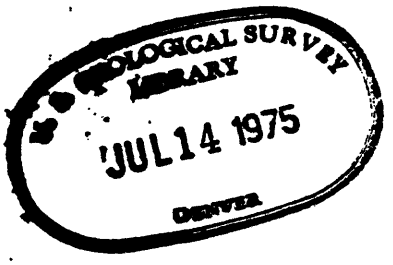
UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

HYDROLOGIC RECONNAISSANCE OF THE MONTEZUMA CREEK-ANETH AREA, SOUTHEASTERN UTAH

By C. T. Sumsion

Open-File Report 75-268



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HYDROLOGIC RECONNAISSANCE OF THE MONTEZUMA CREEK-ANETH AREA, SOUTHEASTERN UTAH

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ABSTRACT

The Montezuma Creek-Aneth area is in the northeastern part of the Navajo Indian Reservation in southeastern Utah. It is a semiarid area along the San Juan River near the communities of Montezuma Creek and Aneth. Within the Blanding Basin, geologic formations exposed are of Jurassic and Quaternary age. The rock strata are nearly horizontal, dipping gently northeastward. Wells derive small quantities of water for domestic use from aquifers in the Morrison Formation and the Bluff Sandstone of Jurassic age, but aquifers in deeper formations contain saline water or brine. Alluvium consisting of sand and gravel along the San Juan River is a potential source of additional moderately large quantities of water to shallow wells for industrial use and public supply. The chemical quality of water in the alluvium is good and varies directly with the discharge of the San Juan River.

INTRODUCTION

An investigation was made in January 1974 at the request of the U.S. Public Health Service, Office of Environmental Health, Indian Health Service, to determine the occurrence and chemical quality of potable ground water in the Montezuma Creek-Aneth area in the northeastern part of the Navajo Indian Reservation in southeastern Utah (fig. 1). The Public Health Service is considering the advisability of constructing a municipal supply system because of the accelerated economic growth and consequent increasing demand for water in the area. The study area was about 1 mi (1.6 km) wide and included both sides of the San Juan River near the communities of Montezuma Creek and Aneth.

The field investigation was made during the last week of January 1974. On-site inspection, aerial photographs, and published geologic and topographic maps of the U.S. Geological Survey were used to delineate surface features. Well drillers' reports, mostly from State records, provided additional ground-water data. Data on chemical quality of water were obtained from Geological Survey, State, and industrial records.

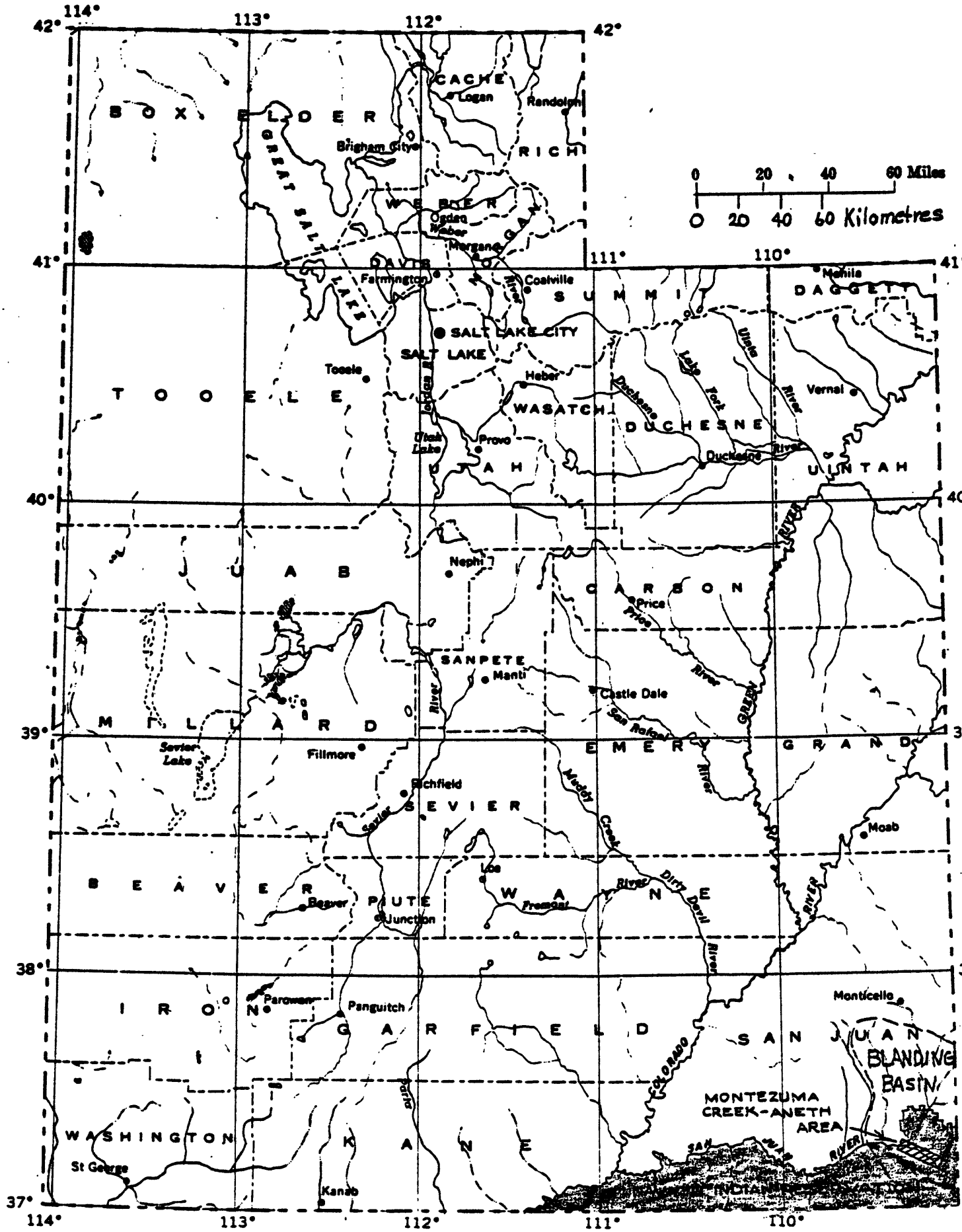

Figure 1.--Location of the Montezuma Creek-Aneth area.

