near stream level. Dark red sandstone, part of which has a salt and pepper appearance.
(D-23-10)9bbd-2	UTSR-17	Weathered hand specimen from near base of formation and near road to Swazy Cabin, about 100 ft north of Cliff Dweller Spring (table 10). Brown sandstone with specks of unidentified mineral.
Sample from the Moss Back Sandstone Member of the Chinle Formation		
(D-22-13)35bcc-2	UTSR-10	Hand specimen from the mouth of an old mine adit in the south wall of canyon. Slightly weathered banded cream and tan firm sandstone.

Table 13.--Descriptions of rock samples analyzed for hydrologic properties and grain-size distribution, and of sampling sites--Continued.

Location	Sample No.	Description
Samples from the Sinbad Limestone Member of the Moenkopi Formation		
(D-17-12)1bba-1	-	Suite of 1 ft cores from petroleum-test well (table 11); from depths of 3,128-3,136 ft. Table 4 gives average of four samples.
(D-24-13)23cdc-1		Suite of 1 ft cores from petroleum-test well (table 11).
	1	Depth 2,083-2,084 ft; gray-tan very finely crystalline sugary dolomite.
	2	Depth 2,084-2,085 ft; Do.
	3	Depth 2,085-2,086 ft; Do.
	1-6	Depth 2,083-2,089 ft; Do. Air permeability range: 0.13-48 md. Porosity range: 4.4-20.4 percent.
	7	Depth 2,089-2,090 ft; gray-tan very finely crystalline sugary dolomite.
	8-23	Depth 2,090-2,106 ft; Do. Air permeability range: 0.04-1.0 md. Porosity range: 3.9-11.4 percent.
	24-28	Depth 2,108-2,113 ft; gray-tan very finely to finely crystalline dolomite. Air permeability range: 0.02-0.25 md. Porosity range: 0.06-6.9 percent.
	29	Depth 2,118-2,119 ft; gray-tan very finely crystalline slightly shaly dolomite.
(D-25-13)12bac-1		Suite of 1 ft cores from petroleum-test well (table 11); from depths of 1,876.5-1935 ft.
	1-6	Depth 1,876.5-1,882 ft; dark tan-gray silty limy very fine grained sandstone. Air permeability range: 0.05-0.12 md. Porosity range: 3.1-5.8 percent.
	7	Depth 1,882-1,883 ft; dark gray very finely crystalline silty limestone.
	8-12	Depth 1,883-1,888 ft; dark tan-gray silty limy very fine grained sandstone. Air permeability range: 0.03-0.10 md. Porosity range: 1.8-4.6 percent.
	13-15	Depth 1,892-1,895 ft; dark tan-gray silty limy very fine grained sandstone. Air permeability range: 0.3-0.4 md. Porosity range: 1.0-3.6 percent.
	16-19	Depth 1,899.5-1,903 ft; dark tan-gray silty limy very fine grained sandstone. Air permeability range: 0.04-2.7 md. Porosity range: 2.0-7.9 percent.
	20-21	Depth 1,920-1,922 ft; dark tan-gray very finely crystalline silty limestone. Air permeability range: 0.27-1.8 md. Porosity range: 7.1-13.8 percent.
	22-23	Depth 1,922-1,924 ft; dark tan-gray very finely crystalline silty dolomite. Air permeability range: 0.75-1.1 md. Porosity range: 10.1-10.8 percent.
	24-26	Depth 1,924-1,927 ft; dark tan-gray very finely crystalline silty limestone. Air permeability range: 0.03-0.04 md. Porosity range: 1.1-1.9 percent.
	27	Depth 1,927-1,928 ft; dark tan-gray very finely crystalline silty dolomite.
	28-33	Depth 1,928-1,934 ft; Do. Air permeability range: 0.07-0.77 md. Porosity range: 4.8-9.0 percent.
	34	Depth 1,934-1,935 ft; dark gray-tan very finely crystalline dolomite.
	36	Depth 1,936-1,937 ft; Do.
Samples from the Kaibab Limestone		
(D-24-13)23cdc-1		Suite of 1 ft cores from petroleum-test well (table 11); from depths of 2,200-2,236 ft. Samples are variously anhydritic or conglomeritic and contain pyrite.
	30-51	Depth 2,200-2,222 ft; gray to gray-tan very finely to finely crystalline dolomite. Air permeability range: 0.01-0.06 md. Porosity range: 0.4-2.4 percent.
	52	Depth 2,222-2,223 ft; tan finely crystalline dolomite.

Table 13.--Descriptions of rock samples analyzed for hydrologic properties and grain-size distribution, and of sampling sites--Continued.

Location	Sample No.	Description
Samples from the Kaibab Limestone.--Continued		
(D-24-13)23cdc-1 Continued	53-59	Depth 2,223-2,230 ft; tan very finely to finely crystalline dolomite. Air permeability range: 0.05-0.15 md. Porosity range: 4.6-8.8 percent.
	60	Depth 2,230-2,231 ft; tan very finely to finely crystalline dolomite.
	61	Depth 2,231-2,232 ft; Do.
	62-65	Depth 2,232-2,236 ft; Do. Air permeability range: 0.06-1.9 md. Porosity range: 7.4-9.1 percent.
Samples from the Coconino Sandstone		
(D-21-11)25ddd-1	UTSR-13	Weathered hand specimen from outcrop at east edge of scoured bare bottom of Cottonwood Draw and west of nearby county road. Gray to tan, massive sandstone that has crust of desert varnish.
(D-21-11)25ddd-2	UTSR-13A and UTSR-13B	Pair of core holes, about 1 ft apart, at site of UTSR-13. Cut 2.25-in. cores. Hole 13A, on south, cut to depth of 2 ft and cased with sealed aluminum tubing for soil moisture measurements. Hole 13B, on north, cut to depth of 0.5 ft. Sandstone was very hard.
	UTSR-13A-1	Depth 0.0-0.15 ft.
	UTSR-13B-1	Depth 0.0-0.20 ft.
	UTSR-13B-2	Depth 0.20-0.45 ft.
	UTSR-13A-3	Depth 0.80-1.10 ft.
	UTSR-13A-5	Depth 1.45-1.80 ft. Thin-section description: medium sandstone; quartzarenite. This sample is homogeneous, moderately sorted sandstone consisting of almost 100-percent quartz. These grains generally are equant in shape and subrounded to subangular. Grain size ranges from 0.04-0.46 mm. The moderately packed grains display concavo-convex and sutured contacts. The sample consists of monocrystalline quartz grains with straight or undulose extinction. Rutile needles and zircon are common inclusions. Rare polycrystalline and composite grains also are present. Secondary quartz overgrowths cement the sample. Faint dust rims delineate these overgrowths on a few grains. This cementation is incomplete, however, and remaining intergranular pore space accounts for 12 percent of the sample. Traces of microcline, plagioclase feldspar, muscovite, and calciteare found in the sample.
	UTSR-13A-6	Depth 1.80-2.00 ft. Laboratory reported sample too hard to disaggregate for sieve analysis.
(D-23-11)27bca-1	UTSR-23	Core hole in bare, weathered outcrop on slope southwest of abandoned petroleum-test well foundation and east of county road; near top of the formation. Cut 2.25-in. core to depth of 4.5 ft. Hole bottom in damp limestone that was very hard to cut. Hole cased with sealed aluminum tubing for soil moisture measurements. Upper 1.2 ft not used for permeability determination because of natural vertical fracture.
	UTSR-23-1	Depth 0.0-0.1 ft. Used for soil carbonate determination.
	UTSR-23-4	Depth 1.45-2.10 ft.
	UTSR-23-5	Depth 2.10-2.50 ft.
	UTSR-23-6	Depth 2.50-2.85 ft.
	UTSR-23-9	Depth 3.70-4.15 ft.
(D-23-13)8cbc-1	UTSR-12	Hand specimen from strongly weathered outcrop on terrace at west side of a flat-topped butte and south of an abandoned petroleum-test well; on a jeep trail. Sample from near top of formation. White to gray sandstone that weathers to yellow color. Here and elsewhere in general area, these weathered outcrops have irregular patches of bright red color, which probably relate to localized iron concentration.
Samples from rocks of Mississippian age		
(D-25-13)12bac-1		Suite of 1 ft cores from petroleum-test well (table 11); from a depth of 3,823-3,840 and 3,941-3,960 ft. All samples were very finely crystalline dolomite.

