1972

Water Resources of Part of Canyonlands National Park, Southeastern Utah

C. T. Sumsion

E. L. Bolke

UNITED STATES
DEPARTMENT OF THE INTERIOR
Geological Survey

WATER RESOURCES OF PART OF CANYONLANDS NATIONAL PARK, SOUTHEASTERN UTAH

by

C. T. Sumsion and E. L. Bolke

OPEN-FILE REPORT

72-363

Prepared for the U.S. National Park Service

Salt Lake City, Utah

1972

Contents

Contents--Continued

Illustrations

Tables

WATER RESOURCES OF PART OF CANYONLANDS NATIONAL PARK, SOUTHEASTERN UTAH

By C. T. Sumsion and E. L. Bolke

Abstract

Canyonlands National Park is in about the center of the Canyon Lands section of the Colorado Plateaus physiographic province in southeastern Utah. The part of the park discussed embraces an area of about 400 square miles comprising isolated mesas, precipitous canyons, and dissected broad benches near the confluence of the Green and Colorado Rivers, the only perennial streams in the area. The climate is arid to semiarid; normal annual precipitation ranges from less than 8 to about 10 inches. Potential evapotranspiration is about 41 inches annually.

Geology of the park is characterized by nearly horizontal strata that dip gently northward. Exposed rock formations and deposits range in age from Middle Pennsylvanian to Holocene. Owing to the elevated and deeply dissected topography, only parts of the Cedar Mesa and White Rim Sandstone Members of the Cutler Formation of Permian age have potential for development of wells. Strata above and below them support only small springs, are dry, or contain brine.

In the northwest part of the park, the Green River at Taylor Canyon is a potential source of surface water for public supplies for the Island In The Sky area and a small part of the northwest White Rim area. It will require filtration and treatment before use. In the same area, two unused wells in Taylor Canyon will supply enough water for present requirements from the White Rim Sandstone Member of the Cutler Formation, about 140 gallons per minute combined, but yield mineralized water that will require treatment before use. Springs yielding good water at the Island In The Sky and White Rim are mostly intermittent and too small for public-water supply. Most of the White Rim area is dry, having no usable ground water. In The Needles area, wells provide water of good quality from the Cedar Mesa Sandstone Member of the Cutler Formation. Springs yielding good water in the same area are available for supplementary supplies. West of The Needles, The Grabens area is without springs or potential aquifers bearing usable water.

During 1970 about 510,000 gallons of water was used in Canyonlands National Park. Of this amount, 110,000 gallons was supplied to Island In The Sky by tank truck from a source outside the park, and about 400,000 gallons was withdrawn from the well in use at The Needles. Estimated total annual requirements in 10 years (1980) may be as much as 6 million gallons. Sources of water supplies within the park now in use and potential sources of surface water or ground water outlined by this investigation will meet the estimated requirements. Development of rainfall-collection and cistern-storage systems could furnish small emergency sources of water for waterless areas on the White Rim and in The Grabens.

Introduction

Purpose and scope

The need for data and information on water resources is particularly great in Canyonlands National Park due to a rapid increase in the number of visitors (and consequently the rapid development of facilities), the general aridity of the region, the scarcity of usable water, and the lack of previous studies related to water resources in this locality. In 1967 the U.S. Geological Survey, at the request of the U.S. National Park Service, began an investigation to locate and appraise the water resources of the park. Extensions to the area of the park on November 16, 1971, are not included in this report; they include The Maze, Horseshoe Canyon, and some smaller areas.

Included in this report are geologic and hydrologic information from previous oil and mineral resources studies and information from a regional hydrologic summary of areas in and near Canyonlands National Park. The report provides new data, information, and specific guidelines for the development of ground water by wells and from springs. The perennial streams, the Green and Colorado Rivers, are evaluated for their potential usefulness as sources of water supplies.

Previous investigations and acknowledgments

Geologic investigations in the area, most of which contain only brief discussions of water resources, include studies by Baker (1933, 1946), McKnight (1940), Witkind (1964), Lewis and Campbell (1965), Williams (1964), and Williams and Hackman (1971).

A regional study of the upper Colorado River basin by Iorns, Hembree, and Oakland (1965) supplies basic data and summarizes the quantitative and qualitative hydrology of a region including the Canyonlands National Park.

National Park Service Superintendent Bates E. Wilson has a detailed knowledge of the Canyonlands area based on a lengthy residence therein. He provided much useful information, and his cooperation and assistance and that of the rangers and other staff personnel of the National Park Service are gratefully acknowledged. Information about the Taylor Canyon wells was provided by Mr. J. C. Osmond, consulting geologist, Salt Lake City, Utah.

Geographic setting

Location and accessibility

During the investigation, Canyonlands National Park embraced an area of about 400 square miles in southeastern Utah (fig. 1). The area discussed in this report is that included within the park boundaries on the U.S. Geological Survey special topographic map--Canyonlands National Park and vicinity, Utah (1969). The areas added to the park on November 16, 1971, are not included in this report.

Island In The Sky, between the Green and Colorado Rivers, is accessible by paved and unsurfaced roads; it is 32 miles from U.S. Highway 160 and 42 miles from Moab. The Needles area, southeast of the confluence of the Green and Colorado Rivers, is accessible by a paved road; it is 38 miles from U.S. Highway 160 and 73 miles from Monticello. The Grabens area is accessible only by 4-wheel drive vehicles or on foot. A paved road to the confluence, which will touch the north ends of several grabens and connect with others, is planned for the future.

Physiography and drainage

Canyonlands National Park is typical of the Canyon Lands section of the Colorado Plateaus physiographic province (fig. 1). In this region, gently dipping strata are intricately dissected by deep canyons that separate high sheer-walled mesas and plateaus.

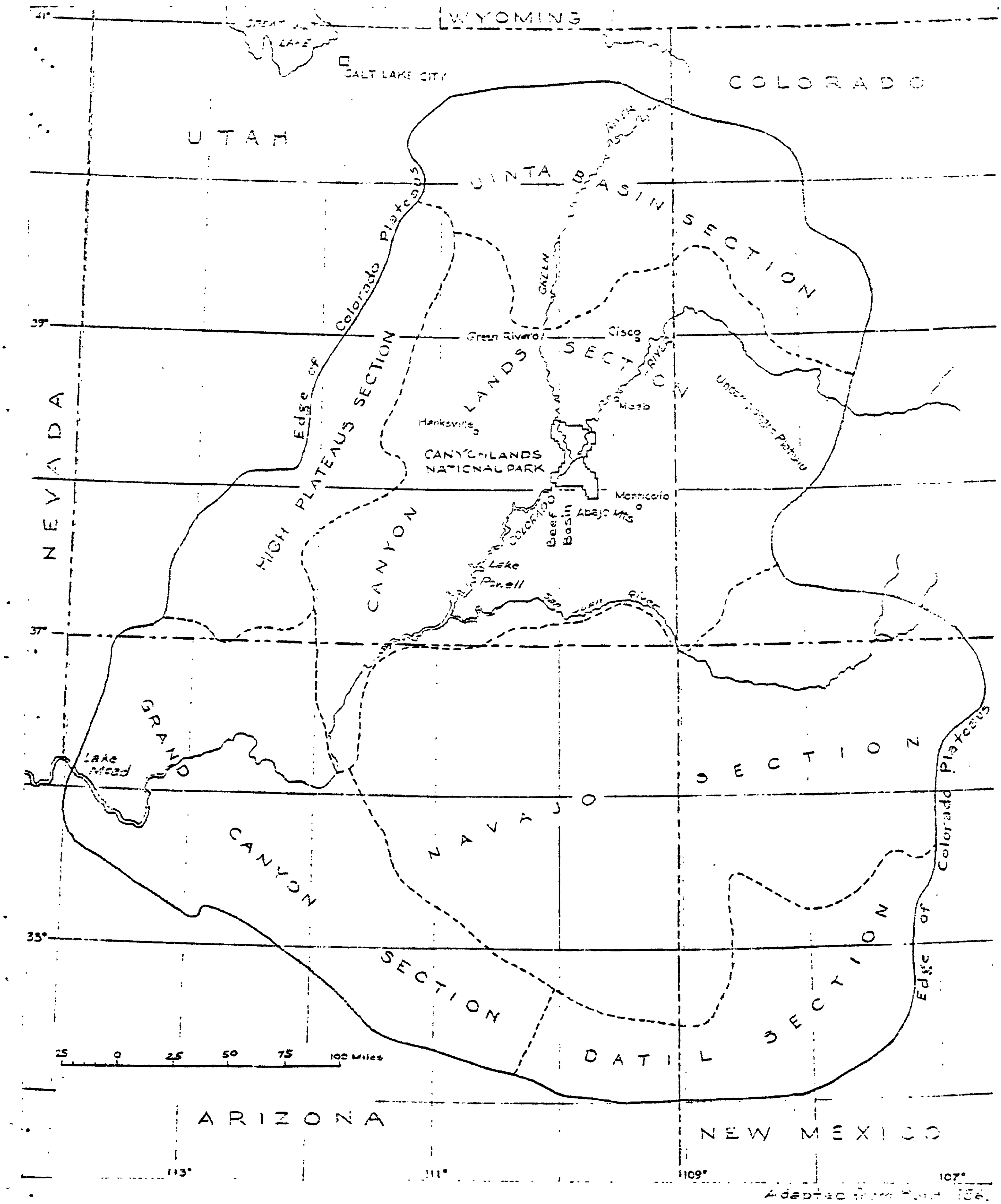

Figure 1.--Index map of the Colorado Plateaus physiographic province showing the location of Canyonlands National Park.

The Island In The Sky comprises Willow Flat, Grand View Point, and Grays Pasture (fig. 1A). It is adjoined on the northwest by Upheaval Dome, a local structural feature expressed topographically as a circular basin, and contiguous Buck, Bighorn, and Steer Mesas. These areas are the remnants of an elevated, dissected plateau, sparsely covered by juniper and pinyon, that increase in altitude from north to south. Altitudes range from 5,088 feet above sea level on Buck Mesa to 6,400 feet at Junction Butte, an outlier near the southern end of Grand View Point. On nearly all sides, Island In The Sky and its contiguous mesas are isolated by sheer-walled brownish-red slopes and cliffs that rise as much as 1,500 feet from the benches of the surrounding White Rim (fig. 2). The White Rim is formed mainly by the light-colored strata of the White Rim Sandstone Member of the Cutler Formation. Altitudes along the White Rim range from 4,000 feet west of Steer Mesa to about 5,200 feet south of Junction Butte; the rim is as much as 1,300 feet above the rivers in the southern part of the area. The White Rim is deeply dissected by numerous red-hued dry canyons of starkly barren aspect that are tributary to the Green River on the west and to the Colorado River on the east.

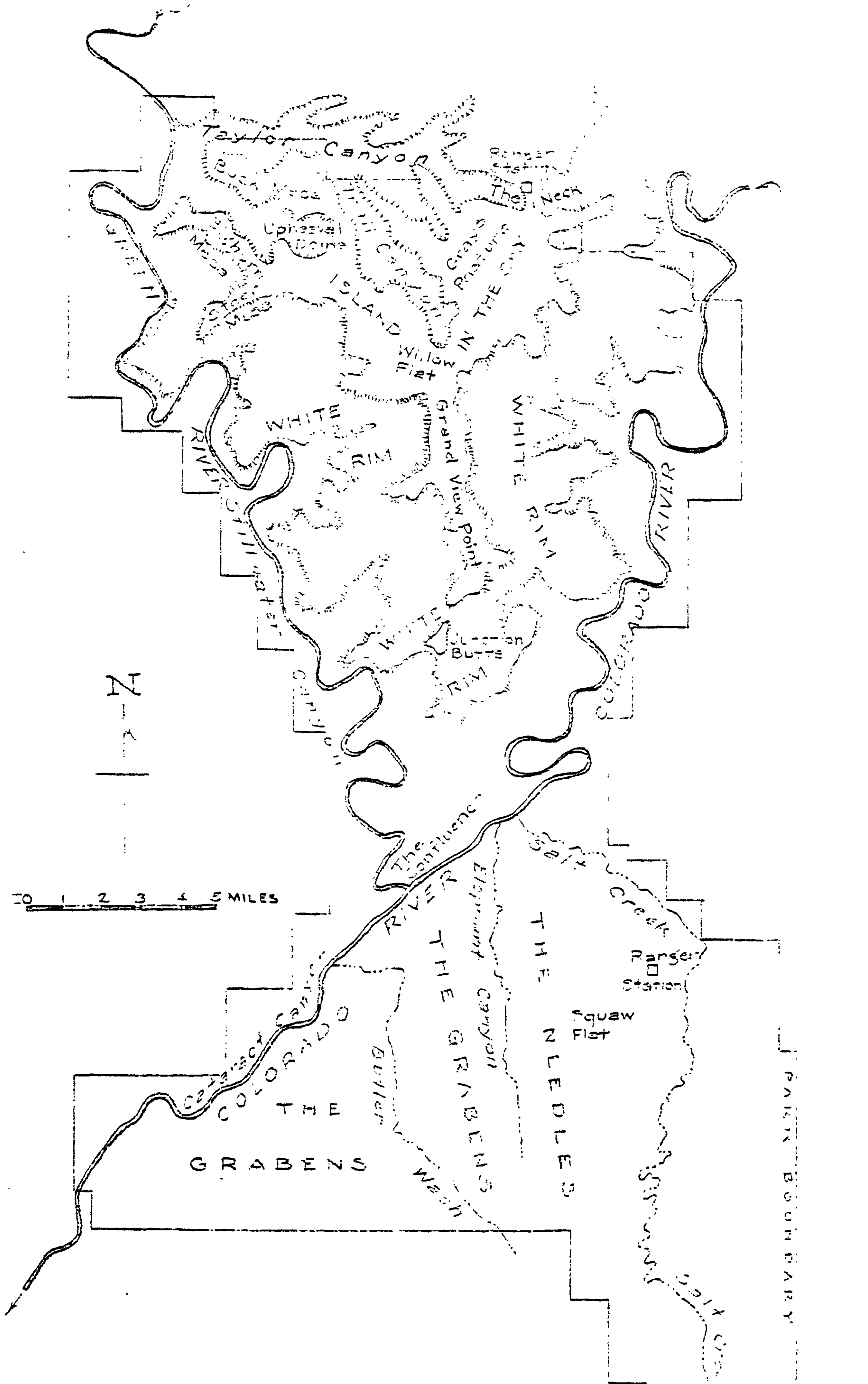

Figure 1A.--Index map of major features of Canyonlands National Park.