Well-numbering system

The system of numbering wells in Utah is based on the cadastral land-survey system of the U.S. Government. The number, in addition to designating the well, 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); 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 within the 10-acre (4 hm^2) tract. If a well 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-40-24)32cdd-1 designates the first well constructed or visited in the SE¼SE¼SW¼ sec. 32, T. 40 S., R. 24 E. The numbering system is illustrated in figure 2.

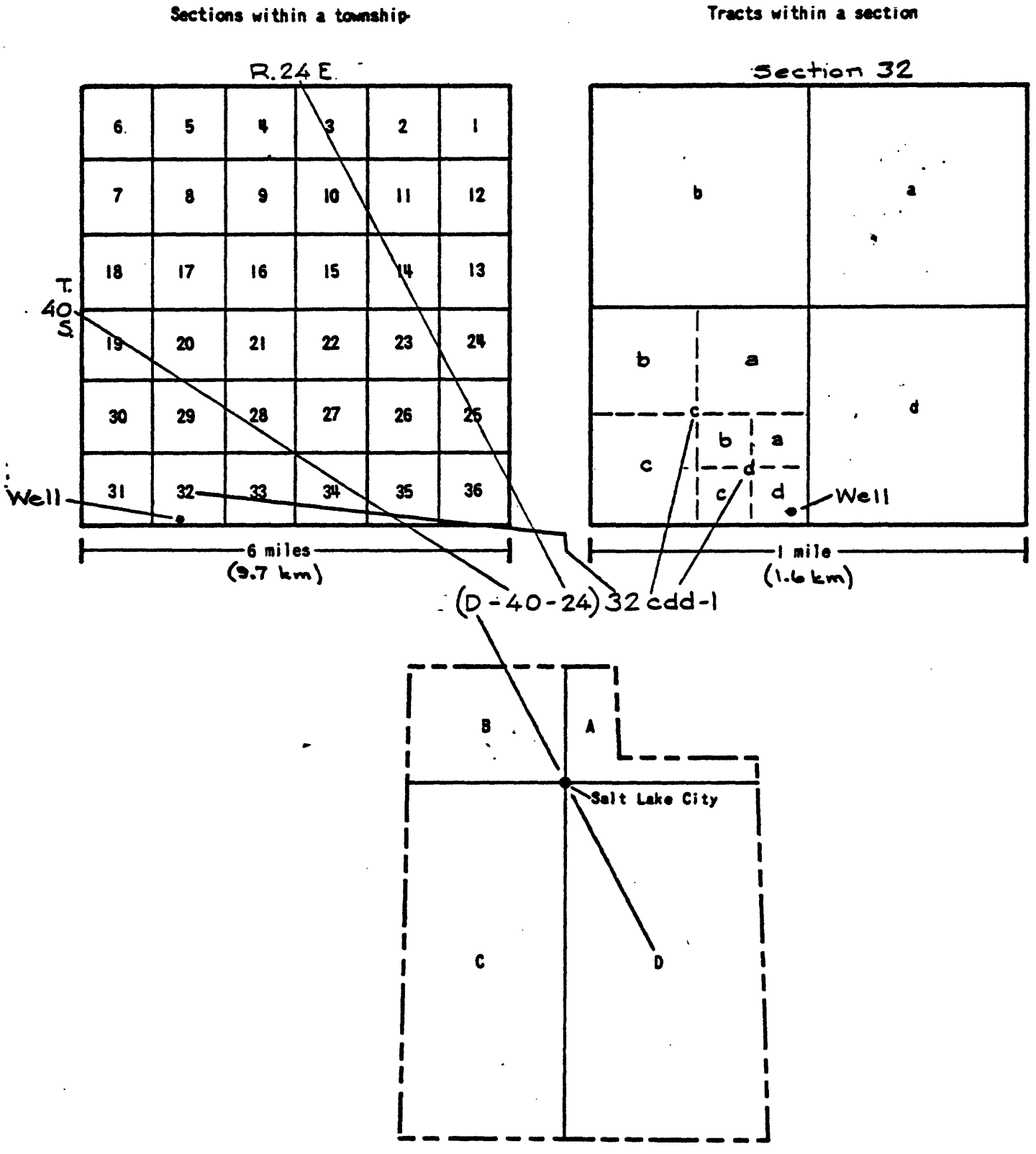

Figure 2.—Well-numbering system used in Utah.

Metric (SI) units

Most numbers are given in this report in English units followed by metric units in parentheses. The conversion factors used are shown to four significant figures. However, in the text the metric equivalents are shown only to the number of significant figures consistent with the accuracy of the number of English units.

