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U. S. GEOLOGICAL SURVEY
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WATER SUPPLY FOR THE HOLE-IN-THE-ROCK, BULLFROG BASIN,
AND CASTLE BUTTE RECREATION SITES IN THE GLEN CANYON
NATIONAL RECREATION AREA, UTAH

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PURPOSE OF REPORT

The National Park Service needs water supplies for the Hole-in-the Rock, Bullfrog Basin, and Castle Butte recreation sites, which are in the Glen Canyon National Recreation Area of Utah (fig. 1), and, consequently,

Figure 1.--Index map of Utah showing physiographic subdivisions and location of the Glen Canyon National Recreation Area.

the Park Service requested that the U.S. Geological Survey evaluate the possible sources of water supply at each site. The author visited the National Recreation Area during June 4-10, 1963, and collected geologic and hydrologic data. Geologic data included lithologic and structural descriptions; hydrologic data included evaluations of the water-bearing properties of the rocks, and of the location, abundance, and size of springs and seeps. Samples of water for chemical analysis were collected from two springs (Nos. 2 and 5, table 1) and a deep well. The fieldwork was complemented by study of pertinent existing data on geology and hydrology. This report is based on all available data.

Many of the chemical analyses included in this report were available prior to the field investigation for the report and none of the sampling points are at the recreation sites. The rocks of the formations in and near the Glen Canyon National Recreation Area, however, are generally homogeneous in mineral content, and ground water in these formations probably does not change significantly in chemical quality.

HOLE-IN-THE-ROCK

Geology

The recreation site at Hole-in-the-Rock (fig. 2) is underlain by the

Figure 2.--Geology and springs sampled in the vicinity of the Hole-in-the-Rock site.

Kayenta Formation of Late Triassic(?) age. About 150 feet of brownish-red, very fine grained, soft sandstone makes up the Kayenta at the site. The Wingate Sandstone of Late Triassic age underlies the Kayenta and is a light red, very fine grained, massive sandstone about 300 feet thick. Lying above the Kayenta and making up the bluffs to the north and west of the recreation site is the Navajo Sandstone of Triassic(?) and Jurassic ages. The Navajo, a light-reddish-tan, fine-grained, massive sandstone, is at least 1,000 feet thick in the vicinity of the recreation site. Jointing is strongly developed in the Wingate and Navajo Sandstones and to a lesser extent in the Kayenta Formation. Planar-bedding and crossbedding are well developed in all formations.

Hydrology

The Wingate and Navajo Sandstones and the Kayenta Formation have a relatively good water-bearing potential. The well-developed jointing and bedding afford many avenues of movement for percolating water. Lichens and other plant life along bedding planes attest to active seepage, although much of the seepage apparently is seasonal. Springs that would be above the high-water mark of Lake Powell were not found in the vicinity of the recreation site. The springs that feed the stream in Llewellyn Gulch originate in the Navajo Sandstone several miles upstream from the recreation site. The discharge of the stream was estimated to be 25 gpm (gallons per minute). The National Park Service reported that the stream apparently dwindles to a "trickle" every fall and that the springs would be covered by the water of Lake Powell. These are the only springs that could be used as a source of water in the vicinity of the recreation site.

Ground water from the Wingate and Kayenta Formations (No. 2 about 45 miles northeast and No. 9 about $1\frac{1}{2}$ miles north of the recreation site; table 1) is satisfactory for public supply except that hardness exceeds 100 ppm (parts per million) and softening may be desirable. The weighted average quality of the water of the Colorado River at Hite (fig. 1) is indicated in table 1 (No. 4) for comparison. Water obtained directly or indirectly from Lake Powell probably will be similar in chemical quality to the weighted average of the river.

Conclusions

The lack of usable springs in the vicinity of the Hole-in-the Rock recreation site leaves two alternatives for obtaining a water supply. A well could be drilled into the Kayenta Formation and the Wingate Sandstone or water could be pumped directly from Lake Powell. If a well is drilled after Lake Powell fills, it probably will yield water that has seeped into the formations from the lake. More than one well may be necessary for an ample supply of water for the recreation site. This cannot be determined, however, until the first well is drilled and tested. Water pumped directly from Lake Powell would be a highly dependable supply, but it might require treatment for suspended sediment and organic content.