The Green River flows in Stillwater Canyon southeastward through Canyonlands National Park to its confluence with the Colorado River for a meandering channel distance of about 46 miles (fig. 2). The gradient of the Green River from Valentine Bottom to the Colorado River averages about 1.6 feet per mile. Small isolated valley flats with brush-covered natural levees lie adjacent to the river in the upper part of the canyon. One of these flats, Anderson Bottom, is an abandoned meander on the west bank; it is used as a camping area by boaters.

The Colorado River meanders for a channel distance of about 40 miles southwestward through the park to its confluence with the Green River. Its gradient averages about 1.1 feet per mile through this distance. The altitude at the confluence is about 3,875 feet. Valley flats are present but smaller and less common along the Colorado River than along the Green River. From the confluence to Lake Powell, the Colorado River flows southwestward through Cataract Canyon for a meandering channel distance of about 15 miles. The gradient of the Colorado River through Cataract Canyon averages about 11 feet per mile.

The Needles area is characterized by sculptured and weathered sandstone standing as blocky measas, buttes, and spires above an intricate system of narrow, steep-walled, meandering canyons. Intermittent streams of The Needles area flow northward to the Colorado River from the slopes of the Abajo Mountains and Beef Basin. Salt Creek, longestof these streams, is about 40 miles long and has an average gradient of about 95 feet per mile. The upper channel of Salt Creek consists of deeply entrenched meanders that may reflect its development on mudstone and siltstone of the Moenkopi Formation that subsequently was removed by erosion. The lower part of the channel of Salt Creek and its tributaries appear to be controlled mainly by fractures in the Cedar Mesa Sandstone Member of the Cutler Formation.

The Grabens, a complex of horsts separated by graben valleys, and each bounded by wide northeast-trending fracture zones, lies west of The Needles. The Grabens is crossed by Butler Wash and Cross Canyon, both of which trend generally northward to the Colorado River. Butler Wash, the longer of these intermittent streams, is about 23 miles long and has an average gradient of about 138 feet per mile. Cross Canyon is not a continuous stream course; it is interrupted by sinks at fracture zones that trend across the drainage. Many of the graben valleys drain to sinks.

Climate

The climate of the Canyonlands area is arid to semiarid. Normal (1931-60) annual precipitation slightly exceeds 10 inches in higher parts of Island In The Sky and southernmost parts of The Needles. At lower altitudes, normal annual precipitation is less than 8 inches. Slightly more precipitation falls during the summer than in the winter months. Much of the summer precipitation is from local storms of high intensity that cause heavy runoff in stream courses that are normally dry. Climatic data from the Canyonlands weather stations and other stations in this region are presented in figure 3. The average 1966-69 precipitation at Canyonlands-The Neck is 8.95 inches, slightly below the normal estimated for the area from isohyetal maps (U.S. Weather Bureau, 1963a, b). At Canyonlands-The Needle, average precipitation for the same period, 8.57 inches, is slightly above the estimated normal.

Summer daytime temperatures at Canyonlands National Park commonly range from moderately warm in the uplands areas to hot in the lower canyons and barren benches. Seasonal ranges of temperature are wide; temperature extremes at Canyonland-The Neck are 100°F (37.8°C) and 0°F (-17.8°C) for the period 1966-69. At Canyonlands-The Needle, extreme temperatures are 103°F (39.4°C) and -11°F (-23.9°C) for the same period.

Potential evapotranspiration in the Canyonlands area greatly exceeds annual precipitation, so that a condition of soil-moisture deficiency exists. It is estimated that annual potential evapotranspiration at Canyonlands National Park is about 41 inches (Iorns and others, 1965, pl. 4).

Vegetation

Two principal communities of vegetation exist in Canyonlands National Park; a pinyon-juniper climax and a blackbrush climax. The pinyon-juniper climax occurs at altitudes of about 4,000 to 6,000 feet, mainly on the plateaus and mesas of Island In the Sky and the higher southern parts of The Needles. The most common junipers are Rocky Mountain juniper (*Juniperus scopulorum*), one-seed juniper (*J. mono-sperma*), and Utah juniper (*J. osteospera*). The common pinyon of this community is the Colorado pinyon (*Pinus edulis*). Subfoliage species represented are bitterbrush (*Purshia tridentata*), big sagebrush (*Artemesia tridentata*), mountain-mahogany (*Cercocarpus montana*), and cliffrose (*Cowania stansburiana*). Some herbaceous species of this community are blue grama (*Bouteloua gracilis*), galleta (*Hilaria jamesi*), bluebunch wheatgrass (*Agropyron spicatum*), and western wheatgrass (*A. smithi*).

The blackbrush climax occurs in sandy nonalkaline soils at lower altitudes, less than 4,500 feet, along the canyon tributaries and terraces of the Green and Colorado Rivers, the White Rim, and lower reaches of The Needles and The Grabens. Some of the plants associated with blackbrush (*Coleogyne ramosissima*) are four-wing saltbrush (*Atriplex canescens*), Mormon tea (*Ephedra* sp.), yucca (*Yucca* sp.), snakeweed (*Gutierrezia sarothrae*), and galleta. Where alkaline soils are present, saltgrass (*Distichlis stricta*) and alkali sacaton (*Sporobolus airoides*) grow.

Phreatophytes, a less-prominent plant community, grow where there is sufficient moisture in soils and sand, where seeps or springs are present, and along flood plains of the rivers. Willow (*Salix* sp.), cattail (*Typha latifolia*), horesetail (*Equisetum* sp.), giant reedgrass (*Phragmites communis*), greasewood (*Sarcobatus vermiculatus*), and tamarisk or saltcedar (*Tamarix gallica*) are the most common of these plants. Some of the phreatophytes serve as indicators of near-surface ground water (Meinzer, 1927, p. 15-59). In Canyonlands National Park, the presences of willow and giant reedgrass, usually along intermittent stream channels, are the most common indicators of shallow ground water.

General geology

The exposed rock formations in Canyonlands National Park attain a maximum thickness of more than 5,000 feet. The oldest and lowermost rocks exposed are in Cross Canyon and Lower Red Lake Canyon (fig. 2). These rocks are the upper part of the Paradox Member of the Hermosa Formation; they are largely evaporites of Middle Pennsylvanian age (Lewis and Campbell, 1965, p. 709). Older rocks, not exposed, have been penetrated by oil-test wells in the Canyonlands area; their stratigraphic units are given in the appendix. The youngest indurated formation in the park is the Navajo Sandstone of Triassic(?) and Jurassic age, which forms gracefully rounded buttes above the general level of the plateau of Island In The Sky. Eolian deposits of silt and sand partly reworked by storm runoff occur irregularly on mesas, plateaus, benches, and broad slopes throughout the area. Alluvial deposits of sand, gravel, and silt are present in stream courses and their flood plains. These unconsolidated deposits are of Holocene age.

Stratigraphy

Schists, gneisses, and related metamorphic rocks of Precambrian age have been penetrated by oil-test wells near the Canyonlands area, but are not exposed there. The nearest surface exposure of rocks of this system is in the Uncompahgre Plateau in western Colorado.

Quartzite, limestone, dolomite, and shale strata of Cambrian age have been penetrated by oil-test wells near the Canyonlands area, but are not exposed in or near the park. These stratigraphic units are equivalent to those exposed in western Utah and southwestern Colorado--the Tintic Quartzite, Ophir Formation, Hartmann and Bowman Limestones, and the Lynch Dolomite (Knight and Cooper, 1955, p. 61).

The presence of rock strata of Ordovician and Silurian age has not been confirmed in or near the park. Rocks of Ordovician age may be present, but those of Silurian age are probably absent (Lewis and Campbell, 1965, p. 6).

Well data indicate the presence of rocks of Devonian age throughout the subsurface of the Canyonlands area (Lewis and Campbell, 1965, p. 6). Strata of Devonian age include the Aneth[1/] and Elbert Formations and the Ouray Limestone (Knight and Cooper, 1955, p. 63).

The presence of subsurface rocks of Mississippian age is indicated by data from oil-test wells in the Canyonlands area. These rock strata, referred to as Leadville Limestone in the appendix, are considered to be equivalent to the Madison and Leadville Limestones exposed in western Utah and southwestern Colorado, respectively (Lewis and Campbell, 1965, p. 6).

Subsurface rocks of Pennsylvanian age in the Canyonlands area include the Molas Formation, the unnamed lowest limestone member of the Hermosa Formation, and the lower part of its Paradox Member (appendix).

1/ Not adopted by the U.S. Geological Survey.

A listing of the exposed formations and deposits of the Pennsylvanian, Permian, Triassic, Jurassic, and Quaternary Systems in Canyonlands National Park, together with descriptions of their lithology and water-bearing characteristics are presented in table 1. The Tertiary System is not represented in Canyonlands National Park.

Structure

Rock strata in Canyonlands National Park dip generally northward, at angles of less than 3 degrees from the horizontal. At Upheaval Dome, however, the strata have much steeper dips locally. Anticlines and synclines with very gentle dips and plunges (less than 1 degree) are superimposed on the northward-dipping strata. They influence, somewhat, the generally northward movement of ground water through the aquifers.

Grays Pasture syncline trends northwestward from Buck Canyon-Lathrop Canyon basin, through Grays Pasture and Taylor Canyon, slightly north of Upheaval Dome, to the vicinity of the Green River (fig. 2). The northwestward plunge of the syncline causes a northwestward to westward movement of ground water in the White Rim Sandstone Member of the Cutler Formation in the vicinity of Taylor Canyon.

Upheaval Dome is a structural dome but a topographic basin. The White Rim Member in the vicinity is elevated so that the sandstone member contains no water in the Willow Flat area. A local synclinal ring about the dome retains, in the basal part of the Wingate Sandstone, small amounts of ground water which discharges at Holeman Spring, south of the dome.

A short structure ~~of limited extent~~, Meander anticline, trends northeastward from near the confluence of the Green and Colorado Rivers to The Loop, a direction nearly normal to the trend of regional linear structures (fig. 2). The trend of Meander anticline suggests a possible relation of the anticline to the structure of The Grabens area, because of its nearness and similar alinement. However, the Meander anticline is not related to the trend of The Grabens, but, like the folds along the Eagle and Colorado River Valleys of central Colorado, it is what may be termed an "erosional" anticline, formed because removal of the rock load by river erosion allowed downward compression of underlying evaporites on either side, pushing up the rocks beneath the stream (Baker, 1933, p. 71-72; S. W. Lohman, oral commun., 1971). Meander anticline does not contain fresh-water aquifers.

Lockhart anticline and Rustler dome are in the eastern part of Canyonlands National Park, not extending far west of the Colorado River (fig. 2). There are no fresh-water aquifers in the area of these structures.

Faults in Canyonlands National Park are localized. South of the confluence of the Green and Colorado Rivers, a complex of braided normal faults outline the structural valleys and basins of The Grabens. Displacements by these faults do not appear to exceed ~~about~~ 300 feet. A few faults of small displacement, less than about 50 feet, are associated with the structure of Upheaval Dome. Faults in The Grabens and Upheaval Dome result from doming caused by intrusive evaporites in the subsurface Paradox Member of the Hermosa Formation. Subsequent removal of the evaporites by ground-water solution may have resulted in subsidence with associated faulting of the strata overlying the evaporite sequence. The faults and fault zones are generally open, promoting rapid drainage of the faulted Cedar Mesa Sandstone Member of the Cutler Formation, the Rico Formation, and the Hermosa Formation above river level in The Grabens. This rapid drainage precludes the possibility of recovering the percolating water by means of wells.

Water resources

Surface water

The Colorado and Green Rivers are the only perennial streams in Canyonlands National Park. Their characteristics are presented for consideration of use of these streams as sources of water supplies for the park. In a few places, short stretches of their intermittent tributary stream courses have small perennial flow where fed by springs. The monthly and yearly mean discharge of the Colorado and Green Rivers at the gaging stations nearest the park, near Cisco, Utah and at the town of Green River, Utah, show that the greatest discharge is in March or April through August, and the least discharge is in January or February (tables 2 and 3). No water is diverted from these streams between the gaging stations described in tables 2 and 3 and Canyonlands National Park. Annual contributions to the Colorado River by the intermittent flow of its tributaries, between the gage near Cisco and the park, are less than 1 percent of the average discharge of the river. The intermittent tributaries of the Green River, between the gage at Green River and the park, yield less than 3 percent of the river's average discharge (Iorns and others, 1965, p. 257). Flow-duration data for the Colorado and Green Rivers are given in table 4, and the relation between water discharge and chemical quality is given in table 5. These data are presented as an aid for planning water-treatment facilities for public-water supplies in the event that river water might be considered for use.