English Unit (Multiply)	Abbreviation	(by)	Metric Unit (to obtain)	Abbreviation
Acres		0.4047	square hectometres	hm^2
Cubic feet per second	ft^3/s	.02832	cubic metres per second	m^3/s
Feet	ft	.3048	metres	m
Gallons	gal	3.785	litres	l
Gallons per minute	gal/min	.06309	litres per second	l/s
Inches	in	25.4	millimetres	mm
Miles	mi	1.609	kilometres	km
Feet per mile	ft/mi	.1894	metres per kilometre	m/km

Chemical concentration is given only in metric units--milligrams per litre (mg/l). For concentrations less than 7,000 mg/l, the numerical value is about the same as for the English unit, parts per million.

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

$$°F = 1.8(°C) + 32$$

GEOGRAPHIC SETTING

Topography and streamflow

The Montezuma Creek-Aneth area, in the southeastern part of the Canyon Lands section of the Colorado Plateaus physiographic province (Fenneman and Johnson, 1946), is characterized by landforms typical of a semiarid environment. Altitudes range from 4,400 feet (1,340 m) above mean sea level on the San Juan River about 1 mile (1.6 km) downstream from the mouth of Montezuma Creek to about 5,000 feet (1,520 m) on some of the higher buttes and mesas southeast of Aneth.

The width of the San Juan River flood plain averages about 0.75 mile (1.2 km) between Montezuma Creek and Aneth. The river has an average fall of about 6.5 ft/mi (1.23 m/km) for a distance of about 10 miles (16 km) along the trend of the valley between Aneth and Montezuma Creek. The average annual discharge (1926-72 water years) of the San Juan River at Shiprock, N. Mex., is 2,203 ft^3/s (62.4 m^3/s) or 1,596,000 acre-feet (1,969 hm^3) per year.

The area is drained by many intermittent and ephemeral streams tributary to the San Juan River. McElmo Creek, which joins the river at Aneth (fig. 3) has a small discharge during most of the year but is commonly dry for short periods in the late summer; its average annual discharge (1951-72 water years) near the Colorado-Utah State line--about 20 miles (32 km) upstream--was about 44.1 ft^3/s (1.25 m^3/s) or 31,950 acre-feet (39.4 hm^3) per year (U.S. Geol. Survey, 1972, p. 368). The other main tributaries to the San Juan River in the study area, Montezuma and Desert Creeks, are both intermittent streams.

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Climate

Average annual precipitation near Aneth during 1969-72 was 9.74 inches (247 mm). The average annual temperature was 56.0°F (13.5°C) (table 1) (U.S. Environmental Science Services Administration, 1970-73). Temperatures range from near 0°F (-18°C) to more than 100°F (38°C). The greatest precipitation is normally from intense convective storms of local extent in September and October. Snowfall during winters is common.

Annual evaporation is estimated to be more than 46 inches (1,168 mm) (Iorns and others, 1965, pl. 8).

Geology and hydrology

The Montezuma Creek-Aneth area is part of the south side of the Blanding Basin (fig. 1), an area of geologic downwarp. The geologic formations in the Montezuma Creek-Aneth area are nearly flat; strata dip generally northeastward at less than 1 degree. Basin configuration is illustrated by a structure-contour map complied by Haynes, Vogel, and Wyant (1972, sheet 2).

Geologic formations exposed within the Blanding Basin are of sedimentary origin and of Jurassic or Quaternary age. Water wells penetrate unexposed formations of Triassic and Jurassic age, and many oil-test wells in the area penetrate deeper and older formations. A summary of the formations, their physical characteristics, and water-bearing properties is presented in table 2.

Table 1.--Average annual temperature and precipitation at Aneth Plant, 1969-72 [U.S. Environmental Science Services Administration, Environmental Data Service (1970-73)]

	Temperature (°F)	Precipitation (inches)
January	32.3	0.63
February	40.7	.35
March	46.2	.53
April	54.8	.10
May	66.6	.14
June	74.2	.34
July	81.6	.64
August	80.2	.78
September	69.1	1.64
October	55.1	2.79
November	41.0	.66
December	30.2	1.14
Average annual	56.0	9.74

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Ground-water recharge in the Montezuma Creek-Aneth area is mainly from snowmelt along the western to southwestern rim of the Blanding Basin, about 20-30 miles (32-48 km) to the northwest. Ground water discharges naturally into the San Juan River, where the latter intersects saturated water-yielding strata. Some water is lost by evapotranspiration along the river flood plain.

Wells penetrating the Bluff Sandstone of Jurassic age in the area are reported to yield usable water in quantities sufficient for domestic use or for livestock--1 to 10 gal/min (0.06 to 0.63 l/s). Wells penetrating the Entrada, Navajo, and Wingate Sandstones of Jurassic, Jurassic and Triassic(?), and Triassic ages, respectively, are reported to yield from 30 to 157 gal/min (1.9 to 9.9 l/s) of saline water, which may be suitable for some industrial purposes. Aquifers in deeper formations yield saline water or brine. Records of selected wells in consolidated formations are given in table 5, and chemical analyses of water from selected wells are given in table 7.

Alluvium consisting mostly of sand and gravel along the course of the San Juan River yields relatively large quantities of water to wells--66 to 250 gal/min (4.2 to 15.8 l/s). The river is the source of water in these deposits; water levels in these wells are directly related to river stage. Records of selected wells in the alluvium are given in table 6; nearly all are industrial-supply wells yielding water of good chemical quality.

