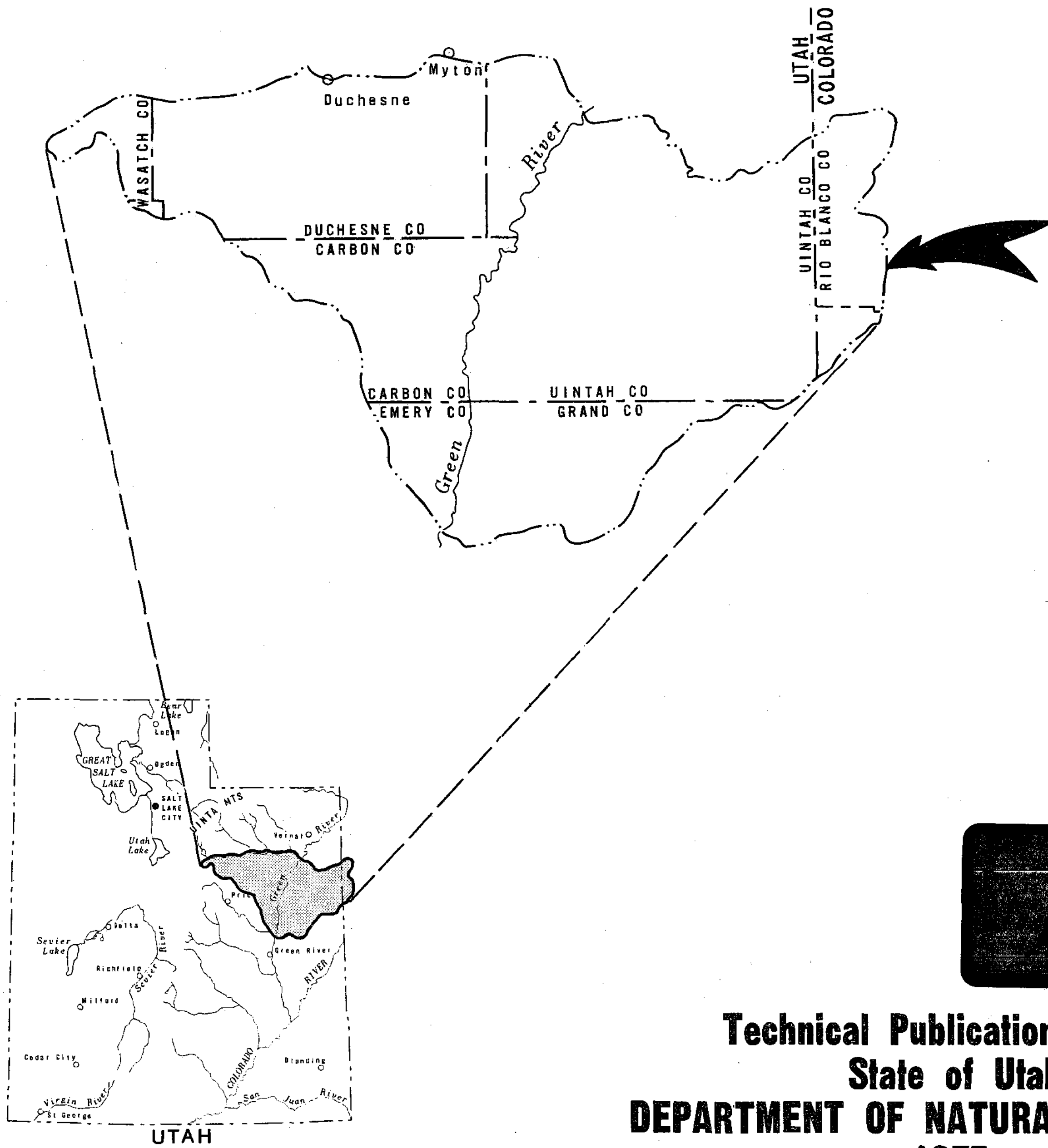
HYDROLOGIC RECONNAISSANCE OF THE SOUTHERN UINTA BASIN, UTAH AND COLORADO



SOUTHERN UINTA BASIN

Technical Publication No. 49
State of Utah
DEPARTMENT OF NATURAL RESOURCES
1975

STATE OF UTAH
DEPARTMENT OF NATURAL RESOURCES

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HYDROLOGIC RECONNAISSANCE OF THE SOUTHERN UINTA BASIN, UTAH AND COLORADO

by

Don Price and Louise L. Miller
U.S. Geological Survey

Prepared by
the United State Geological Survey
in cooperation with
the Utah Department of Natural Resources
Division of Water Rights

1975

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Metric units

Most numbers are given in this report in English units followed by metric units in parentheses. The conversion factors used are:

English Units (Multiply)	English Abbreviation	(by)	Metric Units (to obtain)	Metric Abbreviation
Acres	acre	0.4047	Square hectometres	hm^2
Acre-feet	acre-ft	.0012335	Cubic hectometres	hm^3
Cubic-feet	ft^3	.02832	Cubic metres	m^3
Feet	ft	.3048	Metres	m
Gallons	gal	3.7854	Litres	l
		.0037854	Cubic metres	m^3
Gallons per minute	gal/min	.06309	Litres per second	l/s
Inches	in.	25.4	Millimetres	mm
Miles	mi	1.6093	Kilometres	km
Square miles	mi^2	2.59	Square kilometres	km^2

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

Chemical concentration in terms of ionic interacting values is given in milliequivalents per litre (meq/l). Meq/l is numerically equal to the English unit, equivalents per million.

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

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ABSTRACT

The southern Uinta Basin covers about 4,900 square miles (12,690 km^2) in northeastern Utah and northwestern Colorado. For the most part, it is an arid to semiarid region; during the period 1941-70, average annual precipitation ranged from less than 8 inches (203 mm) in the north-central part to more than 26 inches (660 mm) in the extreme western part. The area is sparsely populated, averaging about one person for every 4.5 square miles (12 km^2). It is utilized mainly for livestock grazing and the production of oil and gas; the area is noted for its large reserves of oil shale.

The average annual volume of precipitation that fell on the southern Uinta Basin is estimated to have been about 3.1 million acre-feet (3,800 hm^3) during the period 1941-70. Net imports of water from the Duchesne River for irrigation within the southern Uinta Basin average about 70,000 acre-feet (86.3 hm^3) per year as of 1972.

About 94 percent of the average annual water supply from precipitation and imports is consumed within the southern Uinta Basin by evapotranspiration and sublimation from the winter snowpack. Phreatophytes along perennial and intermittent streams consume an estimated 204,000 acre-feet (252 hm^3) of water annually, and another 184,000 acre-feet (227 hm^3) is estimated to leave the area annually as surface and subsurface runoff and irrigation return flow.

Total recoverable ground water in storage in unconsolidated deposits and in the upper 100 feet (30.5 m) of saturated consolidated rocks is estimated to be on the order of 3.2 million acre-feet (3,947 hm^3), with ground-water recharge providing an estimated average annual replenishable supply of about 120,000 acre-feet (148 hm^3). Most of the ground water occurs in fine-grained sedimentary rocks and is generally yielded slowly to wells and springs--less than 50 gal/min (3.2 l/s)--in most places. The more highly permeable unconsolidated deposits beneath the alluvial plains of larger streams can yield more than 100 gal/min (6.3 l/s), but these deposits are thin and of small extent, containing only about 190,000 acre-feet (234 hm^3) of recoverable water in storage.

Both the surface water and ground water are saline throughout a major part of the southern Uinta Basin. Only in the headwater areas along the south rim of that subbasin can fresh water generally be found. The concentration of dissolved solids in water from streams for which analyses were available ranges from less than 400 mg/l in headwater areas to more than 7,000 mg/l in the lower reaches of some streams. The concentration of dissolved solids in ground water for which analyses were available ranges from less than 200 mg/l from shallow aquifers in headwater areas to more than 100,000 mg/l in samples collected from deep oil tests.

The opportunity to develop large water supplies from sources within the southern Uinta Basin is limited by the generally poor chemical quality and uneven time and areal distribution of the water. The most promising opportunities for obtaining large sustained water supplies are surface reservoir storage of runoff in the headwaters of the larger streams, such as Willow Creek, or development of the alluvial aquifers adjacent to the larger streams, including the Green, White, and Duchesne Rivers.

INTRODUCTION

This report summarizes the findings of an investigation of the water resources of the southern Uinta Basin conducted by the U.S. Geological Survey in cooperation with the Utah Department of Natural Resources, Division of Water Rights. The purpose of the investigation was to evaluate the water resources of the southern Uinta Basin on a reconnaissance level and to provide information to assist in future planning and development of the water and related land resources.

The investigation was started in July 1971 and continued intermittently through December 1973. Most of the basic data used in the study were gathered from the files of the Geological Survey, the Division of Water Rights, and the Utah Division of Oil and Gas Conservation. Supplementary data on wells, springs, streamflow, and vegetation were collected in the field during five 3-5 day trips during the summer of 1971 and spring and summer of 1972. Much of the basic data collected for the investigation are included in tables 10-15.

A number of agencies provided assistance in obtaining data for the study. Personnel of the Utah Division of Oil and Gas Conservation assisted in obtaining ground-water quality data from oil and gas companies operating in the area; personnel of the U.S. Bureau of Land Management provided information about wells and springs on Bureau-administered land in the area; and personnel of the Ute Indian Tribe provided information about wells and springs on lands in the Uintah-Ouray Indian Reservation. The cooperation and assistance of these people, personnel of oil and gas companies who provided information, and all individual well and spring owners interviewed during the investigation is gratefully acknowledged.

The water resources of the southern Uinta Basin have received little previous study. Woolley (1930) and Thomas (1952) described the hydrology of the Green River, including the reach that passes through the Uinta Basin. Some hydrologic information about the area is included in a comprehensive study of the water resources of the Upper Colorado River Basin by Iorns and others (1964 and 1965). Feltis (1966) compiled some information about availability and chemical quality of water and briefly described the water-bearing properties of some of the geologic units in the Uinta Basin. Weir (1970) compiled considerable geohydrologic data collected from an oil-shale exploration well in the north-central part of the southern Uinta Basin.

The Uinta Basin includes about 10,000 square miles (25,900 km^2) in northeastern Utah and northwestern Colorado. The area described in this report includes that part of the Uinta Basin that lies south of the Strawberry, Duchesne, and White Rivers in Utah and Colorado. It includes approximately 4,900 square miles (12,690 km^2)--mostly in Duchesne and Uintah Counties, Utah, but also in parts of Carbon, Emery, Grand, Utah, and Wasatch Counties, Utah, and Garfield and Rio Blanco Counties, Colo. (See fig. 1.)

The southern Uinta Basin is sparsely populated, averaging about one person for every 4.5 square miles (12 km^2). Most of the total estimated population (about 1,100 in 1972 as estimated from the 1970 U.S. Census) is concentrated along the Duchesne River between Duchesne and Myton. Probably less than 100 people reside in the remaining part of the southern Uinta Basin, which includes mostly Federal and Uintah-Ouray Indian Reservation land. However, the economy of such communities as Roosevelt and Vernal, Utah, which are in the northern Uinta Basin, and Rangely, Colo., is based partly on natural resources of the southern Uinta Basin.

The southern Uinta Basin is noted for its oil and gas production and its large reserves of oil shale. With the exception of exploration for and production of fossil fuels, the land is utilized almost exclusively for livestock grazing and recreation. There are about 26,000 acres (10,520 hm^2) of irrigated cropland in the Duchesne-Myton-Pleasant Valley area, and the principal crops are meadowgrass, alfalfa, and small grains.

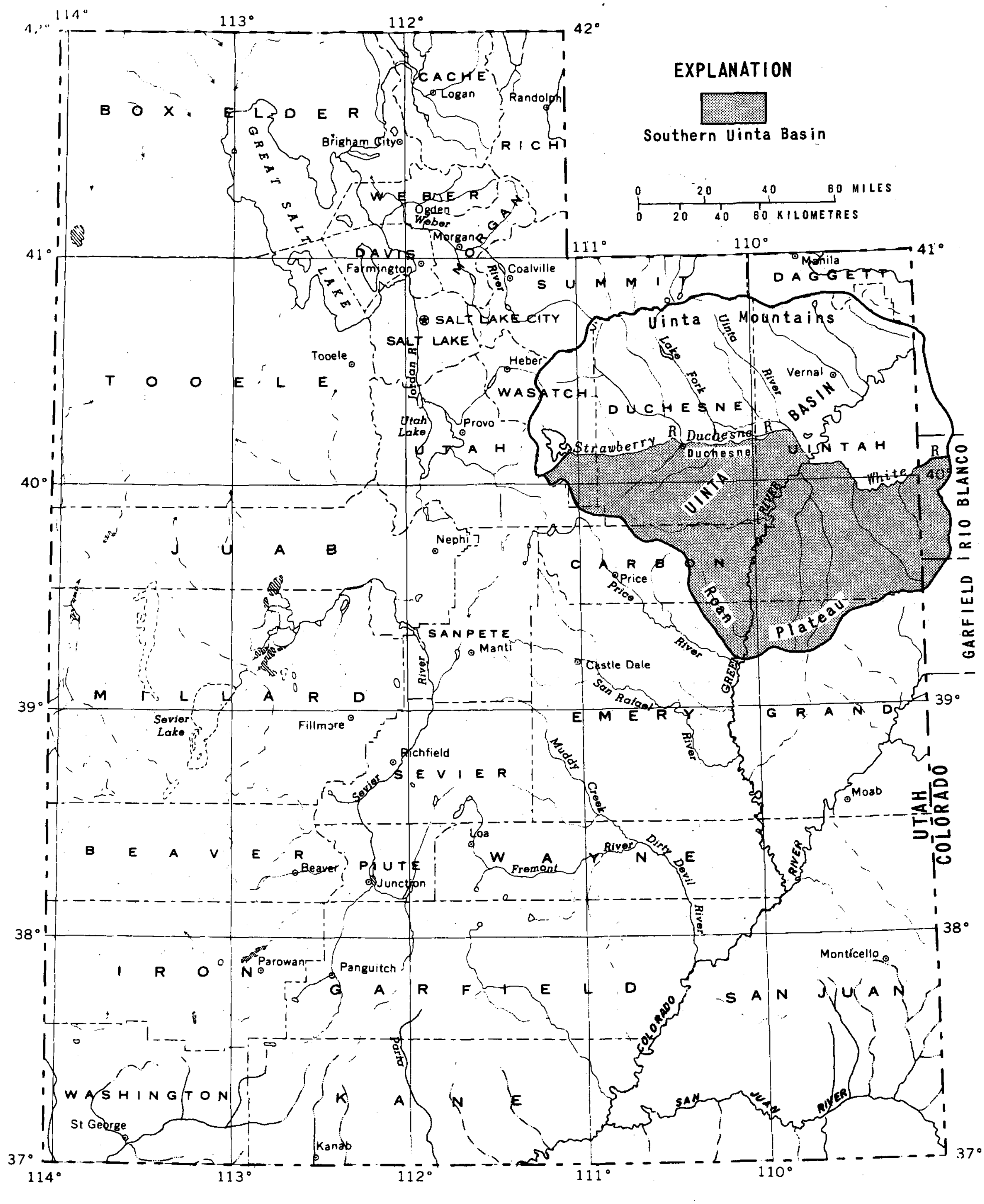

Figure I.— Location of the southern Uinta Basin.

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 (fig. 2). Numbers designating the township and range (in that order) follow the quadrant letter, and all three are enclosed in parentheses. The number after the parentheses indicates the section, and is followed by three letters indicating the quarter section, the quarter-quarter section, and the quarter-quarter-quarter section--generally 10 acres (4 hm^2);[1] the letters a, b, c, and d indicate, respectively, the northeast, northwest, southwest, and southeast quarters of each subdivision. The number after the letters is the serial number of the well or spring within the 10-acre (4 hm^2) tract; the letter "S" preceding the serial number denotes a spring. If a well or spring cannot be located within a 10-acre (4 hm^2) tract, one or two location letters are used and the serial number is omitted. Thus, the number (D-9-17)21dca-1 designates the first well constructed or inventoried in the NE¼SW¼SE¼ sec. 21, T. 9 S., R. 17 E., and the number (D-16-17)3c-S1 designates the first spring inventoried in the SW¼ sec. 3, T. 16 S., R. 17 E., as related to the Salt Lake base line and meridian.

In the Uinta Basin, part of the "D" quadrant has been subdivided by the Uintah base line and meridian as shown in figure 2. Wells and springs in this land parcel are numbered in the same manner described above, but the numbers are preceded by the letter "U" to show that they are related to the Uintah base line and meridian. Thus well U(C-4-4)1daa-1 is the first well constructed or inventoried in the NE¼NE¼SE¼ sec. 1, T. 4 S., R. 4 W., Uintah base line and meridian.

[1]Although the basic land unit, the section, is theoretically a 1-mile (1.6 km) square, many sections are irregular. Such sections are subdivided into 10-acre (4 hm^2) tracts, generally beginning at the southeast corner, and the surplus or shortage is taken up in the tracts along the north and west sides of the section.

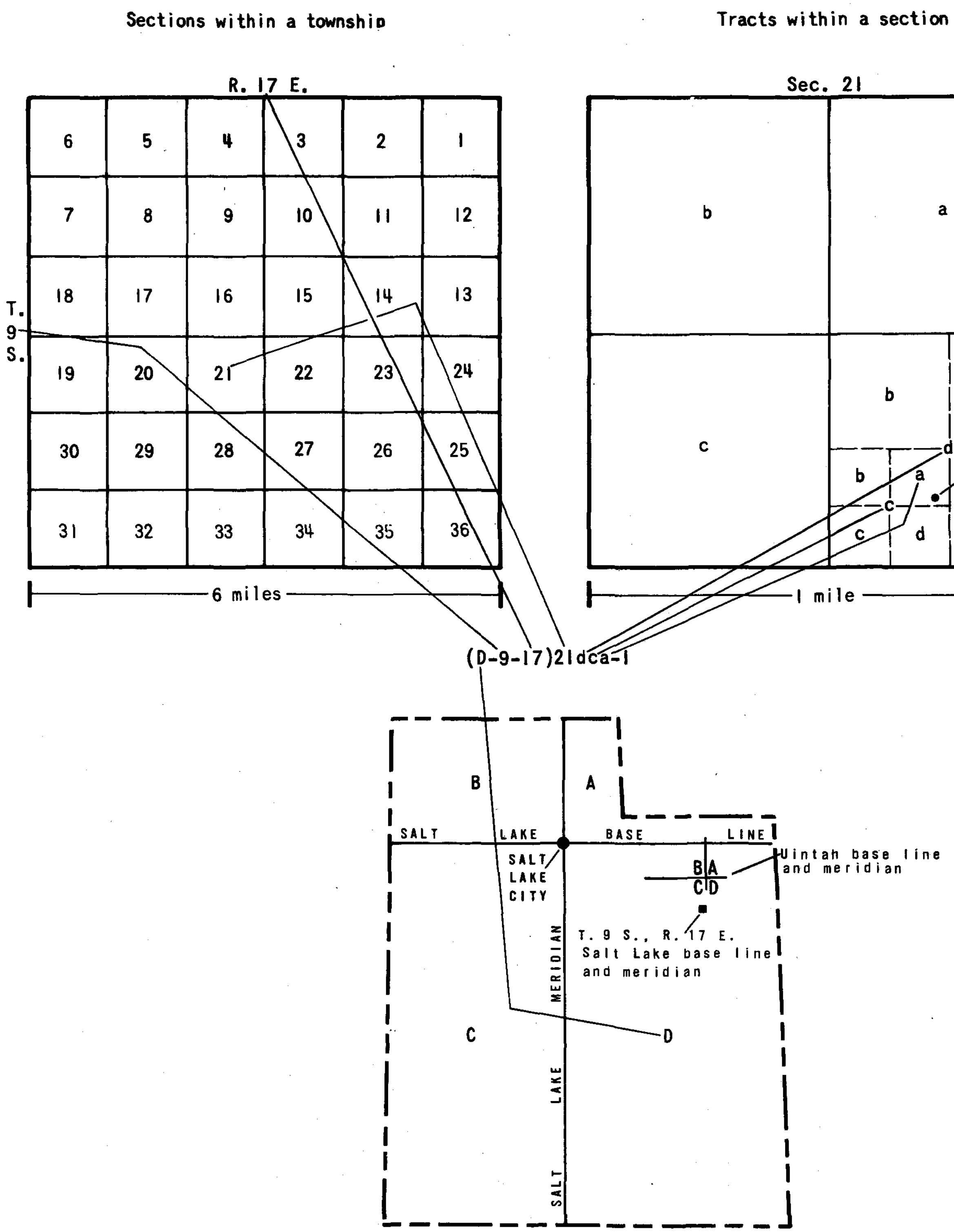

Figure 2.— Well- and spring-numbering system used in Utah.

GENERAL HYDROLOGIC ENVIRONMENT

Physiography and drainage

The Uinta Basin is in the Colorado Plateaus physiographic province (Fenneman and Johnson, 1946). It is a broad east-west trending structural basin bounded on the north by the lofty Uinta Mountains and on the south by the high Roan Plateau. The area of this report lies entirely on the south flank of the basin and is dissected into two nearly equal parts by the deeply incised southward-flowing Green River.

The surface of the southern Uinta Basin ascends rather uniformly from an altitude of about 4,700 feet (1,433 m) above mean sea level near the confluence of the Green, White, and Duchesne Rivers to more than 9,000 feet (2,743 m) along the crest of the Roan Plateau. Continuity of this surface is interrupted by deep narrow canyons of the Green River and its larger tributaries. The canyons have step-back walls whereby harder rock layers form vertical cliffs while the softer rock layers form gentle slopes. Maximum depths in the larger canyons exceed 1,000 feet (305 m), and the floors of even the largest canyons generally are less than half a mile (0.8 km) wide at their widest sections. Prominent mesas, benches, and flats, such as Flat Rock Mesa, Pariette Bench, and Wolf Flat dominate the interstream areas (pl. 1).

The lowest point in the southern Uinta Basin is about 4,200 feet (1,280 m) where the Green River crosses the south boundary; the highest point is about 10,285 feet (3,135 m) at Bruin Point, near the head of Range Creek (pl. 1). Thus, total relief in the area is more than 6,000 feet (1,829 m).

The principal streams that originate in the southern Uinta Basin are consequent. Most of these streams flow generally northward. Exceptions include Nine Mile and Range Creeks and Pariette Draw, which flow generally eastward. All drainage is ultimately to the Green River, which is the largest tributary of the Colorado River.

General geology

The geology of the southern Uinta Basin has been intensely studied from the standpoint of its oil and gas production and evaluation of oil-shale reserves. Selected references that describe the geology of the southern Uinta Basin are given on pages 46-48.