BULLFROG BASIN

Geology

The Entrada Sandstone of Late Jurassic age underlies the Bullfrog Basin site (fig. 3). The formation consists of an upper resistant sand-

Figure 3.--Geology in the vicinity of the Bullfrog Basin site.

stone sequence and a lower soft sandstone sequence totaling about 700 feet in thickness. The sandstones are fine grained, crossbedded, and red, orange, and white. Gypsiferous beds may be interbedded with the sandstone beds. Beneath the Entrada is the Carmel Formation of Middle and Late Jurassic age which chiefly comprises about 100 feet of red shaly sandstone interbedded with massive, reddish-brown, fine-grained sandstone. The Carmel may also contain some limestone and gypsiferous beds at the recreation site. The Navajo Sandstone underlies the Carmel and crops out in the Waterpocket Fold (fig. 1), and along Bullfrog Creek and the Colorado River. The sandstone generally is medium grained, white, and strongly crossbedded, and it is about 800 feet thick. The Kayenta Formation underlies the Navajo and the Wingate Sandstone underlies the Kayenta. The Kayenta and Wingate have small areas of outcrop in the Waterpocket Fold and each is about 300 feet thick. They consist of rocks similar to those at the Hole-in-the-Rock site.

Jointing is well developed only in the Navajo Sandstone. The Entrada and Carmel Formations have beds that are loosely cemented and relatively porous. The areal dip is less than 5 degrees to the east or away from the Waterpocket Fold.

Hydrology

Springs in the vicinity of the Bullfrog Basin site have small discharges and flow only in response to local storms or seasonal rains. Many do not yield potable water, probably because the water has seeped through the gypsiferous beds in the Entrada and Carmel Formations.

All the formations from the Entrada down to the Wingate are likely to contain ground water at the recreation site. They are relatively permeable, they have relatively large areas of outcrop, and they crop out in the topographically higher Waterpocket Fold where rainfall probably is greater than at the recreation site. Water that enters the rocks in the Waterpocket Fold percolates eastward toward the recreation site.

Water from a spring (No. 7, table 1) that issues from the Entrada Sandstone about 7 miles north of the recreation site meets the recommendations of the U.S. Public Health Service (1962) for drinking water supplies. The Entrada and the Carmel Formations may contain gypsiferous beds at the recreation site, however, and may yield water that contains considerable dissolved sulfate. Water from a well (No. 1, table 1) tapping the Carmel at Hanksville (fig. 1) contains large amounts of chloride and the treatment necessary to make it potable has been costly. Water obtained from the springs in the Navajo, Kayenta, and Wingate Formations (No. 2 about 33 miles northeast, No. 9 about 21 miles southwest, and No. 10 about 26 miles southwest of the recreation site; table 1) meets the recommendations of the Public Health Service for drinking water supplies but softening may be necessary. Water from Lake Powell may percolate into these formations if the regional water table is below the lake level or if pumping lowers the water table below the level. A well drilled after the lake is filled may have a larger and more stable yield than a well drilled sooner.

Conclusions

A well drilled to the base of the Wingate Sandstone, or about 2,000 feet, may obtain an ample amount of water for the recreation site, although more than one well may be necessary. This cannot be determined, however, until the first well is drilled and tested. If nonpotable water is encountered in the Entrada and Carmel Formations it should be kept out of the well by casing that is cemented to the top of the Navajo Sandstone. Potable water should be encountered in the Navajo, Kayenta, and Wingate Formations. Lake Powell, when filled, will cover the Navajo Sandstone and part of the Carmel Formation in the vicinity of the recreation site. Water from the lake may percolate continuously into these formations if the regional water table is below the lake level or if pumping lowers the water table below the lake level. Thus a well drilled after the lake is filled may be able to obtain an ample supply of water from the Carmel or Navajo Formations.

Direct pumping from Lake Powell is an alternative for obtaining a water supply at the recreation site. Water obtained directly or indirectly from the lake probably will be similar in chemical quality to the weighted average quality of the Colorado River (No. 4 in table 1).