The chemical quality of the water in the alluvium is directly related to the chemical quality of the river water, and the chemical quality of the river water is directly related to its discharge. The relation of concentration of dissolved solids to water discharge, San Juan River at Shiprock, N. Mex., is shown in figure 4, and the concentration of dissolved solids and water discharge for the 1969 water year, when mean discharge was 2,118 ft^3/s (59.98 m^3/s), are shown in figure 5. The discharge of the San Juan River and the chemical quality of its water in the Montezuma Creek-Aneth area may be approximated by use of data obtained at Shiprock, N. Mex.

WATER REQUIREMENTS

Municipal water requirements for the area are not known but can be estimated from the average per-capita use of water for rural public supplies in 1970 (Murray and Reeves, 1972, p. 4)--about 63 gallons (238 1) per day. Assuming an annual increase of 5 percent, estimated per-capita use in 1975 should be about 80 gallons (303 1) per day.

POTENTIAL WELL SITES

Specific sites for drilling wells are not described, but the following generalized information may be applied in selecting well-site locations.

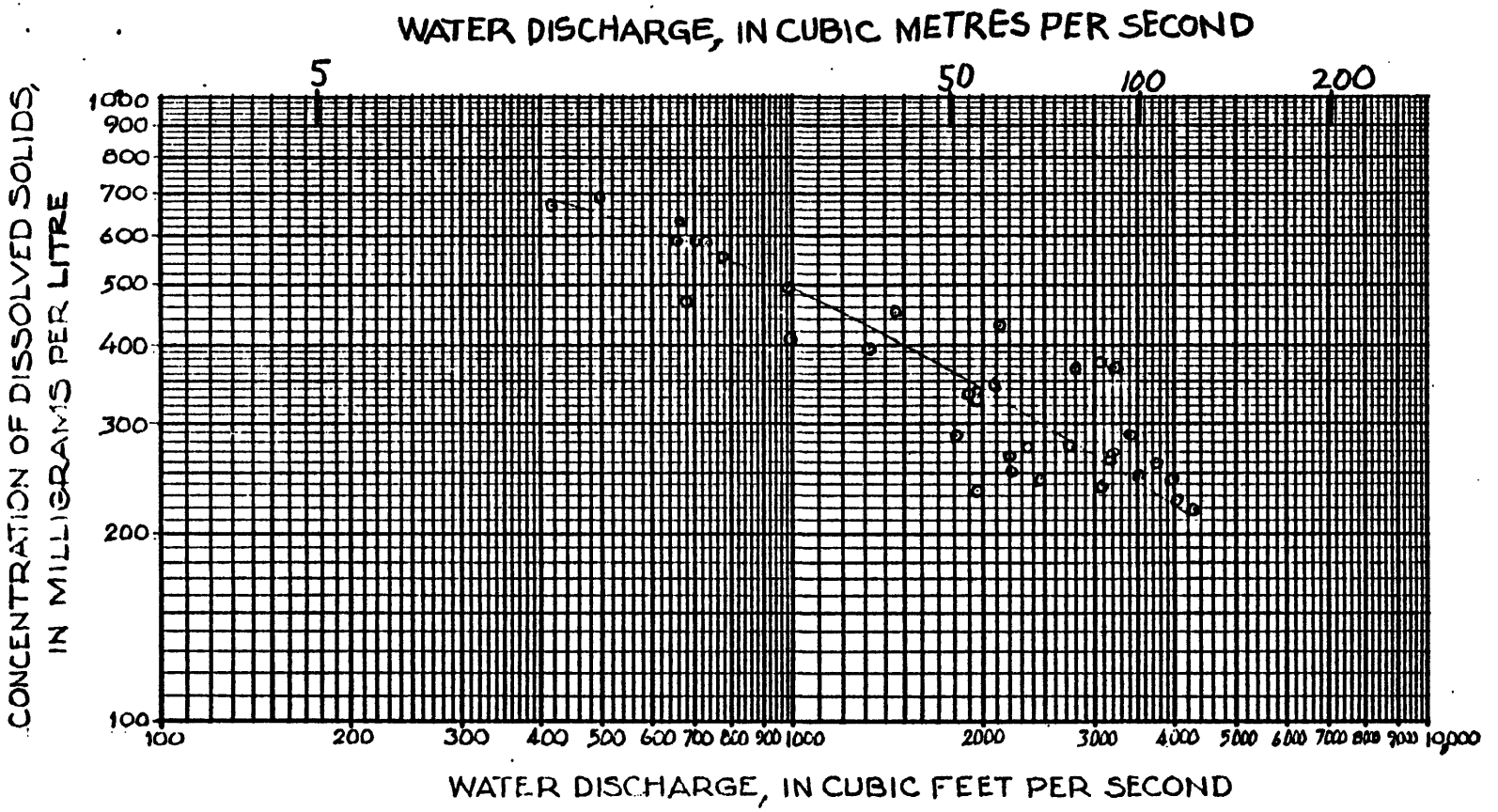

Figure 4. Relation of concentration of dissolved solids to water discharge, San Juan River at Shiprock, N. Mex. Curve is based on monthly average discharges and monthly weighted-average concentrations for water years 1966 and 1969-70.

