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GEOLOGICAL SURVEY

Open-File Report 57-121

POSSIBILITY OF DEVELOPING A GROUND-WATER SUPPLY AT THE CHACO CANYON NATIONAL MONUMENT, SAN JUAN COUNTY, NEW MEXICO

By

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Prepared in cooperation with the
NATIONAL PARK SERVICE

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(Not reviewed for conformance with editorial standards of the Geological Survey)

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INTRODUCTION

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The largest of four tracts that compose the Chaco Canyon National Monument, one of the most important archeological sites in North America, and the monument headquarters, are in T. 21 N., Rs. 10 and 11 W., in southern San Juan County, N. Mex. Hereafter in this report "Chaco Canyon National Monument" will refer to this, the largest tract. The monument headquarters and Pueblo Bonito, the point of principal interest at the monument, are on a graded dirt road about 25 miles south of the Blanco Trading Post on State Highway 44, and about 64 miles north of Thoreau, N. Mex., on U. S. Highway 66 (fig. 1).

Mr. Charles Sharp, Superintendent of the Chaco Canyon National Monument, reported that the number of visitors to the monument has increased significantly in recent years. Construction of a paved road from State Highway 44 to the monument, and a visitor center and improvement of the camping area, are planned. More visitors will be attracted to the monument. A new headquarters building has been proposed for construction near the residences (pl. 1). Consequently, the water requirement is expected to exceed 10,000 gallons per day in the near future, according to Mr. Kell of the National Park Service.

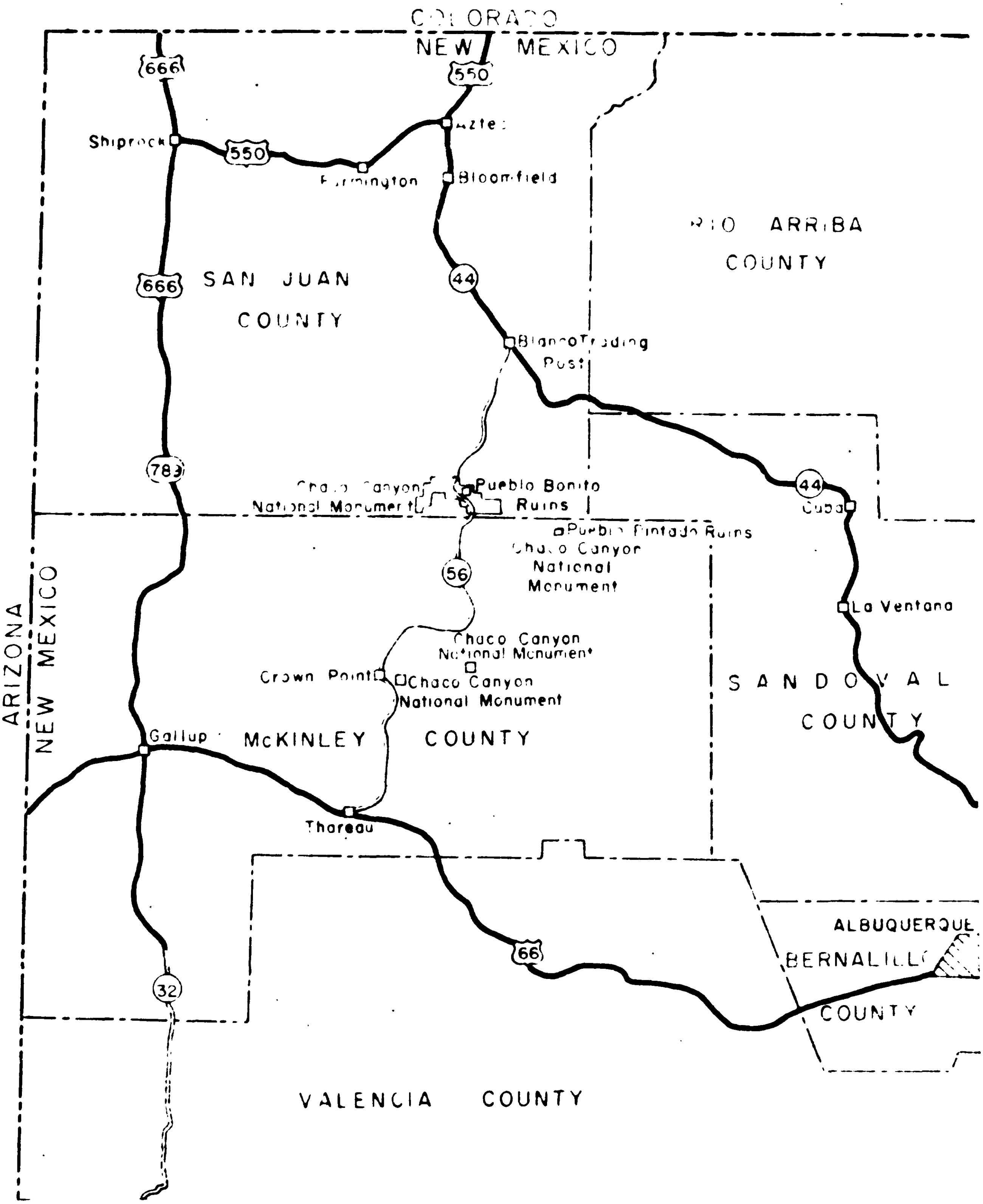

Figure 1.--Index map of northwest New Mexico showing the location of Chaco Canyon National Monument.

The water supply for the monument is obtained from three shallow dug wells (15 to 20 feet deep), which are on low benches in the Chaco River channel and are 1 to 3 miles from the proposed monument headquarters and visitor center. The average yield of the wells is less than 5 gpm and the wells are susceptible to filling with floodwater. Water is pumped from the wells with small-capacity lift pumps powered with gasoline motors which are in pits beside the wells. Two of the wells supply water to the nearby monument headquarters and to two residences. The third well serves two residences near the proposed headquarters site. A pipeline about a mile long transmits water from this well to a storage tank above the residences. The lift from the well to the storage tank is about 150 feet.