CASTLE BUTTE

Geology

The recreation site at Castle Butte is underlain by the Wingate Sandstone, Chinle Formation, and Moenkopi Formation, all of Triassic age (fig. 4). The Wingate, a light reddish-brown, massive, crossbedded sandstone,

Figure 4.--Geology and spring sampled in the vicinity of the Castle Butte site.

makes up the "battlement" of the castle. Directly beneath the Wingate is the Chinle, comprised mainly of reddish sandstone, siltstone, and claystone. The Shinarump, the basal member of the Chinle, comprises yellow, orange, and gray sandstone, siltstone, claystone, and conglomerate. The thickness of these formations, which make up most of the Castle Butte topographic feature, is about 700 feet. The Moenkopi Formation underlies the Shinarump and makes up the valley floor around Castle Butte as well as its base. The Moenkopi comprises about 200 feet of reddish sandstone, siltstone, shale, and conglomerate.

The Cutler Formation of Permian age underlies the Moenkopi and is about 1,300 feet thick. It consists of an upper member of light fine-grained sandstone; a middle member of red shale, siltstone, and sandstone; and a lower member of light fine-grained crossbedded sandstone. The Rico Formation of Pennsylvanian and Permian age underlies the Cutler, is about 600 feet thick, and consists of interbedded sandstone, siltstone, shale, and limestone. Jointing is developed in all the formations at the recreation site, but it is strongest in the sandstone beds.

Hydrology

Very few springs and seeps are in the vicinity of the Castle Butte recreation site. Known springs generally have very small discharges and flow in response to seasonal rains. A spring in Red Canyon (No. 5 in table 1 and fig. 4) had an estimated flow of 25 gpm on June 9, 1963, and it is the largest spring known around Castle Butte. This spring, however, will be covered by Lake Powell.

The Happy Jack mining operation (fig. 1), about 10 miles east of Castle Butte, reportedly had encountered little or no water in the Moenkopi and Chinle Formations. A deep well drilled near the mine started in the Cutler Formation and encountered water at only two horizons--at about 900 and 1,500 feet. The first aquifer, which was in the Cutler, reportedly contained poor quality water. The well obtains all the water from the 1,500-foot horizon, which probably is near or at the base of the Rico Formation. As the static water level is reported to be about 1,000 feet, the water apparently is under artesian pressure. The well was tested by pumping for about 170 hours with a pump rated at 10 gpm, and the drawdown during this test was reported to be about 50 feet. The well undoubtedly could be pumped at a greater rate. Except for excessive iron content, the water (No. 7, table 1) conforms to the recommendations of the U.S. Public Health Service (1962) for public supply.

The water from the Chinle (No. 8, table 1; sample collected 3 $\frac{1}{4}$ miles southwest of Castle Butte), Moenkopi (No. 5, table 1 and fig. 4), and Cutler (No. 3, table 1; sample collected 17 miles northeast of Castle Butte) Formations contains large amounts of dissolved solids and would not be suitable for public supply.

Conclusions

A water supply from springs cannot be obtained in the vicinity of the Castle Butte recreation site. Wells or direct pumping from Lake Powell offer the only solutions for obtaining a supply. Aquifers containing good quality water are not known in the rocks overlying the Rico Formation, but the Rico does contain good quality water. A well at the Castle Butte site would penetrate about 2,000 feet before reaching the Rico and possibly another 600 feet before striking water in the Rico.