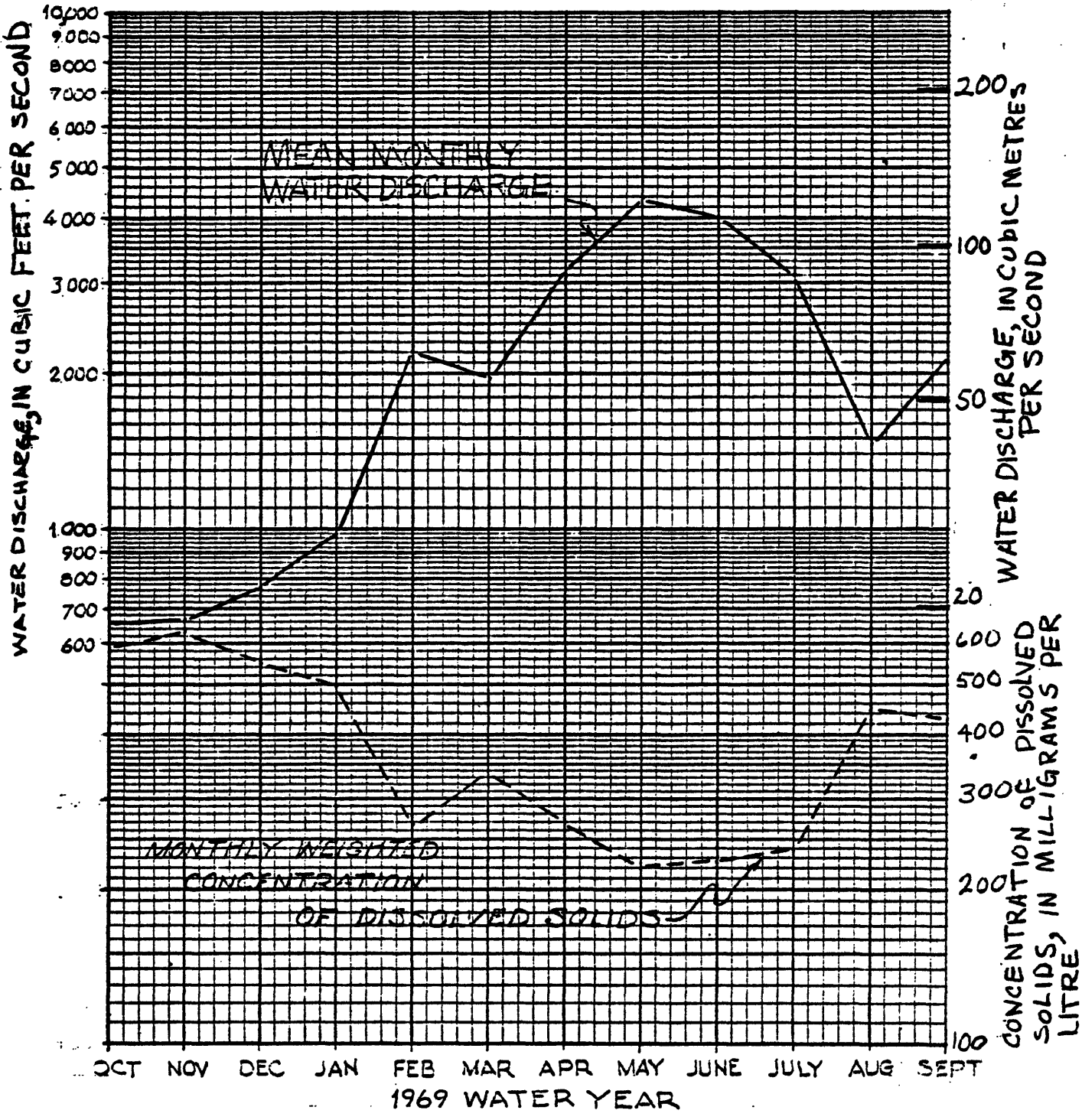

Figure 5. Concentration of dissolved solids and water discharge, San Juan River at Shiprock, N. Mex., 1969 water year.

Water supplies sufficient for domestic use or for livestock may be obtained from wells in the Morrison Formation and the Bluff Sandstone or from the alluvium along the San Juan River. Wells in the consolidated formations need not be drilled deeper than the base of the Bluff, as the underlying Summerville Formation is not reported to yield water to wells, and the deeper formations yield saline water or brine (tables 3 and 5). Throughout the Montezuma Creek-Aneth area, the base of the Bluff is at an altitude of about 4,200 feet (1,280 m). Water in the Morrison and the Bluff is under artesian pressure, and some of the wells are reported to flow (table 3). Drillers' logs of wells that penetrated the Morrison, Bluff, and deeper formations are given in table 6.

Wells drilled in the alluvium along the San Juan River commonly are on artificially raised areas or dikes about 5 feet (1.5 m) higher than the alluvial surface to insure that the well head and pump motor will not be inundated by floods. These wells range in depth from about 20 to 60 feet (6-18 m) (table 4), and similar shallow wells in alluvium should yield water in sufficient quantities for the near-future requirements of existing communities in the area. Water from these wells may need to be chlorinated for municipal use. Treatment of the water may be necessary, particularly during periods of low discharge of the river (figs. 4 and 5), to reduce hardness or the amount of dissolved solids. If fine sediment is present in the well water, it could be removed by a sand filter or other filtering system. The extent of alluvium in the Montezuma Creek - Aneth area is shown in figure 3, with locations of selected wells. Drillers' logs of selected wells in alluvium are given in table 7.

FUTURE INVESTIGATIONS

A detailed hydrologic study of the entire Blanding Basin would provide water users and planners with more precise information about the extent of aquifers, the quantitative characteristics of the aquifers, and the delineation of chemical types of ground water. Such a study might reveal hydrologic changes that have occurred or that may be taking place as a result of past development and would serve as a guide in planning future optimum development of ground water throughout the area.

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Table 3.--Records of selected wells in consolidated formations

Altitude: Above mean sea level as interpolated from topographic maps.
Well yield: b, bailed; f, artesian flow; p, pumped.
Use: D, domestic; N, industrial; P, public supply; U, unused.
Other data available: C, chemical analysis in table 5; D, driller's log in table 6.