The Uinta Basin is a large synclinal trough formed by the deformation of Tertiary and older rocks. The main axis of the syncline trends generally eastward and lies roughly 10 to 20 miles (16 to 32 km) north of the northern boundary of the southern Uinta Basin (fig. 3). Thus, the rock strata in the southern Uinta Basin dip generally to the north. Exposed rocks range in age from Cretaceous to Holocene but pre-Cretaceous rocks have been penetrated by oil and gas wells and tests. (See pl. 1).

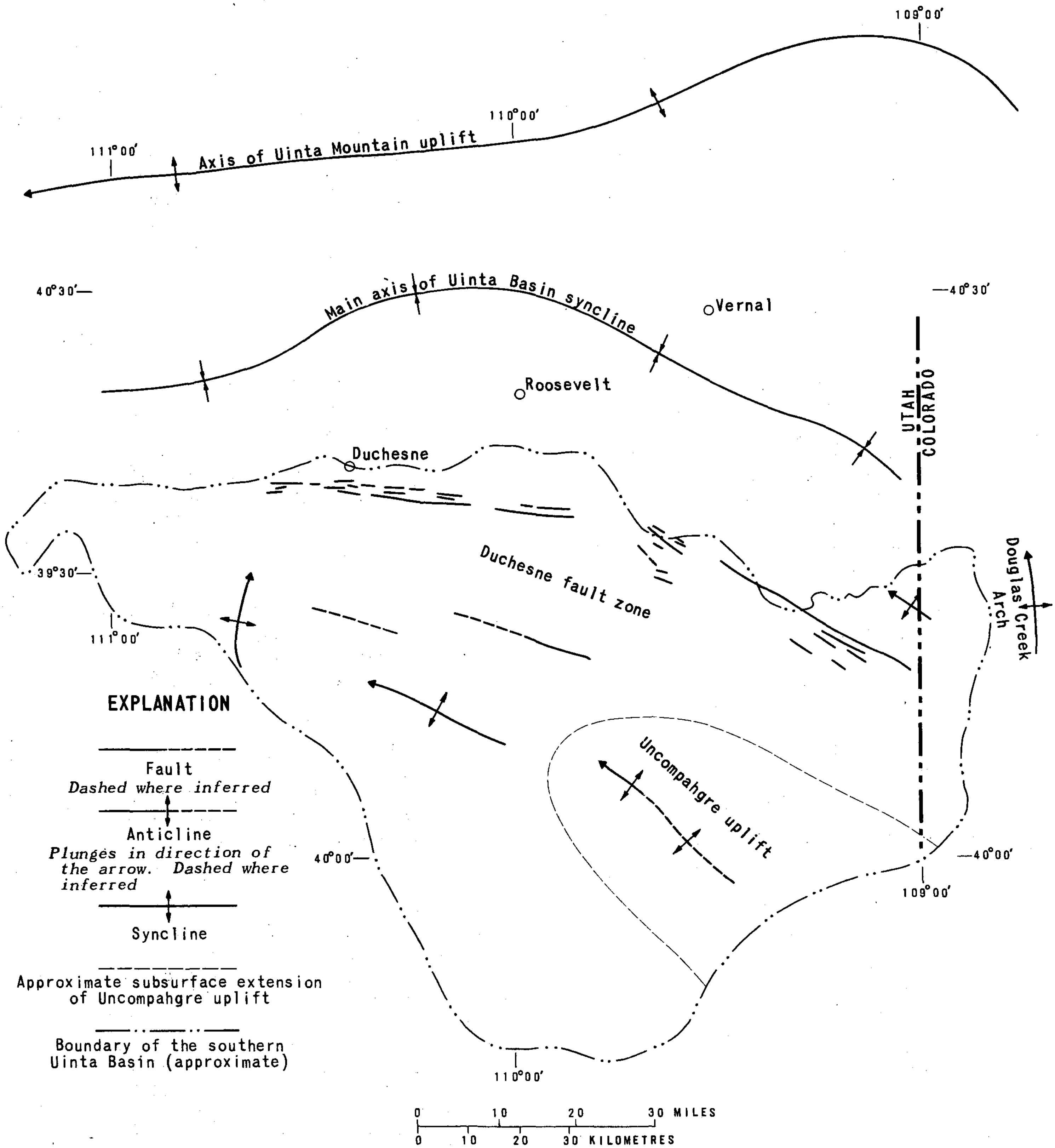

Figure 3.– Sketch showing major structural features in the Uinta Basin (after Ritzma, 1957).

The general lithologic character and water-bearing properties of the geologic formations that are exposed in the southern Uinta Basin are given in table 1. Older rocks that are encountered in the subsurface are exposed along the south flank of the Uinta Mountains, a short distance to the north, or in the Book Cliffs, to the south. The general stratigraphic section of these rocks prepared by Cashion (1967, p. 5) after Kinney (1955) is given in the following table:

System	Unit	Thickness (ft)	Dominant lithology
Cretaceous	Mesaverde Formation (Group)	1,100	Sandstone and shale
	Mancos Shale	5,070-5,290	Shale, siltstone, and sandstone
	Dakota Sandstone	95- 135	Sandstone and shale
	Cedar Mountain Formation[1]	50- 176	Sandstone and shale
Jurassic	Morrison Formation	830- 930	Sandstone, mudstone, and shale
	Curtis Formation	150- 270	Sandstone, shale, and limestone
	Entrada Sandstone	105- 215	Sandstone
	Carmel Formation	125- 390	Shale and sandstone
Jurassic and Triassic	Glen Canyon Sandstone	720-1,030	Sandstone
Triassic	Chinle Formation	230- 355	Shale, sandstone, and conglomerate
	Moenkopi Formation	820-1,120	Sandstone and siltstone
Permian	Park City Formation	70- 195	Limestone and shale
Permian and Pennsylvanian	Weber Sandstone	1,015-1,275	Sandstone
Pennsylvanian	Morgan Formation	1,035-1,450	Limestone and sandstone
Mississippian	Black shale unit	0- 265	Shale and sandstone
	Limestone unit	965-1,220	Limestone
Cambrian	Lodore Formation	0- 155	Sandstone
Precambrian	Uinta Mountain Group	3,000-4,000	Shale and sandstone

[1]Added by writers.

Table 1.--General lithologic character and water-bearing properties of exposed geologic units

Geologic age	Geologic unit	General lithologic character	General water-bearing properties
Quaternary	Unconsolidated deposits	Alluvium, glaciofluvial deposits, terrace gravels, and dune sand. Clay, sand, gravel, and cobbles beneath the alluvial plains of the larger streams and adjacent terraces and in the Pleasant Valley Wash area. Mostly gravel, sand, and silt on benches and in the channels of some ephemeral streams. Thickness generally less than 50 feet (15 m), but locally may be more than 150 feet (46 m) as at well U(C-5-5)34bdd-1 (table 11).	Sand, gravel, and cobble deposits beneath stream valleys generally yield less than 50 gal/min (3.2 l/s), but may yield more than 100 gal/min (6.3 l/s) to large-diameter wells that tap thick saturated sections. Many of the terrace deposits are unsaturated or saturated only part of the year.
Tertiary	Uinta Formation	Mostly thinly bedded shale, siltstone, and fine-grained sandstone with interbedded claystone and limestone. Individual beds generally less than 50 feet (15 m) thick. Maximum aggregate thickness more than 4,000 feet (1,219 m). Many of the strata are oil impregnated and the formation is cut in several places by gilsonite and ozocerite dikes.	Not water bearing in many places, having been drained by deeply incised streams. Where saturated (generally in discontinued perched aquifers) commonly yields less than 5 gal/min (0.32 l/s) to springs; exceptions are in Strawberry River drainage where several springs discharge an estimated 50-500 gal/min (3.2-32 l/s). Yields less than 20 gal/min (1.3 l/s) to most wells.
	Green River Formation	Thinly bedded strata of shale, siltstone, mudstone, fine-grained sandstone; some limestone and tuff. The percentage of thicker, more massive sandstone strata increases to the south. Maximum thickness of the formation exceeds 5,000 feet (1,524 m) in the north-central part of the area. Formation is noted as a source of oil and gas; the Parachute Creek Member, which comprises more than 95 of the exposed formation, contains extensive deposits of oil shale.	Overall permeability is low. All known springs that discharge from the formation discharge from the Parachute Creek Member; most yield less than 10 gal/min (0.63 l/s), and many yield less than 1 gal/min (0.06 l/s). Reported yields to the few wells that tap the formation are generally less than 10 gal/min (0.63 l/s), but several oil tests that tap the formation reportedly had initial flows of more than 100 gal/min (6.3 l/s). Upper part of the formation is not water bearing in many places owing to low permeability or having been drained by deeply incised streams.
	Wasatch Formation	Mostly shale, siltstone, and fine- to medium-grained sandstone with some lenticular conglomerate. Maximum thickness of formation exceeds 4,000 feet (1,219 m). The formation is an important source of oil and gas in the Uinta Basin.	Test data from oil and gas wells indicate that overall permeability is generally low. The formation generally yields less than 50 gal/min (3.2 l/s) of water to springs and wells (oil and gas wells), but more than 100 gal/min (6.3 l/s) to two springs in the area. No water wells are known to tap the formation in the study area.
Tertiary and Cretaceous	Sedimentary rocks, undivided	Includes Colton Formation, Flagstaff Limestone, North Horn Formation, and Mesaverde Group (Tuscher Formation). Consist chiefly of shale, siltstone, mudstone, and fine-grained sandstone; some limestone and lenticular conglomerate and coal beds. Maximum exposed thickness exceeds 2,000 feet (610 m). Maximum aggregate thickness (including units in the subsurface) exceeds 7,000 feet (2,134 m).	Permeability generally low. Support the flow of several widely scattered springs. Yields of three springs discharging from the North Horn Formation ranged from less than 1 gal/min (0.06 l/s) to about 6 gal/min (0.38 l/s). Oil-test data indicate that the rocks would yield less than 10 gal/min (0.63 l/s) of water to individual wells.

Little is known of the water-bearing properties of the older formations where they underlie the southern Uinta Basin. In adjacent areas, those of the older formations that contain sandstone and limestone as dominant lithologies locally have moderate to high permeablity. For example, the Weber Sandstone of Permian and Pennsylvanian age, which was reportedly penetrated by Continental Oil Co. test well no. 22-1 (pl. 2), is a major aquifer in the Ashley Valley oil field just north of the area. (See Goode and Feltis, 1962, and Feltis, 1966.) However, data from the few oil and gas wells and tests that penetrate the older rocks within the southern Uinta Basin indicate that these rocks generally have low permeability and commonly yield very saline to briny water.

Climate

Most of the southern Uinta Basin is arid to semiarid. Above an altitude of about 8,000 feet (2,438 m), the climate is subhumid to humid.

Average annual precipitation (1941-70) ranged from less than 8 inches (203 mm) in the north-central part of the southern Uinta Basin to more than 26 inches (660 mm) in the extreme western part (pl. 1). Annual precipitation at Duchesne ranged from 4.60 to 15.70 inches (117 to 399 mm) and averaged 9.19 inches (233 mm) during 1906-72. A curve of cumulative departure from the 1906-72 average (fig. 4) indicates that dry cycles occurred in the area during the mid-1930's, the late 1950's, early 1960's, and from 1965 to 1972.

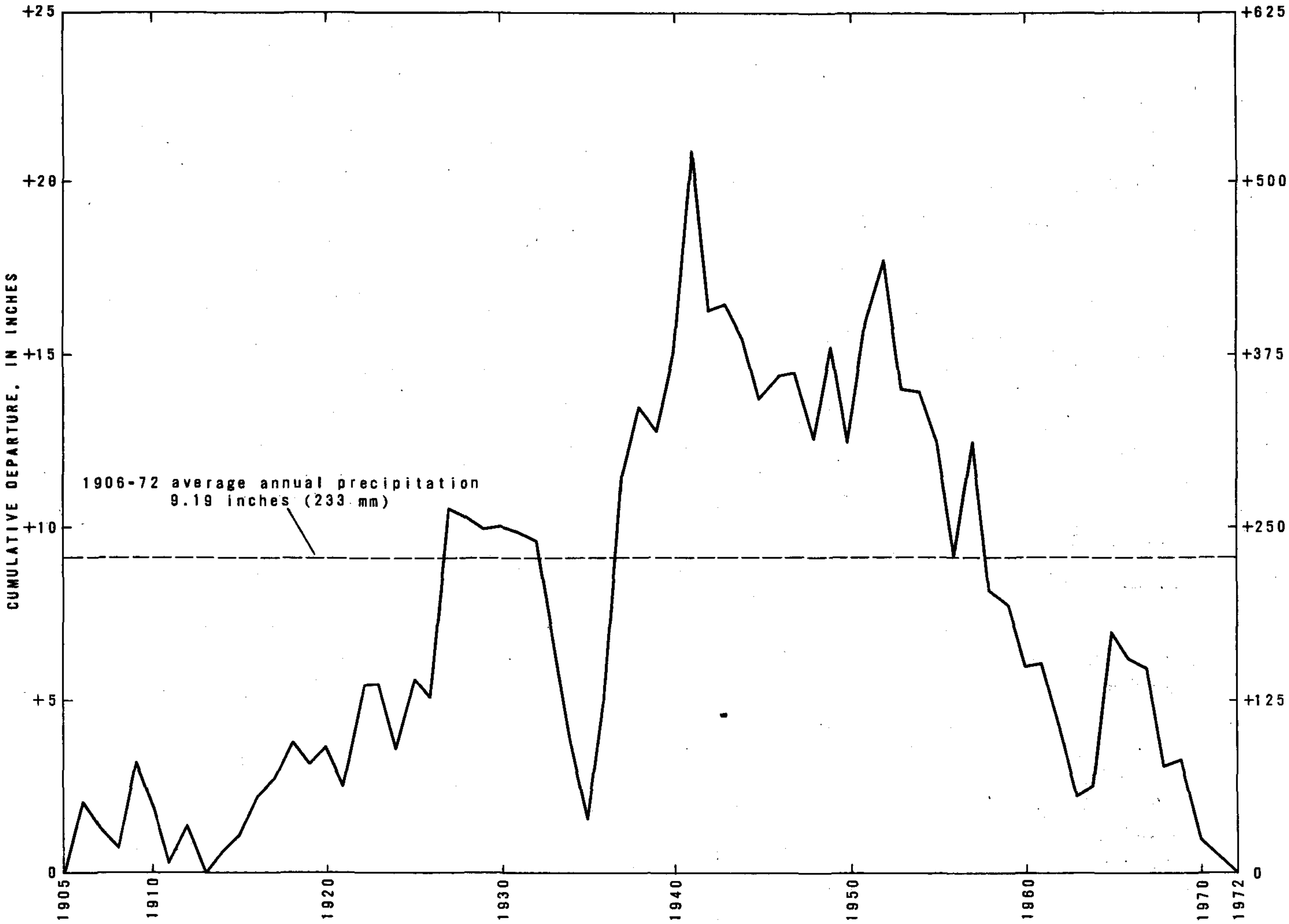

Figure 4.— Cumulative departure from average annual precipitation (1906-72) at Duchesne, Utah.

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According to figure 5, most of the precipitation in the Duchesne area falls during the late summer months. This is the season of peak thunderstorm activity in the Uinta Basin. During these storms, local torrential rains result in rapid runoff and flash floods.

The Uinta Basin has hot summers and cold winters. During the period 1941-72, the mean annual temperature at Duchesne ranged from less than 20°F (-6.5°C) in January to about 70°F (21.0°C) in July (fig. 5). However, minimum midwinter temperatures commonly fall below 0°F (-18.0°C) and maximum midsummer temperatures commonly exceed 90°F (32.0°C).

Despite the cold winters, the growing season is fairly long. The average number of days between the last spring-first fall temperature of 28°F (-2.0°C) ranged from 150 at Myton to 186 at Bonanza for the respective periods of record (table 2).

Table 2.--Number of days between last spring and first fall freeze at four stations

(Data from U.S. Environmental Data Service. Numbers in parentheses are number of years of record; stations are shown on pl. 1)

	Myton	Ouray	Bonanza	Nutter Ranch
Number of days between the last spring and first fall temperature of:				
32°F (0.0°C) or below				
Average	127(19)	130(17)	155(20)	129(9)
Maximum	169	158	188	164
Minimum	95	89	126	97
28°F (-2.0°C) or below				
Average	150(19)	158(17)	186(19)	152(9)
Maximum	191	178	261	176
Minimum	99	146	145	122
24°F (-4.5°C) or below				
Average	173(22)	178(17)	207(17)	163(9)
Maximum	196	215	273	200
Minimum	139	152	159	135

Potential evapotranspiration in the southern Uinta Basin is high. Acccording to Iorns and others (1965, pl. 6), average annual lake evaporation in most of the area exceeds 36 inches (914 mm), which is considerably greater than the average annual supply from precipitation. Potential evapotranspiration at Ouray as determined by the Blaney-Criddle

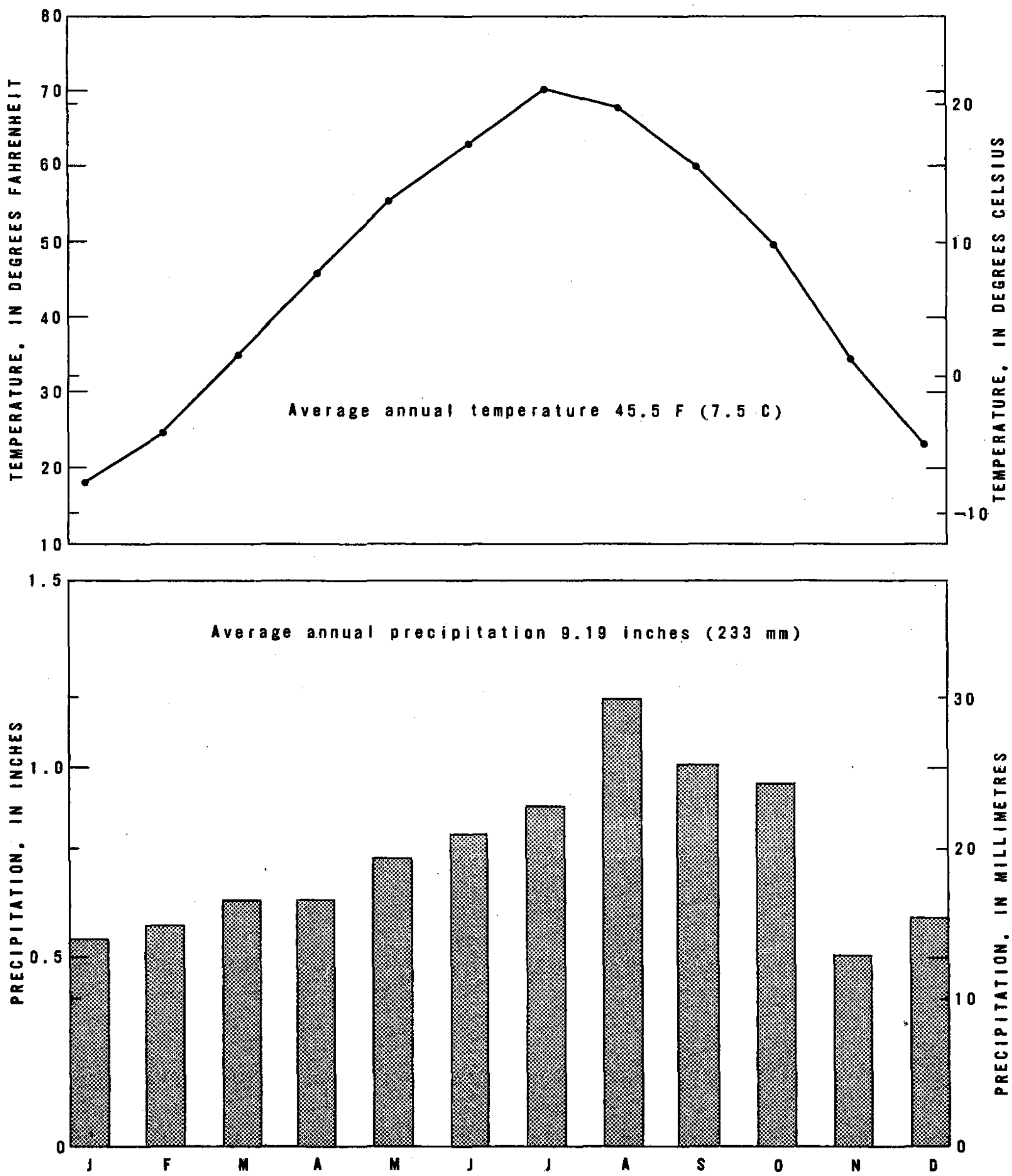

Figure 5.— Average monthly precipitation (1906-72) and average monthly temperature (1941-72) at Duchesne, Utah.

method (Cruff and Thompson, 1967, p. M15-M18) is about 51 inches (1,295 mm), or about nine times the measured average annual precipitation at that station.

Vegetation

Distribution of natural vegetation reflects the availability and chemical quality of water in the southern Uinta Basin. Along the alluvial plains of the Green, White, and lower Duchesne Rivers, where there is a perennial supply of water, the vegetative assemblage consists of a ground cover of greasewood (*Sarcobatus vermiculatus*), with scattered groves of cottonwood (*Populus* sp.), and patches of saltcedar (*Tamarix* sp.) and saltgrass (*Distichilis stricta*). Greasewood also covers most of the lower alluvial plains of the larger intermittent and perennial tributary streams that flow from the southern Uinta Basin, while saltcedar lines the stream channels. This assemblage of greasewood and saltcedar persists in larger stream valleys from the mouths up to about the 6,000-foot (1,829 m) altitude. These two phreatophye types thrive in areas where the soil is too saline or alkaline for most other plants, and they consume tremendous quantities of water.

Rabbitbrush (*Chrysothamnus* sp.), a common phreatophyte that requires a somewhat better quality water than greasewood, was observed only in Evacuation Creek above the Colorado-Utah State line and in Sams Canyon.

The upper reaches of the largest tributary streams support a vegetative assemblage that requires good quality water. This assemblage includes willow (*Salix* sp.), wild rose (*Rosa* sp.), chokecherry (*Prunus virginiana*), and native meadowgrass (*Glyceria* sp.).

Along the lower slopes of the southern Uinta Basin between streams where surface water is scarce and ground water occurs at great depths, the vegetative assemblage consists of sparse growths of shadscale (*Atriplex confertifolia*), sage (*Artemesia* sp.), and various other xerophytic plants. Upslope in the zones of increasingly greater precipitation, the vegetation changes to a sage-juniper (*Juniperus* sp.) -pinyon (*Pinus* sp.) assemblage, which eventually gives way to an assemblage of aspen (*Populus tremuloides*), various conifers, and mountain meadows along the crest of the Roan Plateau.

WATER RESOURCES

In this report the Strawberry-Duchesne-White-Green River system is considered as a drain for the southern Uinta Basin. The main stem flow of these streams is not included in the following quantitative estimates. The streams are, however, a source of supply for the southern Uinta Basin and imports from them to the southern Uinta Basin are noted in the quantitative estimates.