Table 13.--Descriptions of rock samples analyzed for hydrologic properties and grain-size distribution and of sampling sites--Continued.

Location	Sample No.	Description
Samples from rocks of Mississippian age.--Continued		
(D-25-13)12bac-1 Continued	37-41	Depth 3,823-3,828 ft; light tan to tan; one section slightly vuggy. Air permeability range: 0.17-0.70 md. Porosity range: 7.2-12.2 percent.
	42	Depth 3,828-3,829 ft; light tan.
	43-47	Depth 3,829-3,834 ft; light tan; vertical fracture in lower 1 ft.
	48	Depth 3,834-3,835 ft; tan, chalky; vertical fracture.
	49	Depth 3,835-3,836 ft; Do.
	50	Depth 3,836-3,837 ft; Do.
	51-53	Depth 3,837-3,840 ft; Do. Air permeability range: 0.23-0.43 md. Porosity range: 11.3-13.2 percent.
		Unsampled interval
	54-56	Depth 3,941-3,944 ft; light tan to tan. Air permeability range: 0.02-0.08 md. Porosity range: 1.5-4.3 percent.
	57-58	Depth 3,944-3,946 ft; tan.
	59-60	Depth 3,946-3,948 ft; light tan to tan.
	61-62	Depth 3,948-3,950 ft; tan.
	63-67 and 69-72	Depth 3,950-3,960 ft; light tan. Air permeability range: 0.02-0.07 md. Porosity range: 4.6-8.3 percent.

Table 14.--Selected chemical analyses of water samples from water

[Constituents are in milligrams per liter unless otherwise noted;
Abbreviations: ft, feet; gal/min, gallons per minute; °C, degrees Celsius;

Location: See text for description of well- and spring-numbering system. S, well plugged back; W, petroleum-test well converted to or left for use as water well. Prefix R designates half-range east.
Source of water: M, mine shaft; P, petroleum-test well; S, spring; T, test well or test hole; W, water well.
Date: F, sampled from open-hole flow; P, sampled through packer. Note - samples from most petroleum-test wells were collected by means of packer tests.
Analysis by: U.S. Geological Survey, except analyzed or reported by CL, Core Laboratories, Inc., Dallas; CGL, Chemical and Geological Laboratories, Casper; CSO, Cities Service Oil Co.; CTL, California Testing Laboratories, Inc., Los Angeles; FL, Ford Laboratory, Salt Lake City; MFS, Mountain Fuel Supply Co.; PL, Peterson Laboratory, Salt Lake City; RO, Reserve Oil and Gas Co.; ShO, Shell Oil Co.; SO, Superior Oil Co.; UH, Utah Department of Health; VHA, Vaughn Hansen Associates, Salt Lake City.

Location	Source of water	Date	Geologic unit (see tables 1 and 2)	Sample Interval: Depth to top (ft)	Sample Interval: Depth to bottom (ft)	Discharge (gal/min)	Temperature (°C)	Dissolved constituents: Silica (SiO_2)	Iron (Fe) (µg/L)	Calcium (Ca)	Magnesium	Sodium (Na)	Sodium plus Potassium as (Na)	Potassium (K)
(D-15-10)26aaa-1	P	5-13-58	331HMBG	10,060	10,160	-	-	-	-	1,530	396	-	6,580	-
(D-15-11)12cda-1	P	1-21-39	220NVJO	3,095	3,114	-	-	-	m	874	61	-	422	-
(D-15-12)7ccc-1	P	4- -63	300PLZC	7,433	7,986	-	-	-	m	1,444	311	-	10,960	-
8ccd-1	P	8-18-59	300PLZC	8,323	9,174	-	-	-	-	3,496	716	-	21,580	-
(D-15-13)17dbc-1	P	1971	330DSRT	7,990	8,080	-	-	-	-	5,350	915	23,900	-	2,900
18caa-S1	S	9-17-75	111ALVM	-	-	168	13.0	18	30	77	77	120	-	2.6
(D-16-12)1bbd-1	P	1- -53	237SNBD	4,014	4,083	-	-	-	-	-	-	-	-	-
		5- -53	330MDSN	7,831	7,930	-	-	-	-	-	-	-	-	-
4bad-1	P	1953	237SNBD	4,138	4,175	-	-	-	-	-	-	-	-	-
		1953	237SNBD	4,138	4,175	-	-	-	-	-	-	-	-	-
		1953	237SNBD	4,185	4,207	-	-	-	-	-	-	-	-	-
16cbd-S1	S	7-18-79	217CDRM	-	-	2.0e	15.0	7.5	10	3.4	1.1	550	-	2.1
27abb-1	P	1-14-57	310CCNN	4,442	4,458	-	-	-	-	1,360	377	-	4,750	-
		2- -57	330MDSN	6,998	7,132	-	-	-	-	1,940	454	-	18,500	-
(D-16-13)20dab-S1	S	7-18-79	217CDRM	-	-	30 e	29.0	16	20	190	230	550	-	3.4
21ccd-1	P	5- -63	220GLNC	1,784	2,400	50	-	-	-	480	-	-	-	-
		5-17-63	230MNKP	3,494	3,550	-	-	-	-	-	-	-	-	-
(D-17-12)23aba-S1	S	5-18-79	221ENRD	-	-	25	20.0	9.8	20	430	260	850	-	25
(D-17-13)3abd-S1	S	11-21-67	111ALVM	-	-	-	-	17	10	113	168	390	-	5.0
		7-18-79		-	-	.1	21	23	20	190	320	450	-	6.1
30ddd-1S	W	6-28-79	220NVJO	353	560	12	16.0	11	5,000	320	280	2,500	-	4.4
32bdc-1	T	5-19-79	220NVJO	312	400	25 e	17.0	9.2	30	620	210	270	-	30
		5-20-79	220GLNC	312	700	100 e	17.5	9.4	390	620	210	260	-	29
(D-18-10)13aab-S1	S	7-10-79	217CDRM	-	-	4 e	17.5	9.8	10	58	12	74	-	1.3
(D-18-11)33acd-S1	S	7-10-79	221BRSB	-	-	<.1	22.0	7.3	30	10	6.7	850	-	4.5
(D-18-14)9dca-1	T	10-16-33	220NVJO	-	3,180	15	28.0	-	0	684	295	-	351	-
		3-14-47					26.0	-	-	908	288	-	360	-
		9-15-47				-	-	24	-	-	-	-	-	-
		9-17-52				-	-	-	-	847	287	312	-	112
		6-22-56				-	-	-	-	-	-	-	-	-
30ccb-1	P	10-25-62	310KIBB	3,606	3,673	-	-	-	-	2,400	486	-	9,670	-
		10-29-62	310CCNN	3,717	3,868	-	-	-	0	2,400	4,860	-	12,100	-
		10-20-62	330MSSP	6,963	7,083	-	-	-	-	2,400	4,860	-	16,200	-
(D-19-9)1acd-S1	S	10-31-58	221BRSB	-	-	1 e	14.0	7.3	-	7.2	0	-	287	-
26cab-S1	S	9-11-75	221SMVL	-	-	.5	15.5	6.8	-	150	170	710	-	5.7
(D-19-10)15bac-1	W	10-21-76	221CRML	-	476	20	14.0	13	60	510	270	210	-	10
(D-19-13)12ddd-1S	P	10-5-69	310KIBB	3,341	3,373	-	-	-	-	1,680	437	12,500	-	1,400

e, estimated, m, presence of ion verified, but not quantified.
μg/L, micrograms per liter; μmhos/cm, micromhos per centimeter.]