Location	Owner or name	Year drilled	Altitude (feet)	Depth of well (feet)	Casing diameter (inches)	Water level: Feet above or below(-) land surface	Water level: Date of measurement	Geologic source	Well yield: Rate (gal/min)	Well yield: Drawdown: Feet	Well yield: Drawdown: Hours	Use	Other data available
(D-40-23)36aab-1	L. Wheeler	1962	4,420	267	7	10	12-15-62	Bluff Sandstone	1f	-	-	U	D
36abb-1	A. B. Smith	1959	4,420	415	8	Flows	4-13-59	Bluff and Entrada Sandstones	25f	-	-	U	C,D
(D-40-24)31cdb-1	El Paso Natural Gas Co.	1958	4,580	410	16	-	-	Entrada Sandstone	35p	-	-	N	D
31daa-1	do	1958	4,440	350	20	-	-	Bluff and Entrada Sandstones	46b	-	-	N	D
32ccd-1	C. E. Clagston	1967	4,450	260	6	-17.5	11-26-67	Bluff Sandstone	10b	202	1	D,P	C,D
32cdd-1	U.S. Bureau of Indian Affairs, Montezuma Creek School	1968	4,450	-	6	-	-	do	-	-	-	P	C
(D-41-23)12cbd-1	Shell Oil Co.	1956	4,580	612	7	Flows	12- 2-56	Navajo Sandstone	31.5f	-	-	N	C,D
(D-41-24)6bab-1	El Paso Natural Gas Co.	1958	4,620	406	16	Flows	8- 8-58	Entrada Sandstone	30-40f	-	-	N	D
6bba-1	do	1958	4,600	425	16	-	-	do	32p	-	-	N	D
6bba-2	do	1958	4,620	413	16	-	-	Bluff and Entrada Sandstones	35p	-	-	N	D
7bcc-1	Superior Oil Co.	1959	4,690	521	9	-70	3-17-59	do	18p	-	-	N	D
(D-41-25)5adc-1	do	1958	4,640	1,122	11	173	4- 7-58	Navajo and Wingate Sandstones	-	-	-	N	C
16ccc-1	U.S. Bureau of Indian Affairs, Aneth	1942	4,520	1,163	12	Flows	3-10-55	Entrada, Navajo, and Wingate Sandstones	100f	-	-	U	C
16ccc-2	C. R. Petty	1970	4,520	-	-	-	-	Morrison Formation and Bluff Sandstone	10p	-	-	D	C
17cbd-1	Superior Oil Co.	1964	4,462	717	13	180	6-15-64	Navajo Sandstone	157p	318	12	N	C,D
17cda-1	do	1964	4,472	1,050	9	130	3- 9-64	Navajo and Wingate Sandstones	125p	318	12	N	C,D

Table 4.--Records of selected wells in alluvium

[Drillers' logs in table 7]

Location	Owner	Year drilled	Depth of well (feet)	Casing diameter (inches)	Well screen			Water level		Well yield			Depth to pump or bowls (feet)
					Diameter (inches)	Slot size (thousandths of an inch)	Length (feet)	Feet below land surface	Date of measurement	Rate (gal/min)	Drawdown Feet	Drawdown Hours	
(D-40-24) 31bca-1	Texaco Inc.	1963	23	13	10	100	12	.5	2-20-63	92	14	96	-
31bcb-1	do	1962	20	13	12	100	9	5	1-12-62	200	5	72	20
31bdc-1	do	1963	23	13	10	100	10	5	2-22-62	94	15	24	-
31caa-1	do	1961	22	13	12	80	11	5	12-16-61	200	5	72	22
31dbc-1	do	1963	20	13	10	100	11	5	3- 9-63	106	18	32	-
31dbd-1	do	1963	25	13	10	100	11	5	3-12-63	145	20	32	-
31dbd-2	do	1961	33	13	12	100	10	5	11- 3-61	200	5	72	24
(D-41-24) 4aca-1	Phillips Petroleum Co.	1964	25	10	8	100	5	4.6	4-18-64	74	10.5	20	-
4bac-1	do	1963	24	10	8	100	10	8	2- 3-63	195	20.5	24	-
4bac-2	do	1963	24	10	8	100	10	9	2- 8-63	195	17.5	21	-
4bbd-1	do	1963	24	10	10	100	8	8.5	2-10-63	151	20	88	-
5aac-1	do	1961	24	10	10	100	10	5	12- 2-61	180	20	48	-
5aad-1	do	1961	26	17	10	100	9	5	11-23-61	180	20	48	26
13aab-1	Continental Oil Co.	1964	32	12	10	80	10	11	5- 7-64	66	3.8	4	-
13aba-1	do	1964	32	12	10	80	9	11	5- 9-64	66	4	4	-
(D-41-25) 17cba-1	Superior Oil Co.	1961	29	12	12	80	8	5.3	10- 3-61	250	23.6	48	24
17cdb-1	do	1963	61	12	12	100	10	14.7	11- 6-63	75	4	4	29
1/27bcd-1	U.S. Bureau of Indian Affairs, Aneth School	1964	35	12	12	60	10	4	4-20-64	125	8.5	24	-

1/ Chemical analysis in table 5.

Table 5.--Chemical analyses of water from selected wells

Sodium and potassium: Where no value is given for potassium, sodium plus potassium values are reported as sodium.
Analysis by: DH, Utah State Department of Health; GS, U.S. Geological Survey; PH, Palmer Hydrology Co.; SO, Shell Oil Co.