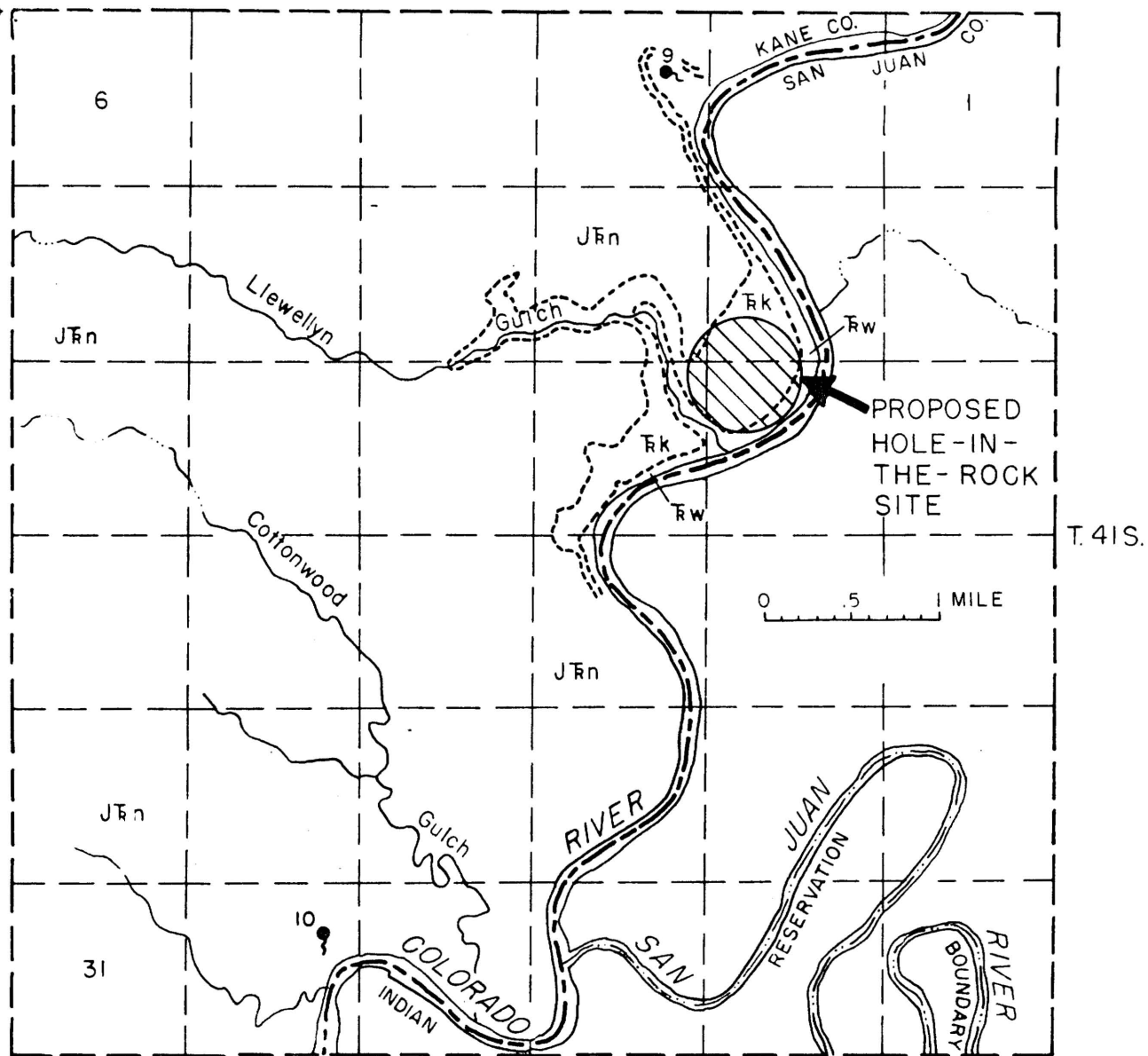
Lake Powell, when filled, will cover the Moenkopi and part of the Chinle (including the Shinarump Member). Lake water will percolate into these formations because they are above the regional water table, and a well drilled after the lake has filled may yield sufficient water for the recreation site. However, a pumping test will be necessary to evaluate whether one well will supply ample water for the site. The quality of the water may be poor because as the water percolates through the three formations it may dissolve objectional amounts of dissolved solids, including sulfate and chloride.

Direct pumping from Lake Powell is the other possible means of obtaining a water supply at the Castle Butte site. Water obtained directly from the lake probably will be similar in chemical quality to the weighted average quality of the Colorado River (No. 4 in table 1).