Previous Investigations

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A ground-water study at the Chaco Canyon National Monument was made by Ross A. Maxwell, Regional Geologist, National Park Service, and a report was submitted to the Park Service in September 1940. This work was supplemented by additional field work by Mr. Maxwell and [illegible] Rothrock, Assistant Chief, Naturalist Division, National Park Service. A joint report containing many basic data on wells and recommending development of wells in sandstones of Cretaceous age, which underlie the area, was submitted by Rothrock and Maxwell to the Park Service in 1942. A large area east, south, and west of the Chaco Canyon National Monument was mapped by the U. S. Geological Survey (Bauer and Reeside, 1921; Sears, 1934; Dane, 1936; Hunt, 1936; Beaumont and O'Sullivan, 1955; O'Sullivan, 1955) as a part of investigations of fuel resources in the San Juan Basin. Water-supply investigations of some localities near the Monument were made by L. C. Halpenny, J. W. Harshbarger, and others of the U. S. Geological Survey, in cooperation with the Bureau of Indian Affairs, as a part of the ground-water investigation of the Navajo Indian lands. Reports on those investigations have not been published.

The fourth segment of the number, which consists of three digits, denotes the particular 10-acre tract in which the well is situated. For this purpose, the section is divided into four quarters, numbered 1, 2, 3, and 4 in the normal reading order, for the northwest, northeast, southwest, and southeast quarters, respectively. The first digit of the fourth segment gives the quarter section, which is a tract of 160 acres. Similarly, the quarter section is divided into four 40-acre tracts numbered in the same manner, and the second digit denotes the 40-acre tract. Finally, the 40-acre tract is divided into four 10-acre tracts, and the third digit denotes the 10-acre tract. Thus, well 21.11.12.344 in San Juan County is in the SE¼SE¼SW¼ sec. 12, T. 21 N., R. 11 W. If a well cannot be located accurately within a 10-acre tract, a zero is used as the third digit, and if it cannot be located accurately within a 40-acre tract, zeros are used for both the second and third digits. If the well cannot be located more closely than the section, the fourth segment of the well number is omitted. Letters a, b, c, ... are added to the last segment to designate the second, third, fourth and succeeding wells recorded in the same 10-acre tract (see fig. 2).

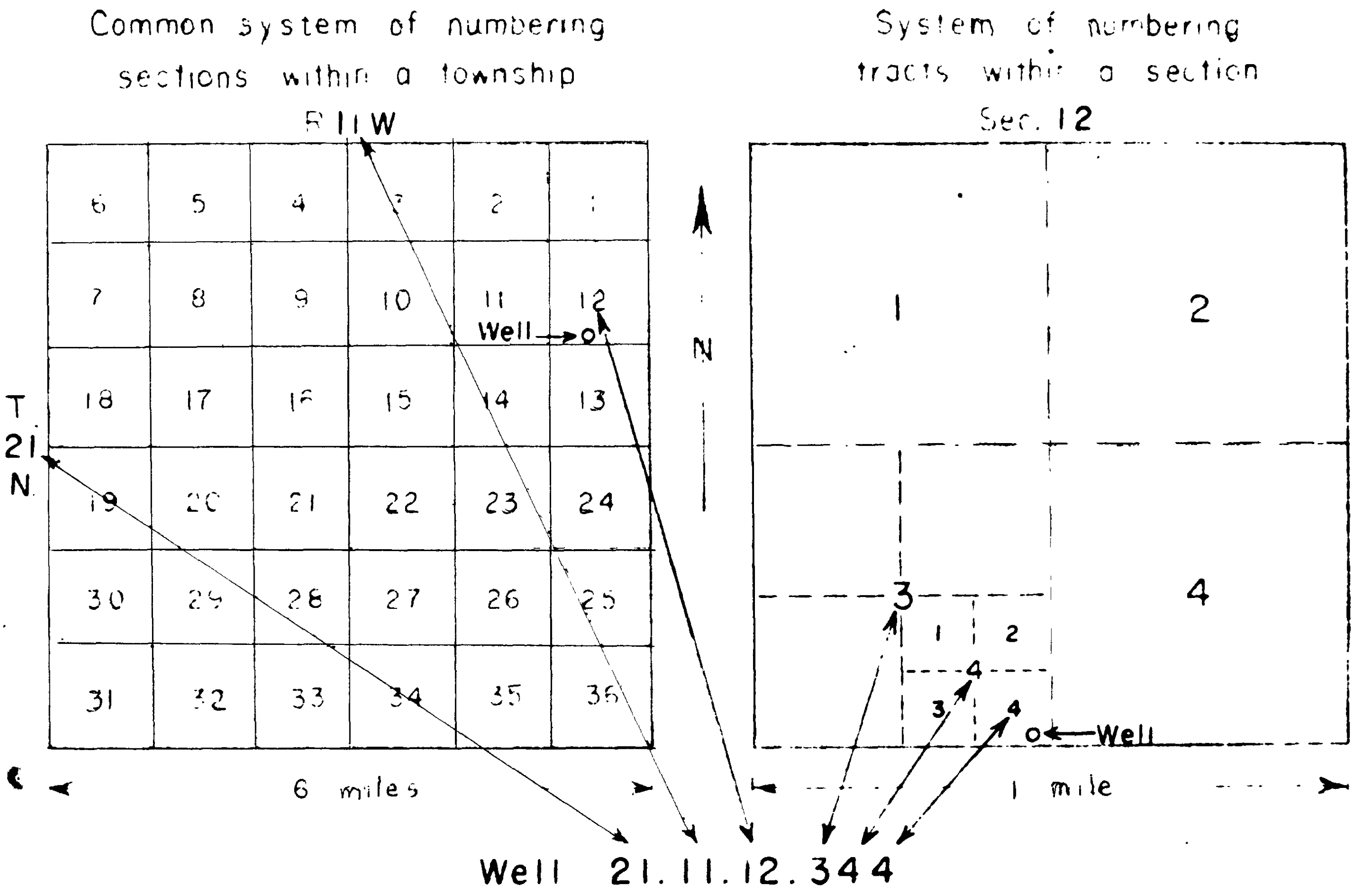

Figure 2. -- System of numbering wells in New Mexico

TOPOGRAPHY AND DRAINAGE

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The Chaco Canyon National Monument is in a region characterized by mesas whose surfaces slope gently to the north. The mesas are separated by a network of intermittent streams. In the past the principal streams eroded deep canyons in the sandstone and shale bedrock. Later, the canyons were partly filled with alluvial silt, clay, sand, and gravel. The courses of the streams within the canyons were frequently changed by the erratic deposition of sediments carried by the streams, but nearly level floors were built across the canyons. The floor of Chaco Canyon, in the monument area, lies 300 to 350 feet below the tops of the mesas on either side of the canyon. The walls of the canyon are nearly vertical.