Bicarbonate (HCO_3)	Carbonate (CO_3)	Alkalinity ($CaCO_3$)	Dissolved constituents							Dissolved solids		Specific conductance (μmhos/cm at 25°C)	Hardness as $CaCO_3$		Sodium-adsorption ratio	pH (units)	Analysis by
			Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Nitrite plus Nitrate (N)	Orthophosphate (PO_4)	Boron (B) (μg/L)	Residue at 180°C	Sum of constituents		Total (Ca, Mg)	Noncarbonate			
634	0	520	2,820	11,600	-	-	-	-	-	-	23,570	36,700	5,500	4,900	-	7.1	ShO
3,070	-	2,520	586	172	-	-	-	-	-	-	3,607	-	2,400	0	-	-	
2,269	-	1,860	8,400	13,100	-	-	-	-	-	-	35,780	42,300	4,900	3,000	-	7.3	CGL
2,147	-	1,760	2,346	38,570	-	-	-	-	-	-	67,770	91,700	12,000	9,900	-	7.2	CGL
3,200	0	2,630	956	49,000	-	-	-	-	-	-	84,600	100,000	17,000	15,000	79	6.2	CGL
395	0	324	480	47	0.2	-	7.2	0.00	120	-	1,080 [1]	1,500	650	320	2.1	7.6	
-	-	-	-	9,700	-	-	-	-	-	-	-	-	-	-	-	-	CSO
-	-	-	-	44,000	-	-	-	-	-	-	-	-	-	-	-	-	CSO
-	-	-	6,400	78,000	-	-	-	-	-	-	-	-	29,200	-	-	6.5	PL
-	-	-	72,000	75,200	-	-	-	-	-	-	-	-	38,400	-	-	6.7	PL
-	-	-	10,400	88,000	-	-	-	-	-	-	-	-	51,320	-	-	6.4	PL
-	-	940	150	79	1.6	-	-	-	620	-	1,360	2,140	13	0	66	-	
2,490	-	2,040	642	8,900	-	-	-	-	-	-	17,200	27,500	4,900	2,900	-	7.9	CGL
4,030	-	3,310	2,710	29,000	-	-	-	-	-	-	54,600	68,800	6,700	3,400	-	6.8	CGL
-	-	250	2,000	130	.4	-	-	-	410	-	3,270	4,170	1,400	1,200	6.3	6.9	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RO
-	-	-	-	18,000	-	-	-	-	-	-	-	-	-	-	-	-	RO
-	-	180	3,300	230	.8	-	-	-	410	-	5,210	6,360	2,100	2,000	8.0	6.4	
506	0	416	1,220	105	.4	9.5	-	.70	250	-	2,438 [2]	2,505	976	560	5.4	7.6	UH
-	-	350	2,000	120	.3	-	-	-	320	-	3,320	4,050	1,800	1,400	4.6	6.2	
-	-	690	5,600	1,100	.7	-	-	-	6,400	-	10,200	12,800	2,000	1,300	25	6.1	
-	-	610	2,000	120	.8	-	-	-	590	-	3,630	4,000	2,400	1,800	2.4	7.2	
-	-	680	2,000	110	.6	-	-	-	520	-	3,650	3,900	2,400	1,700	2.3	7.0	
-	-	240	75	39	.3	-	-	-	80	-	414	703	190	0	2.3	6.1	
-	-	380	1,300	200	1.0	-	-	-	470	-	2,710	3,930	53	0	51	8.8	
2,160	-	1,770	1,560	200	-	.10	-	-	-	-	4,170	-	2,920	1,100	-	-	
2,840	0	2,330	1,540	215	-	-	-	-	400	-	4,170	5,640	3,450	1,120	-	-	
2,760	0	2,260	-	195	-	-	-	-	-	-	-	5,490	-	-	-	-	
2,660	0	2,180	-	-	-	-	-	-	-	-	-	5,430	3,300	1,120	2.4	-	
1,560	0	1,280	-	-	-	-	-	-	-	-	-	4,700	2,440	1,160	-	6.6	
4,050	0	3,320	60	18,800	-	-	-	-	-	-	36,800	50,000	8,000	4,700	-	6.0	CL
3,030	0	2,490	200	22,700	-	-	-	-	-	-	39,400	52,400	26,000	24,000	-	6.0	CL
3,270	0	2,680	29,100	29,110	-	-	-	-	-	-	51,890	75,800	26,000	23,000	-	6.0	CL
329	28	316	181	94	1.9	.70	-	-	-	754	768	1,240	18	0	29	8.8	
332	0	272	1,600	470	.5	-	.06	-	600	-	3,280 [3]	5,240	1,100	800	9.4	8.1	
105	0	86	2,200	270	.4	-	.17	-	1,000	-	3,550 [4]	3,700	2,400	2,300	1.9	7.1	
3,870	0	3,170	2,980	20,300	-	-	-	-	-	-	41,200	55,000	6,000	2,800	70	7.4	CGL

Location	Source of water	Date	Geologic unit (see tables 1 and 2)	Sample Interval: Depth to top (ft)	Sample Interval: Depth to bottom (ft)	Discharge (gal/min)	Temperature (°C)	Dissolved constituents: Silica (SiO_2)	Iron (Fe) (µg/L)	Calcium (Ca)	Magnesium	Sodium (Na)	Sodium plus Potassium as (Na)	Potassium (K)
(D-19-13)12ddd-1W	P	8-11-62	324PRDX	5,518	5,608	-	-	-	0	960	1,020	-	8,450	-
		8-13-62	330MSSP	6,736	6,915	-	-	-	0	2,640	365	-	16,170	-
13bbd-S1	S	5-20-79	221CRTS	-	-	5	18.5	8.4	50	200	250	2,900	-	120
21cbd-1	T	6-27-80	220NVJO	120	310	30 e	15.5	8.3	20	56	52	14	-	6.1
(D-20-9)35ccd-S1	S	5-9-79	221CRML	-	-	3 e	11.0	8.2	30	560	120	63	-	13
(D-20-10)6bdd-1	T	F 8-14-80	220NVJO	152	475	10 e	13.0	8.4	1,100	100	41	42	-	16
		P 7-14-80		147	475	2.8	13.0	8.5	<10	100	40	43	-	15
(D-20-11)3cab-S1	S	5-3-78	111ALVM	-	-	-	-	-	-	259	37	198	-	-
		6-8-78		-	-	-	-	-	-	296	101	210	-	-
4aab-S1	S	10-31-58	231CHNL	-	-	20 e	-	12	-	329	124	-	194	-
		5-3-78				-	-	-	-	263	85	180	-	85
		6-8-78				-	-	-	-	444	218	576	-	-
11bcc-S1	S	5-3-78	111ALVM	-	-	-	-	-	-	280	149	280	-	-
		6-8-78				-	-	-	-	344	161	488	-	-
(D-20-13)15dad-S1	S	6-8-79	220NVJO	-	-	<5 e	13.5	7.3	20	86	110	43	-	8.5
(D-20-14)31cbd-1	W	6-8-79	221CRML	-	150	50 e	15.0	-	-	-	-	-	-	-
		10-31-79					14.0	10	770	88	35	20	-	9.7
(D-20-16)17dab-1	W	8-8-58	112ALVM	-	30	-	-	18	-	147	60	-	234	-
(D-21-9)2bbb-1	T	5-9-79	220NVJO	350	520	100 e	-	9.6	10	180	60	17	-	6.9
		5-10-79		350	640	>100	14.0	8.2	520	160	50	7.5	-	6.5
		5-10-79		350	860	-	-	7.3	10	160	49	10	-	8.1
		5-12-79	220GLNC	350	1,450	200 e	-	7.3	10	130	50	22	-	16
(D-21-13)24cbb-S1	S	9-19-31	230MNKP	-	-	200 e	-	-	-	681	133	-	171	-
(D-21-14)4cbd-1	M	8-14-56	221CRML	-	-	-	-	-	-	-	-	1,000	-	-
5aab-S1	S	8-6-79	221CRML	-	-	<5 e	13.5	8.9	790	120	48	24	-	12
(D-21-15)24cca-1	P	4- -61	330MSSP	9,555	9,652	-	-	-	101,000	4,370	1,600	-	121,000	-
		4- -61	330MSSP	9,705	9,752	-	-	-	3,400	10,120	1,410	-	86,830	-
(D-21-16)9aac-1	W	9-21-60	111ALVM	12	16	-	-	14	-	377	150	-	472	-
34dda-1	P	9-22-47	200MSZC	-	2,627	-	-	15	-	258	235	-	4,180	-
		3-22-48				-	18.0	13	-	1,000	225	-	4,070	-
		9-27-48				6,700 e	16.0	-	-	-	-	-	-	-
		9-17-52				-	-	-	-	870	220	3,180	-	305
(D-21-17)26adc-1	P	4-22-69	324HRMS	6,465	6,615	-	-	-	-	9,640	875	-	53,290	-
(D-22-8)11ccb-1S	W	6- -61	231KYNT	1,400	2,246	-	-	-	-	-	-	-	-	-
23aad-S1	S	4-23-59	221CRML	-	-	5 e	-	15	-	477	226	-	1,670	-
(D-22-9)8aca-S1	S	10-25-79	221CRML	-	-	10 e	17.0	10	-	520	230	170	-	11
(D-22-10)23cbc-1	T	12-27-71	231WNGT	-	83	-	-	7.0	0	68	31	11	-	18
30aca-1	T	6-15-66	230MNKP	-	704	-	-	13	-	40	215	-	292	-
		6-17-66		-	1,080	-	-	9.4	-	12	137	-	247	-
		6-27-66		-	1,200	-	-	7.2	-	112	126	-	316	-
(D-22-13)35bdc-2	T	7-17-80	220NVJO	-	310	20 e	17.5	12	10	160	74	23	-	10
35bcd-S1	S	7-6-79	111ALVM	-	-	<5 e	18.0	11	30	260	120	100	-	15
(D-22-14)6bbc-S1	S	10-28-58	220NVJO	-	-	5 e	7.0	7.1	-	76	33	-	16	-
		2-1-68				-	-	7.0	30	60	32	5.0	-	3.0
28dba-1	W	5-21-80	221ENRD	-	515	<5 e	17.0	33	800	800	220	390	-	1.9
28ddd-1	W	10-28-58	221CRTS	-	265	-	16.0	10	-	321	246	-	551	-
31ddb-1	W	1-9-36	221CRML	-	350	-	-	-	-	-	-	-	-	-
(D-22-16)2bba-1	P	10-21-48	324PRDX	5,100	5,250	-	-	16	-	68,500	9,090	55,950	-	-
2bbd-1	P	7-17-49	324PRDX	5,792	5,896	146	-	10	-	76,200	9,480	58,300	-	-