Location	Date of collection	Temperature (°C)	Milligrams per litre: Dissolved silica (SiO_2)	Dissolved iron (Fe)	Dissolved calcium (Ca)	Dissolved magnesium (Mg)	Dissolved sodium (Na)	Dissolved potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Dissolved sulfate (SO_4)	Dissolved chloride (Cl)	Dissolved fluoride (F)	Dissolved nitrate (NO_3)	Dissolved boron (B)	Hardness as $CaCO_3$ (Ca, Mg)	Noncarbonate hardness as $CaCO_3$	Dissolved solids: Residue at 180°C	Dissolved solids: Sum of determined constituents	Specific conductance (micromhos/cm at 25°C)	Sodium-adsorption ratio	pH	Analysis by
(D-40-23)36abb-1	4-29-59	-	11	-	225	136	2,220		626	0	2,330	2,120	0.3	18	1.1	102	608	-	7,370[1]	10,400	29	7.6	GS
(D-40-24)32ccd-1	7- 2-68	-	9.0	0.30	9.0	5.0	220	10	525	2.9	55	30	.76	.10	.30	44	-	610	-	1,025	52	8.0	DH
32cdd-1	5-27-68	-	8.0	.10	8.0	5.0	216	11	520	5.7	58	25	.70	.00	.27	42	-	586	-	1,095	15	8.3	DH
(D-41-23)12cbd-1	12- 2-56	13.0	-	.00	80	56	2,150	-	649	-	2,560	1,380	-	-	-	-	-	6,872	-	-	45	6.0	SO
(D-41-25)5adc-1	4- 9-58	-	-	-	30	5.8	1,170	-	1,360	0	680	586	-	-	-	99	-	-	3,840	-	51	7.8	PH
16ccc-1	3-10-55	18.0	10	.01	105	74	2,950	28	683	0	1,650	3,500	.1	2.5	-	568	10	-	8,670[2]	12,000	53	7.9	GS
16ccc-2	5-27-70	-	8	.36	6	4	675	6	815	11.3	627	71	3.90	.4	.46	22	-	1,796	-	2,525	52	8.4	DH
17cbd-1	10-12-64	-	10	-	85	41	2,520		548	0	1,360	2,820	.3	.2	-	380	0	-	7,100[1]	11,100	56	7.9	GS
17cda-1	10-12-64	-	9.7	-	112	41	2,560		596	0	1,280	2,970	.4	.2	-	450	0	-	7,270[1]	11,500	52	7.8	GS
27bcd-1	3- 3-64	-	-	.01	34	10	272	-	284	2.48	733	104	.88	-	-	125	-	1,504	-	2,05[illegible]		8.2	DH

[1]Conversion to milligrams per litre by using density of 1.003.
[2]Conversion to milligrams per litre by using density of 1.004.

Table 6.--Drillers' logs of selected wells in consolidated formations

Altitudes are in feet above mean sea level at the well.
Thickness, in feet.
Depth, in feet below land surface
Geologic designations by C. T. Sumsion except where noted.

Material	Thickness	Depth
(D-40-23)36aab-1. Log by L. R. French.		
Alt. 4,420 ft.		
Silt, sand, and gravel	20	20
Shale, red, with lime ribs	210	230
Sand, white; water	30	1/260
Shale, red	7	267
(D-40-23)36abb-1. Log by H. J. Butler.		
Alt. 4,420 ft.		
Topsoil	8	8
Sandrock, red	4	12
Shale, red, with hard ribs	38	50
Sandstone, red	7	57
Shale, red, with hard ribs	53	110
Sandstone, red; little water	110	1/220
Shale, red, with hard ribs	55	275
Sandstone, red	23	298
Shale, red, with hard ribs	62	360
Sandstone, red; water	30	2/390
Shale, red	25	415
(D-40-24)31cdb-1. Log by Branch Drilling Co.		
Alt. 4,580 ft.		
Gravel and sand	30	30
Shale and sand	235	265
Shale	80	345
Sand; water	65	2/410
(D-40-24)31daa-1. Log by Branch Drilling Co.		
Alt. 4,440 ft.		
Boulders	20	20
Sand and shale	80	100
Sand and gravel	75	175
Sand	90	265
Shale	5	270
Sand	50	320
Sand and shale	30	350
Water-bearing strata:	5	1/185
	45	1/265
	50	2/320

Table 6.--Drillers' logs of selected wells in consolidated formations--Continued

Material	Thickness	Depth
(D-40-24)32ccd-1. Log by H. J. Butler. Alt. 4,450 ft.		
Sand	3	3
River gravel	9	12
Shale, red	68	80
Sandrock, red	50	130
Sandrock, red; 1 gal/min of water	25	1/155
Sandrock, light; water to 10 gal/min	105	1/260
(D-41-23)12cbd-1. Log and geologic units in log by C. E. Harmon. Alt. 4,580 ft.		
Morrison Formation on surface, soft red shale	19	19
Bluff Sandstone, medium-hard, gray-to-red sand and shale	395	414
Summerville Formation, hard, red shale with sand streaks	25	439
Entrada Sandstone, soft, light-red sand	70	509
Carmel Formation, hard, red, sandy shale	65	3/574
Navajo Sandstone, very soft, gray sand; water	38	612
(D-41-24)6bab-1. Log by Branch Drilling Co. Alt. 4,620 ft.		
Sand and shale	360	360
Sand; water bearing	45	2/405
Shale	1	406
(D-41-24)6bba-1. Log by Branch Drilling Co. Alt. 4,600 ft.		
Gravel and sand	50	50
Shale, sandy	140	190
Shale	30	220
Sand, hard	130	350
Sand; water	48	2/398
Shale, red	27	425
(D-41-24)6bba-2. Log by Branch Drilling Co. Alt. 4,620 ft.		
Gravel and sand	80	80
Shale	60	140
Sand	100	240
Shale	65	305
Shale, sandy	13	318
Sand; water	22	1/340
Shale, sandy	32	372
Sand; water	36	2/408
Shale	5	413