The modern surface drainage of the region is characterized by flash floods, which have eroded deep channels in the flood-plain deposits. The channel of the Chaco River (commonly termed Chaco wash) in the monument area is 20 to 30 feet deep. The Chaco River heads at the Continental Divide, about 25 to 30 miles southeast of the monument, and flows generally to the northwest.

GEOLOGIC FORMATIONS AND THEIR WATER-BEARING PROPERTIES

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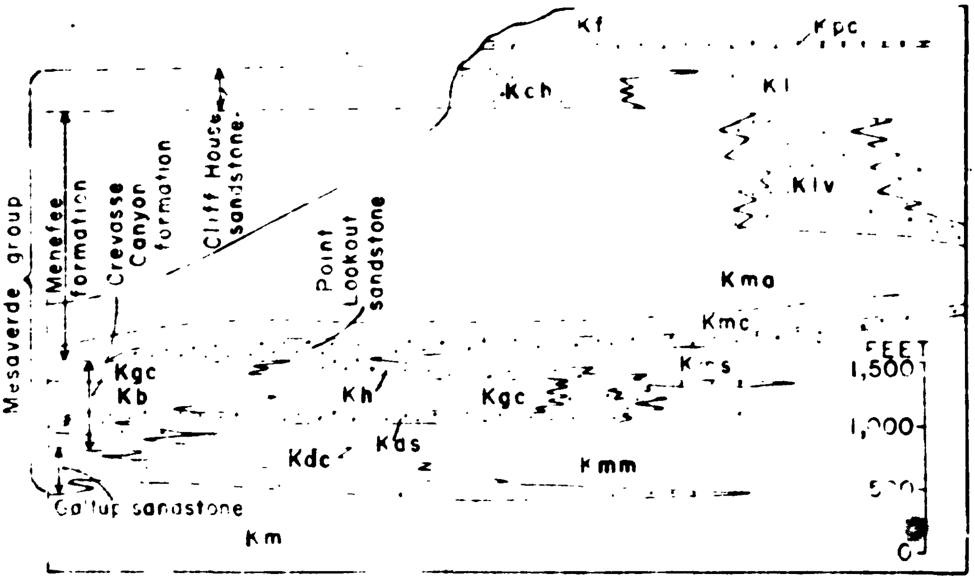
The geologic formations in the area of the monument pertinent to the occurrence of ground water are the Quaternary alluvium of the valleys and the underlying rocks of Cretaceous age. The Cretaceous rocks in the Chaco Canyon area consist predominately of siltstone, but with alternating layers of sandstone, claystone, and coal that dip to the north at a rate of about 100 feet per mile. Of the Cretaceous rocks the sandstones are the potential aquifers. Unconsolidated alluvial deposits of clay, silt, sand, and gravel of Quaternary age occur to a minimum depth of at least 10 feet, and perhaps considerably more, below the floor of Chaco Canyon. These deposits are the present source of water for the monument. The generalized stratigraphic section in the Chaco Canyon area is presented in table 1 and the general stratigraphic relations of the rocks of Cretaceous age in the region are shown diagrammatically in figure 3. The formations are described in descending order on the following pages.

Table 1.--Generalized stratigraphic section in the Chaco Canyon area.

Age	Symbol		Stratigraphic unit	Approximate thickness (feet)
Quaternary	Qal		Alluvium	0 - 40+
Late Cretaceous	Koa		Ojo Alamo sandstone	65 - 130
	Kk		Kirtland shale	500
	Kf		Fruitland formation	180
	Kpc		Pictured Cliffs sandstone	50 - 70
	Kl		Lewis shale	75 - 140
	Kch	Mesaverde group	Cliff House sandstone, upper part	350
	Kmf		Menefee formation	1,300
	Kpl		Point Lookout sandstone	115
	Kms		Satan tongue of Mancos shale (not a part of the Mesaverde group)	85
	Kh		Hosta tongue of Point Lookout sandstone	125
	Kcc		Crevasse Canyon formation:	
	Kgc		Gibson coal member	300
	Kds		Dalton sandstone member	125
	Kmm		Mulatto tongue of Mancos shale (not a part of the Mesaverde group)	450
	Kgs		Gallup sandstone	125
	Km		Mancos shale, lower part	650
Early(?) and Late Cretaceous	Kd		Dakota sandstone	150



(After Beaumont, Dane, and Sears, 1956)

Fig. 3.--Diagrammatic section showing stratigraphic relations of Mesaverde group and its five formations between Gallup and La Ventana, New Mexico. Members of formations and associated beds: Kf--Fruitland formation and younger beds; Kpc--Pictured Cliffs sandstone; Kl--Lewis shale; Kch--Cliff House sandstone with La Ventana tongue (Klv); Kma and Kmc--Allison member and Cleary coal member of Menefee formation; Kh--Hosta tongue of Point Lookout sandstone; Kgc, Kb, Kds, and Kdc--Gibson coal member, Bartlett barren member, Dalton sandstone member, and Dilco coal member of the Crevasse Canyon formation; Km--Mancos shale with Satan (Kms) and Mulatto (Kmm) tongues. Section is not drawn to horizontal scale.