The chemical quality of the Green River in the Canyonlands area is usually better than that of the Colorado River. When discharge of the rivers is greatest, chemical quality of the water is best. The rivers discharge water of chemical quality suitable for public supply about 40 percent of the time. Duration of dissolved-solids concentration of the Green and Colorado Rivers is presented in table 6. Data of flood frequency of the Colorado and Green Rivers at the two gaging stations are given in figures 4 and 5. These streams are remote from existing facilities or developments within the Canyonlands area, and thus present no flood hazards.

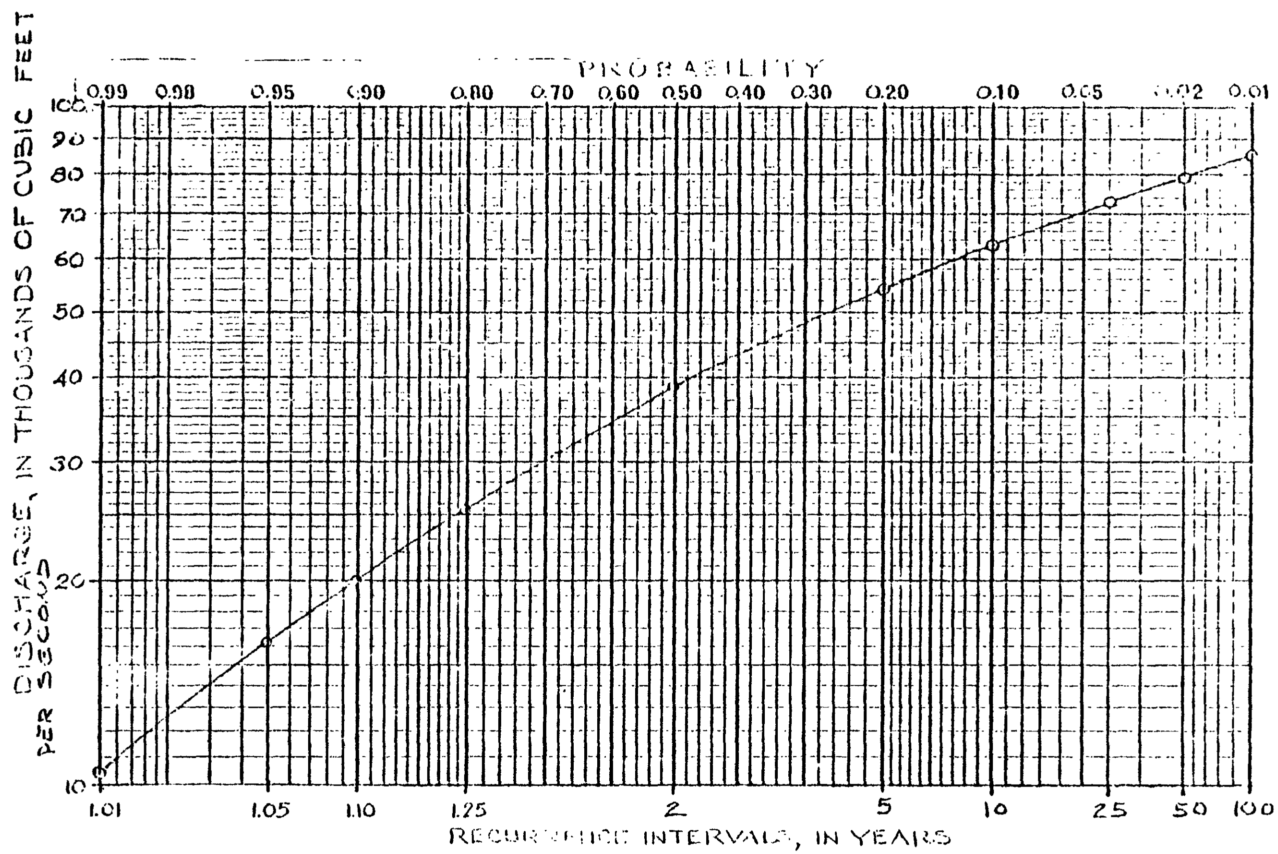

Figure 4.--Flood-frequency curve, Colorado River near Cisco, Utah.

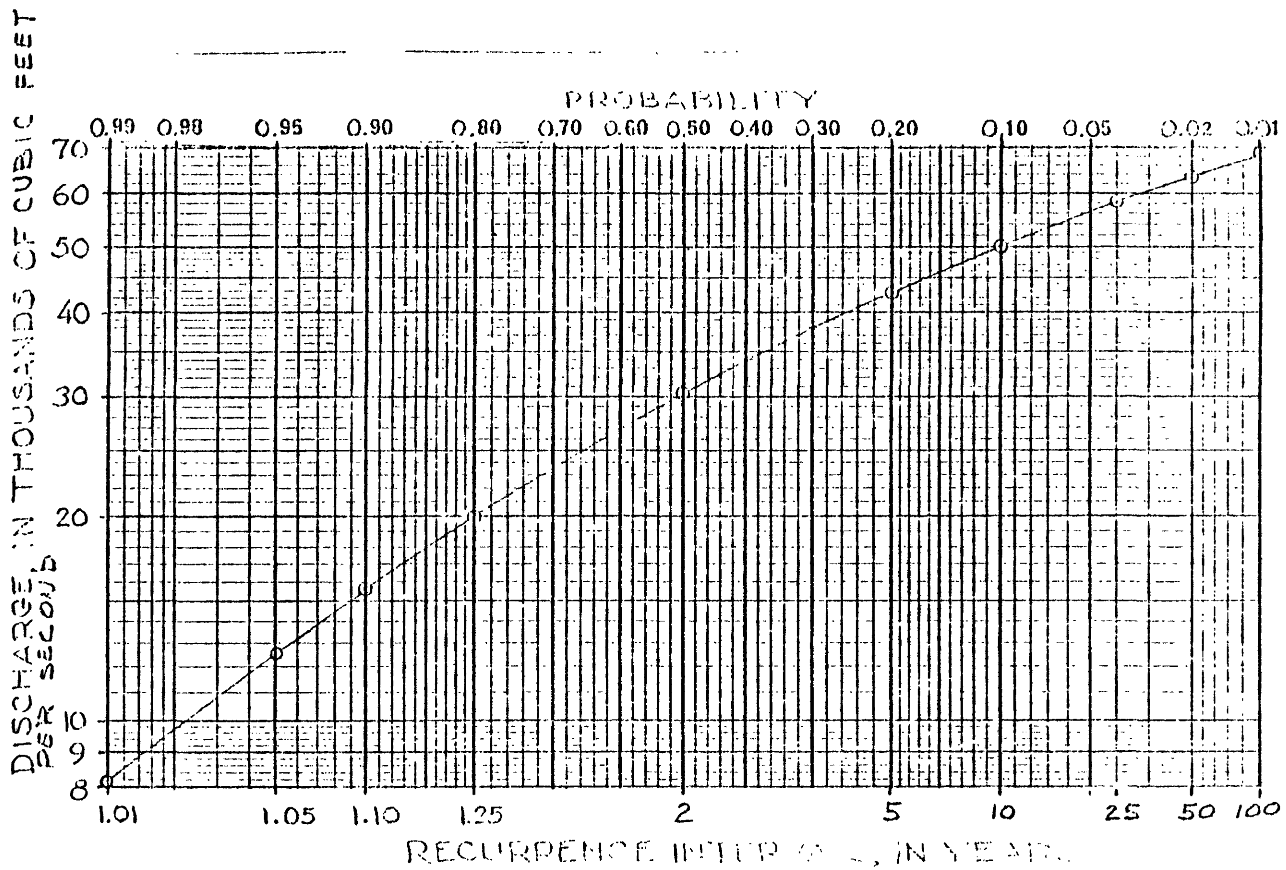

Figure 5.--Flood-frequency curve, Green River at Green River, Utah.

Floods in the tributary drainage systems of Canyonlands National Park occur mainly during the period of summer storms. In The Needles area, Salt Creek drains about 130 square miles with a mean altitude of 5,600 feet. Included within it are the Squaw Flat Campground and The Needles headquarters, maintenance, and residence areas. The floods of Salt Creek at its confluence with the Colorado River for recurrence intervals of from 1.1 to 50 years are shown in figure 6 as a flood-frequency curve, determined by the method of Patterson and Somers (1966, p. 3-13). The flood with a recurrence interval of 1.1 years is calculated to be about 500 cfs (cubic feet per second) at the mouth of Salt Creek. The developed areas at The Needles headquarters and Squaw Flat Campground are high enough and far enough from the stream channels of Salt Creek and its Squaw Canyon tributary so that no flood damage may be expected.

Northwest of Island In The Sky, Taylor Canyon drains about 80 square miles with a mean altitude of 5,200 feet. This area is seldom visited except where the jeep road crosses Upheaval Bottom (fig. 2). The floods of the Taylor Canyon drainage area for recurrence intervals of 1.1 to 50 years are shown in figure 7 as a flood-frequency curve (Patterson and Somers, 1966, p. 3-13). The flood with a recurrence interval of 1.1 years at the mouth of Taylor Canyon is calculated to be about 425 cfs.

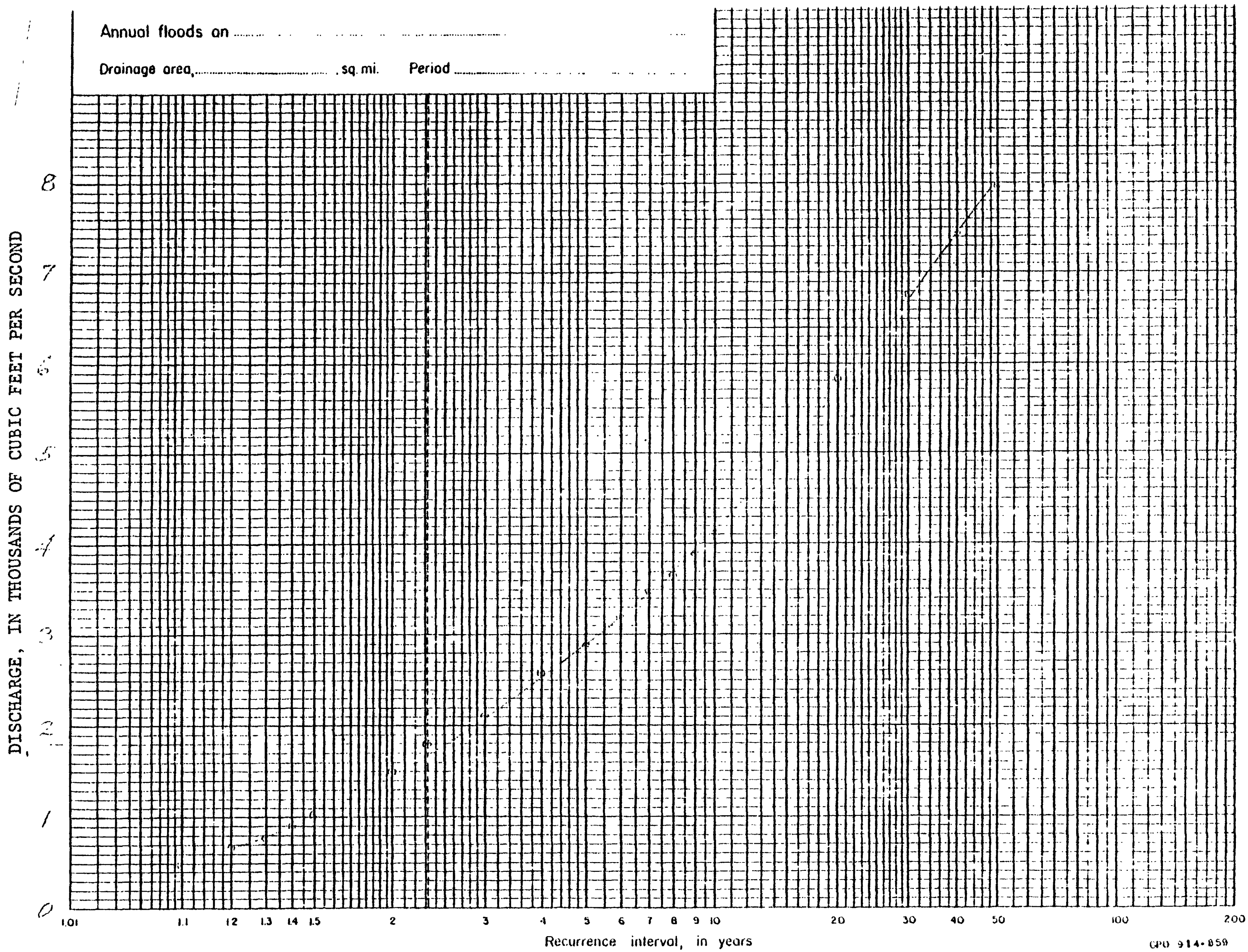

Figure 6.--Flood-frequency curve, Salt Creek at mouth.