Table 6.--Drillers' logs of selected wells in consolidated formations--Continued

Material	Thickness	Depth
(D-41-24)7bcc-1. Log by R. B. Newman.		
Alt. 4,690 ft.		
Surface sand.	20	20
Sand and shale.	334	354
Sand; water	6	1/360
Sand and shale.	85	445
Sand; water	5	1/450
Sand and shale.	62	512
Sand; water	9	2/521
(D-41-25)17cbd-1. Log by L. Ancell.		
Alt. 4,462 ft.		
Sand and gravel	31	31
Hardpan	83	114
Sand and hardpan.	96	210
Hardpan	20	230
Sand.	26	256
Hardpan	196	452
Sand.	265	4/717
(D-41-25)17cda-1. Log by L. Ancell.		
Alt. 4,472 ft.		
Sand and gravel, alluvial sands	30	30
Hardpan	190	220
Sand, Entrada "Formation"	233	453
Sand, Navajo "Formation".	317	770
Hardpan	155	5/925
Sand, Wingate "Formation"	185	1,110
Hardpan, Chinle "Shale"	90	6/1,200

1/ Within Bluff Sandstone.
2/ Within Entrada Sandstone.
3/ Basal member of Entrada Sandstone; Carmel Formation absent in this area.
4/ Navajo Sandstone; probably not total thickness.
5/ Kayenta Formation.
6/ Depth of completed well 1,050 feet.

Table 7.--Drillers' logs of selected wells in alluvium

Thickness, in feet
Depth, in feet below land surface

Material	Thickness	Depth	Percent of total alluvial material
(D-40-24)31bca-1. Log by E. T. Hoard.			
Sand and gravel	21.5	21.5	100
Bedrock	1.5	23	-
(D-40-24)31bcb-1. Log by E. T. Hoard.			
Cobbles	11	11	55
Sand and gravel	6	17	30
Cobbles	3	20	15
(D-40-24)31bdc-1. Log by E. T. Hoard.			
Sand and gravel	21	21	100
Sandrock, red, hard	2	23	-
(D-40-24)31caa-1. Log by E. T. Hoard.			
Sand and gravel, loose	5	5	23
Gravel, large, loose	12	17	54
Gravel, tight	5	22	23
(D-40-24)31dbc-1. Log by E. T. Hoard.			
Sand and gravel, medium	10	10	50
Sand, medium-coarse	10	20	50
(D-40-24)31dbd-1. Log by E. T. Hoard.			
Sand, soft	8	8	32
Sand, soft, coarse	12	20	48
Sand	5	25	20
(D-40-24)31dbd-2. Log by E. T. Hoard.			
Sand, fine	9	9	37
Sand, coarse, soft	15	24	63
Clay, red, hard	9	33	-
(D-41-24)4aca-1. Log by L. Ancell.			
Sand and gravel	24	24	100
Bedrock	1	25	-

Table 7.--Drillers' logs of selected wells in alluvium
Continued

Material	Thickness	Depth	Percent of total alluvial material
(D-41-24)4bac-1. Log by E. T. Hoard.			
Fill dirt	5	5	21
Boulders, gray	3	8	12
Sand and gravel; red bedrock; water at 8 feet	16	24	67
(D-41-24)4bac-2. Log by E. T. Hoard.			
Fill dirt	5	5	21
Boulders, gray	3	8	12
Sand and gravel; red bedrock	16	24	67
(D-41-24)4bbd-1. Log by E. T. Hoard.			
Sand and gravel	5	5	21
Boulders	3	8	12
Sand and gravel; bedrock; water at 8.5 feet	16	24	67
(D-41-24)5aac-1. Log by E. T. Hoard.			
Silt and gravel	15	15	62
Boulders	5	20	21
Gravel, large	4	24	17
(D-41-24)5aad-1. Log by E. T. Hoard.			
Sand and gravel, loose	15	15	58
Boulders, loose	5	20	19
Gravel, large	6	26	23
(D-41-24)13aab-1. Log by L. Ancell.			
Sand, gravel, and boulders	31	31	100
Bedrock	1	32	-
(D-41-24)13aba-1. Log by L. Ancell.			
Sand, gravel, and boulders	30	30	100
Bedrock	2	32	-
(D-41-25)17cba-1. Log by E. T. Hoard.			
Sand; water at 5.3 feet	7	7	24
Sand and boulders	22	29	76

Table 7.--Drillers' logs of selected wells in alluvium
Continued

Material	Thickness	Depth	Percent of total alluvial material
(D-41-25)17cdb-1. Log by L. Ancell.			
Sand, fine, gray, with small gravel	7	7	23
As above with large boulders.	11	18	35
Sand, gravel, and boulders; water at 14.7 feet	13	31	42
Sandstone; not water bearing.	30	61	-
(D-41-25)27bcd-1. Log by L. R. French.			
Clay and silt; water at 4 feet.	7	7	28
Sand and gravel; water bearing.	18	25	72
Siltstone, red.	10	35	-