Wells at the monument were dug 15 to 20 feet deep in the alluvium, but to depths of only 4 to 5 feet into the zone of saturation, because of quicksand. The yield of a well that only partly penetrates a water-bearing zone does not accurately represent the potential yield of a well that fully penetrates the same zone. The potential continuous yield of the partially penetrating dug wells at the monument is estimated to be 2 to 6 gpm. Higher pumping rates are temporarily obtained by withdrawing water from storage in the wells.

A well drilled about 60 feet into the alluvium of Kinnebito Wash, which is similar to and a short distance to the north of Chaco Wash, reportedly produced 40 gallons of water per minute.

Upper Cretaceous Rocks

The Ojo Alamo sandstone, the Kirtland shale, and the Fruitland formation are not present in the Chaco Canyon National Monument, but the Ojo Alamo sandstone is an important aquifer a few miles to the north. The Kirtland shale and Fruitland formation crop out just north of the monument, but they consist chiefly of claystone, which ordinarily does not carry water in usable quantities.

The Pictured Cliffs sandstone, the youngest of the Upper Cretaceous formations in the Chaco Canyon National Monument, crops out in a discontinuous ridge along the crest of the mesa in the northern part of the monument area. This formation is above the water table.

The Lewis shale crops out on the north slope of the mesa in the northern part of the monument. This formation is relatively impervious and largely or entirely above the water table in the monument.

Between the Lewis shale and the Mancos shale is a thick accumulation of sandstone, siltstone, claystone, and coal beds, collectively termed the Mesaverde group (Beaumont, Dane, and Sears, 1956). The Mesaverde group is divided into five formations; in descending order they are the Cliff House sandstone, the Menefee formation, the Point Lookout sandstone, the Crevasse Canyon formation, and the Gallup sandstone. The Satan and Mulatto tongues of the Mancos shale are thick wedges of claystone that interfinger with the Mesaverde group.

The Cliff House sandstone (formerly termed the Chacra sandstone) caps the mesas on both sides of Chaco Canyon for a distance of several miles. The formation is a buff to reddish-brown sandstone containing a few thin beds of gray shale. The lower part of the formation is a massive sandstone which forms prominent cliffs 40 to 50 feet high along the canyon walls. The overlying sandstone units of the Cliff House form a series of step-like ledges back from the principal cliff. The Cliff House sandstone crops out in a large area and apparently receives appreciable recharge from precipitation. South of Chaco Canyon, where the formation has been dissected by erosion, water in the formation is dissipated through innumerable small seeps. North of Chaco Canyon the Cliff House sandstone dips beneath the Lewis shale. Recharge to the sandstone north of the canyon moves downdip to the north and is confined in the Cliff House sandstone by the Lewis shale. As the Cliff House sandstone south of Chaco Canyon is drained and as the area of outcrop to the north of the canyon is small and cut by canyons, wells probably cannot be developed in the Cliff House sandstone less than 3 to 4 miles north of the proposed monument headquarters.

The type and character of native vegetation in some of the tributary canyons on the north side of the Chaco River indicate that a considerable amount of water is transmitted from the Cliff House sandstone to the alluvium in the tributary canyons and, thence, to the alluvium in Chaco Canyon. The Cliff House sandstone is an important aquifer north of the monument, but it is not an aquifer in the proposed monument headquarters area.

The Menefee formation includes the Allison member and the Cleary coal member (formerly the upper part of the Gibson coal member of the Mesaverde formation) (Beaumont, Dane, and Sears, 1956). Both members of the Menefee formation are predominantly claystone or shale containing some beds of coal and sandstone. The total thickness of the Menefee formation in the Chaco Canyon area is about 1,500 feet. The sandstones are white to light gray and largely fine grained; the bedding is irregular. Individual sandstone units range from about 5 to 30 feet in thickness, and locally are well cemented. The Menefee formation crops out along the base of the canyon walls of the Chaco River, in the southern part of the monument, and in a large area to the south. Essentially all the sandstone units in the Menefee formation are water bearing in the Chaco Canyon area, but owing to the fine-grained texture and thinness of the beds, they generally do not yield more than 5 or 6 gpm of water to wells (see table 2). Yields up to 30 gpm have been obtained from some wells that produce from more than one sandstone unit in the Menefee formation. The quality of water in the Menefee formation generally is poor (see table 3).

The Point Lookout sandstone, formerly termed the upper part of the Hosta sandstone member of the Mesaverde formation in the southern part of the San Juan Basin (Beaumont, Dane, and Sears, 195[illegible]), consists of fine- to medium-grained sandstones and is about [illegible] feet thick. The formation crops out to the south in a narrow belt between the Chaco Canyon National Monument and Crown Point, N. Mex. The Hosta tongue of the Point Lookout sandstone, which is about [illegible] feet thick in the Chaco Canyon area, is separated from the rest of the Point Lookout sandstone by about [illegible] feet of shale—the Satan tongue of the Mancos shale. The Hosta tongue crops out in a narrow east-west belt a short distance north of Crown Point. To the west of Crown Point the Hosta tongue merges with the Point Lookout sandstone and forms a single sandstone unit. Precipitation on the outcrops of the Point Lookout sandstone in part seeps to the water table and moves downdip to the north where it is confined by the overlying shales of the Menefee formation. The depth to the top of the Point Lookout sandstone in the vicinity of the monument is about 1,[illegible] feet. The depth to the top of the Hosta tongue of the Point Lookout sandstone is about 2,[illegible] feet. Information on the amount of water that can be obtained or the quality of water from the Point Lookout sandstone is available for only three wells, all of which are between the outcrop area of the formation and the monument. The formation may be a potential aquifer, but the water is probably unfit for domestic use in the Chaco Canyon area.

The Crevasse Canyon Formation in the Chaco Canyon area includes the Gibson coal member and the Dalton sandstone member. The Gibson coal member is about 300 feet thick in the Chaco Canyon area and is predominantly claystone containing some coal beds. The Dalton sandstone member is about 125 feet thick and consists of fine- to medium-grained sandstones. The Crevasse Canyon Formation crops out in an east-west belt a short distance south of Crown Point. The Gibson coal member is relatively impervious and is not a potential aquifer. The Dalton sandstone member supplies water to several wells south of the monument, but it lies at a depth of about 2,650 to 2,775 feet beneath the land surface at the monument. Water from the Dalton sandstone member is of poor quality in the monument area.