Bicarbonate (HCO_3)	Carbonate (CO_3)	Alkalinity ($CaCO_3$)	Dissolved constituents: Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Nitrite plus Nitrate (N)	Orthophosphate (PO_4)	Boron (B) (µg/L)	Dissolved solids: Residue at 180°C	Sum of constituents	Specific conductance (µmhos/cm at 25°C)	Hardness as $CaCO_3$: Total (Ca, Mg)	Noncarbonate	Sodium-adsorption ratio	pH (units)	Analysis by
2,196	0	1,800	320	16,190	-	-	-	-	-	-	29,140	-	6,600	4,800	-	7.5	CL
1,903	0	1,560	800	28,970	-	-	-	-	-	-	50,850	76,400	8,100	6,500	-	7.0	CL
-	-	190	8,000	520	1.0	-	-	-	460	-	12,100	14,300	1,500	1,300	32	6.5	
-	-	250	100	14	1.5	-	-	-	120	-	402	690	350	100	.3	7.8	
-	-	64	1,900	54	.5	-	-	-	870	-	2,760	2,860	1,900	1,800	.6	6.8	
-	-	110	260	16	1.0	-	-	-	190	-	552	870	420	310	.9	7.0	
-	-	250	260	13	.6	-	-	-	170	-	631	968	410	160	.9	-	
212	-	174	970	38	-	-	-	-	-	1,600	-	2,480	800	630	3.0	-	VHA
256	0	210	1,300	30	-	-	-	-	-	2,070	-	3,190	1,200	950	2.7	-	VHA
232	11	209	1,430	36	1.7	0.30	-	-	-	2,430	2,250	2,550	1,330	1,120	2.3	8.4	
2,830	-	2,320	1,060	32	-	-	-	-	-	1,770	-	2,710	1,000	0	2.5	-	VHA
207	-	170	2,870	60	-	-	-	-	-	4,280	-	6,590	2,000	1,800	5.6	-	VHA
256	-	210	1,520	80	-	-	-	-	-	2,455	-	3,770	1,300	1,100	3.4	-	VHA
402	-	330	2,140	30	-	-	-	-	-	3,385	-	5,200	1,500	1,200	5.4	-	VHA
-	-	280	370	63	.4	-	-	-	100	-	857	1,120	620	390	.7	6.7	
-	-	-	-	-	-	-	-	-	-	-	-	680	-	-	-	6.4	
-	-	260	160	9.9	1.7	-	-	-	110	-	492	767	360	100	.5	7.2	
670	0	550	450	72	.2	-	-	-	-	1,310	1,310	1,870	612	62	4.1	7.7	
-	-	300	380	16	.2	-	-	-	100	-	850	1,150	700	400	.3	6.5	
-	-	240	380	9.1	.2	-	-	-	90	-	766	900	610	370	.1	6.9	
-	-	280	290	9.2	.4	-	-	-	100	-	702	1,030	600	320	.2	6.8	
-	-	270	290	14	.5	-	-	-	200	-	692	1,030	530	260	.4	7.2	
1,170	-	960	1,310	208	-	-	-	-	-	3,180	3,080	-	2,250	1,300	-	-	
700	0	574	1,530	215	-	-	-	-	-	-	-	4,470	120	0	40	8.2	
-	-	290	240	12	1.7	-	-	-	140	-	642	992	500	210	.5	6.4	
1,452	0	1,190	2,400	196,400	-	-	-	-	-	-	327,300	250,000	18,000	16,000	-	5.5	CL
366	0	300	300	155,000	-	-	-	-	-	-	254,500	250,000	31,000	31,000		5.0	CL
561	0	460	1,910	95	-	-	-	-	-	-	3,290	3,840	1,560	1,100	5.2	7.2	
2,010	0	1,650	2,360	4,670	-	-	-	-	-	-	12,700	18,200	1,610	0	-	-	
4,400	0	3,610	2,410	4,370	-	-	-	-	-	-	14,300	19,400	3,420	0	30	-	
2,900	0	2,380	-	-	-	-	-	-	-	-	-	18,800	-	-	-	-	
3,720	0	3,050	-	-	-	-	-	-	-	-	-	16,200	3,080	26	25	-	
220	0	180	830	101,000	-	-	-	-	22,000	180,700	165,900	196,100	27,700	28,000	-	6.8	ShO
-	-	-	-	935	-	-	-	-	-	-	-	6,460	-	-	-	-	
116	0	95	3,800	1,200	.8	5.8	-	-	1,500	-	7,450	8,990	2,120	2,020	16	7.4	
-	-	190	2,200	120	.4	-	-	-	-	3,580	3,380	3,660	2,200	2,100	1.6	7.7	
295	0	243	73	8	.4	.50	-	0.10	680	-	360	645	296	53	.3	7.6	UH
572	0	469	1,040	45	-	1.2	-	-	-	1,970	1,930	2,420	982	513	4.0	7.4	
700	0	574	472	45	-	.90	-	-	-	1,260	1,270	1,750	592	18	4.4	7.4	
506	0	415	934	70	-	.50	-	-	-	1,950	1,820	2,460	800	385	4.9	7.8	
-	0	280	450	35	.5	-	-	-	120	-	933	1,290	700	420	.4	7.3	
-	-	250	980	59	.2	-	-	-	100	-	1,700	2,200	1,100	890	1.3	6.8	
267	6	229	112	8	.1	.90	-	-	-	388	5390	607	324	95	.4	8.3	
248	0	206	86	11	.3	.00	-	.40	90	-	5355	540	282	75	.1	8.2	UH
-	-	2,200	1,200	110	.1	-	-	-	540	-	4,080	5,300	2,900	700	3.2	6.6	
2,020	0	1,660	1,120	132	.0	.10	-	-	-	3,460	3,370	4,340	1,810	154	5.6	7.1	
-	-	-	2,380	86	-	-	-	-	-	5,100	-	-	-	-	-	-	
-	583	-	137	231,000	-	-	-	-	490,000	367,000	-	-	210,000	-	53	-	CTL
919	0	754	49	249,000	-	-	-	-	600,000	397,000	394,000	-	230,000	230,000	53	6.3	CTL