Volume of precipitation

The average annual volume of precipitation that fell on the southern Uinta Basin during the period 1941-70 is estimated to be about 3.1 million acre-feet (3,800 hm^3). This estimate (table 3) is based on an isohyetal map compiled by Fields and Adams (1975) for northeastern Utah. The isohyets for the southern Uinta Basin are on plate 1. In compiling the map, several low-altitude stations south of the basin were used for control because of the meager high-altitude precipitation data available in the southern Uinta Basin. Therefore, the estimated volumes of precipitation and ground-water recharge (table 3) may be low.

Table 3.--Estimated average annual precipitation and ground-water recharge from precipitation, 1941-70

Precipitation zone (inches)	Area (acres)	Precipitation		Ground-water recharge	
		Feet	Acre-feet	Percent of precipitation	Acre-feet
Area underlain by Uinta and Green River Formations[1]					
Less than 8	508,600	0.58	295,000	0	0
8 - 10	510,900	.75	383,200	0	0
10 - 12	602,100	.92	553,900	1	5,500
12 - 14	418,400	1.08	451,900	2	9,000
14 - 16	263,800	1.25	329,800	2	6,600
16 - 18	206,700	1.42	293,500	5	14,700
18 - 20	122,000	1.58	192,800	10	19,300
20 - 22	84,100	1.75	147,200	10	14,700
22 - 24	31,600	1.92	60,700	15	9,100
24 - 26	11,800	2.08	24,500	20	4,900
More than 26	14,200	2.25	32,000	25	8,000
Area underlain by Wasatch Formation and undivided rocks[1]					
Less than 8	33,400	0.58	19,400	0	0
8 - 10	126,300	.75	94,700	1	900
10 - 12	109,100	.92	100,400	2	2,000
12 - 14	43,400	1.08	46,900	5	2,300
14 - 16	24,500	1.25	30,600	5	1,500
16 - 18	14,500	1.42	20,600	10	2,100
Totals (rounded)	3,125,000		3,100,000		100,000

[1]Includes local mantle of unconsolidated surficial deposits.

Most of the precipitation that falls within the southern Uinta Basin is consumed by evapotranspiration and by sublimation from the winter snowpack at or near the place of fall. Some of the precipitation results in overland runoff, most of which also is consumed by evapotranspiration within the southern Uinta Basin. A small percentage of the precipitation seeps to the zone of saturation as ground-water recharge. Some of the recharge occurs as seepage through the rocks and soils upon which the precipitation falls and some occurs as seepage from streambeds.

Surface water

Principal streams

The Green, White, Duchesne, and Strawberry Rivers are the largest streams in the Uinta Basin. They all head beyond the boundaries of the southern Uinta Basin and mainly are confined to deep, narrow canyons where they touch on or flow through the area. These rivers receive runoff from the southern Uinta Basin by way of several perennial streams and numerous intermittent and ephemeral streams. The largest of the perennial and intermittent streams are Pariette Draw and Avintaquin, Antelope, and Nine Mile Creeks west of the Green River, and Willow, Bitter, and Evacuation Creeks east of the Green River (pl. 1). These streams drain about 58 percent of the southern Uinta Basin.

Streamflow measurements have been made at existing or former gaging stations along the Green, White, Duchesne, and Strawberry Rivers as well as several of the perennial and intermittent streams that flow from the southern Uinta Basin. Streamflow records collected at these stations are summarized in table 4.

Runoff characteristics

Runoff from the southern Uinta Basin is highly variable. For example, during the 20 years of record at gaging station 09308500 on Minnie Maud Creek, total annual runoff ranged from less than 1,000 acre-feet (1.2 hm^3) to more than 11,000 acre-feet (13.6 hm^3); and during the 18 years of record at gaging station 09307500 on Willow Creek, total annual runoff ranged from less than 10,000 acre-feet (12.3 hm^3) to more than 24,000 acre-feet (29.6 hm^3) (fig. 6).

Most of the runoff is during the spring and early summer (fig. 7) and is produced by melting of the winter snowpack along the high southern rim of the Uinta Basin. During the late summer months, however, cloudburst storms may result in severe local floods. This is evidenced in table 5, which shows that the annual peak discharge at three partial-record gaging stations in the southern Uinta Basin most commonly occurred in July, August, or September. In some parts of the area, stream channels are dry most of the year; consequently, a single summer cloudburst flood may account for a large percentage of the total annual runoff.

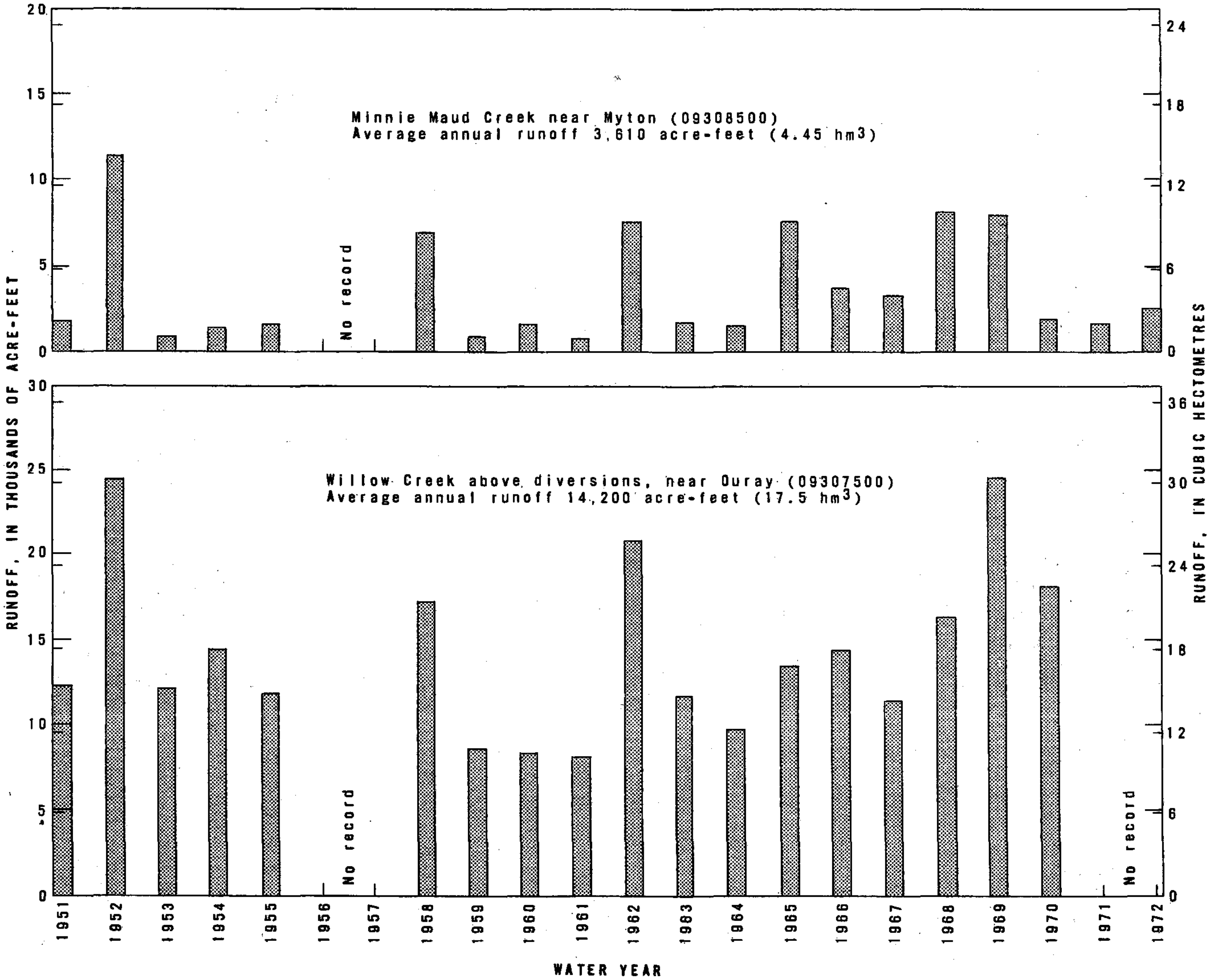

Figure 6.– Total annual runoff at two gaging stations. (Number identifies station on pl. 1.)

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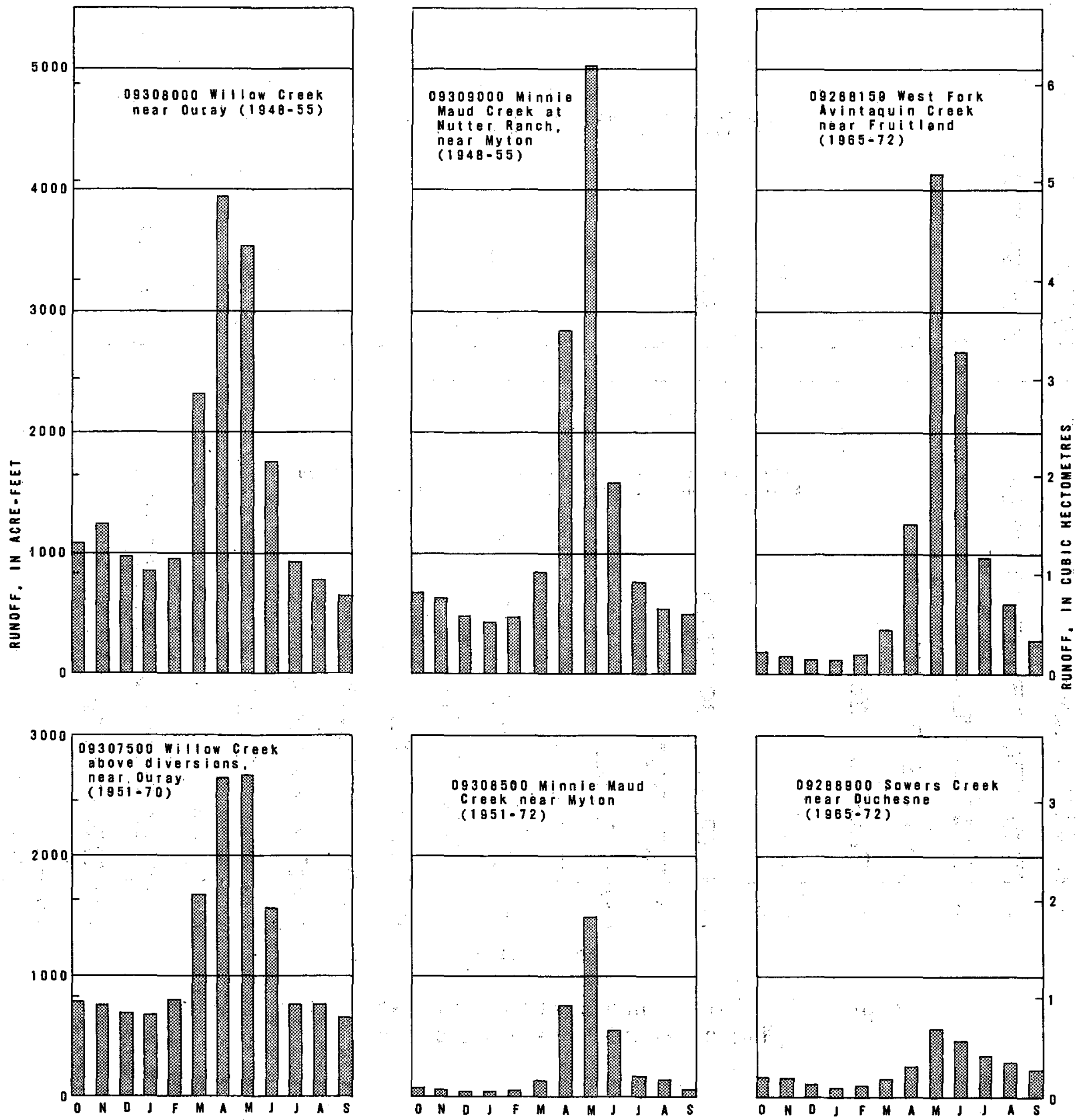

Figure 7.— Average monthly runoff at selected gaging stations. (Number identifies station on pl. 1.)

Table 4.--Summary of streamflow records collected at selected stream-gaging stations

Period of record: Stations with records extending to September 1972 were still in operation as of that date.

Station number (see pl. 1)	Name	Drainage area (mi^2)	Period of record	Average discharge			Extremes (ft^3/s)			
				ft^3/s	Acre-ft/yr	Number of years	Maximum	Date	Minimum	Date
09285000	Strawberry River near Soldier Springs	1/210	Oct. 1942-Sept. 1956; Oct. 1963-Sept. 1972	31.0	22,500	23	1,020	5- 4-52	6.5	1-23-64
09285500	Willow Creek near Soldier Springs	44	June 1943-Sept. 1947	5.3	3,865	4	192	7-30-43	0	During several months of the year
09285700	Strawberry River above Red Creek, near Fruitland	1/360	Oct. 1963-Sept. 1972	58.8	42,600	9	610	5-14-64	9.7	12-8-63
09288150	West Fork Avintaquin Creek near Fruitland	56	June 1964-Sept. 1972	15.0	10,870	8	1,830	8-22-71	.2	1-24-65
09288500	Strawberry River at Duchesne	1/950	June 1908-Nov. 1910; Mar. 1914-Sept. 1968	151	109,300	54	3,490	5- 7-52	1.0	Several days in July 1931
09288900	Sowers Creek near Duchesne	43	May 1964 - Sept. 1972	3.9	2,830	8	202	8- 3-66	0	Part of winter of 1964-65
09295000	Duchesne River at Myton	2,750	Discontinuous, Oct. 1899-Nov. 1910; continuous, July 1911-Sept. 1972	533	386,200	64	12,800	6-10-22	Less than 1.0	7-16-31, several days in Aug. and Sept. 1934
09302000	Duchesne River near Randlett	3,920	Oct. 1942-Sept. 1972	589	426,700	30	10,300	6-13-65	2.2	8-12-61
09306500	White River near Watson	4,020	Apr. 1904-Oct. 1906; May-Nov. 1918; Apr. 1923-Sept. 1972	700	507,200	49	8,160	7-15-29	53	7-19-34
09306800	Bitter Creek near Bonanza	324	Oct. 1970-Sept. 1972	-	-	-	507	8-30-71	0	Many days each year
09307000	Green River near Ouray	35,500	Oct. 1947-Sept. 1955; Oct. 1956-Sept. 1966	5,428	3,930,000	18	43,600	6-11-52	470	July 31, Aug. 1, 1933
09307500	Willow Creek above diversions, near Ouray	300	Aug. 1950-Sept. 1955; Sept. 1957-Sept. 1970	19.6	14,200	18	668	8- 6-63	.3	Aug. 21-23, 1960
09308000	Willow Creek near Ouray	890	July 1947-Sept. 1955; (annual max. 1961, 1962-68)	27.0	19,550	8	2,320 2/2,600	8-27-52 7-31-64	0	Several times
3/09308200	Pleasant Valley Wash tributary near Myton	15	Oct. 1959-Sept. 1972	-	-	-	2,590	7- 9-68	0	Most of the time
09308500	Minnie Maud Creek near Myton	30	Aug. 1950-Sept. 1955; Sept. 1957-Sept. 1972	5.0	3,610	20	1,370	8-25-61	0	Several times
09309000	Minnie Maud Creek at Nutter Ranch, near Myton	230	July 1947-Sept. 1955 2/; (annual max. Oct. 1959-Sept. 1972)	20.4	14,770	8	1,370	8-25-55	0	Do.
3/09309100	Gate Canyon near Myton	5.4	Oct. 1959-Sept. 1972	-	-	-	2/860 860	8- 2-61 9- 6-63	0	Most of the time

1/ Includes approximately 170 square miles tributary to Strawberry Reservoir, from which water is diverted out of the Uinta Basin to the Great Basin.
2/ Estimated.
3/ Records annual maximum discharge only.

The magnitude and frequency of the annual peak discharges at the three stations listed in table 5 are shown in figure 8 by the Log-Pearson Type III analysis data. As shown in figure 8 at station 09309000 on Minnie Maud Creek, a discharge of about 750 ft^3/s (21.2 m^3/s) will be equaled or exceeded on the average of once every 2 years or has a 50 percent probability of occurring in any 1 year. At station 09309100 on Gate Canyon, a discharge of about 300 ft^3/s (8.51 m^3/s) will be equaled or exceeded on the average of once every 2 years or has a 50 percent chance of occurring in any 1 year. At station 09308200 on Pleasant Valley Wash tributary, a discharge of about 1,100 ft^3/s (31.1 m^3/s) would be equaled or exceeded on the average of once every 5 years and has a 20 percent probability of occurring in any 1 year.

Table 5.--Annual peak discharges at three partial-record gaging stations for water years, 1960-72

Annual peak discharge (ft^3/s)	Date
Minnie Maud Creek at Nutter Ranch, near Myton (station 09309000)	
400	Sept. 1, 1960
1,000	Sept. 18, 1961
680	Sept. 22, 1962
690	Sept. 7, 1963
240	July 13, 1964
850	Aug. 16, 1965
620	Aug. 1, 1966
495[1]	Aug. 31, 1967
250	Oct. 5, 1967
460	Sept. 10, 1969
591	Sept. 1, 1971
143	June 17, 1972
Gate Canyon near Myton (station 09309100)	
34[2]	Sept. 17, 1960
860[2]	Aug. 2, 1961
125	Mar. 24, 1962
860	Sept. 6, 1963
840	Aug. 16, 1965
466[2]	Aug. 3, 1966
8.2	June 5, 1967
280	Between May 10 and Oct. 21, 1968
390	Sept. 7, 1969
280	Sept. 6, 1970
280	Sept. 1, 1971
180	June 18, 1972
Pleasant Valley Wash tributary near Myton (station 09308200)	
3.5[2]	Sept. 17, 1960
183	Sept. 9, 1961
230[2]	Feb. 13, 1962
969	Aug. 6, 1963
1,350	June 12, 1965
20	July 1, 1966
2,590[1]	July 9, 1968
93	Sept. 17, 1969
31	Sept. 6, 1970
1,110	Aug. 27, 1971

[1]Determined by field survey.
[2]Estimated.

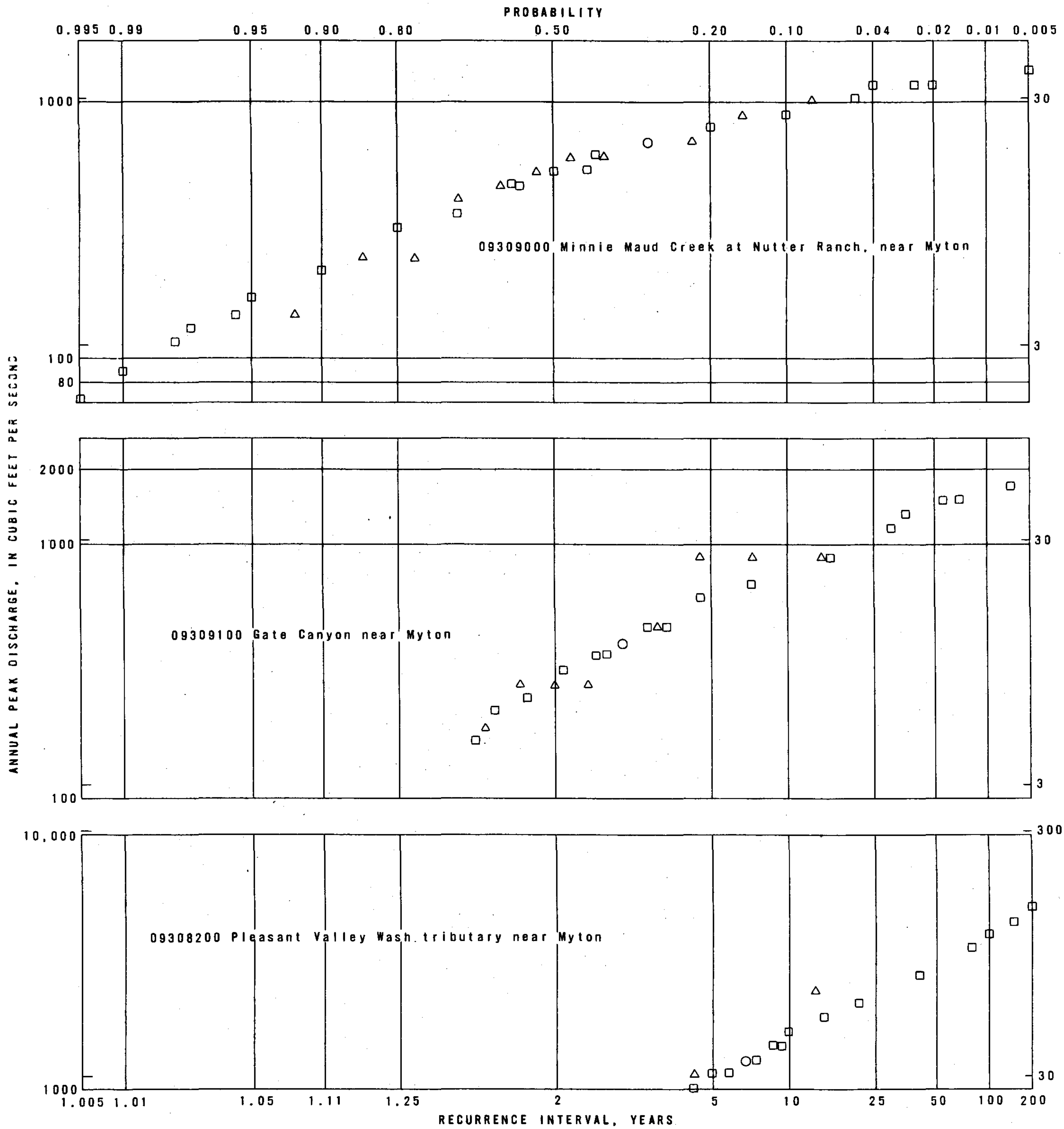

Figure 8.– Magnitude and frequency of annual peak discharges at three partial-record gaging stations. (See pl. I for locations of stations.) △, estimated value from partial-record station; □, calculated value from Log-Pearson Type III analysis; ○, estimated value and calculated value in same position.

Estimated mean annual runoff

Mean annual runoff from the southern Uinta Basin is estimated to be on the order of 134,000 acre-feet (165 hm^3). This estimate is based partly on a method described by Moore (1968) to determine mean annual runoff from ungaged areas using stream-channel geometry characteristics. Estimates of runoff at selected sites are given in table 6.