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EXPLANATION

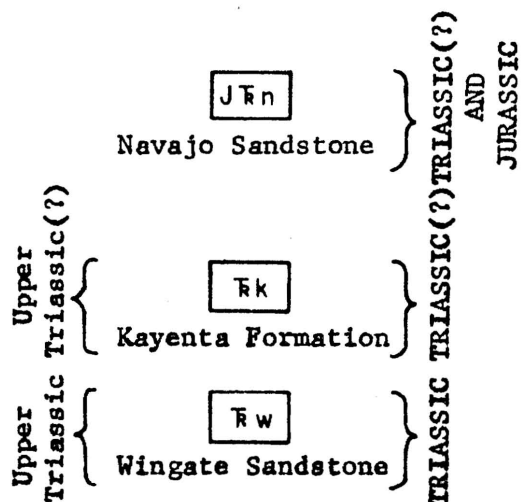
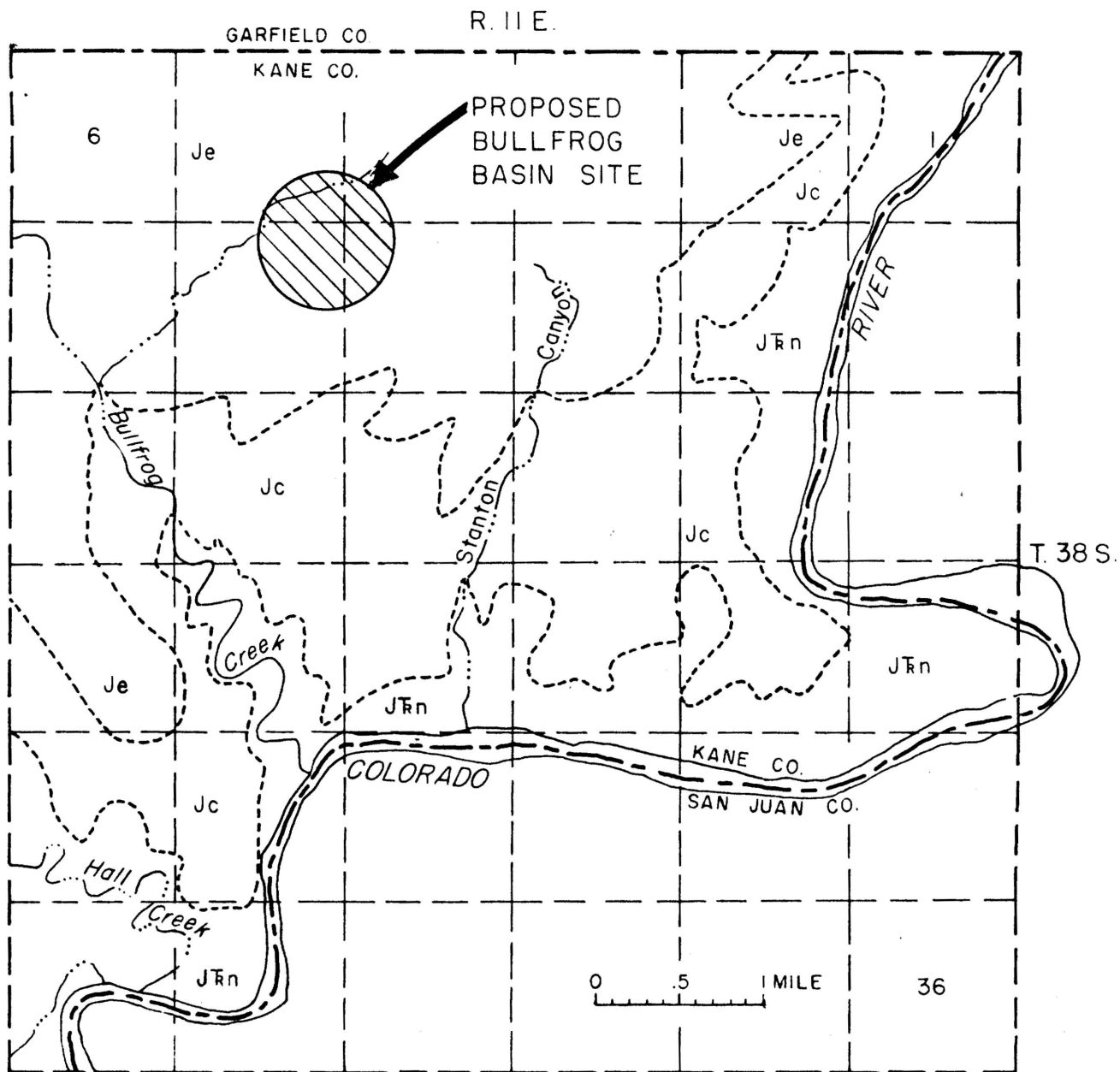


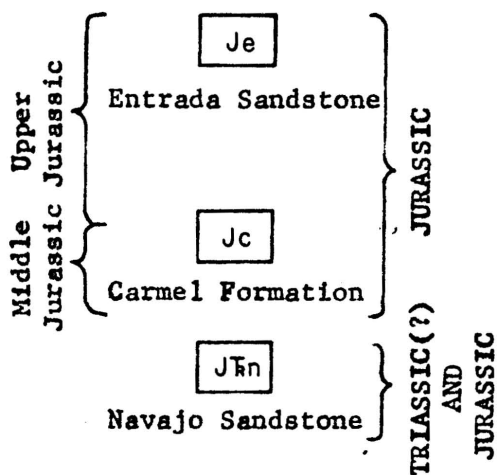
Figure 2.--Geology and springs sampled in the vicinity of the Hole-in-the-Rock site.