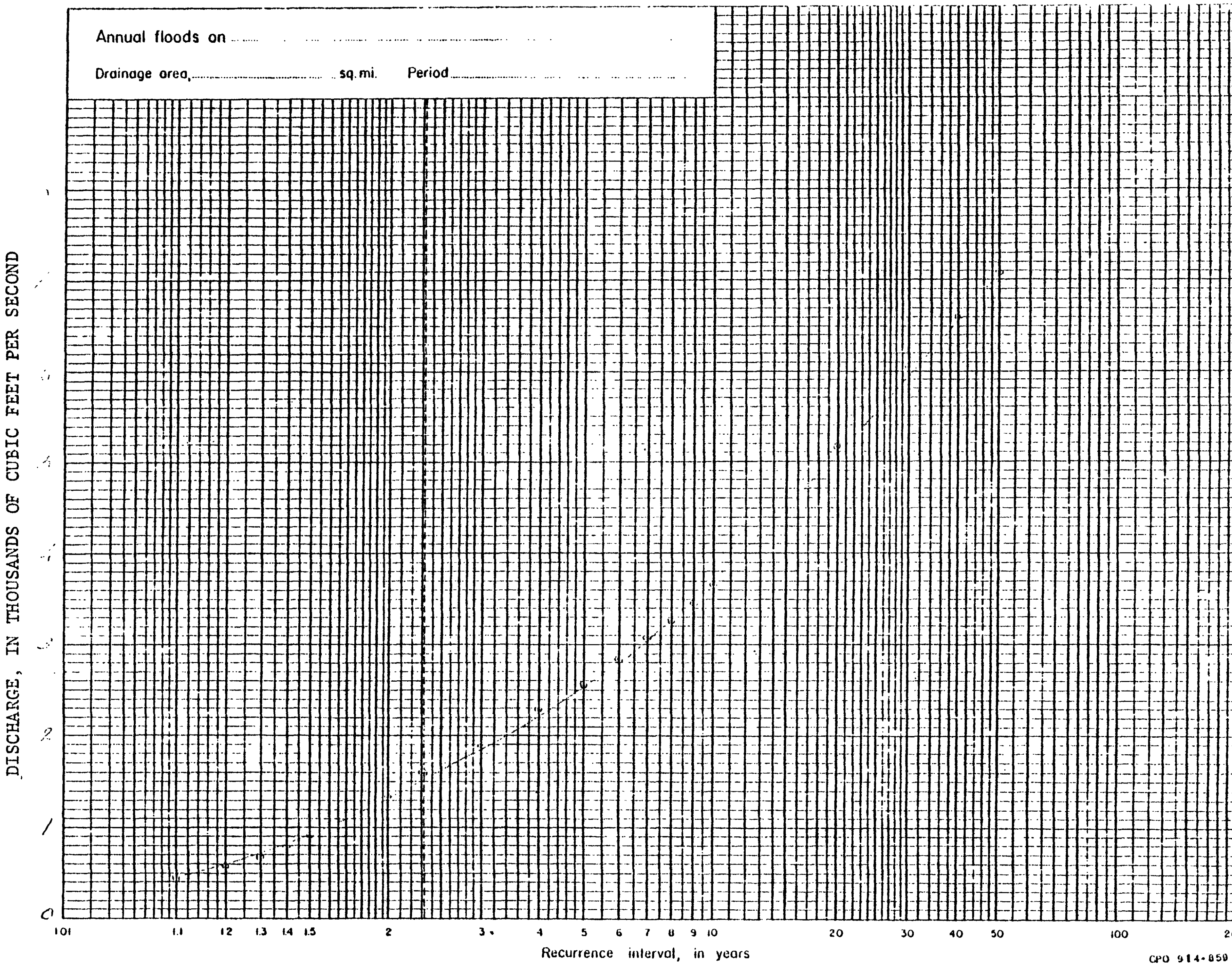

Figure 7.--Flood-frequency curve, Taylor Canyon at mouth.

Ground water

The elevated and deeply dissected topographic character of Canyonlands National Park limits the retention of ground water in permeable formations above the levels of the Green and Colorado Rivers. The summer precipitation falls mainly during short intense storms, and nearly all the rainfall is rapidly dissipated by runoff and evaporation. Snowmelt is the principal source of recharge to the ground-water system. Recharge to the aquifers of The Needles area takes place mainly in the uplands along the northern slopes of the Abajo Mountains, and recharge to the Taylor Canyon area takes place mainly on the plateau northeast of Taylor Canyon. Ground water flows in the direction of the prevailing structural dip--in The Needles area generally northward and in the Taylor Canyon area generally southwestward. In higher areas of the park, scattered small intermittent springs and seeps represent perched water-bearing zones of limited extent. A very small amount of ground water discharges as springs in a few of the tributary canyons of the Green and Colorado Rivers. Nearly all ground water discharges directly into the rivers where they intersect aquifers. Man has not significantly modified natural hydrologic conditions in the park by means of wells or developed springs, and recharge and discharge of ground water therefore may be assumed to be equal.

Chemical quality of the ground water from wells in Canyonlands National Park is generally good in The Needles area (dissolved-solids content - 305-926 milligrams per liter), and highly mineralized in the Taylor Canyon area (dissolved-solids content - 1,720-2,730 milligrams per liter). Below rocks of Permian age, aquifers contain brine having dissolved-solids content exceeding 35,000 milligrams per liter (Hanshaw and Hill, 1969, p. 263). Water from springs in the park is generally potable.

Island In The Sky

On this high, topographically isolated plateau, scattered small intermittent springs are present in the vicinity of The Neck, Willow Flat, and the north rim of Upheaval Dome (fig. 2 and table 7). These springs are not easily accessible. Holeman Spring, a perennial spring south of Upheaval Dome, lies at the foot of a cliff of Wingate Sandstone; it is not ascessible from Island In The Sky.

A test well was drilled at Willow Flat in 1967 by the National Park Service. The test penetrated the White Rim Sandstone Member of the Cutler Formation at depths of about 1,620 to 1,773 feet below land surface (fig. 2 and table 8). The White Rim, about 153 feet thick at this site, was found to be dry. The National Park Service drilled three wells in September 1966 in Taylor Canyon, at the north side of Island In The Sky, about 6 to 8½ miles northwest of the Willow Flat test well. These wells penetrated the White Rim Member (fig. 2), which ranges from about 140 to 161 feet thick in this area and contains water under artesian pressure (table 8). During February and March 1969, aquifer tests were conducted in Taylor Canyon wells 2 and 3 to determine yield, drawdown, and interference between them, and the chemical quality of the water. The wells were pumped separately at nearly constant rates for periods of 48 hours, during which both wells were observed for drawdown and for possible interference. The pumping tests show the discharge of Taylor Canyon well 2 to be about 40 gpm (gallons per minute) and of Taylor Canyon well 3 to be about 101 gpm (table 8). This is enough water for foreseeable requirements at the area proposed for development at Willow Flat. Mutual interference was not observed in the wells, which are about 8,200 feet apart. The difference in the yields of the two wells is probably due to the extent to which the aquifer is jointed or fractured at each well site.

When Taylor Canyon well 1 was drilled, in 1966, Park Service personnel reported a decrease of artesian pressure of about 28 pounds per square inch, or a head loss of about 64 feet, during a 72-hour observation period while the well was flowing about 45 gpm. Specific capacity of the well is 0.4 gpm per foot.

Chemical analyses of water from Taylor Canyon wells 1, 2, and 3 show it to be highly mineralized (table 9); the water will require treatment before use for public supplies.

The Taylor Canyon wells are located on the southwest limb of the Grays Pasture syncline, a nearly imperceptible northwest-plunging structure. The Willow Flat test well is located on the adjoining southwest anticline (fig. 2). Ground-water movement is controlled by the structures as well as the permeability of the White Rim Sandstone Member, the only aquifer in this vicinity capable of yielding sufficient quantities of usable water for development. In this area, ground water moves generally in the direction of plunge of the syncline. The area favorable for obtaining water from the White Rim Member by wells is indicated in figure 2.

Additional test drilling for water in the Island In The Sky (and the White Rim area) is not recommended. The sources of usable ground water have been determined by drilling the Taylor Canyon wells, sources of unusable saline water and brine have been delineated by oil-test drilling records, and dry areas are indicated by the Willow Flat test well and by the elevated exposures of the White Rim Member around Island In The Sky. Additional large sources of water for development of public-water supplies in the Island In The Sky (and the White Rim area) are limited to surface-water supplies from the Green and Colorado Rivers.

White Rim

The White Rim Sandstone Member, a resistant cliff-forming unit which characterizes the White Rim area, is conspicuously jointed and many of the joints are open, permitting rapid drainage. The most prominent joint sets trend northwestward and less well-developed sets trend northeastward. The cliff formed by the White Rim is above the level of the rivers except in the northwest part of the area, and open joints in the cliff preclude the retention of ground water. As quickly as it infiltrates the sandstone and enters the joints of the White Rim, ground water is discharged as intermittent seeps at the base of the cliff.

Hardscrabble Spring, (D-27-17½)13cba-S1, at Hardscrabble Bottom, discharges from a minerals-test hole drilled through the Moenkopi Formation into the White Rim Sandstone Member (fig. 2). No record of the depth of the hole is available, but it was probably about 400 to 500 feet deep. The walls of the hole have collapsed, partly closing the hole, but water under artesian pressure in the underlying White Rim Member continues to seep upward through the collapsed material. The water is of poor chemical quality (dissolved-solids content - 2,730 milligrams per liter) and is not recommended for use (table 9).

Holeman Spring, (D-27-18)27ccb-S1, is accessible from the White Rim trail by following an intermittent stream channel for about 2½ miles northeast of the trail (fig. 2). This spring is perennial and yields water of good chemical quality. It discharges from the base of the Wingate Sandstone south of Upheaval Dome. The spring is undeveloped and is unused except by occasional visitors.

Sheep Spring, (D-27-18)32dcb-S1, discharges water of poor chemical quality (dissolved-solids content - 1,410 milligrams per liter) from the Moenkopi Formation in the same stream channel that leads from the White Rim trail to Holeman Spring.

Water-resources development in the White Rim area will be limited to use of water from the Green and Colorado Rivers, development of Holeman Spring for use in Holeman Spring Basin, and use of ground water from the wells in Taylor Canyon or from other similar wells which may be drilled in the small area where the White Rim Sandstone Member bears water (fig. 2). Throughout most of the White Rim area the White Rim Member is above river level, is deeply dissected or jointed and well drained, and is stratigraphically above formations known to be dry or to contain brine or small quantities of salty water. There is little possibility of obtaining potable water from wells in Holeman Spring Basin, Soda Springs Basin, Murphy Basin, the vicinity of Junction Butte and confluence of the Green and Colorado Rivers, Monument Basin, Buck and Lathrop Canyons, Little Bridge Canyon, the vicinity of Musselman Arch, or Shafer Canyon (fig. 2). Desalination of brines in these areas would be extremely expensive. The small valley flats along the rivers are inaccessible except in a few places. The fluvial sediments in the valley flats are derived mainly from shale ~~formations~~ stata and are so fine grained that they would yield little water, if any, to shallow wells. Water from such shallow wells, if chemically potable, would require chlorination for general use because of potential pollution.

The Needles

Springs in The Needles area discharge from the bedding planes, joints, and fractures of the Cedar Mesa Sandstone Member and the underlying Rico Formation. Except for Lower Jump Spring, (D-30-19)12acb-S1, all the accessible springs in The Needles area discharge potable water of good chemical quality (dissolved-solids content ranges from 54 to 583 milligrams per liter) suitable for public use (tables 10 and 11). Elephant Spring, (D-30-19)9dbd-S1, lies below a vertical drop in the stream channel of Elephant Canyon and within vertical canyon walls; although the spring can be seen from the canyon rim, it is not accessible (fig. 2). The springs in The Needles area are not used except by occasional visitors.

During 1965 the National Park Service drilled four wells near the confluence of Squaw Canyon and Salt Creek and adjacent to the stream channel of Squaw Canyon (fig. 2 and table 12). Needles well 1 was located east of Salt Creek in an area where a silty or very fine sand facies of the Cedar Mesa Sandstone Member failed to yield enough water. Drilling was carried into the underlying Rico Formation, which reportedly yielded salt water; the well was plugged and abandoned. Needles wells 2, 3, and 4 were completed successfully in sandstone of the Cedar Mesa Member and yield potable water of good chemical quality (table 11). In 1968 a fifth well was completed successfully in the Cedar Mesa Member near the confluence of Squaw Canyon and Salt Creek. At the present time only Needles well 3 is in use; Needles well 4 is capped and wells 2 and 5 are used occasionally when required. These wells will provide sufficient water for present and foreseeable requirements in The Needles area. The possibilities of obtaining ground water from additional wells in The Needles area are generally good. The wells should penetrate to the base of the Cedar Mesa Member, ranging in depth from about 150 feet in the vicinity of Squaw Flat Campground to about 200 feet in the southern parts of the area. The underlying Rico Formation, consisting mainly of limestone, yields water to springs from bedding planes, open joints, and fractures, but the chance of penetrating water-bearing fractures in the Rico is small, and it may contain salty water near Salt Creek. Formations beneath the Rico are either dry or contain brine, according to data from oil-test wells.

The Grabens

Located west of Elephant Canyon and south of the Colorado River in the southwestern part of Canyonlands National Park, The Grabens is a structurally unique area where strata are disarranged by numerous nearly vertical faults bounding horsts and grabens (fig. 2). The downfaulted blocks of The Grabens area generally underlie valleys and basins filled with alluvium and windblown sand and silt, in part reworked by streams. Runoff from the hanging valleys and scarps of horsts in the area flows into topographic basins and disappears into the many sinks at the fracture zones between horsts and grabens, and thence into the river. The Colorado River flows through Cataract Canyon on the northwest side of the area; there are no other perennial streams. Springs are not known in The Grabens.

The Cedar Mesa Sandstone Member--the only potential aquifer in The Grabens area--is elevated, faulted, and well drained; there is little possibility of obtaining adequate water by drilling wells. Deeper strata, below river level, contain brines. The Devils Pocket area, Chesler Park area, Butler Flat area, Cyclone Canyon, Red Lake Canyon, and adjacent grabens, therefore, are without potential sources of potable ground water. The Colorado River is a potential source of supply, but it is accessible only with difficulty.