The channel-geometry method of estimating mean annual runoff assumes that the cross-sectional area of a stream channel at a given site is determined by the long-term runoff past that site; it has proven reasonably accurate when tested in gaged drainage basins. The error of estimate using stream-channel geometry is lowest for perennial streams with high annual runoff and highest for ephemeral streams with low annual runoff. According to F. K. Fields (U.S. Geol. Survey, oral commun., 1973) the error of estimate for gaged streams in the Utah part of the Colorado River system was about 14 percent for perennial streams and about 20 percent for ephemeral streams. In the southern Uinta Basin, the estimated runoff in Willow Creek at the site of former station 09308000 (table 6, site 13) was within 3 percent of the average annual gaged runoff for 8 years of record (table 4). The estimated mean annual runoff from Avintaquin Creek is 14,600 acre-feet (18 hm^3) (table 6, site 2). This estimated runoff is only about 7 percent greater than the average annual runoff (1969-72) from that basin as determined by the difference of the gaged discharge of the Strawberry River immediately above (including inflow from Red Creek) and below the mouth of Avintaquin Creek.

The largest discrepancy (about 40 percent) between estimated mean annual runoff and average annual gaged runoff was for Willow Creek at the site of station 09307500 (see tables 4 and 6). Recent high runoff and streambank erosion at the site made it unusually difficult to determine the channel characteristics that result from long-term mean annual runoff.

Stream-channel geometry measurements were made at or near the mouths of all principal streams draining to the Green, White, Duchesne, and Strawberry Rivers. This provided an estimate of runoff from about 3,300 square miles (8,547 km^2) or 67 percent of the southern Uinta Basin.

Most of the area for which channel-geometry determinations were not made included the largely inaccessible areas that drain to the Green River in Desolation Canyon and several of the upland areas that drain to the upper Strawberry River. In order to estimate mean-annual runoff from these areas, an altitude-runoff relation using data given in table 6 was calculated and applied to the inaccessible areas. Because of the numerous small individual drainages in these areas, however, the results proved unsatisfactory. They were too high. Therefore, an estimate for runoff-per-unit-area--27.3 acre-feet (0.03 hm^3) per square mile (2.6 km^2) per year--was determined from data given in table 6 and applied to the entire southern Uinta Basin. This gave an estimate for total annual runoff from the southern Uinta Basin of about 134,000 acre-feet (165 hm^3)--about 90,000 acre-feet (111 hm^3) from basins listed in table 6 and

Table 6.--Estimated mean-annual runoff at selected sites
(Estimates by F. K. Fields and Don Price)

Type: EI, ephemeral or intermittent; P, perennial.

Number on plate 1	Name	Type	Drainage basin: Area (mi^2)	Drainage basin: Mean altitude (ft)	Runoff (acre-ft/yr)
1	Timber Canyon	P	47	4,450	5,800
2	Avintaquin Creek	P	140	8,100	14,600
3	Sams Canyon	EI	24	7,565	1,680
4	Indian Canyon	P	98	7,595	1,270
5	Right Fork Indian Canyon	P	28	7,960	450[1]
6	Coyote Canyon	EI	17	6,295	220
7	Cottonwood Canyon	EI	30	6,935	760
8	Antelope Creek	P[2]	200	7,280	1,270
9	Unnamed	EI	8.6	5,550	840[1]
10	Big Wash	EI	42	6,465	520[1]
11	Peters Wash	EI	14	6,210	730[1]
12	Pariette Draw	P[3]	310	5,875	18,900
13	Willow Creek (At gaging station 09308000)	P[2]	940	7,000	20,100
14	Willow Creek (At gaging station 09307500)	P	310	7,650	8,400[1]
15	Ute Canyon	EI	4.5	6,675	140[1]
16	Cottonwood Wash	EI	140	5,445	850
17	Bitter Creek (At gaging station 09306800)	EI	320	6,945	800
18	Evacuation Creek	EI	300	6,560	2,630
19	do	EI	220	6,860	780[1]
20	Park Canyon	EI	32	6,425	10[1]
21	Hells Hole Canyon	EI	28	6,240	40
22	Gilsonite Draw	EI	8.5	6,160	70
23	Cottonwood Creek	EI	48	5,970	720
24	Shavetail Draw	EI	10	5,660	290
25	Sand Wash	EI	1.1	6,560	110[1]
26	do	EI	10	5,895	1,650
27	Nine Mile Creek	P	230	7,890	14,800[1]
28	do	P	460	7,500	15,800
29	Range Creek	EI	150	7,195	2,160

[1]Represents runoff past the site but not from the project area. Not used to estimate total runoff from the project area.

[2]Intermittent at mouth owing to upstream diversions for irrigation and to consumptive use by native vegetation.

[3]Receives tailwater from the Duchesne River diversions for irrigation in the Pleasant Valley area.

about 44,000 acre-feet (54 hm^3) from those basins for which channel-geometry determinations were not available.

Using runoff maps for Utah compiled by Bagley and others (1964), potential mean annual runoff from the southern Uinta Basin (including the part in Colorado) was estimated to be on the order of 240,000 acre-feet (296 hm^3). This assumes an average mean annual runoff of 0.25 inch (6 mm) for the areas shown on the maps of Bagley and others (1964) that produce less than 1 inch (25 mm) of runoff. This estimate is about 106,000 acre-feet (131 hm^3) greater than the estimate based on channel geometry; and it may be too high because the runoff maps were compiled largely from data collected along the Wasatch Front where consumptive use of streamflow by phreatophytes is not as pronounced as in the southern Uinta Basin (see Bagley and others, 1964, p. 65). Assuming both estimates to be reasonably correct, however, then as much as 106,000 acre-feet (131 hm^3) of the water available for runoff is consumed by evapotranspiration along the principal waterways where consumptive use of water by phreatophytes and other vegetation is greatest. An example of the depletion of streamflow by phreatophytes is illustrated by streamflow data collected along Willow Creek. (See table 7.)

Table 7.--Streamflow data collected along Willow Creek, September 27 and 28, 1972

Specific conductance: f, determined by field conductivity meter; L, determined by laboratory analysis; see also table 13.

Location number (see pl. 1)	Date	Discharge (ft^3/s)	Specific conductance (micromhos/cm at 25°C)	Miles downstream from site S1	Miles between sites
S1	9-27-72	3.52	1,000f	-	-
S2	do	3.07	1,000f	3.2	3.2
S3	do	3.06	1,000f	5.5	2.3
S4	do	2.85	1,010L	8.7	3.2
S5[1]	do	.26	-	19.4	10.7
S6	9-28-72	.25	6,000L	21.5	2.1
S7	do	.08	5,970L	23.0	1.5
S8	do	0	-	25.4	2.4

[1]Undetermined amount of water diverted for irrigation above this site.

According to table 7, there is a streamflow depletion of 0.45 ft^3/s (0.013 m^3/s) in the 3.2-mile (5.1 km) reach of Willow Creek between sites S1 and S2. Along this reach the valley floor is covered with a luxuriant growth of greasewood, and the stream is lined locally with saltcedar. There are no manmade streamflow diversions. Also, it seems unlikely that there is any stream loss to the underlying bedrock formations because artesian conditions apparently exist along this reach as indicated by Sulphur Spring, (D-12-21)19bdd-S1, and artesian well

(D-11-21)31bdd-1 just below the reach. Under such conditions, the stream would be gaining water from rather than losing water to the bedrock aquifers. Therefore, it is assumed that, except for a small amount of evaporation from the stream surface and streambanks, the depletion of 0.45 ft^3/s (0.013 m^3/s) along the reach between sites S1 and S2 is caused entirely by the draft of phreatophytes growing on the alluvial plain. The water is induced to move from the stream to adjacent alluvial aquifers by the pumping effect of the phreatophytes, as shown in figure 9.

This condition exists along the lower reaches of all the larger perennial and intermittent streams in the southern Uinta Basin. It is interesting to note that the stream-loss rate of about 0.14 ft^3/s (0.004 m^3/s) per mile (1.6 km) between sites S1 and S2 approximately equals the average stream-loss rate along the entire 25.4-mile (40.9 km) reach between sites S1 and S8, which includes at least 250 acres (101 hm^2) of irrigated land. Because of the similiarity of physiography, geology, natural vegetation, and irrigated crops in the southern Uinta Basin, this factor might apply to the lower reaches of most of the perennial streams. Probably a higher stream-loss factor exists in lower Nine Mile Creek where natural vegetation is more dense and includes more saltcedar.

It should be noted that the above stream-loss factor was determined at the end of September, when the phreatophytes were going into dormancy. Midsummer consumptive use rate by these plants doubtless would be greater whereas midwinter rates, if any, would be much less. Consumptive use in late September (and the determined stream-loss factor), therefore, might represent the annual mean. These figures are used in the section on ground-water discharge to estimate the annual rate of ground-water discharge by evapotranspiration along major stream courses.

Imports

Water is imported from the Duchesne River for irrigation in the Pleasant Valley area and along the alluvial plain south of the Duchesne River downstream from the town of Duchesne. The largest imports are through the Grey Mountain-Pleasant Valley and Myton Townsite Canals (not discernible on map). Average annual diversions into these two canals were about 70,400 acre-feet (87 hm^3) during the period 1935-72 according to the annual reports of the Duchesne and Strawberry River Commissioner. Several smaller canals and ditches also divert Duchesne River water into the southern Uinta Basin for irrigation on the alluvial plain south of the river. Total diversions into these smaller canals and ditches are not known but probably average less than 5,000 acre-feet (6.2 hm^3) per year. Therefore, total gross annual imports as of 1972 probably averaged about 75,000 acre-feet (92.5 hm^3).

Some streamflow from the westernmost part of the southern Uinta Basin is stored in Starvation Reservoir and some of this water is eventually returned to the area together with the imported water. Average

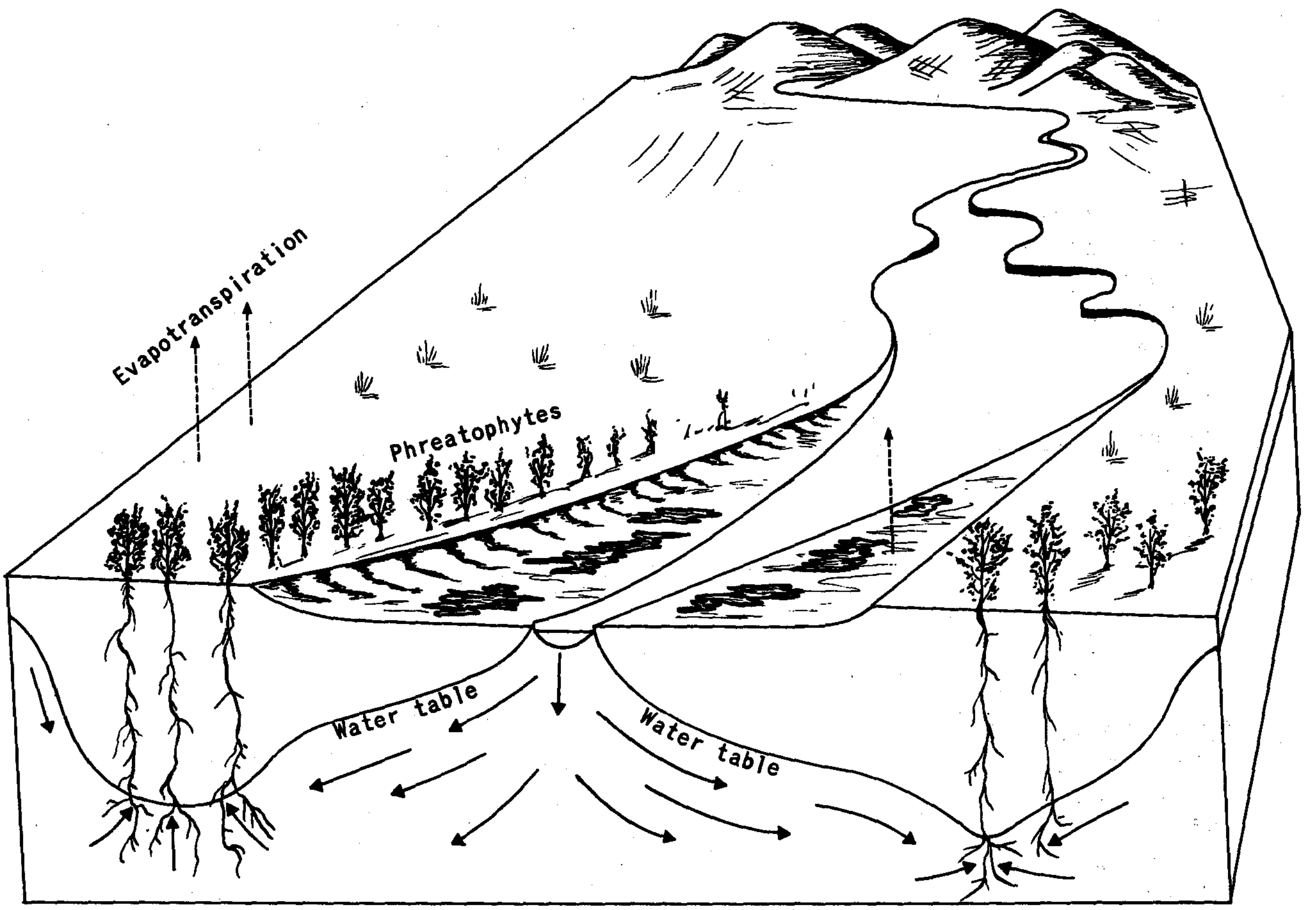

Figure 9.– Sketch illustrating how water moves from streams to adjacent alluvial aquifers and is consumed by phreatophytes.

annual inflow to Starvation Reservoir from the western part of the area is estimated to be on the order of 26,000 acre-feet (32.1 hm^3). Nearly all of this inflow is from Avintaquin, Timber Canyon, and Sams Canyon Creeks (table 6) and from Willow Creek (station 09285500 in table 4). There is no direct method to determine how much water from these streams is returned to the southern Uinta Basin with the imported water. Considering evaporation losses in the reservoir perhaps 91 percent of this water could be released from the reservoir to the Duchesne River and returned to the area with the imported water. This is roughly 24,000 acre-feet (29.6 hm^3) per year, or about 6 percent of the flow of the Duchesne River at Myton. Therefore the estimated average annual import of 75,000 acre-feet (92.5 hm^3) per year is reduced by 6 percent, and the net import is on the order of 70,000 acre-feet (86.3 hm^3) per year.

Some of the imported irrigation water is returned as tailwater to the Duchesne River, and water from the Pleasant Valley area reaches the Green River through Pariette Draw. Records are not available from which to determine the volume of imported irrigation water that is returned to the Duchesne and Green Rivers; but it could average as much as 30 percent of the total diversion, or on the order of 20,000 acre-feet (24.7 hm^3) per year.

Some water also is imported from various sources in the northern Uinta Basin for culinary use in the Duchesne-Myton-Pleasant Valley area. The amount is not known but probably is less than 500 acre-feet (0.6 hm^3) per year. All this water is consumed within the southern Uinta Basin.

Ground water

Recharge

Ground-water recharge in the southern Uinta Basin is derived from precipitation that falls within that subbasin and seepage losses of water imported for irrigation. Geologic structure may permit subsurface inflow through pre-Tertiary rocks, as in the northwestward plunging Uncompahgre uplift (see fig. 3), but there are no data to support this assumption. Also the northward-dipping strata that crop out in the Book Cliffs to the south probably convey some water into the area. However, the amount of inflow is assumed to be small because the zone of potential ground-water recharge high in the Book Cliffs is confined to a few narrow outcropping bands of permeable strata that are capable of intercepting precipitation and runoff and conveying it into the southern Uinta Basin.

The principal source of ground-water recharge is precipitation that falls on the high southern rim of the Uinta Basin. Water from rain and melting snow percolates directly, or from streams, into the underlying sedimentary rocks. Recharge from precipitation was estimated using a method developed by Eakin and others (1951, p. 79-81) and modified by Hood and Waddell (1968, p. 22-23). The method assumes that a fixed percentage of the average annual precipitation becomes ground-water recharge, taking into account such factors as volume, time, and area of distribution of precipitation, geology, and physiography. The estimate includes not only direct recharge from precipitation but also recharge from streamflow.

Because of the predominantly fine-grained nature and low permeability of the rocks in the recharge area, percolation rates are very slow. It is assumed, therefore, that most recharge occurs during the winter when rain and snowstorms are more widespread and of longer duration. The torrential late summer storms, which produce most of the total annual precipitation (p. 12) and significant runoff, are generally of too short duration to significantly add to ground-water recharge. Therefore, it is estimated that only about 100,000 acre-feet (123 hm^3) or about 3 percent of the estimated average annual precipitation becomes ground-water recharge. (See table 3.)

Ground-water recharge from imported irrigation water is significant in the Pleasant Valley area and along the alluvial plain of the Duchesne River. R. W. Cruff and J. W. Hood (U.S. Geol. Survey, written commun., 1974) found that the net loss from the Grey Mountain and Pleasant Valley Canal system averaged 24.5 ft^3/s (0.7 m^3/s) during seepage studies made between May 1972 and June 1973. Part of this water apparently reappears at the surface near the canals where it is consumed by evapotranspiration. This is indicated by patches of phreatophytes and areas of barren soil on which evaporated water has left a crust of alkali. Some of the water that seeps from the canal system, however, does percolate to the ground-water reservoir, as does water from ditches and irrigated fields. Several well owners report that water from their wells is of better chemical quality during the irrigation season than during the nonirrigation season, consistent with the much lower concentration of dissolved solids in water from the Duchesne River. (See tables 13 and 14.)

Assuming that at least 25 percent of the 75,000 acre-feet (92.5 hm^3) of water that is imported from the Duchesne River annually seeps to aquifers from local canals and irrigated land, then total annual recharge from imported water may be on the order of 20,000 acre-feet (24.7 hm^3). Total ground-water recharge from precipitation and imported water, therefore, is on the order of 120,000 acre-feet (148 hm^3).

Occurrence

Ground water in the southern Uinta Basin is in a complex system of shallow unconfined, perched, and deep confined aquifers. Shallow unconfined aquifers exist in the principal recharge area, along the southern rim of the Uinta Basin, where they support the flow of many perennial springs such as PR and Marble Springs (table 12), and in unconsolidated deposits underlying the Pleasant Valley area and the alluvial plains of the larger perennial streams. Most of the wells in the southern Uinta Basin tap the unconsolidated deposits in the Duchesne-Myton-Pleasant Valley area. Perched aquifers exist beneath the tablelands between the major streams where they support the flow of small widely scattered intermittent springs such as (D-10-17)12baa-S1 and (D-11-15)15dbb-S1 (table 12).

Deep artesian aquifers in bedrock underlie a major part of the southern Uinta Basin. Such aquifers have been penetrated by a number of oil and gas wells such as wells (D-11-24)6dbc-1 and 7cac-1, which have been converted to stockwater wells (table 10).

Movement

The available water-level data in the southern Uinta Basin are insufficient to determine the direction of ground-water movement with any degree of accuracy. The few available data indicate that west of the Green River, ground water moves generally northward to the Strawberry and Duchesne Rivers and eastward toward the Green River, with local components of movement toward the larger tributary streams. East of the Green River, ground water generally moves northward toward the White River and westward toward the Green River, with local components of movement toward the larger tributary streams.

The rate of ground-water movement is slow in most places because of the generally low permeability of the rocks through which the water moves. This slow rate of movement allows longer periods of contact between the water and the rock minerals and contributes to the consistently high concentration of dissolved solids in the water. The slow rate of movement is also responsible for the low yields and large water-level drawdowns in many wells that tap these rocks (see table 10).

Some ground water moves from the Colorado part of the southern Uinta Basin to the Utah part, but the annual volume of movement is relatively small. Only about 3,000 acre-feet (3.7 hm^3) of the total estimated average annual recharge to the ground-water system in the southern Uinta Basin (table 3) is in Colorado. It is estimated that about 1,500 acre-feet (1.8 hm^3) per year of this water is consumed within Colorado--about 1,200 acre-feet (1.5 hm^3) by evapotranspiration along the alluvial plains of the White River, Evacuation Creek, and several intermittent creeks, and about 300 acre-feet (0.4 hm^3) by diffuse seepage to the White River (from ground-water discharge factors developed on pages 33-35). Discharge of ground water from wells and springs in the Colorado part of the southern Uinta Basin is insignificant. The remaining 1,500 acre-feet (1.8 hm^3) per year enters Utah as subsurface inflow.

Storage

Estimated recoverable storage.--Large quantities of water are stored in the rocks that underlie the southern Uinta Basin. Because of the generally low permeability of these rocks, however, only a fraction of the water can be withdrawn, and it generally is yielded slowly to wells. Furthermore, the water occurs at great depths beneath the land surface at places along the lower slopes of the southern Uinta Basin, and although physically recoverable, recovery may not be economically feasible.

For this report, the volumes of recoverable water in storage in unconsolidated deposits and in the consolidated rocks are estimated separately and without regard to chemical quality. The unconsolidated deposits have a much greater specific yield (ratio of volume of water yielded by saturated rocks to the total volume of those saturated rocks) than the unconsolidated rocks, but because of their small extent and thickness, the unconsolidated deposits have a much lower storage capacity. The areal extent of the saturated unconsolidated deposits is about 96,000 acres (38,850 hm^2) and their average saturated thickness is about 20 feet (6.0 m). Assuming that they have an average specific yield of 0.10, the volume of recoverable water in them is about 190,000 acre-feet (234 hm^3).

Although water is stored to great depths in the consolidated rocks, recoverable water is estimated for only the upper 100 feet (30.5 m) of saturation in these rocks. Beneath the alluvial plains of the larger streams, the top of the zone of saturation is within 100 feet (30.5 m) of the land surface; but between streams along the lower slopes of the southern Uinta Basin, it is more than 500 feet (152 m) deep. The average specific yield of the consolidated rocks is estimated to be only about 0.01 based on data from well (D-9-20)36ddc-1 (Weir, 1970) and on low yields of most wells and springs that discharge from these rocks. The total volume of rocks in the upper 100 feet (30.5 m) of saturation is on the order of 300 million acre-feet (370,000 hm^3), and, therefore, the volume of recoverable water may be on the order of 3 million acre-feet (3,700 hm^3). Because of the low permeability of these rocks, however, the water is not easily recovered by wells. In most places, yields to individual wells can be expected to be less than 50 gal/min (3.6 l/s).

Water-level fluctuations.--Water-level fluctuations in wells reflect changes in ground-water storage. Rising water levels indicate increases in storage whereas declining water levels indicate decreasing storage. Under natural conditions the ground-water system is in dynamic equilibrium. Average annual recharge and discharge are equal, and the volume of ground water in storage remains constant over a long period of time.

Periodic measurements of water levels have been made in an number of wells in the Uinta Basin to record changes in storage. Measurements at well U(C-4-2)5bba-2, the only water-level observation well in the southern Uinta Basin, are shown by the hydrograph in figure 10. The well taps unconsolidated deposits in the general area of greatest well density in the southern Uinta Basin.