Base from U.S. Geological Survey
topographic maps of Utah, Lake
Canyon and Mt. Ellsworth, 1953

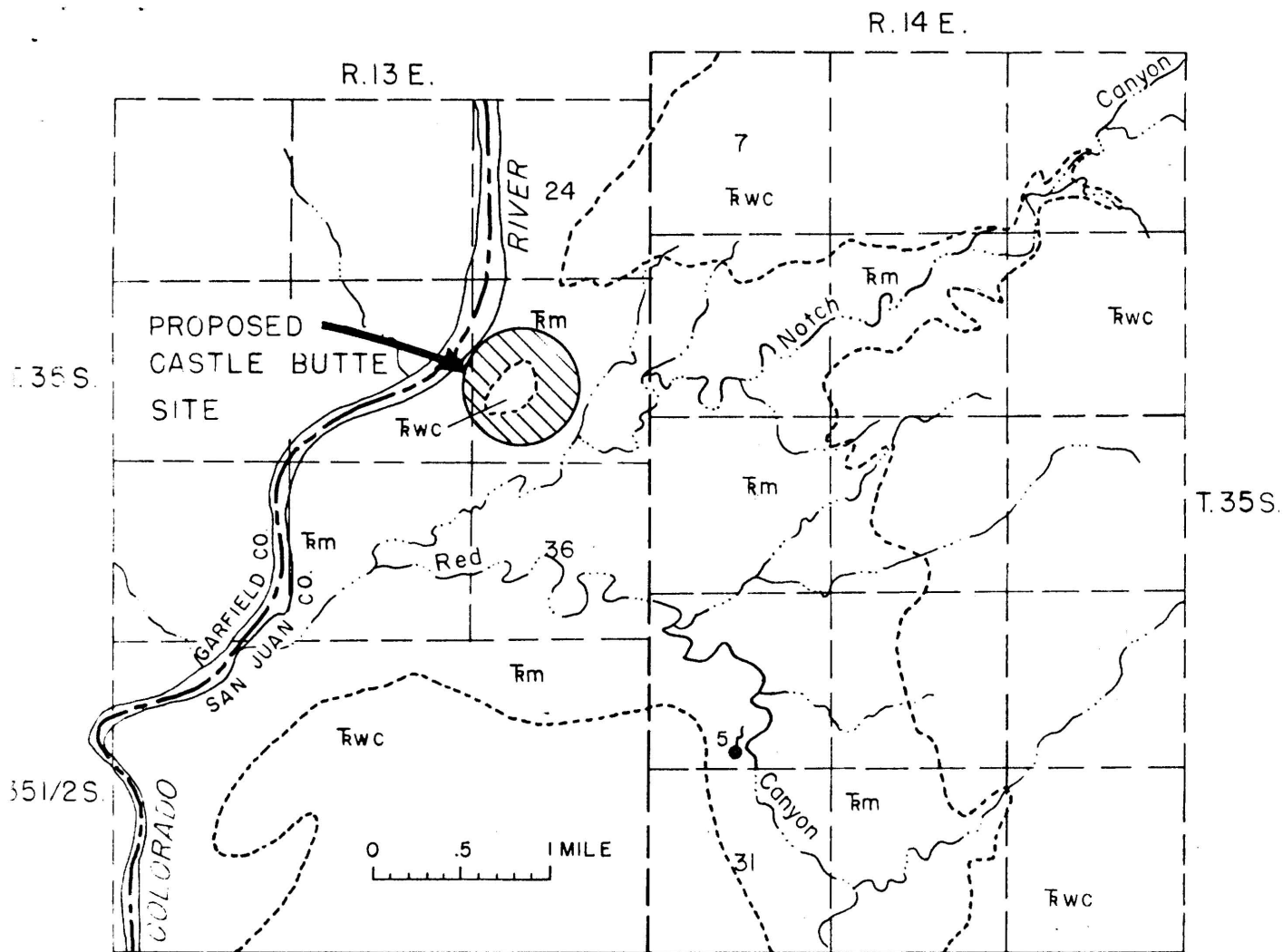
Geology adapted from Hunt, 1953

EXPLANATION



Formation contact,
approximately located

Figure 3.--Geology in the vicinity of the Bullfrog Basin site.