The Mulatto tongue of Mancos shale lies beneath the Dalton sandstone member and consists of about 250 feet of relatively impervious shale. It is not a potential aquifer in the area of this report.

The Gallup sandstone underlies the Mulatto tongue of the Mancos shale and consists of about 125 feet of fine- to coarse-grained sandstone. It crops out in an east-west belt on the north slope of the high ridge between Crown Point and Thoreau, N. Mex. The Gallup sandstone is a source of ground water in the vicinity of Gallup, N. Mex., but it lies at a depth of about 3,025 to 3,150 feet beneath the land surface at the monument. Information on the quality of water in the Gallup sandstone in the vicinity of the monument is not available.

The Mancos shale underlies the Gallup sandstone, and consists of about 250 feet of relatively impervious shale in the Chaco Canyon area (see Fig. 3).

Upper and Lower(?) Cretaceous Rocks

The Dakota sandstone underlies the Mancos shale and is about 150 feet thick. It is fine to coarse grained and is a source of ground water in the vicinity of Gallup and northeastward from Gallup. The depth to the top of the Dakota sandstone at the proposed monument headquarters is about 3,900 feet. Information on the productivity of the Dakota sandstone and on the quality of water in the Dakota sandstone in the monument area is not available.

Rocks older than the Dakota sandstone, which are more than 4,000 feet below the land surface in the Chaco Canyon area, are not described in this report.

QUALITY OF WATER

QUALITY OF WATER

Chemical analyses of samples of water from 17 wells in the vicinity of the monument have been made by the U. S. Geological Survey and the U. S. Soil Conservation Service. The results of the analyses are listed in table 3. Water from University well 2 was the only water that met recommended standards for public water supplies, as adopted by the New Mexico Department of Public Health.

Fluoride in drinking water in concentrations greater than 1.5 ppm is likely to result in permanent mottling of the enamel of teeth if the water is used continually by young children. Smaller concentrations tend to reduce the incidence of tooth decay, particularly in children (Dean and others, 1941). The water from Chaco well 1 exceeded the recommended maximum concentration of fluoride by an insignificant amount. The concentration of fluoride in Chaco well 3 (2.0 ppm) may be sufficiently high to cause minor mottling of the teeth of children who drink the water for a long period of time. Analyses of water from 7 wells that produce from the Cretaceous rocks indicate that the water from 5 of the wells had concentrations of fluoride higher than the recommended maximum limit.

A concentration of sulfate higher than 250 ppm in water, in conjunction with a high concentration of sodium or magnesium, may cause the water to act as a laxative for people who are not accustomed to drinking the water. The laxative effect of the water increases with the concentration of sulfate. The concentration of sulfate in the water from wells in the Chaco Canyon area that produce from Cretaceous rocks ranged between 270 and 1,630 ppm, which is higher than the recommended limit. Water from the alluvium contained 95 to 258 ppm.

The recommended quality-of-water standards for public water supplies adopted by the New Mexico Department of Public Health in 1946 state that "Total solids should not exceed 500 ppm, for a water of good chemical quality. However, if such water is not available, a total solids content of 1,000 ppm may be permitted." The total solids in the water from the present wells at the Chaco Canyon National Monument ranged from 121 to 741 ppm. The concentration of total solids in the water from 7 wells that produce from the Cretaceous rocks in the Chaco Canyon area ranged from 1,030 to 3,210 ppm.

The recommended limit of chloride concentration in drinking water is 250 p.p.m. The concentration of chloride in water from wells that produce from Cretaceous rocks in the Chaco Canyon area ranged from 19 to 305 ppm. Samples of water from two wells contained more than 250 ppm. The concentration of chloride in water from the alluvium ranged from 4 to 12 ppm.

Analyses of ground water in the Chaco Canyon area indicate that the water in the Quaternary alluvium is better chemically than the water from the Cretaceous rocks.

A test well drilled in 1930 near Pueblo Bonito (about 475 feet north of Chaco Wash) reportedly encountered water at a depth of 40 feet, presumably in the alluvium. Casing was driven to a depth of 60 feet in an attempt to case out the shallow water and permit deeper drilling, but the water continued to enter the well because of damage to the casing. The type of rock at the depth of 60 feet was not reported. Drilling was discontinued at a depth of 390 feet. The shallow water reportedly was "bad" (National Park Service records). The chemical analyses of water from Chaco well 1 and University well 2, however, indicate that the report that the shallow water is "bad" is questionable. Water from the alluvium may have become contaminated in the well by coming in contact with the underlying shale and mixing with water from the shale. Also, the reference to "bad" water may have referred to bacterial pollution.

Rothrock and Ross reported that the water from Chaco well 1 was contaminated by bacteria in 1942. Recent tests by the New Mexico Department of Public Health of the water from the monument wells show the water to be bacterially safe for human consumption (National Park Service correspondence file at Chaco Canyon National Monument).

CONCLUSIONS

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In the Chaco Canyon National Monument, ground water in the Quaternary alluvium is the most accessible source of water and is of the best quality. The amount of annual precipitation in northwestern New Mexico has been low for several years, yet the shallow dug wells at the Monument have not failed. The thickness of the alluvium is variable but is more than 40 feet in some places. Where the alluvium is thickest, at least the lower 20 to 30 feet probably is saturated with water. An examination of the alluvial deposits and interpretation of yields of wells in the alluvium indicate that properly screened and developed wells penetrating 20 to 30 feet of saturated alluvium should produce more than [illegible] gpm (more than 3,600 gpd) each. The perennial supply of shallow ground water in the alluvium of Chaco Canyon suggests that the occurrence of water is not limited to the narrow strip of the alluvium lying directly beneath the bed of the wash. The lower part of the alluvium for a distance of at least several hundred feet on each side of Chaco Wash is believed to be saturated.