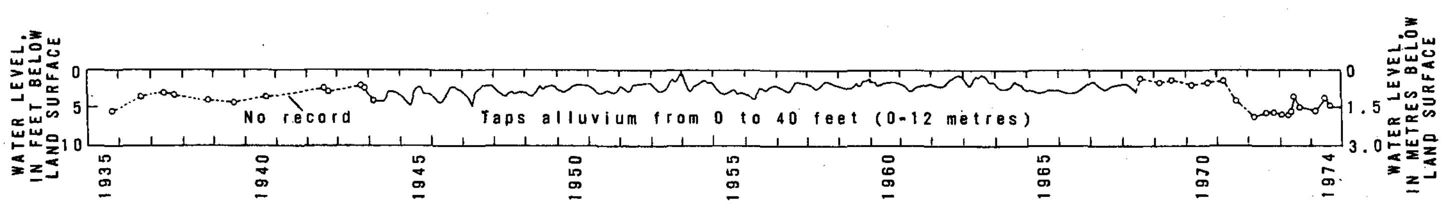

Figure 10.— Depth to the water level in well U(C-4-2)5bba-2 near Myton, Utah.

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According to the hydrograph, water levels fluctuated seasonally during the period 1935-70, reflecting seasonal changes in ground-water storage with little overall change from year to year. During 1971, however, the water level in the well declined about 5 feet (1.5 m). Because there was no known significant increase in ground-water withdrawals in the area during that period, the decline must be attributed to a change in ground-water recharge. There probably has been a decrease in natural recharge owing to recent below normal precipitation in the area (fig. 4), and there may have been a decrease in recharge from irrigation. The unconsolidated deposits in this area apparently receive some recharge by seepage from canals and irrigated land. Probable changes in irrigation diversions and practices in the area may have caused a reduction of recharge from irrigation and resulting water-level decline in the well.

Local year-to-year declines of water levels in consolidated rocks in the northern Uinta Basin have been attributed to continued or increased ground-water withdrawals (Price and Arnow, 1974, p. C16). In the northern Uinta Basin availability of water for recharge is much greater than it is in the southern Uinta Basin. It seems reasonable, therefore, to conclude that any local large-scale withdrawals of ground water from consolidated rocks in the southern Uinta Basin would result in a depletion of storage and a decline of water levels.

Discharge

Ground water is discharged from the southern Uinta Basin by seeps and springs, evapotranspiration, diffuse seepage to the Green, White, Duchesne, and Strawberry Rivers, and by wells. Some ground water may move to the northern Uinta Basin in deep, confined aquifers which dip northward into the northern Uinta Basin. Also, ground water might possibly move along fault and gilsonite-dike zones that cross into the northern Uinta Basin. However, no direct data exist to confirm such movement to the northern Uinta Basin. It is most probable, therefore, that ground water moving northward through the area (at least in the upper 100 feet or 30.5 m of saturated rock) discharges by diffuse seepage to the Strawberry, Duchesne, and White Rivers or their alluvial deposits.

Seeps and springs.--Discharge of ground water through individual seeps and springs in the southern Uinta Basin is estimated to be on the order of 4,500 acre-feet (5.6 hm^3) per year. Most of the springs and seeps are above the 7,000-foot (2,134 m) altitude and are concentrated mostly in the headwater areas of Avintaquin, Willow, and Bitter Creeks (pl. 1). However, a number of springs, including those with the largest yields, are at lower altitudes.

All springs known to have estimated or reported yields of more than 100 gal/min (6 l/s) and a representative sampling of springs with smaller yields are listed in table 12. Assuming that the recorded yields of the four large springs in table 12 approximate the annual average yield of those springs, then they would have a total annual discharge of about 1,300 gal/min (82 l/s) or about 2,100 acre-feet (2.6 hm^3) per year.

At least 270 springs are shown on the U.S. Geological Survey 7½' and 15' topographic quadrangle maps of the southern Uinta Basin. Field observations indicate that the maps show only about half of the springs and seeps actually in the mapped area. Therefore, it is estimated that there are at least 500 individual springs and seeps in the area. Of these 500 springs and seeps, several have reported yields of as much as 60 gal/min (3.8 l/s) (table 12), but most of the springs observed by the writers had yields of 0.5 to 5 gal/min (0.03 to 0.32 l/s). It is concluded from these observations that the average yield per spring is about 3 gal/min (0.19 l/s), and that total annual discharge from them averages about 1,500 gal/min (95 l/s) or about 2,400 acre-feet (3.0 hm^3) per year. This, plus the 2,100 acre-feet (3.0 hm^3) per year from the four large-yield springs, gives a total discharge from springs and seeps of about 4,500 acre-feet (5.6 hm^3) per year.

Some of the water from Stinking Springs, Camel Rocks Springs, and several springs observed by Thomas (1952, p. 23) in Desolation Canyon reaches the Strawberry and Green Rivers and leaves the area as streamflow. Essentially all the water discharged by the other seeps and springs in the southern Uinta Basin is consumed at or near the point of discharge.

Evapotranspiration.--A large volume of ground water is consumed annually by evapotranspiration in the southern Uinta Basin. Most of this water is consumed by greasewood, saltcedar, and saltgrass along the lower reaches of the perennial and larger intermittent streams. The plants are all phreatophytes (water-loving plants that thrive on ground water) that have a high salt tolerance. Under ideal growing conditions and 100 percent plant density, greasewood may consume 2 feet (0.6 m) or more of water annually, and saltcedar may consume as much as 9 feet (2.7 m) (Mower and Nace, 1957, p. 21, and Robinson, 1958, p. 75). The figure for greasewood probably is representative for the southern Uinta Basin, but the figure for saltcedar is somewhat high as it was obtained in a warmer climatic zone with a longer growing season.

As noted earlier, these plants are the dominant vegetation along the alluvial plains of the Green, White, and the lower Duchesne Rivers and the larger streams that head in the southern Uinta Basin. Estimated consumptive use of water in the southern Uinta Basin by these phreatophytes ranges from about 1.5 to 3.5 feet (0.5 to 1.1 m) and totals about 204,000 acre-feet (252 hm^3) per year (table 8). Although essentially all the water consumed by phreatophytes along the flood plains of the perennial streams (the first three groups in table 8) is ground water, much of this water is derived from streamflow induced into the adjacent alluvial aquifers by the pumping effect of the phreatophytes as shown in figure 9 and discussed on pages 24-25. Because this water simply passes through the aquifer to the plant roots at a relatively rapid rate, it has not been regarded as a source of ground-water recharge in this report, nor is it counted as ground-water discharge by evapotranspiration. However, some of the water consumed by phreatophytes is derived directly from the ground-water system (from alluvium that would be saturated even if the phreatophytes did not exist).

Table 8.--Estimated consumptive use of water by phreatophytes in nonirrigated areas

Area	Phreatophyte	Areal extent (acres)	Average use factor (ft/yr)	Consumptive use (acre-ft/yr)
Flood plains of the Green and White Rivers	Greasewood, cottonwood, saltcedar, and saltgrass	22,100	3.5	77,400
Flood plains of Duchesne and Strawberry Rivers	Greasewood, saltcedar, saltgrass, cottonwood, and willow	3,700	3.0	11,100
Flood plains of the following streams and their tributaries: Avintaquin, Indian Canyon, Antelope, Willow, Bitter, Evacuation, Nine Mile, and Range Creeks, and Pariette Draw	Greasewood, saltcedar, saltgrass, and some rabbitbrush; cottonwood and willow in upper reaches of streams	45,000	2.5	112,500
Sams, Lake, and Coyote Canyons; Cottonwood Wash; Cottonwood Creek, Colo.	Rabbitbrush in Sams Canyon; greasewood in other drainages	3,200	.75	2,400
		Total (rounded)		204,000

The percentage of consumed water that is derived from induced seepage from streamflow may be approximated from measured streamflow depletion between sites S1 and S2 on Willow Creek (table 7). Discharge of ground water only by evapotranspiration is equal to the total estimated consumptive use of water by phreatophytes (table 8) minus that percentage estimated to be from induced seepage from streamflow. According to table 7, the streamflow depletion between sites S1 and S2 on September 27, 1972, was 0.45 ft^3/s (0.013 m^3/s). As noted on pages 24-25, this loss is attributed entirely to consumptive use of water by phreatophytes growing along the alluvial plain of the stream between the two sites, and the consumptive use rate may approximate the annual mean. Therefore, the consumptive use of streamflow by phreatophytes between sites S1 and S2 may total about 300 acre-feet (0.4 hm^3) per year. About 200 acres (80.9 hm^2) of phreatophytes in this reach have an estimated annual water requirement of about 2.5 feet (0.8 m) or 500 acre-feet (0.6 hm^3). With an annual contribution of 300 acre-feet (0.4 hm^3) from induced streamflow, the annual draft from ground water without the induced streamflow component is about 200 acre-feet (0.2 hm^3), or 40 percent of the total consumptive use. If this factor were applied to the estimated consumptive use of water by phreatophytes along perennial streams (the first three categories in table 8) in the southern Uinta Basin, about 80,400 acre-feet (99.2 hm^3) would be from ground water. An estimated additional 2,400 acre-feet (3.0 hm^3) of ground water is consumed along intermittent and ephemeral streams. Therefore, the total estimated discharge of ground water by evapotranspiration is estimated to be on the order of 83,000 acre-feet (102 hm^3) per year.

Diffuse seepage to the Green, White, Duchesne, and Strawberry Rivers.--Some ground water discharges from the southern Uinta Basin to the Green, White, Duchesne, and Strawberry Rivers. Part of this water is consumed by evapotranspiration along the courses of those streams and part leaves the Uinta Basin in the Green River.

The volume of ground water that leaves the southern Uinta Basin by diffuse seepage to the Green, White, Duchesne, and Strawberry Rivers cannot be determined with any degree of accuracy from available data. A provisional estimate is made from the meager stream discharge records, which themselves are partly estimated.

Streamflow records in the files of the Geological Survey indicate that the average (1941-70) rate of gain in flow of the Green River between the gaging stations near Ouray (site 3070 on pl. 1) and Green River, Utah (about 9 miles or 14.5 km south of the southern Uinta Basin), was about 200 ft^3/s (5.7 m^3/s) (F. K. Fields and D. B. Adams, U.S. Geol. Survey, written commun., 1974). Subtracting the average (1941-70) rate of inflow (102 ft^3/s or 2.9 m^3/s) from the Price River, which enters the Green River just downstream from the southern Uinta Basin, the net measured gain in flow of the Green River between Ouray and Green River, Utah, was found to be about 100 ft^3/s (2.9 m^3/s) during the period 1941-70. To this should be added the unmeasured evapotranspiration loss along this reach of the river. Thomas (1952, p. 29) estimated that the rate of evapotranspiration loss in the reach between Ouray and Green River, Utah, totaled 54 ft^3/s (1.5 m^3/s) during a reconnaissance of the river in September 1948. Assuming this approximates the average rate of loss during the period 1941-70, then the actual rate of gain in flow (net measured gain plus evapotranspiration loss) during that period would have been about 150 ft^3/s (4.2 m^3/s), or on an annual basis--about 108,600 acre-feet (134 hm^3) per year. For practical purposes, all this gain in flow is attributed to inflow from the southern Uinta Basin. (Other than from the Price River, there is insignificant inflow between the southern Uinta Basin and Green River, Utah.)

Estimates of mean annual runoff in the streams listed in table 6 that drain to the Green River below Ouray totaled about 57,000 acre-feet (70.3 hm^3). Using the area-runoff relation--27.3 acre-feet (0.03 hm^3) per year per square mile (2.6 km^2)--discussed on page 22, total runoff from all other streams draining to the Green River below Ouray is estimated to be about 25,000 acre-feet (30.8 hm^3) per year. Another 2,000 acre-feet (2.5 hm^3) per year probably enters the Green River in this reach from individual springs, according to Thomas (1952, p. 23). Therefore, total inflow to the Green River from streams and individual springs is estimated to be on the order of 84,000 acre-feet (104 hm^3). Subtracting this from the total gain in flow of 108,600 acre-feet (134 hm^3) per year leaves about 25,000 acre-feet (30.8 hm^3) per year, which may be attributed to diffuse seepage of ground water directly into the stream channel. This is about 200 acre-feet (0.24 hm^3) per river mile (1.6 km), of which 100 acre-feet (0.1 hm^3) per river mile (1.6 km) is assumed to be contributed from each side of the river.

The rocks that bound the Green, White, Duchesne, and Strawberry Rivers are lithologically similar; therefore, on the average, they are assumed to have similar permeabilities. Ground-water gradients toward the White, Duchesne, and Strawberry Rivers from the south are on the average about half as steep as gradients to the Green River (see pl. 1). Therefore, the diffuse seepage of ground water to the former three streams from the south probably averages only about 50 acre-feet (0.06 hm^3) per mile (1.6 km) per year. Along the total 137-mile (220 km) courses of these streams, therefore, total ground-water inflow from the southern Uinta Basin may be on the order of 7,000 acre-feet (8.6 hm^3) per year. Total annual discharge of ground water by diffuse seepage to the Green, White, Duchesne, and Strawberry Rivers then is estimated to be on the order of 30,000 acre-feet (37.0 hm^3) per year, all of which leaves the area as part of the ground-water component of streamflow.

Wells.--Ground water is discharged from both water wells and oil and gas wells in the southern Uinta Basin. According to the records of the Utah Division of Oil and Gas Conservation, approximately 600,000 gallons (2,271 m^3) of water were produced from oil and gas wells in the area during 1972. This is less than 2 acre-feet (0.002 hm^3). Total discharge from the few known flowing artesian wells (table 10) amounts to about 400 acre-feet (0.5 hm^3) per year. Annual discharge from all other wells in the area is estimated to total about 100 acre-feet (0.1 hm^3). Most of these wells are concentrated in the Duchesne-Myton-Pleasant Valley area where many are used only for stock or standby-domestic supply. Total annual discharge from all wells in the southern Uinta Basin, therefore, is estimated to be on the order of 500 acre-feet (0.6 hm^3).

SUMMARY OF QUANTITATIVE ESTIMATES

Table 9 summarizes the estimated values for various components of the hydrologic system in the southern Uinta Basin.

About 94 percent of the average annual volume of water entering the southern Uinta Basin from precipitation and imports is consumed by evapotranspiration within that subbasin. The remaining 6 percent enters the Green, White, Duchesne, and Strawberry Rivers--mostly as overland runoff.

CHEMICAL QUALITY OF WATER

General

The types and amounts of dissolved solids in water in the southern Uinta Basin vary greatly over short distances both areally and with depth. The dissolved-solids concentrations of most streams increase rapidly in a downstream direction, especially during low-flow periods in late summer; and the dissolved-solids concentrations of the ground water change markedly from one aquifer to another. Streamflow ranges from fresh to moderately saline and ground water ranges from fresh to briny, according to the following classification used by the U.S. Geological Survey.

Class	Dissolved solids (milligrams per litre)
Fresh	0- 1,000
Slightly saline	1,000- 3,000
Moderately saline	3,000-10,000
Very saline	10,000-35,000
Briny	More than 35,000

Table 9.--Summary of quantitative hydrologic estimates

Component	Hydrologic balance Long-term average in acre-feet per year
Inflow:	
Precipitation (p. 15)	3,100,000
Imported water, net (p. 25)	70,000
Total	3,170,000
Outflow:	
Overland runoff (p. 22)	134,000
Irrigation return flows (p. 27)	20,000
Ground-water outflow (p. 35)	30,000[1]
Subtotal (rounded)	184,000
Evapotranspiration in subbasin	2,986,000[2]
Ground-water system:	
Recharge:	
From precipitation (p. 28)	100,000
From imported water (p. 28)	20,000
Total	120,000
Discharge:	
Evapotranspiration along waterways (p. 33)	83,000
Subsurface outflow (p. 35)	30,000
Seeps and springs (p. 31)	4,500
Wells (p. 35)	500
Total	118,000
Recoverable ground water in storage:	Acre-feet
In unconsolidated deposits (p. 30)	190,000
In consolidated rocks[3] (p. 30)	3,000,000
Total (rounded)	3,200,000

[1]Includes about 2,000 acre-feet of surface flow to the Green and Strawberry Rivers from individual springs.

[2]Calculated difference between total inflow and other components of outflow.

[3]Upper 100 feet of saturated rock only.

In general, water at the higher altitudes is freshest. There appears to be no clear correlation between water quality and geology, although water from the Uinta Formation, which crops out in the lower altitudes, seems to be consistently more saline. The ratio of individual dissolved constituents seems to be more closely related to the relative concentration of total dissolved solids rather than to the geologic source of the water. The general chemical quality of water in the southern Uinta Basin is shown on plate 3.

Surface water

Table 13 contains chemical analyses of water collected from streams at miscellaneous sites throughout the southern Uinta Basin. Only selected analyses are included in table 13. For regular water-quality stations on the Green, White, and Duchesne Rivers (stations 09307000, 09306500, and 09302000 on pl. 1, and sites 22, 21, and 20 on pl. 3). Additional analyses, beginning in 1950, of water from those sites are available in the files of the Geological Survey.

The discharge weighted average concentrations of dissolved solids in the Green, White, and Duchesne Rivers at sites 22, 21, and 20, for the period 1964-66, respectively, were 457, 484, and 702 mg/l. Recorded concentrations of dissolved solids in the Green and White Rivers generally are less than 1,000 mg/l throughout the year, but the concentrations of dissolved solids in the Duchesne River commonly exceed 1,000 mg/l and occasionally exceed 2,000 mg/l during late irrigation and low-flow periods.

The dissolved-solids concentrations in water samples from streams that head in the southern Uinta Basin ranged from 343 mg/l near the head of Minnie Maud Creek (site 8) to 7,240 mg/l near the lower end of Bitter Creek (site 18). There is a marked increase in the dissolved-solids concentration of water collected from downstream sites (sites 14 and 17) over that from upstream sites (sites 12 and 16) on Hill and Willow Creeks. The higher concentrations of dissolved solids in water in the lower stream reaches is common to all streams sampled; it is attributed to inflow of saline ground water, to irrigation return flows, and to concentration of dissolved solids by evapotranspiration of the stream water.

In the headwater areas, where dissolved-solids concentrations are low, the stream water is of a calcium bicarbonate type, whereas water in the lower stream reaches generally contains magnesium and sodium as the dominant cations, and sulfate is the dominant anion. Exceptions occur during high runoff periods in the lower reaches of streams that drain the extreme western part of the study area. Because of rapid runoff from these relatively short drainage basins, water in the lower reaches is fresh and either of a mixed or calcium bicarbonate type, as indicated by analyses of water from Timber Canyon and Avintaquin Creeks (table 13).

Ground water

Chemical analyses of water sampled from water wells and springs are given in table 14; analyses of water from oil and gas wells and tests are given in table 15. The dissolved-solids concentrations in water sampled from springs ranges from 190 mg/l at Horse Ridge Spring(?) to 7,702 mg/l at Stinking Spring. Water from springs in the headwater areas of the principal streams above an altitude of about 8,000 feet (2,438 m) generally contains less than 1,000 mg/l of dissolved solids, whereas water from springs in the lower altitudes generally contains more than 1,000 mg/l. The high-altitude springs are near their recharge areas, whereas the low-altitude springs sampled are generally far removed from their recharge areas. Therefore, water discharging from the high-altitude springs has had less time of travel in the aquifer system and less opportunity to dissolve minerals.

The dissolved-solids concentrations in water from water wells (including several water-producing oil and gas tests that were converted to water wells) range from 327 mg/l in well (D-13-14)24dba-1, which is the Green River Formation, to 4,480 mg/l in well U(C-4-2)5bba-2, which taps unconsolidated deposits near their contact with the underlying Uinta Formation. The high concentrations of boron, sulfate, and dissolved solids in water from the latter well indicate that the original source of a large percentage of the water is the Uinta Formation.

Waters sampled from most oil and gas wells and tests were collected from depths of more than 1,000 feet (305 m) and generally are slightly saline to briny. (See table 15.) The only freshwater sampled from oil tests was from wells (D-11-12)14baa-1 and (D-14-20)30bab, which tapped the Green River Formation between depths of 635-650 and 1,883-1,910 feet (194-198 and 574-582 m), respectively. These waters contained only 619 and 818 mg/l of dissolved solids, respectively. The dissolved-solids concentration in water from other oil and gas wells and tests listed in table 15, however, ranges from 1,086 to more than 100,000 mg/l.

Plate 3 shows the ranges of dissolved-solids concentrations that can be expected from at least one aquifer in the southern Uinta Basin. It shows that the only areas where fresh ground water generally is available are along the higher south rim of this subbasin.

In many cases, the dissolved-solids concentrations in the ground water increase with depth. Consequently, even at higher altitudes where freshwater is obtained from springs and shallow wells, deep aquifers are likely to contain saline water. For example, although well (D-14-20)30bab produced freshwater from the Green River Formation at a depth of 1,883-1,910 feet (574-582 m), well (D-14-20)30ac, less than half a mile (0.8 km) to the southeast, produced very saline water from a depth of 3,790-3,820 feet (1,155-1,164 m).

There is no clear correlation between the chemical type of ground water and the geologic source of the water in the southern Uinta Basin. Most of the waters containing less than about 1,000 mg/l of dissolved solids are of the calcium bicarbonate or magnesium bicarbonate type (pl. 3), regardless of geologic source. However, most of the freshest waters are from high-altitude springs that discharge from the Green River Formation. Slightly to moderately saline waters generally are of the sodium bicarbonate or sodium sulfate types. Chloride is a minor constituent in water from water wells and springs in the area but is a major constituent in the very saline to briny waters from deep oil and gas wells and tests.

Although not shown by Stiff diagrams on plate 3, table 15 indicates that a number of the more highly concentrated water samples collected from oil and gas wells and tests in the Uinta and Green River Formations, such as U(C-4-5)14dca-1, are of the sodium carbonate type. Similarly, three water samples from Stinking Spring had sodium and carbonate as the principal cation and anion (table 14). All these waters apparently were in contact with evaporite deposits that contain beds of trona, a hydrous sodium carbonate mineral.

Chemical quality in relation to use

Domestic and stock

The U.S. Public Health Service (1962) has established water-quality standards for drinking water which include dissolved mineral constituents among other parameters. The following table lists the maximum limits recommended by the Public Health Service for some of the more common mineral constituents for which analyses are given in tables 13, 14, and 15.

"The following chemical substances should not be present in a water supply in excess of the listed concentrations * * * where other more suitable supplies are or can be made available." (U.S. Public Health Service, 1962, p. 7.)

Substance	Recommended limit (milligrams per litre)
Chloride (Cl)	250
Fluoride (F)	1.3[1]
Iron (Fe)	.3
Nitrate (NO_3)	45 (10 mg/l expressed as N)
Sulfate (SO_4)	250
Dissolved solids	500

[1]Based on the average maximum daily air temperature of 60.7°F (15.9°C) at Duchesne, Utah (1968-72).