EXPLANATION

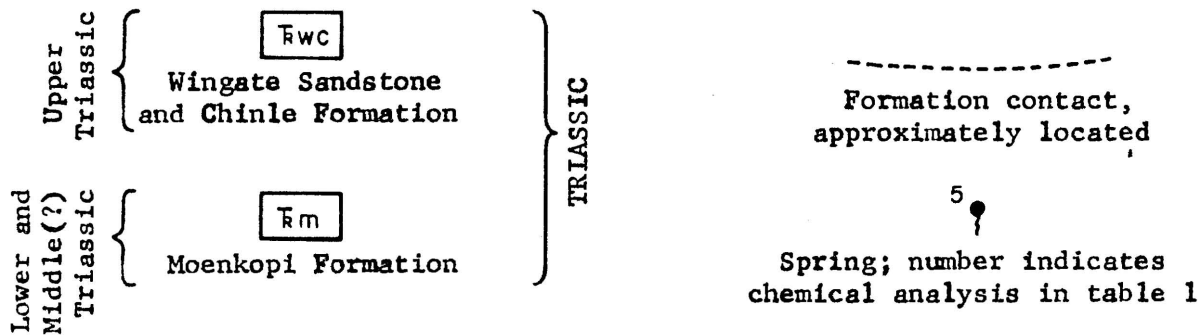


Figure 4.--Geology and spring sampled in the vicinity of the Castle Butte site.

Table 1.--Chemical quality of ground and surface waters in and near the Glen Canyon Natl
[Analyses by U.S. Geological Survey]

Wells, springs, and streams			Stratigraphic unit	Date of collection	Temperature (°F)	Silica (SiO ₂)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Na + K	
Number in this report	U.S.G.S. number	Source								Sodium (Na)	Potassium (K)
1	(D-27-11)34dca-1	Well	Carmel Formation	6-28-52	64	12	2.2	130	5.3	1,160	
2	(D-33-13)5dac-1	Spring	Wingate Sandstone or Kayenta Formation	6-9-63	58	10	-	34	31	46	
3	(D-33-17)2lcdb-1	do.	Cutler Formation	4-23-59	-	17	-	838	202	1,180	
4	1/(D-34-13)35bda	Colorado River at Hite, Utah		2/1914-57	-	-	-	68	23	66	3.1
5	(D-35-14)30dcc-1	Spring	Moenkopi Formation	6-9-63	78	11	-	150	97	342	
6	(D-35-15)4ccd-1	Well	Rico Formation	6-9-63	-	7.6	.91	38	46	19	
7	(D-36-11)32bdb-1	Spring	Entrada Sandstone	4-22-59	-	11	-	35	13	4.3	
8	(D-40-10)10cda-1	do.	Chinle Formation	4-18-59	-	8.3	-	407	140	779	
9	(D-41-9)3adb-1	do.	Wingate Sandstone	4-18-59	-	13	-	45	14	4.0	
10	32adb-1	do.	Navajo Sandstone	4-18-59	-	10	-	29	11	2.5	

1/ Chemical quality of Colorado River water near the Utah-Arizona State line is similar to that at Hite for the same period.

2/ W. V. Iorns, oral communication, 1963; figures are weighted averages and are adjusted to 1957 conditions.

Parts per million										
Bicarbonate (HCO ₃)	Carbonate (CO ₃)	Sulfate (SO ₄)	Chloride (Cl)	Nitrate (NO ₃)	Dissolved solids	Hardness as CaCO ₃	Noncarbonate hardness as CaCO ₃	Percent sodium	Specific conductance (micromhos/cm at 25°C)	pH
182	-	236	1,750	-	3,530	346	-	-	-	-
281	0	63	9.0	0.5	332	210	0	32	562	7.5
1,160	0	1,920	1,800	1.7	6,530	2,920	1,970	47	8,800	6.7
172	-	197	44	-	527	264	123	35	795	-
259	0	770	356	3.2	1,860	775	563	49	2,710	7.5
348	0	26	9.0	.3	318	284	0	12	571	7.4
174	0	1.6	3.0	.4	155	140	0	6	270	7.8
882	0	1,790	490	2.8	4,060	1,590	867	52	5,170	7.3
206	0	4.7	2.5	.6	185	170	1	5	322	7.9
134	0	7.2	2.0	.9	129	116	6	4	224	7.9