One or more test holes will be necessary to determine the saturated thickness of the alluvium, and the best location for a production well. Test drilling would be most effective between the proposed headquarters and the North Fork of the Chaco River because of the convenience of having a well near the proposed monument headquarters and residences, and the desirability of keeping floodwater away from proposed wells. Shallow test holes of small diameter are relatively inexpensive. The alluvium is thin or nonexistent at the site of the proposed monument headquarters, but a satisfactory production well probably could be developed about 1,000 to 1,500 feet south of the proposed headquarters, in the northern part of sec. 23, T. 21 N., R. 10 W. More than one production well may be necessary in order to develop an adequate supply and to insure a supply in the event of failure of pumping equipment.

If adequate water cannot be obtained from the alluvium, it will be necessary to drill wells into rocks of Cretaceous age. The sandstone beds in the Menefee formation will yield 6 to 30 gpm of water to individual wells. The depths to the sandstone beds in the Menefee formation in the Chaco Canyon National Monument range from 300 to 1,000 feet. The deepest beds of the Menefee appear to be the most productive. If water is developed from the Menefee, it may be necessary to mix it with water from the alluvium to reduce the concentrations of certain constituents to acceptable values, particularly the sulfate so far as visitors are concerned, and fluoride as far as children living at the monument are concerned.

The chemical quality of water from the Cretaceous rocks in the vicinity of Chaco Canyon is generally poor. The concentrations of sulfate, dissolved solids, and, in some places, fluoride are higher than recommended maximum limits for drinking water.

Development of water from sandstones below those in the Menefee Formation does not seem practicable at this time, owing to the much greater drilling depth and the generally poor quality of water.

(Re-typed for copy clarity. Underlined items are questionable because of poor copy quality.)
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REFERENCES

Bauer, C.H., 1916, Stratigraphy of a part of the Chaco River Valley, U.S. Geological Survey Professional Paper 98

Bauer, C.H., et al, 1921, Coal in the middle and eastern parts of San Juan County, New Mexico: U.S. Geological Survey Bulletin 716-Q

Beaumont, E.C., et al, 1955, Preliminary geologic map of the Kirtland quadrangle, New Mexico: U.S. Geological Survey Coal Investigation Map C-32

Beaumont, E.C., et al, 1956, Revised nomenclature of Mesaverde group in San Juan Basin, New Mexico: American Association of Petroleum Geologists Bulletin, V. 40, no. 9, p.2149-2162

Dane, C.H., 1936, Geology and fuel resources of the southern part of the San Juan Basin, New Mexico, Part 3, the La Vantana-Chaora Mesa coal field: USGS Bulletin 860-C, p. 81-165

Dane, C.H., 1948, Geologic map of part of eastern San Juan Basin, New Mexico: USGS Oil and Gas Investigation map OM-78

Dean, H.T., et al, 1941, Domestic water and dental caries: Public Health Reports, V. 56

Hunt, C.B., 1936, Geology and fuel resources of the southern part of the San Juan Basin, New Mexico, Part 2, the Mount Taylor coal Field: USGS Bulltein 860-B, p. 31-80

Hunt, C.B., et al, 1933, Preliminary map showing geologic structure of the southern part of the San Juan Basin: U.S. Geological Survey

Lohr, E.W., et al, 1954, The industrial utility of public water supplies in the United States, 1952, part 2, States west of the Mississippi River: U.S.G.S. Water Supply Paper 1300

Maxwell, Ross, 1940, A study of the sources of ground water at Chaco Canyon National Monument: National Park Service

O'Sullivan, R.B., 1955, Preliminary geologic map of the Naschitti quadrangle, San Juan and McKinley Counties, New Mexico: USGS Coal Investigation map C-31

Rothrock, H.E., et al, 1942, Report on a water supply for Chaco Canyon National Monument Headquarters: National Park Service

Sears, J.D., 1934, Geology and fuel resources of the southern part of the San Juan Basin, New Mexico, Part 1, The coal field eastward from Gallup toward Mount Taylor: USGS Bulletin 860-A, p. 1-29

Zieglar, D.L., 1955, Preliminary geologic map of the Toadlena quadrangle, San Juan County, New Mexico: USGS Coal Investigation map C-30

(This combines pages 26 and 27 of USGS Open-file report 57-121)