According to the foregoing table most of the waters in the area, except those from the upper reaches of streams and high-altitude springs, exceed the maximum limit of 500 mg/l for dissolved-solids concentrations. The recommended limit of 250 mg/l for sulfate also is exceeded in many of the water sources, and the maximum recommended limit of 1.3 mg/l for fluoride is exceeded in a number of sources.

The generally poor chemical quality of water in the southern Uinta Basin with regard to suitability for domestic use has made it necessary for water suppliers in the population centers of Duchesne, Myton, and Pleasant Valley to import better quality water from the northern Uinta Basin. Water from many sources in the southern Uinta Basin may not be chemically suitable for drinking.

The State of Montana (McKee and Wolf, 1963, p. 113) rates water for livestock on the basis of dissolved solids as follows:

Rating	Dissolved solids (milligrams per litre)
Good	Less than 2,500
Fair	2,500-3,500
Poor	3,500-4,000
Unfit	More than 4,500

According to this rating, water from most springs, water wells, and upper stream reaches is suitable (but only poor to fair in many cases) for livestock. Water from the lower reaches of some streams, such as Bitter Creek (during low flow), an orifice of Stinking Spring, and certain oil and gas wells, may be unfit for livestock. However, cattle are known to drink water with more than 4,500 mg/l of dissolved solids where better water is not available.

Irrigation

Important characteristics that help to determine the chemical suitability of water for irrigation in arid and semiarid areas are the specific conductance (electrical conductivity) and sodium-adsorption ratio (SAR) of the water (see table 13, 14, and 15). Specific conductance is an index of dissolved-solids concentration of the water and SAR is an index of the ratio of sodium to other cations in the water according to the following equation:

$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}}$$

where the concentrations of the ions are expressed in milliequivalents per litre.

The U.S. Salinity Laboratory Staff (1954, p. 69-81) has devised a method of classifying irrigation water by plotting SAR against conductivity of the water in the diagram shown in figure 11. The classification is based on average conditions with respect to soil texture, infiltration rate, drainage, amount of water applied, climate, and salt tolerance of crops.

According to this classification, water from the Green, White, and Duchesne Rivers at water-quality stations 09307000, 09306500, and 09302000 (sites 22, 21, and 20 in table 13) and from the upper reaches of the streams that drain the southern Uinta Basin has a low sodium-medium to high salinity hazard for irrigation under average conditions. However, water from the lower reaches in Willow, Evacuation, and Antelope Creeks probably would have high to very high sodium and salinity hazards, except perhaps during peak runoff periods.

Although waters from the high-altitude springs have a low sodium-medium to high salinity hazard, ground water in the lower altitudes most likely would have a high to very high sodium and salinity hazard as indicated by the analyses of water from spring (D-12-21)19bdd-S1 and well U(C-4-3)9bbd-1 (table 14). It is interesting to note that water from the only well in the southern Uinta Basin known to be drilled specifically for irrigation--well U(C-5-5)34bdd-2--has a high salinity hazard but a low sodium hazard.

Relative concentrations of boron in water also determine the suitability of the water for irrigation. Wilcox (1958, p. 5) has classified plants as sensitive, semitolerant, and tolerant, according to their ability to withstand the toxic effects of various concentrations of boron. Irrigation water with boron in concentrations of less than 0.3 mg/l is considered suitable for even the most boron-sensitive crops such as corn and legumes, whereas water with concentrations of boron in excess of 4.0 mg/l may be unsuitable for the most boron-tolerant plants such as alfalfa.

According to tables 13 and 14, the concentrations of boron in the southern Uinta Basin range from 0.07 to 10.00 mg/l in water from streams and 0.00 to 22.6 mg/l in water from springs and water wells. The concentration of boron in the Duchesne River near site 20 ranged from 0.12 to 2.99 mg/l and averaged 0.75 mg/l in 22 samples collected between 1942 and 1958 (Iorns and others, 1964, p. 586-587). However, the boron concentration may be somewhat lower upstream where water is diverted for irrigation in the southern Uinta Basin. Major contributions of boron to the Duchesne River come from Indian Canyon Creek, which enters the Strawberry River near its confluence with the Duchesne River above the Grey Mountain-Pleasant Valley Canal diversion, and Antelope Creek, which enters the Duchesne River above the Myton Townsite Canal Diversion. (See table 13.)

The initial source of boron apparently is the evaporite deposits in the Uinta and Green River Formations. Seeps and individual springs, such as U(C-5-6)1caa-S1 and S2, probably contribute most of the boron to the streams, and the boron content is concentrated as the streamflow is depleted by evapotranspiration.

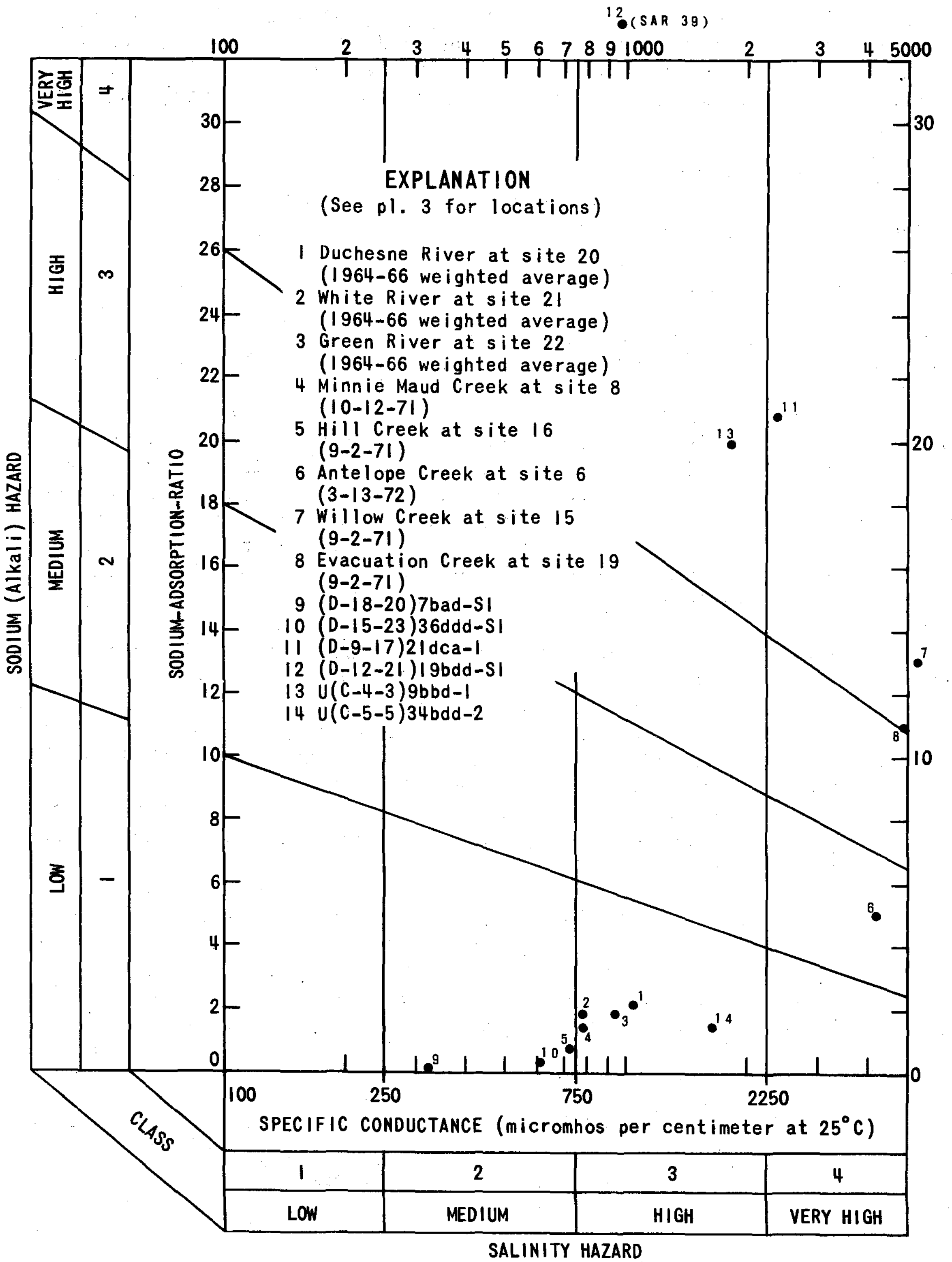

Figure 11.— Diagram used to classify water for irrigation. (From U.S. Salinity Laboratory Staff, 1954.)

AVAILABILITY OF WATER FOR FUTURE DEVELOPMENT

The largest future water needs in the southern Uinta Basin most likely will be for development of oil-shale reserves (including related municipal and satellite industrial needs) in this subbasin and for supplementary irrigation. The amount of water needed for oil-shale development is not known, but preliminary estimates given by the U.S. Department of the Interior (1973, Table III-5) indicate that it might range from about 6,000 to 9,600 acre-feet (7.5-11.8 hm^3) per year for an oil-production capacity of 50,000 barrels per day. Associated public supply and industrial needs could exceed 1,000 acre-feet (1.2 hm^3) per year.

Considerably more irrigation water will be needed in the southern Uinta Basin if all land classified as arable is to be placed under irrigation. Austin and Skogerboe (1970, p. 46-49), for example, indicate that there are about 33,000 acres (13,355 hm^2) of arable land on Pariette Bench, along the White River, and in the Green River bottom between the White River and Willow Creek. Most of this land currently is not irrigated. At a crop requirement of 3 feet (0.9 m) per year, the amount of water needed to irrigate all the land would exceed 100,000 acre-feet (123 hm^3) per year.

Water to meet some of the potential future needs in the southern Uinta Basin could be obtained by increased utilization of the water supply that originates from precipitation entirely on this subbasin. Development of such a supply would be deterred, however, by such factors as uneven time and areal distribution of the supply and generally poor chemical quality of the water.

The water supply from precipitation on the southern Uinta Basin averaged about 3.1 million acre-feet (3,800 hm^3) annually during the period 1941-70. Annual runoff from this subbasin is estimated to average about 134,000 acre-feet (165 hm^3). An estimated 3.2 million acre-feet (3,947 hm^3) of recoverable ground water is stored in the unconsolidated deposits and upper 100 feet (30.5 m) of saturated consolidated rocks in this subbasin, with an estimated average annual replenishable ground-water supply of about 120,000 acre-feet (148 hm^3). Although these figures seem quite impressive, only a small fraction of the water is readily available for development.

Runoff is highly irregular; much of it is in intermittent and ephemeral streams and cannot be relied on for large sustained supplies. The only basins in which development of large sustained supplies by regulation seems possible are the Evacuation, Willow, Nine Mile, Range, and Avintaquin Creek basins. Estimated mean annual runoff from these basins totals about 55,000 acre-feet (61.7 hm^3) per year (table 6). Reservoir storage of runoff from these basins would provide a supply of high-quality water for use during low-flow periods.

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The best potential source for future large-scale development of ground water in the southern Uinta Basin lies in the unconsolidated alluvial deposits along the Green, White, and Duchesne Rivers. These deposits, where saturated, generally are less than 50 feet (15.2 m) thick and are of small extent. Because of their relatively high permeability, however, they seem capable of supporting sustained yields of more than 100 gal/min (6.3 l/s) to large-diameter wells or infiltration systems. The close relation between the surface water and ground water along the major streams in the southern Uinta Basin, however, indicates that such development doubtless would affect streamflow. However, pumping water from the unconsolidated deposits may, by lowering the water table, help to reduce nonbeneficial consumptive use of water by phreatophytes.

The bedrock formations that underlie the southern Uinta Basin are generally not permeable enough to support large sustained withdrawals (more than 500 gal/min or 31.5 l/s) from wells. Much of the Uinta Formation is drained by the deeply incised streams that dissect it, and where it is saturated it yields water slowly to most wells and springs. The Green River Formation seems relatively permeable in the general vicinity of well (D-11-24)7cac-1, but data collected during this study failed to indicate the existence of an extensive permeable "leached zone" such as was reported in the Green River Formation where it underlies the Piceance Creek Basin of Colorado just east of the Uinta Basin (Coffin and others, 1971). The Wasatch and North Horn Formations and sandstone units of the Mesaverde Group appear to be relatively permeable in areas of outcrop in the Range Creek area, but oil-test data indicate that they have low permeability in the subsurface beneath most of the southern Uinta Basin.

A major problem affecting the future development of water that originates from precipitation in the southern Uinta Basin is the generally poor chemical quality of the water. Any plan to develop freshwater supplies for use in the lower parts of this subbasin probably would have to consider conveying the water from higher areas or desalting the water from a local source.

FUTURE STUDIES

The information given in this report provides a general regional appraisal of the water resources of the southern Uinta Basin. Considerable detailed study is needed on a local scale to provide information for better delineation of the chemical quality of the water, for refinement of quantitative estimates given herein, and for evaluation in greater detail of the best potential sources for future development. Additional study may also be required to provide information needed to minimize the effects of oil-shale development on the water quality of the Colorado River system and the environment in general.

Several studies that could be done in the near future are:

1. A systematic study of the hydrologic properties of the Green River Formation, with emphasis on the Parachute Creek Member. The Parachute Creek Member contains the richest oil-shale deposits in the area and may contain a permeable "leached zone" beneath the shale similar to that found in the Piceance Creek Basin of Colorado. Such a study would require detailed examination of all available oil-field geophysical data, test drilling, and aquifer tests.

2. A detailed study of consumptive use of water by phreatophytes along perennial streams such as Willow and Nine Mile Creeks. Determination of water salvage by phreatophyte eradication or replacement would be included in the study. Such a study would require construction of observation wells and installation of special instruments to monitor streamflow, ground-water levels, evaporation, precipitation, and water quality.

3. A qualitative evaluation of the stream-aquifer systems, especially along the Duchesne River.

4. A study to determine the feasibility of upstream regulations of such streams as Willow and Nine Mile Creeks to conserve the water of good quality that normally is lost by outflow during periods of high runoff. The study would include evaluation of possible damsites and methods to convey, distribute, and use the water.

5. A study to determine means of minimizing the effect of oil-shale development on the chemical quality of the Colorado River systems. Such a study would include examination of sites for surface disposal of spent shale and for evaporation of produced brines. It would also include evaluation of sites for subsurface injection of brines. This would require drilling of injection and observation wells and installation of monitoring equipment to determine the environmental impact and the economic feasibility of subsurface injection.

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Table 10.--Records of selected water wells

Casing depth: Depth to bottom of casing or to uppermost opening in casing.
Water-bearing zone(s): Character of material; G, gravel; Ls, limestone; S, sand; Sh, shale; Ss, sandstone.
Altitude of land surface: Above mean sea level, as interpolated from U.S. Geological Survey topographic maps.
Water level: F, well flows under unknown artesian head; figures are feet below land surface and are reported, except for those shown to nearest tenth which were measured by the U.S. Geological Survey.
Yield: Reported, rate assumed to be by pumping except (b) bailing or (f) artesian flow; drawdown assumed to be feet below static water level.
Use: D, domestic; I, irrigation; N, industrial; S, livestock; U, unused.
Remarks and other data available: C, chemical analysis of water in table 14; FC, field determination of specific conductance of the water (micromhos per cm at 25°C); L, lithologic log in table 11.

Location	Owner	Year drilled	Well depth (ft)	Casing depth (ft)	Casing diameter (in.)	Water-bearing zone(s): Depth to top (ft)	Water-bearing zone(s): Thickness (ft)	Water-bearing zone(s): Character of material	Altitude of land surface (ft)	Water level: Feet	Water level: Date measured	Yield: Rate (gal/min)	Yield: Drawdown (ft)	Use of water	Remarks and other data available
(D-9-17)21dca-1	U.S. Bureau of Land Management	1935	22	-	48	6	16	Ls	5,295	2	9- -71	3	-	U	Excavation at Snyder Spring; soil, 0-6 ft; solid lime, 6-22 ft; C.
(D-9-20)20acd-1	Sun Oil Co.	1952	166	-	-	140	15	Ss	4,780	-	-	8b	-	U	Water reported salty; L.
(D-10-20)35bbc-1	U.S. Bureau of Land Management	1964	5,672	168	13 3/8	1,700	-	-	5,240	F	-	58f	-	S	Former gas-producing well; casing 13 3/8 in. to 168 ft; 5 in. to 5,672 ft; C.
(D-10-24)2acc-3	American Gilsonite Co.	1960	31	10	30	10	-	S,G	4,955	10	12-21-60	55	-	N	Representative of several wells that tap alluvium of White River in this area; boulders, 0-22 ft; gravel, 22-31 ft; water from these wells generally is fresh and similar to water in the White River.
(D-11-15)32dcd-1	Preston Nutter Corp.	-	-	-	6	-	-	-	5,780	42.9	4-11-72	-	-	D	C.
(D-11-21)21caa-1	U.S. Bureau of Land Management	1951	610	460	5	350	150	Sh	5,755	300	7- -51	25b	50	S	Blue shale, 0-610 ft.
30bdb-1	L. M. Thorne	1934	18	-	48	-	-	-	5,139	16	-	-	-	S	
31bdd-1	Golden Hatch	1952	711	610	4	701	10	Ss	5,190	F	8-31-71	2f	-	S	C, L.
(D-11-24)6dbc-1	U.S. Bureau of Land Management	1962	5,950	223	13 3/8	1,210 1,350	30 20	- -	5,196	F	-	-	-	S	Former gas-test well; casing 13 3/8 in. to 223 ft; 9 5/8 in. to 2,207 ft; 4½ in. to 4,598 ft; water enters well through annulus between 4½ and 9 5/8 in. casing; C.
7cac-1	do	1962	5,840	216	13 3/8	1,159	241	-	5,268	F	-	175f	-	U	Former gas-test well; casing 13 3/8 in. to 216 ft; 9 5/8 in. to 2,396 ft; water enters well through annulus between 13 3/8 and 9 5/8 in. casing; C.
33dcc-1	do	1936	82	-	-	80	2	Ls	5,780	72	2- -36	8	-	U	Abandoned mine shaft; water reported good; appeared to be also abandoned as well 9-1-71; L.
(D-12-19)13cad-1	-	-	-	-	-	-	-	-	5,505	54.9	9- 2-71	-	-	U	
(D-12-22)34abc-1	Willis Stevens	1961	120	20	20	-	-	-	6,230	78	4- -61	-	-	U	L.
(D-13-14)24dba-1	Pan American Petroleum Corp.	-	-	-	-	-	-	-	8,225	150	7- -66	-	-	-	Assumed to be water supply for oil-test drilling; C.
(D-13-21)15ddc-1	Willis Stevens	1961	52	52	6	35	17	S,G	5,590	35	4- -61	-	-	U	Soil, 0-6 ft; silt and gravel, 6-29 ft; sand and coarse gravel 29-52 ft; water reported brackish.
22aab-1	do	1961	40	15	5	18	7	S,G	5,600	10	4- -61	-	-	U	Water reported brackish; L.
(D-14-18)1bbd-1	Ute Indian Tribe	1964	130	14	8	-	-	-	7,045	68.9	8- 8-72	3	-	S	Original depth, 212 ft; temperature 13.0°C; FC, 7,000; L.
(D-14-19)3cdb-1	do	1960	96	65	5	-	-	-	6,880	80	12- -60	5	96	S	L.
(D-14-22)26aca-1	Willis Stevens	1959	150	-	-	-	-	-	7,080	-	-	-	-	U	Reportedly a dry hole; sand, 0-21 ft; blue shale, 21-150 ft.
(D-15-20)3bab-1	Ute Indian Tribe	1960	108	60	5	-	-	Ss	7,440	52	12- -60	15b	-	S	Water reportedly contained 280 mg/l of dissolved solids; L.
12cca-1	do	1964	120	12	8	-	-	-	7,425	60	6- -64	4b	60	U	Sandstone, 0-60 ft; shale, 60-120 ft; water reported good.
U(C-3-1)33cbc-1	John Uresk	1967	20	20	6	-	-	S,G	5,045	-	-	-	-	D	Temperature 10.0°C; FC, 2,200.
U(C-3-5)31dcd-1	D. T. Jones	1969	200	42	6	31	169	Sh	5,790	24	7- -69	9	169	D	Casing 8 in. to 31 ft; 6 in. 31-42 ft; C.
U(C-4-1)7ccb-1	R. J. Marti	1949	36	16	6	16	9	S,G	5,182	16	4- -49	12b	-	U	L.
17ccc-1	Ken Higley	1951	25	15	48	24	1	S	5,155	10	3- -51	30b	5	D	Blue clay, 0-24 ft; sand, 24-25 ft; water reported hard.
18dcc-1	C. Van Tassell	1945	80	15	6	15	5	S,G	5,185	15	4- -45	60b	10	U	L.
28aba-1	Louis Roberts	1948	150	20	6	125	-	Sh	5,155	20	10- -48	15b	10	U	Topsoil, 0-10 ft; blue shale 10-150 ft.
U(C-4-2)2cda-1	Salt Lake Pipe Co.	1950	108	91	12	93	1	Ss	5,295	25	6- -50	25	49	U	Water "very salty"; original depth, 700 ft; L.
5abb-1	Guy Giles	1945	23	20	6	21	2	G	5,180	8	4- -45	20	2	U	L.
5bba-2	Lamar Neilson	1935	40	-	8	5	27	S,G	5,185	1.8	3- 9-71	-	-	D	Formerly reported as 4-bba-1. Original depth, 1,120 ft; hydrograph in figure 10; C, L.
13daa-2	Alden Kynaston	1969	28	28	6	-	-	Sh	5,195	16.7	5- 6-72	20b	25	S	Clay, 0-6 ft; shale, 6-28 ft; C.
14bbb-1	Marion Ross	1954	65	50	6	63	2	Ss	5,237	24	12- -54	8b	16	U	Boulders, gravel, and sand, 0-36 ft; shale and sandrock, 36-65 ft.
14bcc-1	J. E. Wilkens	1957	80	-	6	10	8	G	5,245	10	11- -57	10b	5	U	L.
U(C-4-3)4daa-1	Jack Liddell	1953	55	33	6	15	15	S,G	5,277	18	12- -53	12	5	D	Reportedly yields soft water; L.
9bbd-1	Latter-day Saints Church	1966	70	46	6	63	7	Ss	5,327	30.7	5- 6-72	10b	30	D	C, L.
10aba-1	John Liddell	1946	250	81	6	71	-	Sh	5,282	12	5- -46	2	-	D	Temperature 10.0°C; FC, 2,900; L.
10abb-1	Roger Hicken	1953	180	70	4	-	-	-	5,280	12	12- -53	10b	4	S	Temperature 12.0°C; FC, 2,450.
10cbb-1	Willis Shepard	1948	56	56	7	40	16	S,G	5,325	38	12- -48	30b	2	D	Clay, 0-40 ft; sand and gravel, 40-56 ft; C.
11dcb-1	R. D. Peatress	1945	95	43	6	45	-	Sh	5,310	31	4- -45	4b	13	D	Well reportedly goes dry in late winter; temperature 11.5°C; FC, 2,750; L.
12aca-1	Robert Alred	1945	40	37	6	37	3	G	5,265	23	3- -45	20b	0	D	FC, 860; L.
12cab-1	Wallace Pitt	-	70	-	6	-	-	-	5,291	-	-	-	-	D	C.
16acb-1	D. Farnsworth	1964	67	62	6	-	-	S,G	5,405	44.8	5- 6-72	12b	44	D	Sand and gravel, 0-62 ft; sandstone, 62-67 ft; temperature 10.0°C; FC, >8,000; water not used for drinking.
U(C-4-4)1daa-1	D. W. Covington	1961	43	-	6	18	22	G	5,360	14	7- -61	10b	8	D	Silt, 0-18 ft; gravel and cobbles, 18-40 ft; bedrock, 40-43 ft; FC, 720.
17acb-1	Carter Oil Co.	1951	715	-	-	701	2	S,Sh	5,850	285	-	18b	-	U	Well yielded briny water; plugged and abandoned.