Other sources of water

Remains of a few flood-breached earthen dams formerly used for stock-water reservoirs are scattered along the White Rim, in The Needles, and in The Grabens (fig. 2). These remnants of reservoirs may collect and retain in their shallow floors small amounts of turbid runoff for a short time after the infrequent storms in this area. These small ephemeral sources of water may be useful in emergencies when no other water is available.

Where small shallow depressions occur in the sandstone surface of the White Rim and Cedar Mesa Sandstone Members of the Cutler Formation, rain pools will accumulate and be retained for several days after periods of precipitation. A sample of water was collected from a rain pool in a depression of the Cedar Mesa Member in The Needles for chemical analysis 8 days after a storm on March 30 and 31, 1970. Precipitation was recorded as 0.16 inch from this storm at Canyonlands-The Needle weather station. The pool covered about 80 square feet, was about 3 inches in average depth, and was estimated to contain about 150 gallons. Water temperature was about 16.0°C (61°F), the pool was clear over a silty bottom, and snails, water beetles, and other aquatic fauna of smaller sizes were present. The water was of good chemical quality; the dissolved-solids content was 131 milligrams per liter (table 11).

To drink water from these sources may involve the risk of ingesting parasitic worms (Ranger Phil Hastings, oral commun., 1970). For the stranded traveler, however, this risk is small compared to the hazard of dehydration.

In some areas of the arid West, water for wildlife is obtained by constructing a paved catchment surface to intercept rainfall which then drains to a cistern. The cistern is partially covered to minimize evaporation yet provide accessible water for small animals and birds. A catchment area of 1,200 square feet (about 35 by 35 ft) should collect an average of more than 1,000 gallons during May through September in this area. Such water, although it may sustain algae, is suitable for emergency use by travelers when no other water is available. Installations such as these could be placed at intervals within the White Rim, The Needles, and The Grabens where no other easily accessible sources of water are available for travelers who may become stranded in hot weather.

Water use

At the present time (1971), nearly all the water used in Canyonlands National Park is supplied by wells. Springs in the park are used only occasionally by visitors, but they are very important in that they furnish water to the wildlife of the area.

The rivers and surface runoff are potential sources of water supplies that are not used at present. Before Canyonlands National Park was established, small earthwork dams on some of the smaller intermittent stream courses at intervals provided water for grazing stock. These small dams, without exception, have been breached by floods.

Water for use at Island In The Sky is transported by tank truck from a supply well near the headquarters of Arches National Monument to a storage tank near the ranger's residence at The Neck.

Water is scarce throughout most of the White Rim. Holeman Spring, the only source of potable water, is not readily accessible to travelers on the White Rim trail, and use of the spring is negligible.

At The Needles, water for use by visitors and personnel of the National Park Service is provided by Needles well 3 (fig. 2). This well, if pumped at the rate of 4 gpm for 12 hours per day, will provide more than 500,000 gallons for public-water supplies during the period of April through September. Well 3 is reportedly pumped continuously for longer periods without noticeable drawdown (Maintenance Superintendent J. R. Miller, oral commun., 1969). Water for other uses, such as road construction, is presently provided by Needles well 2. Well 2 discharged 2,419,000 gallons during 28 days of continuous pumping in 1969 (about 60 gpm) without diminished discharge. Water level in the well was reported to have recovered within about 3 days. If this well is pumped at the rate of 60 gallons per minute for 12 hours per day, it will provide more than 7,900,000 gallons for public-water supplies during the period April through September. Needles wells 2 and 3 will furnish enough water for public supplies at The Needles ranger station and maintenance area and at Squaw Flat Campground.

Throughout The Grabens--including Chesler Park, the Devils Pocket, the Devils Lane, Cyclone Canyon, Butler Flat, and other areas west of Elephant Canyon--potable water is generally not available. The only known spring near this part of the park, Elephant Spring, is inaccessible, lying below vertical cliffs of a box canyon, where it may be seen but not reached. There are no other known sources of water supplies in The Grabens area.

Average annual per capita use of water in Canyonlands National Park, for all purposes including use by park personnel and visitors, is estimated to be about 15 gallons per day. When camping facilities are more fully developed, per capita use of water may increase to an estimated 30 gallons per day. The annual numbers of visitors to Canyonlands National Park and annual water use are given in table 13. The estimated number of visitors to the park within 10 years (1980) may be about 200,000 annually and annual water use may be as much as 6 million gallons. Sources of water now in use and the sources of ground water and surface water outlined by this investigation will provide sufficient water supplies, where available, to meet the estimated future demand.

Table 13.--Numbers of visitors and water use at Canyonlands National Park, 1965-70

[Data from Maintenance Superintendent J. R. Miller, oral commun., 1970]

Water use estimated except m, metered.

Year	Numbers of visitors			Water use, in gallons		
	Island In The Sky	The Needles	Totals	Island In The Sky	The Needles	Totals
1965	14,878	4,548	19,426	80,000	295,000	375,000
1966	14,793	5,441	20,234	80,000	295,000	375,000
1967	16,292	6,863	23,155	80,000	295,000	375,000
1968	18,150	8,168	26,318	80,000m	297,000m	377,000m
1969	17,639	8,396	26,035	87,300m	300,000	387,300
1970	19,382	13,978	33,360	110,000m	400,000	510,000

Recommendations for future studies

Future water-resources investigations in Canyonlands National Park should include periodic measurements of spring discharge for those springs that might be used for development. Detailed geologic and hydrologic studies of well-site areas should precede well drilling where this may be planned in the future. If rainfall-collection systems are constructed, measurements of cistern storage should be made at biweekly or monthly intervals to determine more accurately the average rate of precipitation in the areas. Samples of water in cistern storage should be collected for chemical and biological analysis. If the present boundaries of Canyonlands National Park are extended to include new terrain, geologic and hydrologic investigations should keep pace with expansion in order to provide a basis for the orderly planning and development of water resources.

Summary

The possible sources of surface-water supplies in Canyonlands National Park are the Green and Colorado Rivers. Other streams are intermittent, discharging occasional runoff from storms that occur mainly during the summer. The rivers discharge water of chemical quality suitable for public-water supplies about 40 percent of the time. River water contains the greatest concentration of dissolved solids during the winter when discharge is least, and the least concentrations of dissolved solids during the summer when discharge is greatest. Thus, the best surface water will be available during the summer when demands on water supplies are greatest in the park. Use of river water for public supplies will require filtration and treatment to remove suspended sediment and undesirable amounts of dissolved constituents and a water distribution system to conduct it to the area of use. The Green River usually has water of better chemical quality than the Colorado River.

Springs that discharge potable water are too small and remote to be of use for all required public supplies at the Island In The Sky and White Rim areas. The springs at Island In The Sky are known to become seeps or to disappear during periods of drought. Holeman Spring can be useful at the White Rim if it is developed and made accessible to travelers on the White Rim trail. Springs in The Needles area produce potable water, but they are not needed for water supplies at the present time (1971). The springs most likely to be developed for use are Lost Canyon Spring in The Needles area and Holeman Spring at the White Rim area. It is suggested that monthly discharge measurements be made of Lost Canyon Spring and Holeman Spring. There are no springs in The Grabens.

Taylor Canyon wells 2 and 3 will provide enough water from the White Rim Sandstone Member for public supplies at Island In The Sky, but the water is mineralized and will require treatment before use. Drilling additional wells in other parts of Island In The Sky is not recommended; strata beneath Island In The Sky are dry or contain salty water or brine. Wells in The Needles area will provide enough potable water from the Cedar Mesa Sandstone Member for foreseeable requirements to about 1980. Additional wells are not recommended at present in The Needles area, but may be needed for future water-supply requirements. Wells are not recommended in The Grabens area; strata there are dry or contain brine.

Where no other sources of water are available for travelers in Canyonlands National Park, water may be obtained at times from rain pools in depressions of the sandstone surface of the Cedar Mesa and White Rim Sandstone Members or from the shallow floors of old stock-water reservoirs. In some waterless areas, such as The Grabens, parts of the White Rim (Monument Basin, for example), and The Needles area, rainfall collection systems could be constructed as possible sources of water for emergency use.

Selected references

Baker, A. A., 1933, Geology and oil possibilities of the Moab district, Grand and San Juan Counties, Utah: U.S. Geol. Survey Bull 841, 95 p., 11 pls.

______1946, Geology of the Green River Desert-Cataract Canyon region, Emery, Wayne, and Garfield Counties, Utah: U.S. Geol. Survey Bull. 951, 122 p., 20 pls.

Benson, M. A., 1968, Uniform flood frequency estimating methods for federal agencies: Water Resources Research, v. 4, no. 5, p. 891-908.

Criddle, W. D., Harris, Karl, and Willardson, L. S., 1962, Consumptive use and water requirements for Utah: Utah State Engineer Tech. Pub. 8 (revised), 47 p.

Cruff, R. W., and Thompson, T. H., 1967, A comparison of methods of estimating potential evapotranspiration from climatological data in arid and subhumid environments: U.S. Geol. Survey Water-Supply Paper 1839-M, 28 p.

Fenneman, N. M., 1931, Physiography of western United States: New York, McGraw-Hill Book Co., 534 p.

Fenneman, N. M., and Johnson, D. W., 1946, Physical divisions of the United States: U.S. Geol. Survey Misc. Maps and Charts, 1 sheet, scale 1:7,000,000.

Ferris, J. G., Knowles, D. B., Brown, R. H., and Stallman, R. W., 1962, Theory of aquifer tests: U.S. Geol. Survey Water-Supply Paper 1563-E, p. 69-173.

Gregory, H. E., 1938, The San Juan country: U.S. Geol. Survey Prof. Paper 188, 123 p., 26 pls.

Hanshaw, B. B., and Hill, G. A., 1969, Geochemistry and hydrodynamics of the Paradox Basin region, Utah, Colorado, and New Mexico: Chem. Geology, v. 4, p. 263-294.

Harrison, T. S., 1927, Colorado-Utah salt domes: Am. Assoc. Petroleum Geologists Bull., v. 11, no. 2, p. 125.

Hunt, C. B., 1956, Cenozoic geology of the Colorado Plateau: U.S. Geol. Survey Prof. Paper 279, 99 p.

Iorns, W. V., Hembree, C. H., and Oakland, G. L., 1965, Water resources of the Upper Colorado River Basin--Technical report: U.S. Geol. Survey Prof. Paper 441, 370 p., 9 pls.

Knight, R. L., and Cooper, J. C., 1955, Suggested changes in Devonian terminology of the Four Corners area, in Four Corners Geol. Soc. (Guidebook), Field Conf. (No. 1): p. 56-58.

Lewis, R. Q., Sr., and Campbell, R. H., 1965, Geology and uranium deposits of Elk Ridge and vicinity, San Juan County, Utah: U.S. Geol. Survey Prof. Paper 474-B, 60 p., 2 pls.

McKnight, E. T., 1940, Geology of area between Green and Colorado Rivers, Grand and San Juan Counties, Utah: U.S. Geol. Survey Bull. 908, 147 p., 13 pls.

Meinzer, O. E., 1927, Plants as indicators of ground water: U.S. Geol. Survey Water-Supply Paper 577, 95 p., 12 pls.

Patterson, J. L., and Somers, W. P., 1966, Magnitude and frequency of floods in the United States--Part 9. Colorado River Basin: U.S. Geol. Survey Water-Supply Paper 1683, 475 p., 1 pl.

Robinson, T. W., 1958, Phreatophytes: U.S. Geol. Survey Water-Supply Paper,1423, 84 p.

Stokes, W. L., ed., 1964, Geologic map of Utah: Utah Univ.

U.S. Environmental Science Services Administration, Environmental Data Service, 1967-69, Climatologic data, Utah, 1966-69: v. 68-70, nos. 1-13.

U.S. Weather Bureau, 1931-66, Climatological data, Utah, 1930-65: v. 32-67, nos. 1-13.

_______1963a, Normal annual and May-September precipitation (1931-60) for the State of Utah: Map of Utah, 1 sheet, scale 1:500,000.

_______1963b, Normal October-April precipitation (1931-60) for the State of Utah: Map of Utah, 1 sheet, scale 1:500,000.

Whitaker, G. L., 1969, Summary of maximum discharges in Utah streams: Utah Dept. Nat. Resources Tech. Pub. 21, 42 p.

Williams, P. L., compiler, 1964, Geology, structure, and uranium deposits of the Moab quadrangle, Colorado and Utah: U.S. Geol. Survey Misc. Geol. Inv. Map I-360, 2 sheets, scale 1:250,000.

Williams, P. L., and Hackman, R. J., compilers, 1971, Geology, structure, and uranium deposits of the Salina quadrangle, Utah: U.S. Geol. Survey Misc. Geol. Inv. Map I-591, 2 sheets, scale 1:250,000.

Witkind, I. J., 1964, Geology of the Abajo Mountains area, San Juan County, Utah: U.S. Geol. Survey Prof. Paper 453, 110 p., 5 pls.

APPENDIX

Well- and spring-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[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 within the 10-acre tract; the letter "S" preceding the serial number denotes a spring. If a well or spring cannot be located within a 10-acre tract, one or two location letters are used and the serial number is omitted. Thus (D-28-19)6caa-1 designates the first well constructed or visited in the NE¼NE¼SW¼ sec. 6, T. 28 S., R. 19 E., and (D-28-19)d-S designates a spring known only to be in the southeast quarter of the same section.

1/ Although the basic land unit, the section, is theoretically a 1-mile square, many sections are irregular. Such sections are subdivided into 10-acre 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.

Other sites where hydrologic data were collected are numbered in the same manner, but three letters are used after the section number and no serial number is used. The numbering system is illustrated in figure 8.