Table 2: Explanation

Location number: See Plate 2

Stratigraphic unit: See Table 1 for explanation of geologic symbols

Use of Water:
D - domestic
P - public supply
S - stock

Remarks: An., chemical analysis given in Table 1

57-121

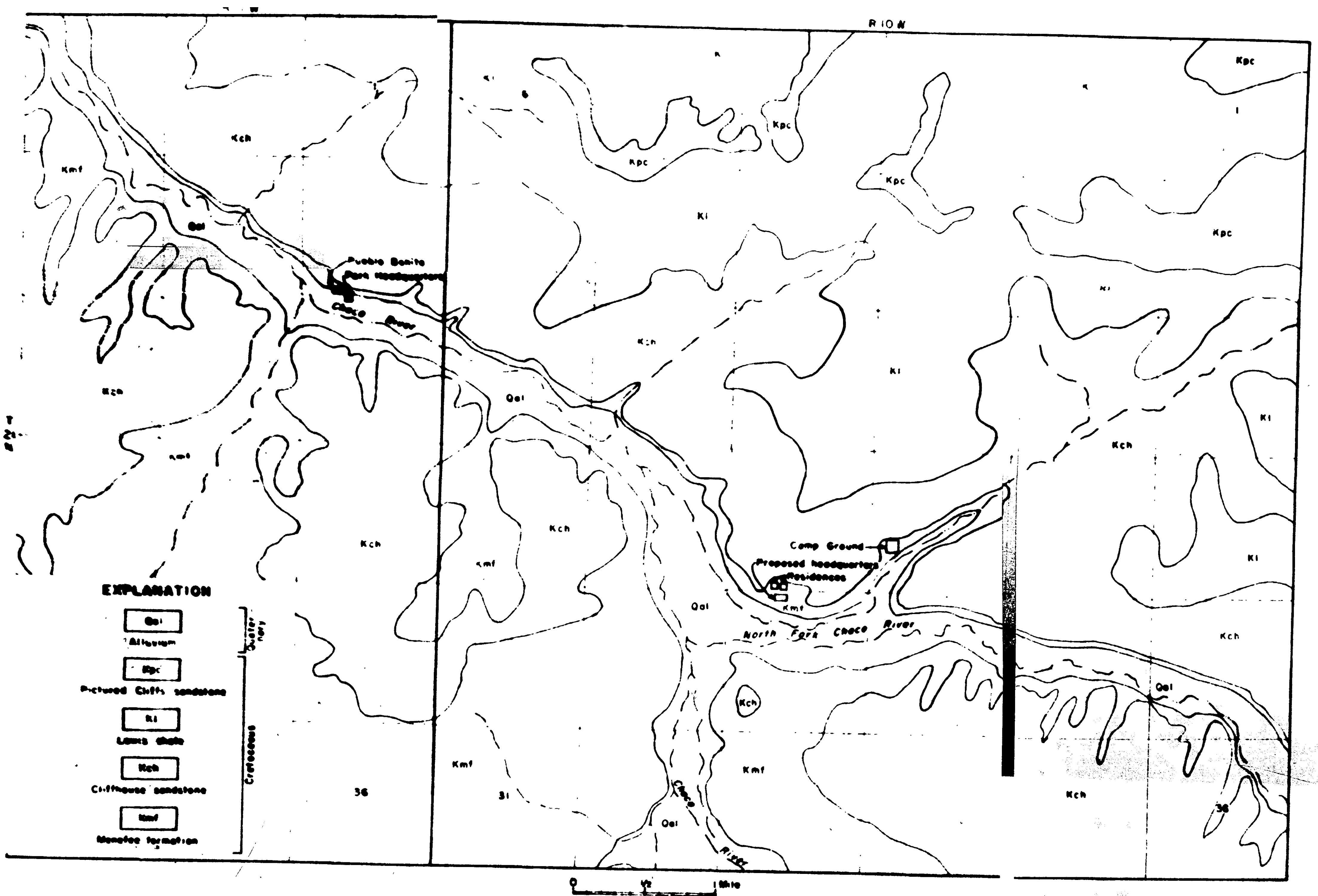
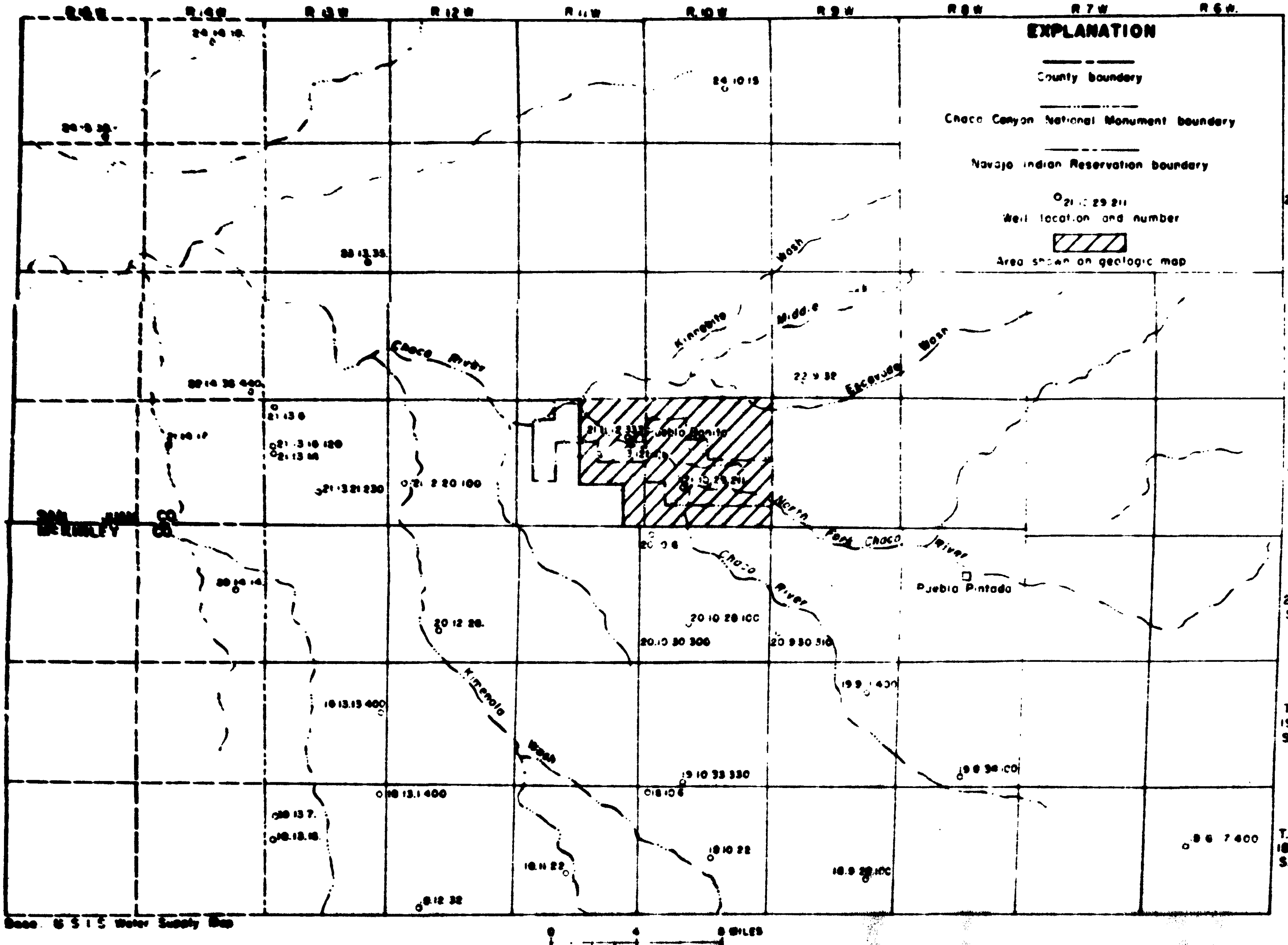


Plate I.—Geologic map of the Chaco Canyon National Monument headquarters area, New Mexico



Base: U S G S Water Supply Map

Plate 2.—Location of selected wells in the vicinity of Chaco Canyon National Monument, New Mexico

Table 3: Chemical analyses of water from wells in the vicinity of Chaco Canyon National Monument, San Juan County, New Mexico (Chemical constituents in parts per million)

THE FOLLOWING TABLE IS NOT READABLE, BUT THIS IS THE ONLY COPY AVAILABLE.