Table 10.--Records of selected water wells - Continued

Location	Owner	Year drilled	Well depth (ft)	Casing depth (ft)	Casing diameter (in.)	Water-bearing zone(s)			Altitude of land surface (ft)	Water level		Yield		Use of water	Remarks and other data available
						Depth to top (ft)	Thickness (ft)	Character of material		Feet	Date measured	Rate (gal/min)	Drawdown (ft)		
U(C-4-6)9abb-1	Peatress	1948	25	20	6	22	3	S	5,748	16	12- -48	8	4	D	Original depth, 120 ft but plugged back because it produced "very bad" water with gas; temperature 11.0°C; FC, 1,340; L.
U(C-4-7)14aaa-1	Pender Ranch	1947	12	12	4	-	-	-	5,875	-	-	-	-	D	Temperature 9.0°C; FC, 1,050.
17dbc-1	Sam Mott	1944	19	15	6	12	-	G	5,945	7	11- -44	7	-	D	Temperature 11.0°C; FC, 660.
35dcd-1	Thomas Olsen	1948	500	-	4	-	-	-	6,960	84	-	15	-	U	Casing pulled, well abandoned; L.
U(C-5-5)34bdd-1	W. C. Foy	1960	170	169	6	170	-	G	6,740	F	7- -60	120	21	-	Water reportedly of good quality; L.
34bdd-2	do	1961	161	65	12	-	-	-	6,610	F	-	300	18	I	Reported flow, 12 gal/min on completion; found flowing about same rate 4-13-72; C, L.
U(C-5-8)25aab-1	Thomas Olsen	1948	175	155	4	165	6	Ss	7,599	140	7- -48	5	15	S	L.

Table 11.--Selected drillers' logs of wells

Altitudes are in feet above sea level for land surface at well as interpolated from U.S. Geological Survey 7½-minute topographic maps.
Thickness, in feet.
Depth, in feet below land surface.

Material	Thickness	Depth
(D-9-20)20acd-1. Log by Garnett Birchell. 1952. Alt. 4,780 ft.		
Topsoil	3	3
Shale, blue	57	60
Sandstone, gray	13	73
Shale, blue; interbeds of brown shale	67	140
Sandstone, soft, light; salty water	25	165
Not reported	1	166
(D-9-20)27aac-1. Log by De Kalb Agricultural Association. 1959. Alt. 4,845 ft.		
Clay, varicolored, and silt	460	460
Sand, fine to coarse, light green	10	470
Limestone	30	500
Clay, silt, and sand, light gray	30	530
Clay, silt, and sand, gray, green, and purple	90	620
Clay, silt, and dolomite	10	630
Alternating shale, siltstone, and sandstone beds	660	1,290
Shale, silty, brown, and dolomite, "oil"; water at 2,720 ft	1,670	2,960
Clay, silt, and sand, light gray	110	3,070
Limestone, gray and gray green	210	3,280
Clay, silt, and sand, light gray, green gray, and tan	40	3,320
Clay and silt, gray, green, and tan, with trace of sandstone	320	3,640
Dolomite and limestone, tan	60	3,700
Clay, silt, and sand, green and light gray	280	3,980
Silt and sand, white and light gray, friable and oolitic; water bearing	50	4,030
Clay, silt, and sand, gray and green, with trace of limestone	930	4,960
Clay, tan, dense; fossils(?)	100	5,060
Clay and silt, varicolored	75	5,135
(D-11-21)31bdd-1. Log by C. W. Anderson. 1952. Alt. 5,190 ft.		
Topsoil	15	15
Gravel; water (salty) bearing	235	250
Shale, dark red	250	500
Shale, blue	198	698
Sandstone, porous	13	711
(D-11-24)33dcc-1. Log by C. M. Erb. 1936. Alt. 5,780 ft.		
Soil and gravel	15	15
Limestone	57	72
Gilsonite, low grade	8	80
Lime bed, fractured; water bearing	2	82
(D-12-22)34abc-1. Log by Everett Osborne. 1961. Alt. 6,230 ft.		
Sand, gravel, and conglomerate	12	12
Shale, blue gray	66	78
Sandstone, gray	24	102
Shale, green and buff	18	120
(D-13-21)22aab-1. Log by Everett Osborne. 1961. Alt. 5,600 ft.		
Topsoil	8	8
Clay, silty, sandy	10	18
Sand and gravel	7	25
Mud and silt, blue	15	40
(D-14-18)1bbd-1. Log by Uintah Basin Drilling Co. 1964. Alt. 7,045 ft.		
Clay and sand	14	14
Bedrock	32	46
Sandstone	6	52
Shale, blue	108	160
Shale; oil bearing	52	212
(D-14-19)3cdb-1. Log by Uintah Basin Drilling Co. 1960. Alt. 6,880 ft.		
Bedrock and clay	10	10
Shale, gray	26	36
Shale, gray and green	44	80
Sand, white	4	84
Shale, gray and green	12	96
(D-15-20)3bab-1. Log by Uintah Basin Drilling Co. 1960. Alt. 7,440 ft.		
Clay and rock	7	7
Sandstone, yellow	57	64
Sand, white	3	67
Sandstone, yellow	38	105
Sand, white	3	108
U(C-4-1)7ccb-1. Log by Garnett Birchell. 1949. Alt. 5,182 ft.		
Topsoil and gravel	16	16
Sand and gravel	9	25
Clay, blue	11	36
U(C-4-1)18dcc-1. Log by J. C. Zimmerman. 1945. Alt. 5,185 ft.		
Clay, yellow	2	2
Sand and gravel	18	20
Clay, blue	60	80
U(C-4-2)2cda-1. Log by Robinson Drilling Co. 1950. Alt. 5,295 ft.		
Topsoil	3	3
Clay, coarse gravel, and sand	7	10
Gravel, coarse, boulders, and little clay	4	14
Gravel and boulders; some water	4	18
Sandrock	4	22
Clay, dark yellow	11	33
Sandrock	2	35
Clay, blue	13	48
Sandrock	6	54
Clay, blue	6	60
Clay, blue and red	5	65
Clay, blue	28	93
Sandrock; water bearing	1	94
Clay, sandy, blue	6	100
Clay, sandy, blue, with hard shells	11	111
Shale, blue	23	134
Shale, red	9	143
Shale, blue	17	160
Shale, sandy, blue	41	201
Sandrock	4	205
Shale, sandy, blue	145	350
Shale, sandy, red	5	355
Sandrock	15	370
Shale, sandy, blue	32	402
Shale, sandy, brown	5	407
Shale, sandy, blue	10	417
Shale, sandy, brown	11	428
Shale, sandy, blue	82	510
Shale, sandy, brown	70	580
Shale, blue	20	600
Shale, brown	15	615
Shale, blue	55	670
Shale, red	10	680
Shale, blue	20	700
U(C-4-2)5abb-1. Log by Klippel Bros. 1945. Alt. 5,180 ft.		
Topsoil	6	6
Clay, sandy	7	13
Sandstone, fine	8	21
Gravel, coarse; water bearing	2	23
U(C-4-2)5bba-2. Log by Ellery Grant. 1935. Alt. 5,185 ft.		
Soil, clayey	5	5
Sand and gravel; water bearing	27	32
Clay, blue	5	37
Sand; water bearing	24	61
Shale, blue	99	160
Sandstone, water bearing	6	166
Shale, blue	302	468
Sandstone	24	492
Slate rock	8	500
Shale, blue	42	542
Unknown	578	1,120
(Well plugged back to 40-foot depth)		
U(C-4-2)14bcc-1. Log by Uintah Basin Drilling Co. 1957. Alt. 5,245 ft.		
Topsoil	10	10
Gravel	8	18
Sandrock	62	80
U(C-4-3)4daa-1. Log by Uintah Basin Drilling Co. 1953. Alt. 5,2 7 ft.		
Clay	15	15
Gravel and sand	25	40
Clay, blue	15	55
U(C-4-3)9bbd-1. Log by Uintah Basin Drilling Co. 1966. Alt. 5,327 ft.		
Clay	8	8
Clay and gravel	7	15
Sand and cobbles	26	41
Slate	22	63
Sandrock	7	70
U(C-4-3)10aba-1. Log by Klippel Bros. 1946. Alt. 5,282 ft.		
Topsoil	18	18
Sand and gravel	14	32
Shale, blue	6	38
Shale, gray, with cobble rocks and gravel	33	71
Shale, blue	3	74
Sandstone	1	75
Shale, gray, rotten	1	76
Sandstone	1	77
Shale, sandy, gray	31	108
U(C-4-3)10aba-1. - Continued		
Shale, hard, with thin shells	7	115
Shale, sandy	30	145
Shale, blue, sticky	35	180
Sandstone, soft	8	188
Shale, blue, sticky	2	190
Shale, sandy	10	200
Shale, brown, hard	2	202
Shale, blue	43	245
Shale, brown	5	250
U(C-4-3)11dcb-1. Log by Klippel Bros. 1945. Alt. 5,310 ft.		
Topsoil	2	2
Boulders and yellow clay	12	14
Clay, yellow	13	27
Shale, gray	12	39
Shale, red	5	44
Shale, gray, crumbly	1	45
Shale, gray	50	95
U(C-4-3)12aca-1. Log by Klippel Bros. 1945. Alt. 5,265 ft.		
Topsoil	2	2
Clay, sandy, with boulders	12	14
Clay, sandy	21	35
Sandstone, fine grained	2	37
Gravel, medium; water bearing	3	40
Clay, heavy	-	-
U(C-4-6)9abb-1. Log by Klippel Bros. 1948. Alt. 5,748 ft.		
Alluvium	22	22
Sand; water bearing	3	25
Shale, slatey gray	10	35
Sand, black	15	50
Shale, slatey gray	17	67
Limestone, shelly	2	69
Shale, slatey gray	5	74
Sand; water bearing	3	77
Sand, black; water bearing	43	120
U(C-4-7)35dcd-1. Log by Klippel Bros. 1948. Alt. 6,960 ft.		
Alluvium	36	36
Sandstone, brown	6	42
Limestone	8	50
Sandstone, brown	18	68
Sandstone, gray	16	84
Sandstone, black; water bearing	12	96
Limestone	21	117
Shale, sandy, yellow	47	164
Shale, gray	17	181
Unknown	3	184
Sandstone, gray	11	195
Limestone	17	212
Shale, sandy, yellow	41	253
Limestone	8	261
Shale, sandy, yellow	33	294
Sandstone, red	26	320
Shale, sandy, yellow	45	365
Shale, sandy, brown	45	410
Sandstone, black, hard	42	452
Shale, bentonitic	29	481
Sandstone, yellow, hard	7	488
Shale, bentonitic	12	500
U(C-5-5)34bdd-1. Log by Uintah Basin Drilling Co. 1960. Alt. 6,740 ft.		
Sand, silty	12	12
Gravel and cobbles	157	169
Not reported	1	170
U(C-5-5)34bdd-2. Log by Uintah Basin Drilling Co. 1961. Alt. 6,610 ft.		
Soil and clay	20	20
Clay	45	65
Gravel	2	67
Clay	9	76
Gravel	4	80
Clay	7	87
Gravel	8	95
Sand and gravel	5	100
Clay	5	105
Gravel	25	130
Clay and sand	5	135
Sand	8	143
Shale; oil bearing	4	147
Rock, solid	3	150
Shale; oil bearing	11	161
U(C-5-8)25aab-1. Log by Klippel Bros. 1948. Alt. 7,599 ft.		
Alluvium	114	114
Sandstone	40	154
Shale, sandy, gray	11	165
Sandstone; water bearing	6	171
Sandstone, hard	4	175

Table 12.--Records of selected springs

Altitude of land surface: Above mean sea level as interpolated from U.S. Geological Survey topographic maps.
Geologic source: Qay, unconsolidated deposits; Tu, Uinta Formation; Tgp, Parachute Creek Member, Green River Formation; Tw, Wasatch Formation; KTnh, North Horn Formation.
Discharge: Rate estimated or measured (m) by U.S. Geological Survey; otherwise reported (r) by owner or user; <, less than.
Use: D, domestic; I, irrigation; S, livestock; U, unused.
Remarks and other data available: C, chemical analysis of water in table 14; FC, field determination of specific conductance of the water (micromhos/cm at 25°C).

Location	Name or owner	Altitude of land surface (ft)	Geologic source	Discharge			Use	Remarks and other data available
				Rate (gal/min)	Temper- ature (°C)	Date		
(C-10-17)12baa-S1	Unknown	5,420	Tu	<0.5	-	3-16-72	-	Undeveloped; probably intermittent and used by livestock; C.
(D-11-15)15dbb-S1	do	6,660	Tgp	<.5	-	3-16-72	-	Do.
(D-11-17)20aca-S1	do	5,600	Tgp	<.5	-	3-16-72	-	Do.
(D-11-18)20cba-S1	do	4,800	Tgp	1		3-16-72	S	Undeveloped; rises from streambed, nearby seeps along canyon walls; C.
(D-12-21)19bdd-S1	Sulphur Spring	5,335	Tgp	20	19.5	8-30-71	U	Part of flow is collected in small tank that overflows to marshy area; entire flow is consumed by rushes and other vegetation in the general area; C.
(D-13-14)24adb-S1	Pan American Oil Corp.	8,275	Tgp	-	-	-	-	C.
(D-13-19)8aa-S1	Unknown	6,150	Tgp	.25	-	8- 8-72	-	FC, 2,200.
(D-13-23)27acd-S1	do	6,180	Tgp	<.5	-	4-12-72	-	Undeveloped; probably intermittent and used by livestock; C.
(D-13-25)13add-S1	Mud Spring	6,475	Tw	Dry	-	9- 1-71	U	Formerly used for domestic and stock supply; reportedly dry in recent years.
17bdb-S1	Flat Rock Spring	7,230	Tgp	Dry	-	9- 1-71	-	Reportedly dry in recent years.
29bab-S1	Indian Spring	7,050	Tgp	2	11.5	9- 1-71	S	Piped to stockwatering troughs; reported to yield as much as 10 gal/min; C.
(D-14-14)4abd-S1	Pan American Oil Corp.	9,500	Tgp	-	-	-	-	C.
(D-14-19)33aad-S1	Charlie Brown Spring	7,120	Tgp	<.5	-	9- 2-71	S	Piped to two stockwatering troughs; C.
(D-14-22)25cac-S1	Pine Spring	7,060	Tgp	4.5m	8.0	8- 9-65	S	Piped to stockwatering trough; discharge measured by U.S. Bureau of Land Management; C.
(D-14-24)21ccc-S1	Unknown	6,580	Tgp	10	10.0	9-12-72	S	Piped to stockwatering trough; C.
(D-15-19)4bba-S1	Secret Spring	7,190	Tgp	<.5	-	9- 2-71	-	Undeveloped; almost completely desiccated when visited; C.
(D-15-20)15bbd-S1	Flat Rock Spring	7,240	Tgp	.13m	-	8-31-71	S	Piped to stockwatering trough; C.
(D-15-23)36ddd-S1	PR Spring	8,010	Tgp	5.6m	8.5	9-17-64	S	Piped to stockwatering trough; discharge measured by U.S. Bureau of Land Management; C.
(D-15-25)7bcc-S1	Unknown	7,438	Tgp	.2m	10.5	9-23-73	S	Piped to stockwatering trough; C.
(D-16-16)31aaa-S1	Waldo Wilcox	5,590	Qay	15	11.0	4-11-72	I	Flows directly to Range Creek; discharge reportedly increases in response to irrigation upvalley from spring; FC, 860.
32dda-S1	do	5,430	Tw	150r	11.0	4-11-72	I	Piped from collector box to nearby field; owner measured discharge of 150 gal/min and reported the rate to be fairly constant throughout the year; C.
(D-16-17)3c-S1	Camel Rock Spring	4,800	Tw	225	-	9-25-48	-	C.
(D-16-18)24bcd-S1	Pinto Springs	7,925	Tgp	<1	-	8-31-71	S	Discharges to small ravine which appears to gain in flow along about a 50-foot reach; water ponded for stockwatering; C.
(D-16-22)23dcd-S1	Cedar Camp Spring	7,900	Tgp	5	-	7- 2-60	D,S	Piped to stockwatering trough; discharge measured by U.S. Bureau of Land Management.
(D-17-16)10cac-S1	Waldo Wilcox	5,040	KTnh	6r	-	-	D	Combined flow of (D-17-16)10cac-S1 and 10cca-S1 piped to several ranch houses for culinary use; C.
10cca-S1	do	5,040	KTnh	6r	-	-	D	Do.
15bac-S1	do	5,030	KTnh	<1	11.5	4-11-72	U	Undeveloped; discharges from fractured rock directly into Range Creek; FC, 1,000.
(D-17-17)20ccc-S1	Unknown	4,240	KTnh	-	-	-	-	C.
(D-17-19)9aca-S1	Bolon Spring	8,400	Tgp	5	-	8-31-71	S	Ponded just below spring area for livestock watering; FC, 400.
28bab-S1	Seeley Spring	8,920	Tgp	1.7m	6.0	8-31-71	S	Piped to small pond; C.
(D-18-19)25cbb-S1	Unknown	8,710	Tgp	5	5.0	8-31-71	S	C.
(D-18-20)7bad-S1	Marble Spring	8,970	Tgp	7m	5.0	8-31-71	S	Piped to stockwatering trough; C.
U(C-4-6)17cdc-S1	M. N. McKinnon	6,030	Tu	450r	11.0	9- 3-71	-	Largest of several springs diverted to fish culture ponds; C.
U(C-4-7)14aac-S1, 14bcd-S1, and 14bdd-S1	Stinking Spring	5,880	Tu	5	14.5	5-15-60	U	Discharges from a number of openings into a marshy area on flood plain of the Strawberry River; C.
21daa-S1	Unknown	6,160	Tu	500	8.0	4-10-72	U	Spring rises from streambed; sinks back into streambed within about half of a mile from source; C.
22ccb-S1	do	6,220	Tu	5	5.0	4-10-72	U	Melting snow directly above spring area when sampled; C.
U(C-4-9)35add-S1	do	7,515	Tu	50	5.0	4-10-72	-	Undeveloped; probably used by stock; melting snow directly above spring area when sampled; C.
U(C-5-6)1caa-S1	do	6,240	Tu	30	10.5	5-15-60	-	C.
1caa-S2	do	6,220	Tu	60	9.5	5- 5-60	-	C.
U(C-5-7)12cda-S1	do	6,880	Tu	-	-	-	-	C.
18acd-S1	-	7,450	Tu	<1	4.0	4-10-72	S	Melting snow directly above spring; water piped to storage tank and hence to stockwatering trough; C.
U(C-5-10)10dcb-S1	Big Beaver Spring	9,360	Tu	.1m	7.5	9-17-72	S	Piped to stockwatering trough; C.
U(C-5-12)25aad-S1	Race Track	8,600	Tu	17r	-	-	S	Has concrete headbox.
U(C-7-8)1acd-S1	Ross Station Spring	8,290	Tgp	5	9.0	8- 9-71	S	Piped to stockwatering trough.
U(C-7-9)9dcd-S1	Horse Ridge Spring(?)	9,770	Tgp	-	-	-	-	Assumed to be Horse Ridge Spring from reported general location; C.

Table 13.--Selected chemical

Discharge: e, estimated; m, measured.
Sodium: Where no value is reported for potassium, Na + K has been calculated and is reported as sodium.