Table 14.--Selected chemical analyses of water samples from water

Location	Source of water	Date	Geologic unit (see tables 1 and 2)	Sample Interval: Depth to top (ft)	Sample Interval: Depth to bottom (ft)	Discharge (gal/min)	Temperature (°C)	Dissolved constituents: Silica (SiO_2)	Iron (Fe) (µg/L)	Calcium (Ca)	Magnesium	Sodium (Na)	Sodium plus Potassium as (Na)	Potassium (K)
(D-22-16)25bbc-1	P	3-21-73	310CCNN	2,585	2,605	-	-	-	-	515	120	5,700	-	170
			310PRMN	3,442	3,480	-	-	-	-	2,450	598	24,400	-	620
			321HKTL	4,175	4,232	-	-	-	-	1,470	598	86,600	-	770
			330MSSP	9,225	9,280	-	-	-	-	9,560	1,200	64,400	-	2,700
25ad-S	S	9-17-52	221ENRD	-	-	-	-	-	-	-	-	-	-	-
25dc-S	S	9-17-52	221BRSB	-	-	-	-	-	-	642	96	1,400	-	59
(D-22-17)34bda-1	P	8- -58	330MSSP	10,050	10,170	-	-	-	-	9,760	.1	-	66,730	-
(D-23-8)21bdc-S1	S	7-18-79	221CRML	-	-	5 e	-	-	-	-	-	-	-	-
30bdb-S1	S	7-18-79	221CRML	-	-	10 e	-	-	-	-	-	-	-	-
(D-23-9)2ccb-1	W	8-12-71	310CCNN	-	690	-	-	9.0	250	216	112	10	-	8.0
(D-23-10)9bbd-S1	S	10-31-58	231WNGT	-	-	<1	-	7.5	-	127	112	-	39	-
12ddd-1	W	10-31-58	230MNKP	-	217	4 e	11.0	4.6	-	238	400	-	204	-
		7-19-79				7.2	12.5	6.9	540	270	350	170	-	53
28dbb-1	P	6- -61	330MSSP	-	2,197	-	-	-	0	400	340	416	-	-
		7- -61	330MSSP	-	2,265	-	-	-	0	160	196	-	331	-
(D-23-13)34dbd-S1	S	10-28-58	111ALVM	-	-	15 e	16.0	10	-	303	126	-	36	-
(D-23-14)25bca-1	T	F 7-22-80	220NVJO	460	700	20 e	17.0	8.1	320	110	41	19	-	11
		P 7-23-80		450	700	14	16.5	8.1	400	94	40	19	-	10
36bdd-1	T	7-19-80	221CRML	-	110	30 e	15.0	10	80	500	170	120	-	20
		7-19-80	221CRML	-	205	100 e	15.0	-	-	-	-	-	-	-
(D-23-15)21bab-1	P	8-31-59	330MSSP	7,500	7,702	-	-	-	-	1,440	208	7,290	-	-
(D-23-16)3bca-1	P	8-23-61	330MSSP	8,530	8,715	-	-	-	-	9,590	1,260	55,900	-	-
15dca-1	P	9- -61	310WTRM	-	2,510	3.3	-	-	-	474	86	681	-	-
		10- -61	330MSSP	8,210	8,440	-	-	-	-	5,090	2,920	65,000	-	-
(D-23-17)15cba-1	P	3- -61	330MSSP	8,678	8,768	-	-	-	-	3,469	752	-	84,660	-
17ada-1	P	12- -62	330MSSP	8,732	8,738	-	-	-	-	6,300	1,000	-	56,200	-
17dbc-1	P	12- -62	330MSSP	8,709	8,716	-	-	-	-	5,780	1,450	-	56,850	-
(D-24-9)5bcb-1	W	7-19-79	231CHNL	-	-	10 e	14.5	5.5	1,000	230	130	150	-	100
(D-24-13)11adb-1S	W	5-14-80	220JRSC	-	1,508	10	17.0	6.9	60	110	66	16	-	11
36dba-1	W	5-13-80	200MSZC	-	1,202	13	15.0	8.3	780	300	230	35	-	16
(D-24-14)21adb-1	W	6-7-79	220NVJO	-	-	8	15.0	7.6	270	78	47	5.0	-	7.7
(D-24-15)6caa-1S	W	6-7-79	220NVJO	230	-	10 e	15.5	7.1	2,800	170	60	62	-	17
(D-25-11)33dbd-1	T	3-7-75	220NVJO	380	400	60	-	3.4	50	150	66	46	-	8.2
(D-25-15)32cac-1	W	7-11-56	220NVJO	-	720	-	-	-	-	125	86	-	28	-
(D-26-11)9bbb-1	W	3-8-80	220NVJO	802	844	-	-	16	150	229	30	75	-	273
R(D-25-17)20daa-1	P	1-25-61	330MSSP	6,361	6,386	-	-	-	0	560	1,070	-	9,660	-

1 Includes 3 µg/L Li, 13 µg/L Se, and 30 µg/L Zn.
2 Includes 20 µg/L Zn.
3 Includes 2 µg/L As, 11 µg/L Pb, 240 µg/L Li, 10 µg/L Se, and 20 µg/L Zn.
4 Includes 2 µg/L Pb, 70 µg/L Li, 11 µg/L Sr, and 240 µg/L Zn.
5 Includes 80 µg/L Mn, and 20 µg/L Zn.
6 Includes 1.2 mg/L Ba, 200 µg/L Mn.
7 Includes 3 mg/L H_2S.

			Dissolved constituents							Dissolved solids			Hardness as $CaCO_3$				
Bicarbonate (HCO_3)	Carbonate (CO_3)	Alkalinity ($CaCO_3$)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Nitrite plus Nitrate (N)	Orthophosphate (PO_4)	Boron (B) (ug/L)	Residue at 180°C	Sum of constituents	Specific conductance (umhos/cm at 25°C)	Total (Ca, Mg)	Noncarbonate	Sodium-adsorption ratio	pH (units)	Analysis by
1,840	0	1,510	1,550	8,000	-	-	-	-	-	-	17,000	24,400	1,800	270	59	7.5	MFS
207	0	170	2,850	42,000	-	-	-	-	-	-	73,000	95,700	8,600	8,400	115	7.4	MFS
73	0	60	3,500	136,000	-	-	-	-	-	-	229,000	224,000	6,100	6,100	481	8.1	MFS
451	0	370	1,200	121,000	-	-	-	-	-	-	200,000	200,000	29,000	28,000	165	6.6	MFS
-	-	-	-	-	-	-	-	-	-	22,200	-	33,700	-	-	-	-	
495	0	406	-	-	-	-	-	-	-	-	-	7,980	2,000	1,590	14	-	
257	0	211	670	123,700	-	-	-	-	-	202,900	-	-	30,280	30,000	-	6.5	SO
-	-	-	-	-	-	-	-	-	-	-	-	3,000	-	-	-	-	
-	0	-	-	-	-	-	-	-	-	-	-	6,000	-	-	-	-	
700	0	576	412	14	.1	.00	-	.00	150	-	[6]1,214	1,650	1,000	430	.1	7.2	UH
648	0	531	285	24	.2	.2	-	-	-	943	914	1,380	778	247	.6	8.1	
465	0	381	2,100	81	1.0	.40	-	-	-	3,570	[7]3,260	3,650	2,240	1,860	1.9	8.2	
-	-	530	1,800	93	1.1	-	-	-	1,000	-	3,060	3,670	2,100	1,600	1.6	6.7	
573	0	470	900	1,350	-	-	-	-	-	3,978	-	6,060	2,400	1,900	3.7	7.5	CL
586	0	481	1,000	284	-	-	-	-	-	-	2,260	3,910	470	0	6.7	7.0	CL
191	6	167	1,120	14	.2	.20	-	-	-	1,820	1,840	1,960	1,280	1,110	.4	8.4	
-	-	200	280	5.7	.6	-	-	-	130	-	596	927	440	240	.4	6.8	
-	-	220	230	6.0	.9	-	-	-	100	-	541	842	400	180	.4	6.6	
-	-	550	1,600	68	.5	-	-	-	270	-	2,820	3,230	1,900	1,400	1.2	6.7	
-	-	-	-	-	-	-	-	-	-	-	-	3,060	-	-	-	-	
769	0	631	3,090	11,700	-	-	-	-	-	25,700	24,100	35,500	4,500	3,800	47	6.9	CGL
366	0	300	951	106,000	-	-	-	-	-	196,000	174,000	186,000	29,000	29,000	143	6.4	CGL
720	0	591	1,780	410	-	-	-	-	-	3,790	3,780	4,230	1,500	950	7.6	7.1	CGL
465	0	381	2,090	116,000	-	-	-	-	-	197,600	191,300	220,000	25,000	24,000	180	6.9	CGL
793	-	650	3,025	136,200	-	-	-	-	-	-	228,500	220,000	12,000	11,000	-	7.7	CGL
525	-	431	1,240	99,500	-	-	-	-	-	-	164,500	183,000	20,000	19,000	-	6.5	CGL
378	-	310	1,275	101,000	-	-	-	-	-	-	166,500	183,000	20,000	20,000	-	6.5	CGL
-	-	320	990	93	.3	-	-	-	1,100	-	1,890	2,450	1,100	790	2.0	7.2	
-	-	200	360	2.9	.3	-	-	-	100	-	694	1,060	550	350	.3	8.0	
-	-	180	1,500	29	.4	-	-	-	220	-	2,230	2,530	1,700	1,500	.4	7.4	
-	-	180	230	4.7	.5	-	-	-	90	-	489	776	390	210	.1	6.7	
-	-	210	530	25	.6	-	-	-	150	-	1,000	1,430	670	460	1.0	6.4	
405	0	332	400	6.0	.2	.10	-	.16	<10	1,070	879	1,550	750	420	.8	7.0	FL
340	-	279	394	26	-	-	-	-	-	944	827	1,590	666	390	-	7.5	CGL
273	0	224	615	4.0	.3	<.01	-	.00	195	1,099	1,120	1,300	696	470	1.2	7.1	FL
433	0	355	5,000	15,050	-	-	-	-	-	-	31,780	47,830	5,800	5,400	-	5.5	CL