Table 3.--Chemical analyses of water from wells in the vicinity of Chaco Canyon National Monument, San Juan County, N. Mex. (Chemical constituents in parts per million)

Location number	Owner or name	Date collected	Stratigraphic unit a/	Silica (SiO$_2$)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO$_3$)	Carbonate (CO$_3$)	Sulfate (SO$_4$)	Chloride (Cl)	Fluoride (F)	Nitrate (NO$_3$)	Boron (B)	Hardness as CaCO$_3$: Calcium, magnesium	Hardness as CaCO$_3$: Noncarbonate	Dissolved solids: Parts per million	Dissolved solids: Tons per acre-foot	Specific conductance (micromhos at 25°C)	Percent sodium	Sodium adsorption ratio	Temperature (°F)	pH
10.12.32.	[illegible]ece[illegible]ti	[illegible]	Kpl	[illegible].8	-	[illegible]	19	[illegible]		[illegible]	[illegible]	1,[illegible]	[illegible]	.9	0.1	-	[illegible]	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-
1[illegible].12.32.	do.	[illegible]/[illegible]/51	Kds	-	-	-	-	[illegible]		[illegible]	0	575	54	1.1	-	-	[illegible]	0	-	-	1,[illegible]	97	[illegible]	-	-
1[illegible].13.1.400	U. S. Indian Service	[illegible]/[illegible]/49	Kpl	-	-	6.5	1.7	756		605	0	6[illegible]	305	4.[illegible]	[illegible]	-	[illegible]	0	[illegible],970	[illegible]	[illegible],150	99	[illegible]	70	-
19.3.34.100	do.	[illegible]/20/4[illegible]	Kmf	-	-	5.5	[illegible]	[illegible]		646	20	270	43	2.[illegible]	1.[illegible]	-	[illegible]	0	1,[illegible]	1.47	1,[illegible]	98	38	36	-
1[illegible].1[illegible].1[illegible].400	do.	[illegible]	Kpl	11	-	21	7.0	7[illegible]1		451	0	1,[illegible]	[illegible]	1.	.	-	[illegible]5	0	[illegible]	[illegible]	,370	95	37	[illegible]	-
20.9.30.[illegible]10 b/	[illegible] Smith	-	Kmf	-	-	10	2	540		[illegible]	0	2[illegible]	50	-	-	-	-	-	1,[illegible]	-	-	-	-	-	-
20.10.6. b/	Sargent Ranch	1950	Kmf	-	-	1.7	[illegible]	512		51[illegible]	55	460	55	-	-	-	-	-	1,700	-	-	-	-	-	-
20.10.2[illegible].100 b/	[illegible] Smith	-	Kmf	-	-	17	Tr.	569		215	[illegible]	910	34	-	-	-	-	-	,[illegible]	-	-	-	-	-	-
20.10.30.300 b/	Benedum Trees Oil Co.	-	Kds	-	-	10	4	5[illegible]2		21[illegible]	29	920	36	-	-	-	-	-	1,[illegible]90	-	-	-	-	-	-
21.10.29.211	Chaco No. 3	[illegible]/1[illegible]/[illegible]	Kpl	10	0.05	29	10	[illegible]5		3[illegible]	0	[illegible]53	10	[illegible]	[illegible].1	-	114	[illegible]	721	1.00	1,150	31	9.3	62	7.9
21.11.12.[illegible]33 b/	Chaco No. 1	195[illegible]	Qal	-	-	4[illegible]	0	174		2[illegible]	12	210	12	-	-	-	-	-	[illegible]	-	-	-	-	-	-
21.11.12.335 b/	do.	9/1[illegible]/[illegible]	Qal	10	.1[illegible]	24	[illegible]	193		37[illegible]	0	193	[illegible]	1.[illegible]	.2	-	9[illegible]	0	[illegible]5	.[illegible]6	9[illegible]	[illegible]2	[illegible]	31	7.9
21.11.1[illegible].121 b/	University No. 2	do.	Qal	10	.19	35	10	113		296	0	95	7.[illegible]	1.	1.2	-	93	0	[illegible]4	.[illegible]6	665	72	[illegible]	52	7.9
21.13.21.230	U. S. Indian Service	5/ 7/5[illegible]	Kmf	-	-	-	-	-		954	26	-	[illegible]	.	-	-	1	-	-	-	,[illegible]	-	-	-	[illegible].5
24.14.10.	do.	[illegible]/1 /52	Kpc	-	-	-	-	-		-	73	-	[illegible]	-	-	-	-	-	-	-	[illegible],[illegible]	-	-	72	-
24.15.35. c/	do.	[illegible]/15/53	Kpc	-	-	-	-	-		451	24	-	4,150	-	-	-	211	0	-	-	1[illegible],[illegible]	-	-	-	[illegible].2
24.15.35 c/	do.	[illegible]/21/53	Kch	-	-	-	-	-		540	[illegible]	-	535	-	-	-	4[illegible]	0	-	-	[illegible],[illegible]20	-	-	-	[illegible].2
24.15.35	do.	[illegible]/[illegible]	Kch	22	-	5[illegible]	1[illegible]	1,070		391	14	1,[illegible]	274	1.[illegible]	[illegible]	-	1[illegible]0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-

a/ See table 1 for explanation of symbol.
b/ Analysis by U. S. Soil Conservation Service.
c/ Indicates water from different depths, not shown in table 2.