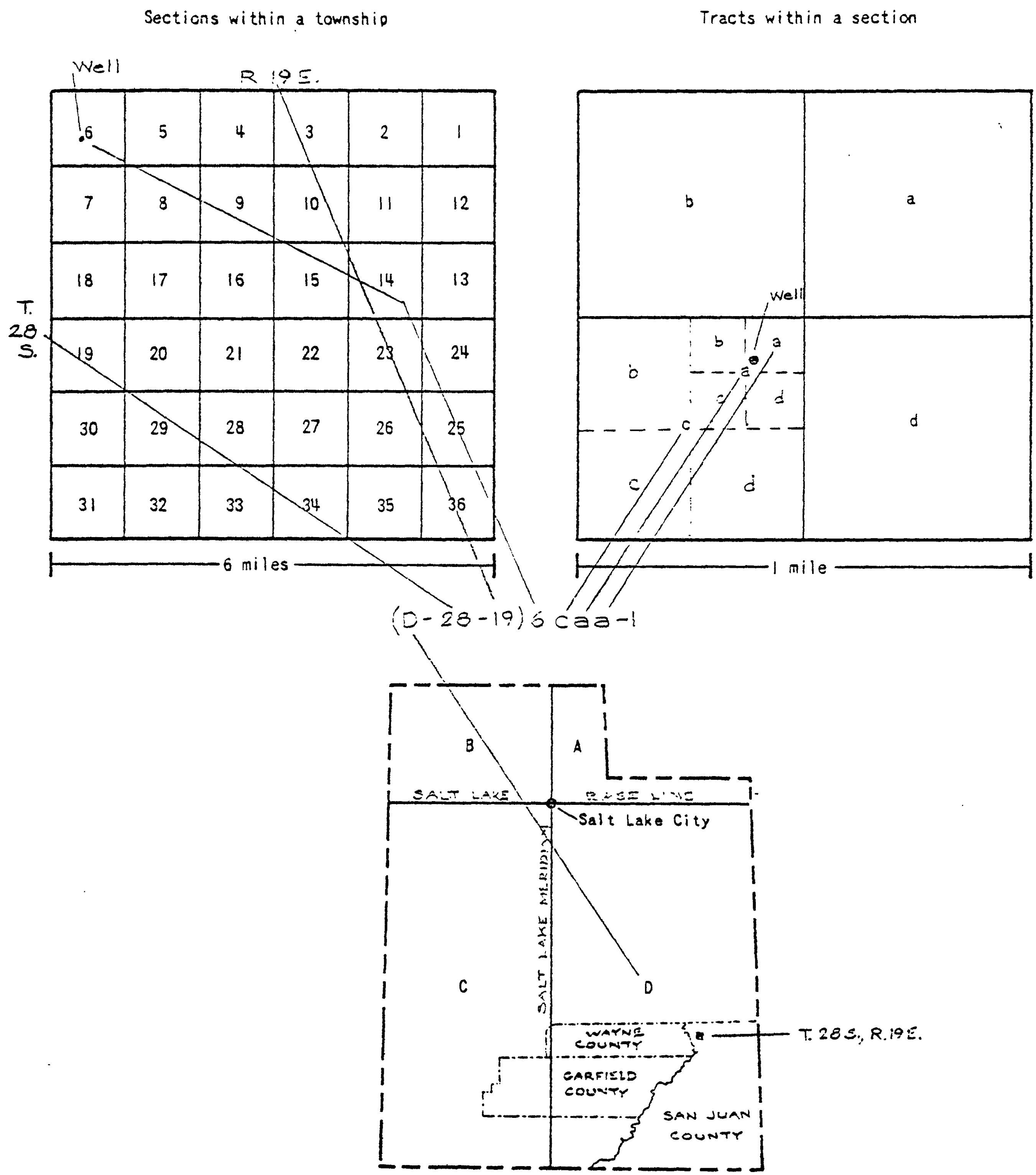

Figure 8.--Well- and spring-numbering system used in Utah.

Use of metric units

The results of chemical analyses and temperature measurements are given in this report in metric units, rather than the more familiar English units. Temperature are given in degrees Celsius, and concentrations are reported in milligrams per liter or milliequivalents per liter.

Degrees Celsius (°C) are the units used for reporting temperature in the metric system. One degree Celsius is equal to 9/5 degrees Fahrenheit, and the freezing point of water is 0° on the Celsius scale. The following table may be used to convert the temperature data given in this report to the more familiar Fahrenheit scale:

Unnumbered table (next page) here.

Milligrams per liter (mg/l) is the base unit for expressing the concentration of chemical constituents in solution, and it represents the weight of solute per unit volume of water. For concentrations of less than about 7,000 mg/l, this unit is numerically very nearly equal to the unit parts per million (ppm), which was formerly used by the U.S. Geological Survey.

TEMPERATURE-CONVERSION TABLE

Temperatures in °C are rounded to nearest 0.5 degree. Underscored temperatures are exact equivalents. To convert from °F to °C where two lines have the same value for °F, use the line marked with an asterisk (*) to obtain equivalent °C.

°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F
-20.0	-4	-10.0	14	0.0	32	10.0	50	20.0	68	30.0	86	40.0	104
-19.5	-3	-9.5	15	+0.5	33	10.5	51	20.5	69	30.5	87	40.5	105
-19.0	-2	-9.0	16	1.0	34	11.0	52	21.0	70	31.0	88	41.0	106
-18.5	-1	-8.5	17	1.5	35	11.5	53	21.5	71	31.5	89	41.5	107
-18.0 *	0	-8.0 *	18	2.0 *	36	12.0 *	54	22.0 *	72	32.0 *	90	42.0 *	108
-17.5	0	-7.5	18	2.5	36	12.5	54	22.5	72	32.5	90	42.5	108
-17.0	1	-7.0	19	3.0	37	13.0	55	23.0	73	33.0	91	43.0	109
-16.5	2	-6.5	20	3.5	38	13.5	56	23.5	74	33.5	92	43.5	110
-16.0	3	-6.0	21	4.0	39	14.0	57	24.0	75	34.0	93	44.0	111
-15.5	4	-5.5	22	4.5	40	14.5	58	24.5	76	34.5	94	44.5	112
-15.0	5	-5.0	23	5.0	41	15.0	59	25.0	77	35.0	95	45.0	113
-14.5	6	-4.5	24	5.5	42	15.5	60	25.5	78	35.5	96	45.5	114
-14.0	7	-4.0	25	6.0	43	16.0	61	26.0	79	36.0	97	46.0	115
-13.5	8	-3.5	26	6.5	44	16.5	62	26.5	80	36.5	98	46.5	116
-13.0	9	-3.0	27	7.0	45	17.0	63	27.0	81	37.0	99	47.0	117
-12.5	10	-2.5	28	7.5	46	17.5	64	27.5	82	37.5	100	47.5	118
-12.0 *	10	-2.0 *	28	8.0 *	46	18.0 *	64	28.0 *	82	38.0 *	100	48.0 *	118
-11.5	11	-1.5	29	8.5	47	18.5	65	28.5	83	38.5	101	48.5	119
-11.0	12	-1.0	30	9.0	48	19.0	66	29.0	84	39.0	102	49.0	120
-10.5	13	-0.5	31	9.5	49	19.5	67	29.5	85	39.5	103	49.5	121

For temperature conversions beyond the limits of the table, use the equations C = 0.5556 (F - 32) and F = 1.8(°C) + 32. The formulae say, in effect, that from the freezing point of water (0°C, 32°F) the temperature in °C rises (or falls) 5° for every rise (or fall) of 9°F.

Stratigraphic logs of selected wells in Canyonlands National Park

Altitude: In feet above mean sea level.
Depth: In feet below land surface at well site.
Thickness: In feet.

Stratigraphic unit	Depth	Thickness	Remarks
Taylor Canyon well 1 (D-27-17½)1ddc-1. Altitude: 4,000 feet.			
Moenkopi Formation	Surface	373	Water at 39 ft sealed off.
Cutler Formation:			
White Rim Sandstone Member	373	127	Water flows at 45 gpm.
Total depth	500		
Taylor Canyon well 3 (D-27-18)9baa-1. Altitude: 4,170 feet.			
Moenkopi Formation	Surface	420	Water at 55 ft sealed off.
Cutler Formation:			
White Rim Sandstone Member	420	165	Water, rises 388 ft above source.
Total depth	585		
Taylor Canyon well 2 (D-27-18)10aaa-1. Altitude 4,240 feet.			
Moenkopi Formation	Surface	461	
Cutler Formation:			
White Rim Sandstone Member	461	124	Water, rises 407 ft above source.
Total depth	585		

Stratigraphic unit	Depth	Thickness	Remarks
Husky Oil Co., Buck Mesa No. 1 (D-27-18)26bab-1. Altitude: 5,732 feet.			
Glen Canyon Group	Surface	870(?)	Dry.
Chinle Formation	870(?)	450(?)	
Moenkopi Formation	1,320	445	
Cutler Formation:			
White Rim Sandstone Member	1,765	130	Dry.
Unnamed arkosic member	1,895	597	
Rico Formation	2,492	470	Dry.
Hermosa Formation	2,962	3,315	Lost circulation from 3,857 to 4,085 ft.
Leadville Limestone	6,277	328+	Brine from 6,260 to 6,400 ft.
Total depth	6,605		

Stratigraphic unit	Depth	Thickness	Remarks
Rosen Oil Co., Grays Pasture No. 1 (D-27-19)27cad-1. Altitude: 6,120 feet.			
Navajo Sandstone	Surface	348	
Kayenta Formation	348	94	
Wingate Sandstone	442	543	
Chinle Formation	985	438	
Moenkopi Formation	1,423	467	
Cutler Formation:			
White Rim Sandstone Member	1,890	70	Dry.
Unnamed arkosic member	1,960	800	
Rico Formation	2,760	430	Salty water.
Hermosa Formation:			
Unnamed upper member	3,190	1,550	Salty water.
Paradox Member	4,740	2,410	
Unnamed lower member	7,150	332	
Molas Formation	7,482	75	
Leadville Limestone	7,557	178+	Black salty sulfur water (brine)
Total depth	7,735		
Willow Flat test well (D-28-19)6caa-1. Altitude: 6,100 feet.			
Dune sand	Surface	8	
Navajo Sandstone	8	37	
Kayenta Formation	45	115	
Wingate Sandstone	160	560	
Chinle Formation	720	455	Muddy, 780 to 800 feet.
Moenkopi Formation	1,175	445	
Cutler Formation:			
White Rim Sandstone Member	1,620	153	Dry.
Total depth	1,773		

Stratigraphic unit	Depth	Thickness	Remarks
Needles well 4 (D-30-19)25cdc-1. Altitude: 5,080 feet.			
Dune sand	Surface	8	
Cutler Formation:			
Cedar Mesa Sandstone Member	8	69+	Water at 52 ft, rises 26 ft above source.
Total depth	77		
Pure Oil, Lost Canyon No. 1 (D-30-20)19dca-1. Altitude: 5,007 feet.			
Cutler Formation:			
Cedar Mesa Member	Surface	185(?)	Dry(?). No water reported.
Rico Formation	185(?)	380(?)	Do.
Hermosa Formation:			
Unnamed upper member	565	1,320	Do.
Paradox Member	1,885	2,031	Evaporites (salt).
Unnamed lower member	3,916	461	
Leadville Limestone	4,377	531	
Ouray Limestone	4,908	120	
Elbert Formation:			
Unnamed upper member	5,028	129	
McCracken Sandstone Member	5,157	58+	
Total depth	5,215		
Needles well 2 (D-30-20)20dad-1. Altitude: 4,940 feet.			
Allvuial sand	Surface	56	Water at 21 ft.
Cutler Formation:			
Cedar Mesa Sandstone Member	56	9+	Water bearing.
Total depth	65		

Stratigraphic unit	Depth	Thickness	Remarks
Needles well 1 (D-30-20)21cbb-1. Altitude: 4,930 feet.			
Alluvial sand	Surface	17	
Cutler Formation:			
Cedar Mesa Sandstone Member	17	190	Dry(?), silty sandstone.
Rico Formation	207	46+	Salty water.
Total depth	253		Well plugged and abandoned.
Needles well 3 (D-30-20)30cba-1. Altitude: 5,020 feet.			
Alluvial sand	Surface	42	Water at 32 ft.
Cutler Formation:			
Cedar Mesa Sandstone Member	42	10+	Water bearing.
Total depth	52		

72-363

Figure 3.--Average annual precipitation and temperature at Canyonlands National Park and normal annual precipitation and temperature of stations at Hanksville, Moab, and Monticello.

Table 3.--Monthly and yearly mean discharge of the Green River at Green River, Utah

Station no. 3150, Green River at Green River, Utah (1914-69)

Location: Lat 38°59'10", long 110°09'02", in NW¼NW¼SW¼ sec. 15, T. 21 S., R. 16 E., Emery Co., on right bank 100 feet upstream from railroad bridge, 1 mile southeast of town of Green River, 22 miles upstream from San Rafael River, at mile 117.4 upstream from mouth.

Drainage area: 40,600 square miles, approximately.

Period of record: October 1894 to October 1899, October 1904 to current year. Published as "at Blake" 1894-99, as "near Elgin" 1911, and as "at Little Valley, near Green River" 1910-23.

Gage: Water-stage recorder. Datum of gage is 4,040.18 feet above mean sea level. Prior to Nov. 6, 1914, staff, wire-weight, or chain gages at several sites within 7 miles of present site at various datums. Nov. 6, 1914, to June 20, 1924, water-stage recorder at site 7 miles downstream at different datum. June 21 to Sept. 18, 1924, chain gage, and Sept. 19, 1924 to May 7, 1947, water-stage recorder, at site 100 feet downstream at present datum.