PUBLICATIONS OF THE UTAH DEPARTMENT OF NATURAL RESOURCES,
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TECHNICAL PUBLICATIONS

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No. 2. The Ogden Valley artesian reservoir, Weber County, Utah, by H. E. Thomas, U.S. Geological Survey, 1945.

*No. 3. Ground water in Pavant Valley, Millard County, Utah, by P. E. Dennis, G. B. Maxey and H. E. Thomas, U.S. Geological Survey, 1946.

*No. 4. Ground water in Tooele Valley, Tooele County, Utah, by H. E. Thomas, U.S. Geological Survey, in Utah State Engineer 25th Biennial Report, p. 91-238, pls. 1-6, 1946.

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*No. 6. Ground water in the Escalante Valley, Beaver, Iron, and Washington Counties, Utah, by P. F. Fix, W. B. Nelson, B. E. Lofgren, and R. G. Butler, U.S. Geological Survey, in Utah State Engineer 27th Biennial Report, p. 107-210, pls. 1-10, 1950.

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*No. 12. Reevaluation of the ground-water resources of Tooele Valley, Utah, by J. S. Gates, U.S. Geological Survey, 1965.

*No. 13. Ground-water resources of selected basins in southwestern Utah, by G. W. Sandberg, U.S. Geological Survey, 1966.

*No. 14. Water-resources appraisal of the Snake Valley area, Utah and Nevada, by J. W. Hood and F. E. Rush, U.S. Geological Survey, 1966.

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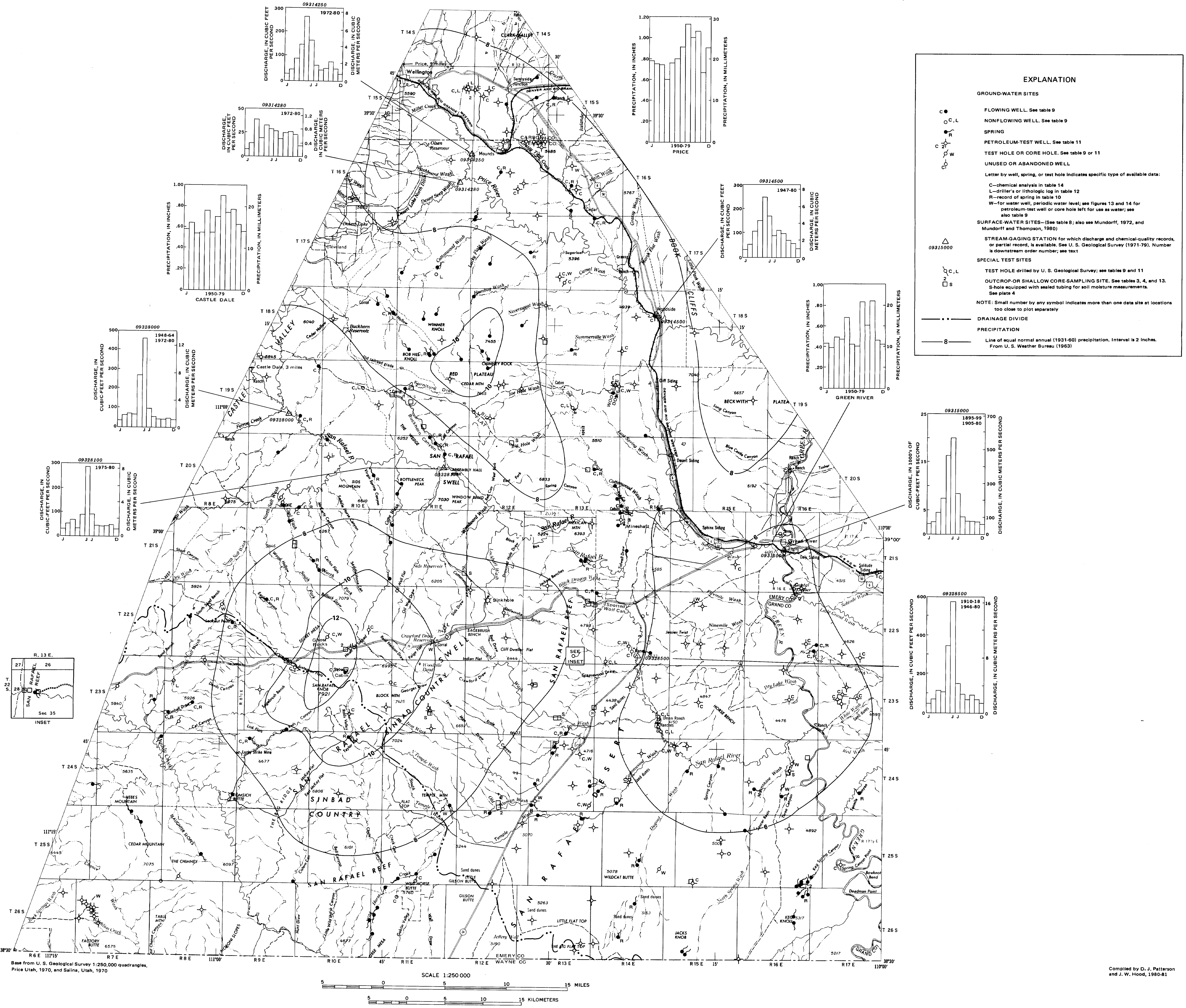
TECHNICAL PUBLICATION NO. 78
1984
PLATE 1



MAP SHOWING HYDROLOGIC- AND GEOLOGIC-DATA SITES, CLIMATOLOGIC DATA, AND STREAM-FLOW IN THE NORTHERN SAN RAFAEL SWELL AREA, UTAH.