Average discharge: 56 years (1914-69), 4,410,750 acre-feet per year; 6,093 cfs.

Extremes: Period of record-Maximum discharge 68,100 cfs, June 27, 1917 (gage height 14.53 ft at site and datum then in use); minimum 255 cfs Nov. 26, 1931; minimum gage height 4.08 feet Aug. 1, Dec. 5, 1934.

Remarks: Records good. Diversions for irrigation above station. Flow regulated by Flaming Gorge Reservoir (see station 9-2344) since Nov. 1, 1962.

Monthly and yearly mean discharge (1914-69), in acre-feet and in cubic feet per second

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	The year
Acre-feet	166,480	149,880	121,500	117,210	138,360	266,540	456,810	999,290	1,161,870	465,380	214,290	152,780	4,410,750
cfs	2,708	2,519	1,976	1,906	2,491	4,335	7,677	16,252	19,526	7,569	3,485	2,568	6,093

Table 8.--Records of wells in Island In The Sky and the White Rim area

Name of well	Location number	Altitude (ft)	Depth (ft)	Static water level, in feet above(+) or below(-) land surface	Yield (gpm) / Drawdown (ft)	Specific capacity (gpm/ft)	Date of measurement	Aquifer	Remarks (CQ; chemical analysis in table 9)
Taylor Canyon 1	(D-27-17½)1ddc-1	4,000	500	+115	45/115	0.4	9-15-66	White Rim Sandstone Member	Flows; CQ.
Taylor Canyon 3	(D-27-18)9baa-1	4,170	585	-32	101/338	.3	3- 3-69	do.	Capped; CQ.
Taylor Canyon 2	(D-27-18)10aaa-1	4,240	585	-54	40/390	.1	2-20-69	do.	Do.
Willow Flat Test	(D-28-19)6caa-1	6,100	1,773	Dry	-	-	7-19-67	None	Capped; stratigraphic log in Appendix A.

72-363

Table 10.--Records of springs in The Needles area

Discharge: m, measured and e, estimated.

Name of spring	Location number	Altitude (ft)	Aquifer	Discharge (gpm)	Date	Permanence	Remarks (CQ; chemical analysis in table 11)
Loop Trail	(D-29½-19)36bbc-S1	4,390	Rico Formation	<0.1m	4- 7-70	Intermittent	CQ
Elephant	(D-30-19)9dbd-S1	4,750	do.	2e	4- 9-70	Perennial	Inaccessible.
Lower Jump	(D-30-19)12acb-S1	4,730	Cedar Mesa Sandstone Member	<.1e	5-20-69	Intermittent	CQ
Lower Little	(D-30-19)14aab-S1	4,780	Rico Formation	13m	4- 7-70	Perennial	Do.
Lower Big	(D-30-19)15adc-S1	4,780	do.	5m	4- 8-70	do.	Relatively inaccessible; CQ.
Little	(D-30-19)23add-S1	4,950	Cedar Mesa Sandstone Member	1e	3- 5-70	Intermittent	CQ
Squaw	(D-30-19)25cdc-S1	5,060	do.	10e	5- 2-68	Perennial	Do.
Big	(D-30-19)26cbc-S1	5,080	Rico Formation	2m	5- 2-68	do.	Do.
Soda	(D-30-19)27cdd-S1	5,180	Cedar Mesa Sandstone Member	.1m	7-17-68	do.	Do.
Lost Canyon	(D-30-20)31cdd-S1	5,030	Alluvium	10e	9- 4-69	do.	Probably originates from Cedar Mesa Member; CQ.
Cave	(D-30-20)20cdd-S1	4,930	Cedar Mesa Sandstone Member	<.1e	4- 7-70	Perennial	Contaminated by cow manure.
Hannover	(D-30½-19)34cac-S1	5,200	do.	.1e	10- 9-68	Intermittent	CQ.
Echo	(D-31-19)3bda-S1	5,270	do.	3e	12- 2-70	Perennial	Do.
Dorius	(D-31-19)4adc-S1	5,400	do.	<.1e	5-20-69	do.	Do.
Peekaboo	(D-31-20)6ada-S1	5,020	do.	3m	5- 2-68	do.	Do.

72-363

Table 2.--Monthly and yearly mean discharge of the Colorado River near Cisco, Utah

Station no. 1805, Colorado River near Cisco, Utah (1914-69)

Location: Lat 38°48'38", long 109°17'34", in NE¼NW¼NW¼ sec. 17, T. 23 S., R. 24 E., Grand Co., on left bank 1 mile downstream from Dolores River, 11 miles south of Cisco, 36 miles downstream from Colorado-Utah State line, 97 miles upstream from Green River, and 235 miles upstream from San Juan River, at mile 1,002.3.

Drainage area: 24,100 square miles, approximately, upstream from gage.

Period of record: January 1895 to current year (1895 to 1910, calendar-year estimates only). Monthly discharge only for some periods, published in WSP 1313. Published as Grand River near Moab, October 1913 to November 1914, and as Grand River near Cisco, November 1914 to September 1917.

Gage: Water-stage recorder. Altitude of gage is 4,090 feet from river-profile map. Prior to Nov. 10, 1914, several staff and chain gages at bridge near Moab, 31 miles downstream, at datum 3,937.73 feet above mean sea level.

Average discharge: 56 years (1914-69), 5,537,570 acre-feet per year; 7,649 cfs.

Extremes: Period of record-Maximum discharge, 76,800 cfs, June 19, 1917 (gage height 19.7 ft); minimum recorded, 558 cfs, July 21, 1934 (gage height 0.44 ft). Maximum discharge known, about 125,000 cfs, July 4, 1884, from flood records at Fruita, Colo.

Remarks: Records good. Diversions above station for irrigation and power, including several transmountain diversions. Flow regulated by Blue Mesa Reservoir (see station 9-1246) since Nov. 27, 1965.

Monthly and yearly mean discharge (1914-69), in acre-feet and cubic feet per second

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	The year
Acre-feet	223,100	202,670	175,800	161,520	158,910	207,260	507,780	1,337,470	1,520,750	569,290	263,640	201,430	5,537,570
cfs	3,628	3,406	2,859	2,627	2,861	3,371	8,534	21,752	25,557	9,259	4,288	3,385	7,649

Table 7.--Records of springs in Island In The Sky and White Rim area

Discharge: e, estimated and m, measured.

Name of spring	Location number	Altitude (ft)	Aquifer	Discharge (gpm)	Date	Permanence	Remarks (CQ; chemical analysis in table 9)
Hardscrabble	(D-27-17½)13cba-S1	3,990	White Rim Sandstone Member	1e	3- 4-70	Perennial	Seeps from a collapsed minerals-test drill hole; CQ.
Holeman	(D-27-18)27ccb-S1	4,640	Wingate Sandstone	8m	5-14-68	do.	CQ.
North	(D-27-18)15bdc-S1	4,890	do.	1.5m	5-15-68	Intermittent	Relatively inaccessible; CQ.
Sheep	(D-27-18)32dcb-S1	4,240	Moenkopi Formation	3e	3- 4-70	Perennial	Discharges in wash; CQ.
Cabin	(D-27-19)21bdc-S1	5,680	Navajo Sandstone	1m	10-24-67	Intermittent	Relatively inaccessible; CQ.
Neck	(D-27-19)22bbc-S1	5,670	do.	2.2m	4-11-68	do.	Do.
Willow Seep	(D-28-18)1abc-S1	5,920	do.	.1e	11-13-69	do.	A water source for wildlife; CQ.

72-363

Table 12.--Records of wells in The Needles area

Name of well	Location number	Altitude (ft)	Depth (ft)	Static water level, in feet below land surface	Yield (gpm) / Drawdown (ft)	Specific capacity (gpm/ft)	Date of measurement	Aquifer	Remarks (CQ; chemical analysis in table 11)
Needles well 4	(D-30-19)25cdc-1	5,080	77	24	$\frac{13}{28}$	0.5	5-20-65	Cedar Mesa Sandstone Member	
Needles well 5	(D-30-20)20aca-1	5,000	78	22	$\frac{44}{66}$	.7	7-17-68	do.	CQ
Needles well 2	(D-30-20)20dad-1	4,940	65	21	$\frac{33}{10}$	3.3	4-10-65	do.	CQ
Needles well 1	(D-30-20)21cbb-1	4,930	253	-	-	-	3-14-65	Rico Formation	Salt water at 207 feet, well abandoned.
Needles well 3	(D-30-20)30cba-1	5,020	52	18	$\frac{4}{20}$	.2	4-27-65	Cedar Mesa Sandstone Member	CQ

72·363

Table 4.--Flow-duration table

(From Iorns, Hembree, and Oakland, 1965, p. 150, 257)

[Italicized figures are for water years 1914-57 adjusted to 1957 conditions; figures opposite indicated water years are historical flow-duration data]

Station No.	Station name	Daily discharge, in cubic feet per second, that was equaled or exceeded for indicated percentage of time																			Average discharge (cfs)	Aver annu disch (acre
		0.01	0.06	0.15	0.6	2.0	4.0	7.0	12	20	30	40	50	60	70	80	90	97	99.4	99.9		
1805	Colorado River near Cisco, Utah-----------	62,270	59,540	55,710	47,950	38,090	30,970	25,250	18,760	11,020	6,060	4,200	3,540	3,180	2,820	2,520	2,160	1,580	975	746	7,639	5,534
	1916-17, 1923-57----	74,000	65,200	60,000	51,000	40,500	33,300	26,700	19,200	11,000	5,900	4,050	3,400	3,040	2,760	2,500	2,150	1,570	995	765	7,783	5,638
3150	Green River at Green River, Utah-----------	63,430	56,430	51,450	41,720	32,100	25,850	20,210	14,800	9,267	5,614	3,881	2,966	2,439	2,091	1,793	1,424	1,006	637	462	6,292	4,558
	1895-99, 1906-57----	67,000	59,000	53,900	44,000	34,100	27,500	21,400	15,650	10,300	5,895	4,050	3,100	2,500	2,130	1,790	1,410	1,010	698	500	6,658	4,823

72-363

Table 9.--Chemical analyses of water from selected sources in Island In The Sky and the White Rim area

[Analyses by U.S. Geol. Survey]

Source and location number	Geologic source	Date of collection	Temperature (°C)	Specific conductance (micromhos per cm at 25°C)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Hardness $CaCO_3$ Carbonate	Hardness $CaCO_3$ Noncarbonate	pH
					Milligrams per liter														
Hardscrabble Spring (D-27-17½)13cba-S1	White Rim Sandstone Member	3- 4-70	10.0	2,810	9.5	0.09	513	78	125	30	300	1,430	74	2.2	0.0	2,730	1,600	1,350	7.8
Holeman Spring (D-27-18)27ccb-S1	Wingate Sandstone	5-14-68	15.0	440	10	.00	43	30	15	3.5	272	24	8.3	.4	.3	261	232	9	7.9
Sheep Spring (D-27-18)32dcb-S1	Moenkopi Formation	3- 4-70	9.0	1,680	9.4	.09	160	105	94	15	219	765	28	.5	.0	1,410	830	650	7.7
Cabin Spring (D-27-19)21bdc-S1	Navajo Sandstone	10-24-67	9.0	197	8.1	.00	24	8.5	1.9	1.4	106	6.8	4.9	.1	5.0	108	95	8	7.5
Willow Seep (D-28-18)1abc-S1	do.	11-13-69	14.5	812	12	.05	80	49	13	3.4	447	19	20	.2	.4	500	400	33	7.9
Taylor Canyon well 1 (D-27-17½)1ddc-1	White Rim Sandstone Member	10- 8-68	13.0	2,870	8.5	.18	505	102	137	30	328	1,640	80	3.0	.6	2,730	1,680	1,410	7.7
Taylor Canyon well 3 (D-27-18)9baa-1	do.	3- 3-69	19.5	2,970	7.7	.30	393	78	233	43	382	1,160	140	3.7	.2	2,570	1,300	986	7.7
Taylor Canyon well 2 (D-27-18)10aaa-1	do.	2-20-69	20.0	2,560	7.4	.20	144	19	400	43	591	480	280	2.8	.3	1,720	440	0	8.0

72-363
Table 6

Table 6.--Duration table of dissolved-solids concentration

(From Iorns, Hembree, and Oakland, 1965, p. 158, 265)

[Table based on measured or partly estimated streamflow for the water years 1914-57 adjusted to 1957 conditions and on applicable chemical-quality records]

Station No.	Station name	Dissolved-solids concentration, in milligrams per liter, that was equaled or exceeded for indicated percentage of time																			Weighted-average concentration (mg/l)
		99.99	99.94	99.85	99.4	98	96	93	88	80	70	60	50	40	30	20	10	3	0.6	0.1	
1805	Colorado River near Cisco, Utah	238	239	240	241	248	258	273	309	415	660	895	1,030	1,130	1,240	1,350	1,470	1,680	1,810	1,850	547
3150	Green River at Green River, Utah	222	222	222	225	230	240	270	326	430	570	655	700	735	755	775	800	820	850	860	427

Table 1.--Lithology and water-bearing characteristics of exposed formations and deposits in Canyonlands National Park

[Adapted, with modifications, from Baker (1933), McKnight (1940), Williams (1964), Lewis and Campbell (1965), and Williams and Hackman (1971)]

System	Group	Formation	Member	Thickness (feet)	Lithology and water-bearing characteristics
Quaternary	(The ages of these deposits are undifferentiated)			0 - 12	Alluvial and eolian deposits, undifferentiated; mostly wind-deposited silt and sand on mesa tops, benches, broad slopes, and valleys; in part reworked by ephemeral runoff from storms; not known to yield water to wells or springs.
				0 - 62	Alluvial deposits, mainly sand, gravel, and silt in intermittent stream courses and their flood plains, and in canyon-bottom flood plains of the Green and Colorado Rivers; ground water is present as underflow in alluvium of the larger intermittent streams and the rivers. Yields good water to wells at Squaw Canyon and Salt Creek and springs at Lost Canyon, upper Elephant Canyon and Big Spring Canyon in The Needles area.
		Unconformity			
Jurassic	Glen Canyon Group	Navajo Sandstone		0 - 300	Pale-yellowish-orange to pale-reddish-brown fine- to medium-grained sandstone, in massive tabular sets of eolian crossbeds; includes sparse thin beds of gray sandy limestone with thin stringers and blebs of red chert; yields good water to a few small ephemeral springs in the Island In The Sky area.
Triassic(?)		Kayenta Formation		200 - 250	Irregular beds of red, tan, gray, and lavender shale, siltstone, sandstone, and locally thin to medium strata of tan-weathering gray silty limestone; not known to yield water in Canyonlands National Park.
Triassic		Wingate Sandstone		230 - 300	Medium-reddish-orange fine-grained sandstone in massive tabular sets of eolian crossbeds; yields good water to Coleman Spring, but generally too elevated and well drained to yield water in the park.
		Chinle Formation	Church Rock Member	200 - 475	Reddish-brown and variegated gray-brown siltstone, reddish-gray sandstone, lenses of conglomerate, and sparse intrastratal laminae of gypsum; not known to yield water in the park because of its elevated and well-drained position.
			Moss Back Member	0 - 150	Gray to greenish-gray thinly to thickly crossbedded fine-grained sandstone with layers of siltstone, calcareous sandstone, and conglomerate; lignitic debris, pyrite, and other metallic deposits not uncommon; too elevated and well-drained to yield water in the park.
		Unconformity			
		Moenkopi Formation	Unnamed upper member	250 - 400	Brownish-red to red thin to medium beds of siltstone, gray fine-grained micaceous, sandstone with thin lenses of quartz-grit conglomerate, and thin layers of brown mudstone; not known to yield water in the park.
			Hoskinnini Tongue	70 - 100	Reddish-brown to light-brown thin to thick beds of siltstone and fine- to medium-grained sandstone in tabular beds with sparse thin lenticular layers of light-gray limestone; yields water to Sheep Spring in the White Rim area, but not known to yield water in other areas of the park.
		Unconformity			
Permian		Cutler Formation	White Rim Sandstone Member	1[illegible] - 212	White, gray, and tan medium- to coarse-grained eolian crossbeds of quartz sandstone in medium to thick tabular sets; yields mineralized water to wells in Taylor Canyon; too elevated and well drained to bear water in other areas of the park.
			Unnamed arkosic member	0 - 450	Reddish-brown, reddish-purple, and reddish-orange, thin to thick crossbeds and tabular beds of coarse-grained conglomeratic arkosic sandstone with sparse thin lenses of red siltstone; intertongues complexly with other members of the Cutler Formation; not known to yield water in the park.
			Organ Rock Tongue	0 - 130	Reddish-brown sandy siltstone, thin lenticular beds of red silty sandstone and mudstone, and sparse laminae of gypsum; not known to yield water in the park.
			Cedar Mesa Sandstone Member	0 - 700	White, gray, tan, and light-red medium- to coarse-grained eolian crossbeds of quartz sandstone in extensive thick lenticular sets; yields good water to wells and springs in The Needles area.
Pennsylvanian		Rico Formation		300 - 450	Gray limestone with abundant red chert, red siltstone and purple, gray, and green marl and limestone; calcareous crossbedded sandstone; all in thin to medium beds; yields good water to springs in The Needles area, but contains saline water in the White Rim area.
		Hermosa Formation (in part)	Unnamed upper member	800±	Gray thin to thick beds of fossiliferous limestone; gray crossbedded fine-grained micaceous sandstone; and gray mudstone with red-gray laminae of sandy siltstone; contains brine.
			Paradox Member (upper part)	300+ (incomplete)	Banded-to-massive salt, gypsum, and anhydrite with thin layers of black shale; grades upward into black and gray shale, fossiliferous brown calcareous sandstone, and dark-gray dolomite with black chert; contains brine.
	(Base of exposed formations)				

72-363

Table 11.--Chemical analyses of water from selected sources in the Needles area

[Analyses by U.S. Geol. Survey]

Source and location number	Geologic source	Date of collection	Temperature (°C)	Specific conductance (micromhos per cm at 25°C)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Hardness ($CaCO_3$) Carbonate	Hardness ($CaCO_3$) Noncarbonate	pH
					Milligrams per liter														
Loop Trail Spring (D-29½-19)36bbc-S1	Rico Formation	4- 7-70	10.0	1,020	8.3	0.04	30	18	162	5.4	251	57	170	0.5	1.3	583	148	0	7.8
Lower Jump Spring (D-30-19)12acb-S1	Cedar Mesa Sandstone Member	5-20-69	13.0	3,250	14	.15	43	156	504	10	662	639	474	1.2	2.0	2,180	750	207	8.1
Lower Little Spring (D-30-19)14aab-S1	Rico Formation	4- 7-70	10.5	571	9.2	.02	59	21	39	3.6	338	25	16	.3	.2	337	234	0	7.6
Lower Big Spring (D-30-19)15adc-S1	do.	4- 8-70	10.5	405	7.7	.05	46	17	19	2.8	233	13	5.8	.1	1.0	236	182	0	7.7
Little Spring (D-30-19)22add-S1	Cedar Mesa Sandstone Member	3- 5-70	9.0	404	5.6	.03	58	11	12	3.4	203	38	10	.3	.0	237	188	17	7.4
Squaw Spring (D-30-19)25cdc-S1	do.	5- 2-68	14.0	475	8.0	-	68	18	12	1.5	294	18	6.2	.2	.3	279	244	3	7.8
Big Spring (D-30-19)26cbc-S1	Rico Formation	5- 2-68	16.0	439	4.6	-	63	18	7.8	2.0	276	13	4.1	.2	1.2	257	230	4	7.7
Soda Spring (D-30-19)27cdd-S1	Cedar Mesa Sandstone Member	7-17-68	22.0	571	9.5	.01	90	20	6.6	3.5	362	18	6.2	.0	.1	334	308	11	7.7
Lost Canyon Spring (D-30-19)31cdd-S1	Alluvium	9- 4-69	13.5	611	14	.02	71	34	13	3.6	414	8.8	10	.1	.1	365	316	0	8.0
Hannover Spring (D-30½-19)34cac-S1	Cedar Mesa Sandstone Member	10- 9-68	13.0	101	1.6	.04	18	2.9	.7	1.0	60	3.8	1.6	.1	1.3	54	56	7	7.4
Echo Spring (D-31-19)3bda-S1	do.	12- 2-70	12.0	450	6.0	.01	73	9.4	4.9	1.9	282	12	3.2	.2	.2	250	139	220	8.1
Dorius Spring (D-31-19)4adc-S1	do.	5-20-69	13.0	405	6.2	.07	69	12	3.0	1.1	279	1.8	3.8	.2	.7	228	221	0	8.1
Peekaboo Spring (D-31-20)6ada-S1	do.	5- 2-68	13.0	640	6.8	-	48	43	29	3.9	336	52	21	.4	.3	380	296	20	7.8
Rain pool (D-30-19)14dbc	do.	4- 8-70	16.0	150	1.4	-	25	1.7	2.7	2.6	65	22	4.1	.2	.1	131	70	16	7.2
Needles well 4 (D-30-20)20aca-1	do.	10- 9-68	15.0	1,490	16	.07	88	73	162	1.6	536	223	128	.9	.3	926	520	80	8.0
Needles well 3 (D-30-20)30cba-1	do.	5- 2-68	14.0	1,380	17	-	36	92	150	3.4	496	214	122	1.1	.5	867	468	61	7.9
Needles well 2 (D-30-20)20dad-1	do.	5- 2-68	15.0	524	8.4	-	71	22	19	1.6	322	17	9.3	.3	.2	305	268	4	7.9

72-363

Table 5.-- Relation between water discharge and chemical quality of water

(From Iorns, Hembree, and Oakland, 1965, p. 165, 278)

[Data are for the water years 1914-57 adjusted to 1957 conditions. Chemical quality data and weighted averages are in milligrams per liter]

Mean discharge (cfs)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Boron (B)	Dissolved solids (residue at 180°C): Milligrams per liter	Dissolved solids: Tons per acre-ft	Dissolved solids: Tons per day	Hardness as $CaCO_3$: Calcium magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Specific conductance (micromhos at 25°C)	Sodium-adsorption ratio
1805. Colorado River near Cisco, Utah																
62,270	39	6.8	13	2.2	120	53	2.4	0.04	238	0.32	40,010	126	27	18	378	0.5
59,540	39	6.9	14	2.2	121	55	2.5	.04	239	.33	38,420	126	27	19	380	.5
55,710	40	7.1	15	2.2	122	57	2.5	.04	240	.33	36,100	129	29	20	380	.6
47,950	41	7.5	16	2.2	125	63	2.6	.04	241	.33	31,200	134	31	20	380	.6
38,090	43	8.5	18	2.2	128	73	3.0	.05	248	.34	25,510	142	38	21	390	.7
30,970	45	9.3	22	2.2	134	85	3.2	.05	258	.35	21,570	150	40	24	403	.8
25,250	47	11	25	2.3	139	97	3.6	.05	273	.37	18,610	162	48	25	435	.9
18,760 1/	51	13	31	2.5	146	121	4.5	.05	309	.42	15,650	180	61	27	480	1.0
11,020	60	17	47	2.7	160	176	6.6	.06	415	.56	12,350	220	88	31	645	1.4
6,060	70	25	79	3.6	178	281	11	.08	660	.90	10,800	278	132	38	1,010	2.1
4,200	84	33	106	4.3	194	389	15	.09	895	1.22	10,150	345	186	40	1,300	2.5
3,540 2/	97	37	123	4.9	202	460	17	.10	1,030	1.40	9,840	394	228	40	1,480	2.7
3,180	102	40	138	5.1	211	506	19	.11	1,130	1.54	9,700	419	246	41	1,600	2.9
2,820	109	46	160	5.6	219	575	21	.12	1,240	1.69	9,440	461	282	43	1,740	3.2
2,520	125	50	172	5.9	230	650	24	.14	1,350	1.84	9,190	518	329	42	1,850	3.3
2,160 3/	142	60	190	6.7	230	770	29	.17	1,470	2.00	8,570	601	412	40	2,000	3.4
1,580	180	78	210	8.5	230	975	35	.22	1,680	2.28	7,170	770	581	37	2,280	3.3
975	220	85	215	10	230	1,080	48	.27	1,810	2.46	4,760	898	710	34	2,400	3.1
746	235	90	220	12	230	1,150	60	.28	1,850	2.52	3,730	956	768	33	2,450	3.1
7,639	66	21	62	3.2	162	233	8.8	.07	547	.74	11,280	251	118	35	806	1.7
3150. Green River at Green River, Utah																
63,430	44	10	19	1.9	160	52	8.5	0.07	222	0.30	38,020	151	20	21	345	0.7
56,430	44	10	19	1.9	160	52	8.6	.07	222	.30	33,820	151	20	21	350	.7
51,450	44	10	19	2.0	160	52	8.6	.07	222	.30	30,840	151	20	21	350	.7
41,720	44	10	20	2.0	160	54	8.6	.07	225	.31	25,350	151	20	22	350	.7
32,100	45	10	21	2.2	160	59	8.8	.08	230	.31	19,930	154	22	23	355	.7
25,850	45	11	23	2.3	160	64	9.2	.08	240	.33	16,750	158	26	24	375	.8
20,210	45	11	25	2.4	160	69	10	.08	270	.37	14,730	158	26	25	410	.9
14,800 1/	46	12	29	2.6	162	80	11	.09	326	.44	13,030	164	32	27	475	1.0
9,276	50	14	37	2.8	169	104	15	.09	430	.58	10,760	182	44	30	615	1.2
5,614	57	20	56	3.1	193	153	23	.10	570	.78	8,640	224	66	35	780	1.6
3,881	65	26	75	3.4	214	210	30	.11	655	.89	6,860	269	94	37	890	2.0
2,966 2/	71	31	86	3.6	228	252	36	.11	700	.95	5,610	304	118	38	945	2.1
2,439	74	34	95	3.8	230	280	39	.11	735	1.00	4,840	324	136	39	1,000	2.3
2,091	76	36	100	3.9	232	300	43	.12	755	1.03	4,260	338	148	39	1,030	2.4
1,793	78	39	106	4.0	234	322	46	.12	775	1.05	3,750	355	163	39	1,060	2.4
1,424 3/	81	41	112	4.2	236	345	50	.12	800	1.09	3,080	370	177	39	1,100	2.5
1,006	83	42	119	4.5	238	360	54	.13	820	1.12	2,230	380	184	40	1,130	2.7
637	85	43	122	5.0	240	370	57	.14	850	1.16	1,460	388	192	40	1,170	2.7
462	87	44	122	5.4	240	370	58	.14	860	1.17	1,070	398	201	40	1,170	2.7
6,292	54	18	45	2.8	181	130	19	.09	427	.58	7,260	208	60	32	608	1.4

1/ 12 percentile of water discharge.

2/ 50 percentile of water discharge.

3/ 90 percentile of water discharge.

Figure 2.--Geologic and hydrologic map of Canyonlands National Park.