UNITED STATES DEPARTMENT OF THE INTERIOR
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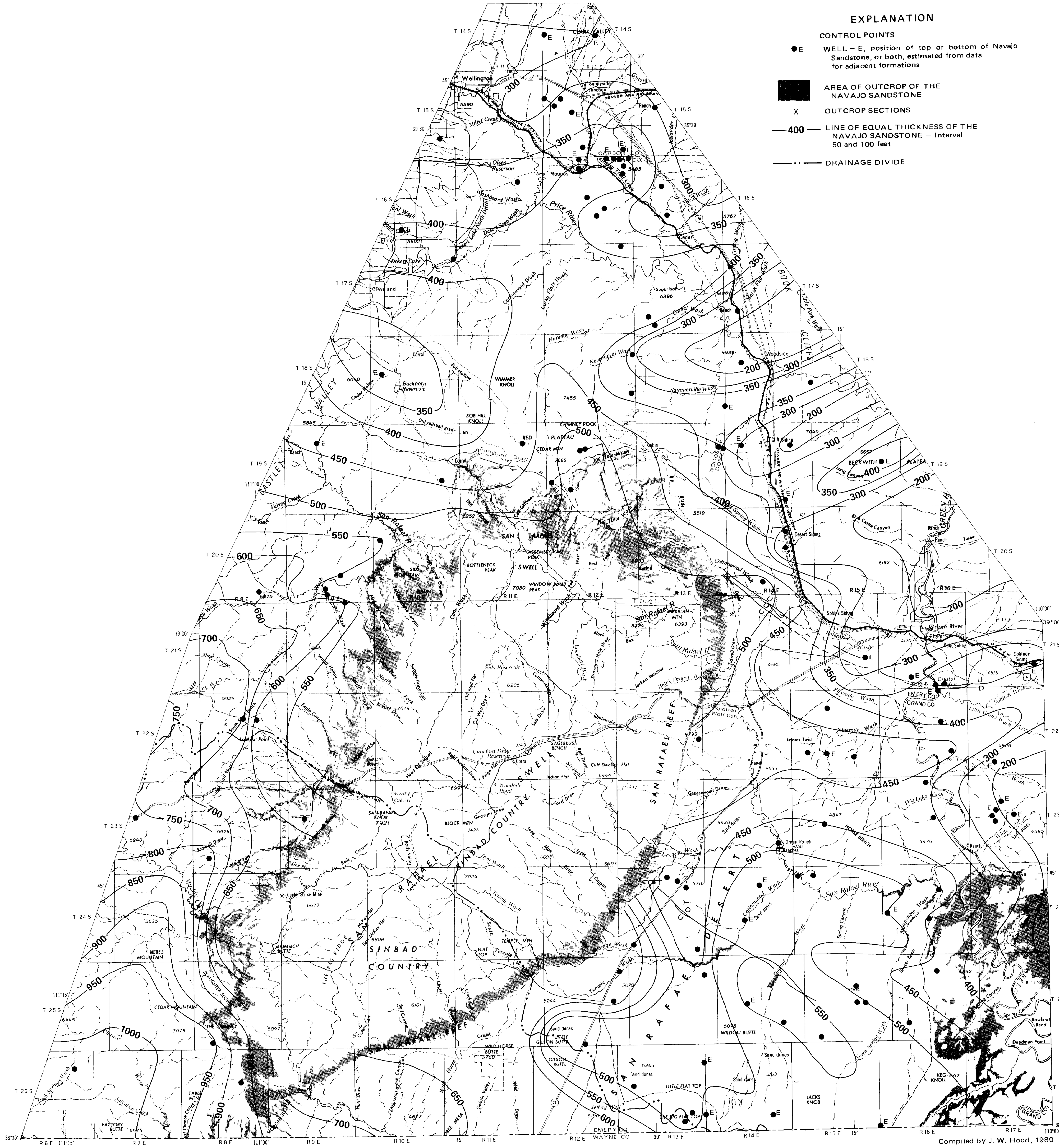
TECHNICAL PUBLICATION NO 78
1984
PLATE 3



Base from U. S. Geological Survey 1:250,000 quadrangles, Price Utah, 1970, and Salina, Utah, 1970

SCALE 1:250 000

5 0 5 10 15 MILES

5 0 5 10 15 KILOMETERS

National Geodetic Vertical Datum of 1929

MAP SHOWING THICKNESS OF THE NAVAJO SANDSTONE IN THE NORTHERN SAN RAFAEL SWELL AREA, UTAH.

UNITED STATES DEPARTMENT OF THE INTERIOR
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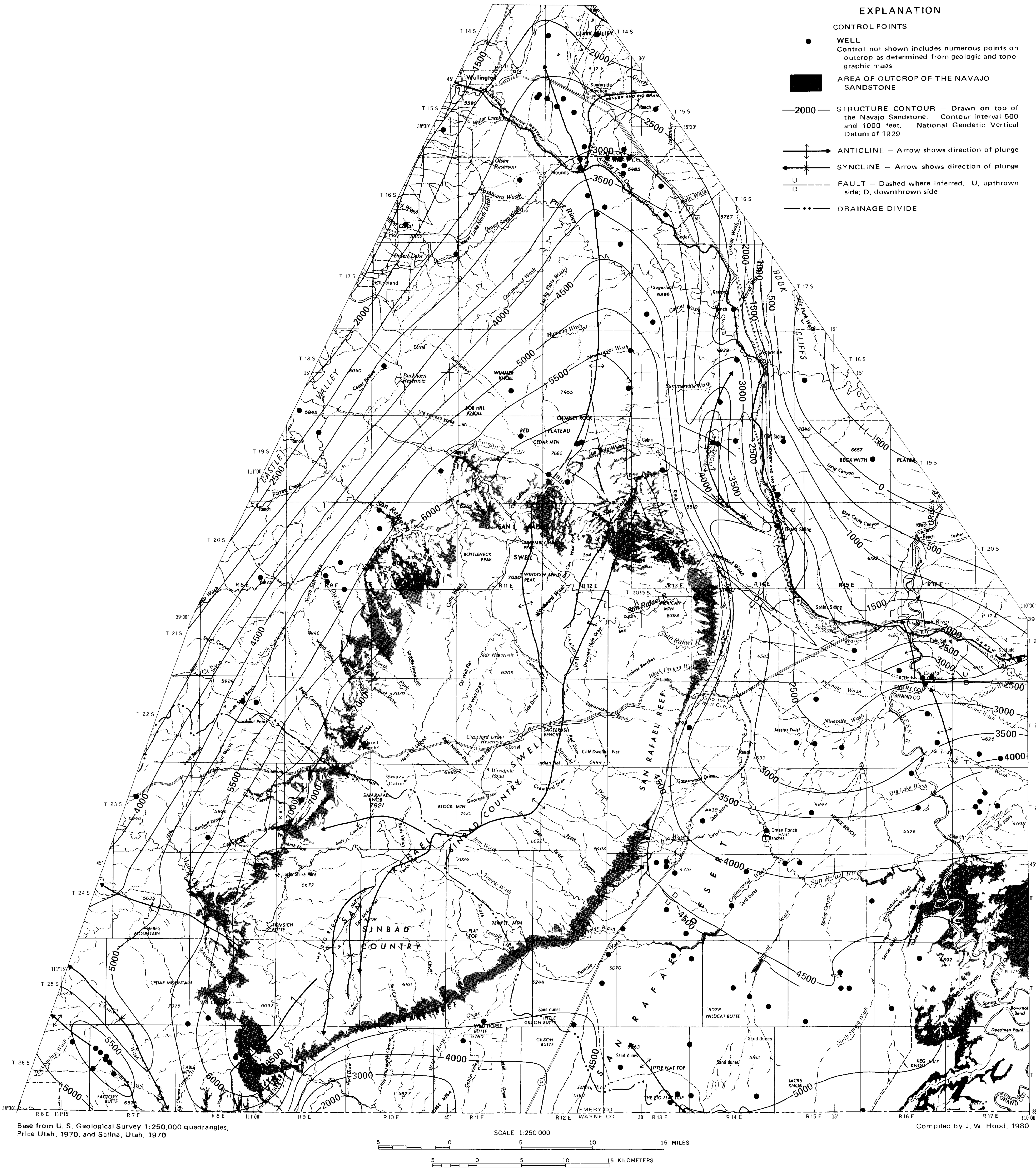
TECHNICAL PUBLICATION NO. 78
1984 PLATE 4



MAP SHOWING STRUCTURE CONTOURS ON THE TOP OF THE NAVAJO SANDSTONE IN THE NORTHERN SAN RAFAEL SWELL AREA, UTAH.

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1984 PLATE 5

EXPLANATION

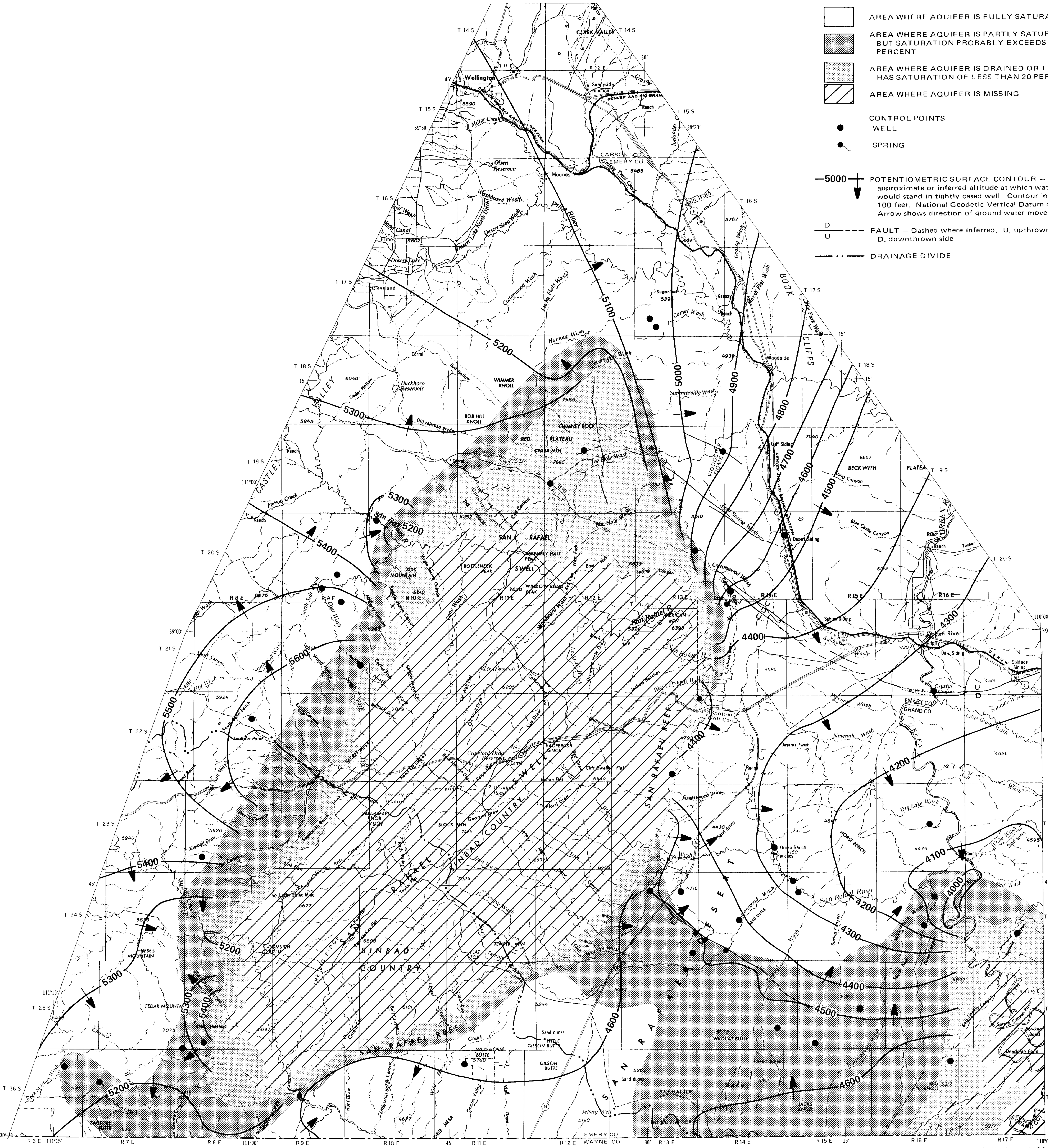
- AREA WHERE AQUIFER IS FULLY SATURATED
- AREA WHERE AQUIFER IS PARTLY SATURATED BUT SATURATION PROBABLY EXCEEDS 20 PERCENT
- AREA WHERE AQUIFER IS DRAINED OR LOCALLY HAS SATURATION OF LESS THAN 20 PERCENT
- AREA WHERE AQUIFER IS MISSING

CONTROL POINTS
- WELL
- SPRING

—5000— POTENTIOMETRIC-SURFACE CONTOUR — Shows approximate or inferred altitude at which water level would stand in tightly cased well. Contour interval 100 feet. National Geodetic Vertical Datum of 1929. Arrow shows direction of ground water movement

D/U ---- FAULT — Dashed where inferred. U, upthrown side; D, downthrown side

—·· — DRAINAGE DIVIDE



Base from U. S. Geological Survey 1:250,000 quadrangles, Price Utah, 1970, and Salina, Utah, 1970

Compiled by J. W. Hood, 1980

SCALE 1:250 000

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5 0 5 10 15 KILOMETERS

National Geodetic Vertical Datum of 1929

MAP SHOWING THE APPROXIMATE POTENTIOMETRIC SURFACE FOR THE NAVAJO SANDSTONE AQUIFER IN THE NORTHERN SAN RAFAEL SWELL AREA, UTAH.

UNITED STATES DEPARTMENT OF THE INTERIOR
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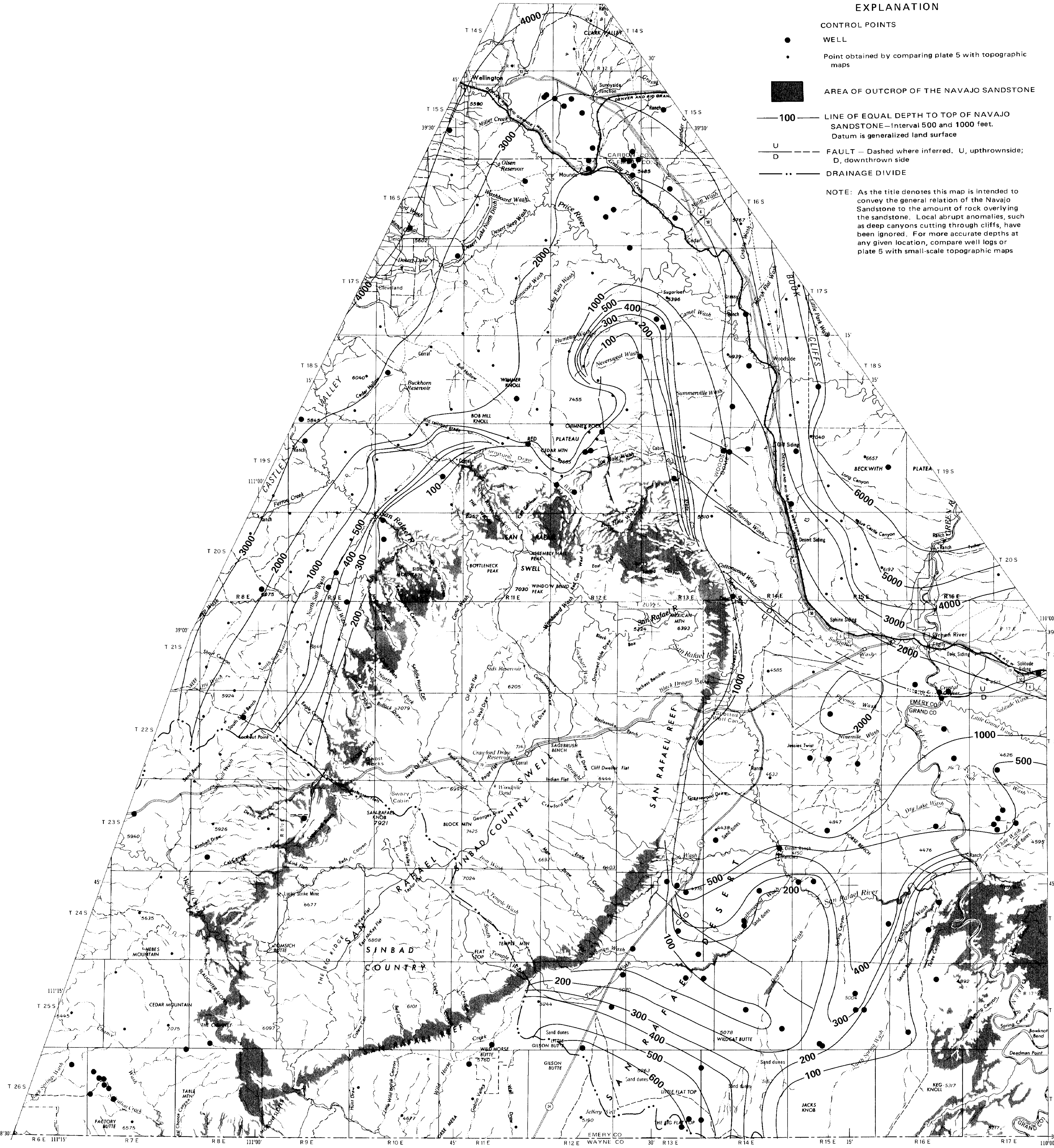
1984
PLATE 6



Base from U. S. Geological Survey 1:250,000 quadrangles, Price Utah, 1970, and Salina, Utah, 1970

SCALE 1:250 000

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5 0 5 10 15 KILOMETERS

National Geodetic Vertical Datum of 1929

Compiled by D. J. Patterson and J. W. Hood, 1980–81

MAP SHOWING THE GENERALIZED DEPTH TO THE NAVAJO SANDSTONE IN THE NORTHERN SAN RAFAEL SWELL AREA, UTAH.