Number (see pl. 3)	Stream	Date of collection	Temperature (°C)	Discharge (ft^3/s)	Milligrams							
					Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)
1	Timber Canyon Creek	4-10-72	-	-	28	47	34	40	1.6	366	6	29
2	Avintaquin Creek	4-10-72	-	-	24	43	31	56	1.8	350	0	60
3	Indian Canyon Creek	5- 7-58	-	12m	34	50	59	149		526	0	226
		9- 3-71	10.0	3e	27	76	140	490	7.9	948	0	1,000
4	Sowers Creek	4-13-72	2.0	3e	39	78	72	93	5.2	439	0	320
5	do	4-13-72	4.5	3e	28	170	170	290	8.2	549	0	1,200
6	Antelope Creek	3-13-72	11.0	3e	26	200	270	450	11	573	0	2,000
7	Pariette Draw	3-16-72	7.0	10e	11	210	130	1,100	4.5	345	0	2,800
8	Minnie Maud Creek	5- 6-58	-	107m	19	59	27	29		294	-	69
		8-27-58	-	1.4m	18	51	42	60		329	-	145
		10-12-71	9.5	.6m	18	56	44	61	1.8	350	0	150
9	do	5- 6-58	-	211m	23	60	32	42		338	-	84
		6-12-58	-	2.0m	19	58	94	168		606	0	361
10	Rock Creek	6-19-47	-	5.7m	26	47	28	72		270	-	53
		9-19-47	-	5.5m	-	53	35	30		301	-	81
11	Range Creek	4-11-72	13.5	2-3e	20	52	60	110	1.8	471	0	190
12	Willow Creek	9-27-72	19.0	2.85m	17	59	51	97	2.6	396	0	240
13	do	9-28-72	14.5	.25m	11	63	230	1,100	6.3	909	82	2,500
14	do	9-28-72	12.5	.08m	10	74	230	1,100	5.7	965	61	2,500
15	do	9- 2-71	17.0	-	15	62	190	930	8.7	831	0	2,300
16	Hill Creek	9- 2-71	17.0	2e	18	72	40	34	2.0	417	0	82
17	do	9- 2-71	16.5	1e	12	42	210	1,000	6.4	960	0	2,300
18	Bitter Creek	4-12-72	18.5	1e	.4	330	610	990	10	410	0	5,000
19	Evacuation Creek	9- 2-71	25.0	.05e	15	160	160	830	8.9	400	0	2,500
20	Duchesne River	(1/)	-	-	-	-	-	186	-	266	0	292
21	White River	(1/)	-	-	-	-	-	72	-	206	-	149
		5- 4-73	7.5	700m	14	67	26	62	2.4	224	0	180
22	Green River	(1/)	-	-	-	-	-	59	-	189	-	170
		4- 6-66	9.0	8,240m	10	46	22	39	4.1	162	0	120
		10- 3-66	14.0	2,910m	5.8	77	34	80	3.5	208	0	266

1/ Constituents are discharge-weighted averages for water years 1964-66.

analyses of water from streams

per litre														
Chloride (Cl)	Fluoride (F)	Nitrate (NO_3) + Nitrite (NO_2) as N	Nitrate (NO_3)	Phosphate (PO_4)	Boron (B)	Iron (Fe)	Manganese (Mn)	Dissolved solids (calculated)	Hardness as $CaCO_3$ Calcium (Ca), Magnesium (Mg)	Hardness as $CaCO_3$ Non-carbonate	Specific conductance (micromhos/cm at 25°C)	Sodium-adsorption ratio	pH
5.1	-	-	-	-	-	-	-	371	260	0	584	1.1	8.4
8.0	0.4	0.10	-	0.09	0.30	0.04	0.01	397	230	0	630	1.6	8.3
14	-	-	2.6	-	2.7	-	-	806	365	0	1,180	3.4	8.1
49	.8	1.70	-	.12	10.00	.16	.05	2,270	770	0	3,090	7.7	8.0
12	-	-	-	-	-	-	-	835	490	130	1,160	1.8	8.2
48	-	-	-	-	-	-	-	2,180	1,100	670	2,810	3.8	8.1
97	2.4	1.60	-	.06	7.80	.05	.00	3,350	1,600	1,100	4,170	4.9	7.9
230	1.1	7.40	-	.06	2.20	.02	.00	4,690	1,100	780	5,730	15	8.0
3.5	-	-	2.3	-	-	-	-	343	258	17	570	.8	8.1
6.0	-	-	.5	-	-	-	-	465	298	28	750	1.5	8.2
7.8	.3	0	-	.03	.10	.03	.01	511	320	34	788	1.5	8.3
5.0	-	-	2.2	-	-	-	-	296	282	5	658	1.1	8.0
15	-	-	4.1	-	-	-	-	1,000	532	35	1,470	3.2	8.2
80	-	-	1.0	-	-	-	-	440	232	12	513	2.1	-
6.0	-	-	1.2	-	-	-	-	354	276	30	585	.8	-
13	.4	.15	-	.12	.11	.01	.01	680	380	0	1,040	2.5	6.2
9.0	-	-	-	-	-	-	-	670	360	32	1,010	2.2	8.2
120	-	-	-	-	-	-	-	4,560	1,100	220	6,000	14	8.6
120	-	-	-	-	-	-	-	4,580	1,100	240	5,970	14	8.4
76	.4	.21	-	.15	6.50	.12	.04	4,000	940	260	5,190	13	8.3
3.8	.1	.00	-	.15	.07	.07	.03	457	340	2	712	.8	8.1
100	.3	.12	-	.28	5.80	.02	.02	4,150	970	180	5,250	14	8.2
88	1.6	.58	-	.00	2.60	.04	.03	7,240	3,300	3,000	7,520	7.5	8.3
44	.3	.62	-	.15	.41	.03	.05	3,900	1,100	730	4,820	11	8.0
49	-	-	-	-	-	-	-	702	346	154	1,003	2.2	7.9
58	-	-	-	-	-	-	-	484	250	81	756	1.9	7.8
35	.4	.20	-	.15	.09	-	-	499	270	91	774	1.6	8.2
28	-	-	-	-	-	-	-	457	245	89	684	1.6	7.9
18	.4	-	2.7	-	.08	-	-	356	206	73	540	1.2	7.6
38	.4	-	6.3	-	.17	-	-	651	330	159	932	1.9	7.4

Table 14.--Chemical analyses of water

Geologic source: Qay, unconsolidated deposits; Tu, Uinta Formation; Tgp, Parachute Creek Member, Green River Formation; Tgu, Green River Formation, undivided; Tw, Wasatch Formation; KTnh, North Horn Formation.
Sodium: Where no value is reported for potassium, Na + K has been calculated and is reported as sodium.

Location	Name or owner	Geologic source	Date of collection	Temperature (°C)	Milligrams Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)
(D-9-17)21dca-1	U.S. Bureau of Land Management	Tu	9- 3-71	-	11	20	16	510	2.2	467	0	720
(D-10-17)12baa-S1	Unknown	Tu	3-16-72	11.0	14	60	27	980	5.1	571	0	1,600
(D-10-20)35bbc-1	U.S. Bureau of Land Management	Tgu	7-24-64	-	15	.0	7.3	859		1,420	189	9.1
(D-11-15)15dbb-S1	Unknown	Tgp	3-16-72	-	37	32	29	810	5.6	983	0	980
32dcd-1	Preston-Nutter Corp.	-	4-11-72	-	22	75	100	170	2.8	726	0	360
(D-11-17)20aca-S1	Unknown	Tgp	3-16-72	-	-	75	63	1,000	-	690	-	-
(D-11-18)20cba-S1	do	Tgp	3-16-72	8.0	29	78	73	1,000	6.2	809	0	1,800
(D-11-21)31bdd-1	Golden Hatch	Tgu	8-31-71	16.0	15	.7	.7	370	.9	562	65	220
(D-11-24)6dbc-1	U.S. Bureau of Land Management	Tgu	8-26-65	-	12	3.2	.5	438		644	0	334
7cac-1	do	Tgu	8-26-65	-	12	3.2	.5	418		691	0	310
(D-12-21)19bdd-S1	Sulphur Spring	Tgp	8-30-71	-	15	1.6	.6	230	.8	353	32	150
(D-13-14)24adb-S1	Pan American Oil Corp.	Tgp	7-15-66	-	-	73	31	25	1.0	415	0	15
24dba-1	do	Tgp	7-15-66	-	-	59	29	30	1.0	366	0	20
(D-13-23)27acd-S1	Unknown	Tgp	4-12-72	10.5	17	160	200	410	7.3	576	0	1,500
(D-13-25)29bab-S1	Indian Spring	Tgp	9- 1-71	-	24	150	110	140	.7	308	0	850
(D-14-14)4abd-S1	Pan American Oil Corp.	Tgp	7-15-66	-	-	36	60	37	1.0	293	0	153
(D-14-19)33aad-S1	Charlie Brown Spring	Tgp	9- 2-71	-	28	84	61	93	1.3	438	0	300
(D-14-22)25cac-S1	Pine Spring	Tgp	4-12-72	8.0	19	63	86	92	1.9	506	0	240
(D-14-24)21ccc-S1	Unknown	Tgp	9-13-72	10.0	21	130	72	74	1.2	319	0	500
(D-15-19)4bba-S1	Secret Spring	Tgp	9- 2-71	-	-	81	-	130	-	370	-	390
(D-15-20)15bbd-S1	Flat Rock Spring	Tgp	8-31-71	17.0	16	57	16	24	.4	242	0	57
(D-15-23)36ddd-S1	PR Spring	Tgp	9-17-64	8.5	17	65	36	17		302	0	94
(D-15-25)7bcc-S1	Unknown	Tgp	9-12-72	10.5	16	74	48	36	.5	275	0	200
(D-16-16)32dda-S1	Waldo Wilcox	Tw	4-11-72	11.0	23	58	52	66	1.0	449	0	120
(D-16-17)3c-S1	Camel Rock Spring	Tw	9-25-48	-	26	70	41	73		321	0	220
(D-16-18)24brd-S1	Pinto Springs	Tgp	8-31-71	-	22	58	17	10	.6	248	0	33
(D-17-16)10cac-S1 } 10cca-S1 }	Waldo Wilcox	KTnh	4-11-72	-	23	58	54	100	1.2	483	0	190
(D-17-17)20ccc-S1	Unknown	KTnh	9-25-48	-	18	10	5.7	250		492	0	176
(D-17-19)28bab-S1	Seeley Spring	Tgp	8-31-71	6.0	15	57	16	6.4	.4	267	0	13
(D-18-19)25cbb-S1	Unknown	Tgp	8-31-71	5.0	11	60	24	2.7	.7	297	0	29
(D-18-20)7bad-S1	Marble Spring	Tgp	8-31-71	5.0	8.3	49	10	3.3	.3	193	0	16
U(C-3-5)31dcd-1	D. T. Jones	Tu	3-30-72	10.0	18	4.6	6.4	450	1.4	496	52	310
U(C-4-2)5bba-2	Lamar Neilson	Qay	5-22-72	11.5	23	400	230	620	3.9	414	0	2,900
13daa-2	Alden Kynaston	Tu	5- 7-72	14.0	23	95	34	110	3.7	411	0	280
U(C-4-3)9bbd-1	Latter-day Saints Church	Tu	5- 7-72	-	8.6	18	6.2	380	2.4	281	0	530
10cbb-1	Willis Shepard	Qay	5- 3-72	-	17	150	87	460	2.6	278	0	1,400
12cab-1	Wallace Pitt	-	5- 7-72	-	18	66	36	87	1.8	384	0	160
U(C-4-6)17cdc-S1	M. N. McKinnon	Tu	9- 3-71	11.0	15	25	140	790	7.3	761	0	1,200
			5-15-60	13.5	11	23	126	865		1,290	106	1,000
U(C-4-7)14acc-S1	Stinking Spring	Tu	5-18-41	-	10	1.0	6.1	1,760	2.3	1,470	1,060	110
14bcd-S1	do	Tu	5-18-41	-	12	5.6	5.5	3,220	7.0	1,990	2,580	188
14bdd-S1	do	Tu	5-15-60	14.5	34	0	0	3,110		1,380	2,800	11
21daa-S1	Unknown	Tu	4-10-72	8.0	23	32	120	420	4.9	803	17	670
22ccb-S1	do	Tu	4-10-72	5.0	28	140	160	170	4.0	424	0	940
U(C-4-9)35add-S1	do	Tu	4-10-72	5.0	23	86	59	23	2.0	370	0	190
U(C-5-5)34bdd-2	W. C. Foy	-	4-13-72	8.5	30	140	100	100	4.4	474	0	570
U(C-5-6)1caa-S1	Unknown	Tu	5-15-60	10.5	22	61	125	420		988	0	682
1caa-S2	do	Tu	5-15-60	9.5	23	63	118	437		1,020	0	670
U(C-5-7)12cda-S1	do	Tu	5-15-60	10.0	6.3	37	131	779		1,200	144	887
18acd-S1	do	Tu	4-10-72	4.0	45	160	180	21	5.6	467	0	780
U(C-5-10)10dcb-S1	Big Beaver Spring	Tu	9-11-72	7.5	13	77	33	3.4	.8	348	0	52
U(C-7-8)1acd-S1	Ross Station Spring	Tgp	8- 9-71	9.0	47	57	45	62	3.6	475	0	33
U(C-7-9)9dcd-S1	Horse Ridge Spring(?)	Tgp	7-18-60	12.5	12	42	17	3.8		211	0	7.8

from selected springs and water wells

per litre											Specific conductance (micromhos/cm at 25°C)	Sodium-adsorption ratio	pH
Chloride (Cl)	Fluoride (F)	Nitrate (NO_3) + Nitrite (NO_2) as N	Nitrate (NO_3)	Phosphate (PO_4)	Boron (B)	Iron (Fe)	Manganese (Mn)	Dissolved solids (calculated)	Hardness as $CaCO_3$	Noncarbonate hardness as $CaCO_3$			
91	0.2	0.46	-	0.12	0.71	-	-	1,600	120	0	2,350	21	8.3
210	2.1	.65	-	.21	4.90	0.04	0.00	3,190	260	0	4,170	26	7.9
290	-	-	0.3	-	-	-	-	2,070	30	0	3,340	68	9.0
48	3.8	.63	-	.64	11.0	.20	.00	2,440	200	0	3,410	25	8.1
15	-	-	-	-	-	-	-	1,100	600	3	1,620	3.0	7.4
-	-	-	-	-	-	-	-	3,580	450	0	-	21	-
56	4.0	3.60	-	.25	15.0	.02	.00	3,480	490	0	4,580	20	7.8
9.3	.9	.07	-	.06	.29	.03	.02	959	5	0	1,490	75	8.7
60	-	-	1.[illegible]	-	-	-	-	1,170	10	0	1,800	60	8.2
21	-	-	1.4	-	-	-	-	1,110	10	0	1,720	58	8.2
6.3	.2	.51	-	.06	.15	.02	.00	613	6	0	968	39	8.5
6.0	-	-	-	-	-	-	-	356	310	-	550	.6	7.9
8.0	-	-	-	-	-	-	-	327	266	-	499	.8	8.2
140	-	-	-	-	-	-	-	2,720	1,200	750	3,850	5.1	7.8
33	.1	.01	-	.06	.06	.00	.02	1,460	830	570	1,980	2.1	7.7
14	-	-	-	-	-	-	-	445	337	-	688	.9	8.4
18	.2	.13	-	.06	.16	.04	.00	802	460	100	1,160	1.9	7.9
29	1.4	.42	-	.03	.13	.03	.01	783	510	96	1,220	1.8	7.9
13	.3	1.60	-	.06	.07	.02	.00	976	620	360	1,340	1.3	7.4
-	-	-	-	-	-	-	-	-	-	-	1,270	-	7.8
7.9	.1	.68	-	.09	.07	.01	.00	301	210	10	478	.7	7.6
2.8	-	-	.5	-	-	-	-	381	312	64	606	.4	7.7
14	-	-	-	-	-	-	-	524	380	160	851	.8	7.5
7.9	.3	.24	-	.09	.06	.00	.00	550	360	0	876	1.5	7.4
7	-	-	.7	-	-	-	-	596	340	80	842	1.7	-
2.1	.1	1.2	-	.28	.02	.08	.02	270	210	11	443	.3	7.4
11	.4	.17	-	.09	.08	.00	.00	676	370	0	1,050	2.3	7.5
5	-	-	.1	-	-	-	-	707	48	0	1,060	16	-
1.4	.0	.36	-	.21	.00	.01	.01	242	210	0	405	.2	7.7
1.6	.0	.18	-	.03	.01	.00	.04	276	250	5	459	.1	7.7
1.9	.0	2.30	-	.03	.01	.02	.00	194	160	5	326	.1	7.8
140	1.2	.03	-	.12	2.70	.02	.00	1,230	38	0	1,950	32	8.9
84	2.3	.06	-	.03	9.0	1.6	.53	4,480	1,900	1,600	4,700	6.1	7.0
21	-	-	-	-	-	-	-	769	380	40	1,200	2.5	7.7
82	1.4	.17	-	.00	.82	.02	-	1,170	70	0	1,820	20	8.2
94	1.0	3.40	-	.00	.97	.05	.01	2,360	730	500	3,110	7.4	7.7
14	-	-	-	-	-	-	-	572	310	0	926	2.1	7.7
140	.6	7.10	-	2.60	8.20	.01	.00	2,730	640	15	4,300	14	8.1
128	-	-	2.2	-	7.7	-	-	2,910	576	0	3,980	16	8.5
594	-	-	.6	-	12.8	-	-	4,270	28	0	6,790	146	9.3
704	-	-	1.2	-	22.6	-	-	7,702	37	0	11,380	232	9.6
668	-	-	1.3	-	20.0	-	-	7,320	0	0	10,700	-	10.1
92	-	-	-	-	-	-	-	1,770	570	0	2,500	7.6	8.5
52	-	-	-	-	-	-	-	1,700	1,000	660	2,230	2.3	7.9
10	-	-	-	-	-	-	-	575	460	150	884	.5	7.5
26	1.9	.04	-	.12	2.7	.10	.09	1,210	760	370	1,680	1.6	7.3
41	-	-	.9	-	6.3	-	-	1,840	666	0	2,520	7.1	8.0
41	-	-	1.2	-	6.5	-	-	1,860	642	0	2,590	7.5	8.1
124	-	-	4.1	-	6.6	-	-	2,710	632	0	3,690	13	8.8
18	2.9	.08	-	.00	.23	.03	.00	1,440	1,100	760	1,820	.3	8.1
1.6	.4	.12	-	.03	.02	.01	.00	353	330	43	604	.1	7.4
35	.8	1.70	-	.09	.51	.01	.00	525	330	0	800	1.5	7.9
2.8	-	-	.4	-	-	-	-	190	177	4	332	.1	7.3

Table 15.--**Chemical analyses of water**

Geologic source: Tgu, Green River Formation, undivided; Tw, Wasatch Formation; Kmv, Mesaverde Group; Km, Mancos Shale; Jm, Morrison Formation; Je, Entrada Sandstone; Jn, Navajo Sandstone; M, Mississippian rocks, undivided.
Interval sampled: Depth below land surface.
Source of sample: CP, circulation pit; DST, drill-stem test; F, natural flow; PW, water produced with oil or gas; RL, return line; ST, swab test; Tr, treater; WT, wash tank; numbers in parentheses are reported or estimated water yields, in gallons per minute, at time sample was collected.
Date of collection; P, concentrations are in parts per million (conversion to milligrams per liter not possible because data for density were not available).
Sodium: Where no value is reported for potassium, Na + K has been calculated and is reported as sodium.
Specific conductance: Determined in analyses by U.S. Geological Survey, otherwise calculated from determined specific resistivity.
Source of analysis: CGL, Chemical and Geological Laboratories; GS, U.S. Geological Survey; OL, operator or lessee; RME, Rocky Mountain Engineering Co.; UC, Utah State Chemist.

Location	Operator or lessee	Geologic source	Interval sampled (ft)	Source of sample	Date of collection	Milligrams per litre				
						Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)
(D-9-16) 5ddb-1	Diamond Shamrock Corp.	Tgu	4,602- 5,747	WT	3-20-68	-	-	-	-	-
15cbb-1	do	Tgu	4,440- 5,180	DST	3-20-68	-	-	-	-	-
(D-9-20) 22ccb-1	Continental Oil Co.	Jn	17,350-17,851	DST	6-20-72	-	910	120	13,000	-
		M	19,350-20,053	DST	6-19-72	-	7,300	1,300	33,000	4,300
27aac-1	De Kalb Agricultural Association	Tgu	2,726- 2,780 3,970- 4,005	F	4- 2-64	-	-	-	-	-
36ddc-1	Western Oil Shale Corp.	Tgu	1,900- 2,822	DST	7-31-69	9.2	2.8	.8	28,500	102
		Tgu	1,900- 2,959	DST	7-29-69	9.2	4.1	1.2	28,000	104
		Tgu	1,900- 3,234	DST	7-30-69	8.6	4.1	1.2	14,600	53
		Tgu	1,900- 3,234	DST	7-31-69	12	2.0	1.2	16,600	62
(D-10-16) 11acd-1	Mountain Fuel Supply Co.	Tgu	4,289- 4,321	DST	10- 1-64	-	139	67	11,561	118
16dac-1	do	Tgu	3,616- 3,646	DST	4- -63	-	395	78	2,029	105
(D-10-17) 30bbd-1	Miami Oil Producers Inc.	Tgu	3,777- 3,789	DST	8-10-67	-	783	33	4,023	33
		Tgu	4,071- 4,116	DST	8-10-67	-	864	295	19,675	80
(D-10-18) 13cdb-1	Mountain Fuel Supply Co.	Tgu	4,045- 4,080	DST	P11-14-61	-	2,057	269	23,639	
14bbd-1	do	Tgu	2,162- 2,282	DST	3-26-61	-	10	3.0	2,613	
		Tgu	3,681- 3,746	DST	P 4- 1-61	-	592	308	28,667	
		Tgu	3,877- 3,915	DST	P 4- 2-61	-	987	274	26,780	
		Tgu	4,231- 4,310	DST	P 4- 4-61	-	1,918	359	21,560	
(D-10-19) 1cbd-1	do	Tgu	2,850- 2,875	F	10-15-63	-	11	10	3,449	28
(D-10-20) 4ccb-1	do	Tgu	2,900- 3,000	F(120)	7- -63	-	6.0	2.0	1,977	5.0
7cdb-1	do	Tgu	2,070- 2,096	DST	P10-16-60	-	11	8.0	39,367	
		Tgu	3,102- 3,142	DST	10-21-60	-	11	1.0	812	
8cab-1	do	Tgu	3,310- 3,337	DST	7-10-62	-	6.0	-	928	
		Tgu	3,488- 3,514	DST	7-12-62	-	272	92	10,506	
(D-10-21) 16add-1	Tenneco Oil Corp.	Tgu	1,900- 3,520	F(125)	4- 2-64	13	.0	2.4	785	
(D-10-23) 24bba-1	Consolidated Oil and Gas Co.	Tgu	At 3,066	RL	10-15-61	-	2.0	1.0	572	
(D-10-24) 28dcd-1	El Paso Natural Gas Co.	Kmv	5,295- 5,305	ST	6-11-59	-	1,929	82	5,210	
32ca-1	Shell Oil Co.	Tw	4,390- 4,497	DST	P 1-21-62	-	21	11	3,068	
		Kmv	5,230- 5,303	DST	P 1-28-62	-	304	63	10,580	
		Kmv	6,187- 6,494	PW(1)	P 4-30-62	-	648	238	7,917	
		Kmv	6,570- 6,947	ST	P 3-22-62	-	1,040	298	6,323	
(D-11-12) 14baa-1	McCarthy Oil Co.	Tgu	635- 650	F(0.5)	7-22-65	9.8	6.4	4.4	221	
(D-11-15) 2ccc-1	Miami Oil Producers Inc.	Tgu-Tw	4,148- 4,163	DST	10- 3-67	-	559	426	11,704	30
(D-11-16) 3bbc-1	do	Tgu	4,119- 4,170	DST	9-11-67	-	27	10	2,419	16
		Tgu	4,197- 4,218	DST	9-11-67	-	10	-	1,200	6.0
(D-11-24) 8caa-1	Diamond Shamrock Corp.	Tgu	At 1,275	F(70)	9- 6-61	13	3.6	1.5	437	1.6
(D-11-25) 22cda-1	Continental Oil Co.	Km	At 6,225	RL	8- 1-61	-	49	78	1,500	62
(D-12-14) 13acb-1	Carter Oil Co.	Kmv	8,505- 8,617	DST	P 6-27-52	-	350	64	8,198	
		Kmv	8,604- 8,789	DST	P 7- 9-52	-	139	26	4,596	
(D-13-23) 26acd-1	Skyline Oil Co.	Tgu	At 2,000	-	6-15-60	40.5	10.4	7.1	261	
(D-14-20) 7adb-1	Phillips Petroleum Co.	Kmv	7,080- 7,180	DST	9-17-62	-	8.0	2.0	1,672	
30ac	Hiko Bell Mining and Oil Co.	Tw	3,790- 3,820	F(<1)	7-13-65	23	625	93	12,114	
30bab	do	Tgu	1,883- 1,910	ST	7-22-63	-	10	7.0	274	13
(D-15-21) 22dcc-1	Atlantic Refining Co.	Tw	3,134- 3,142	DST	9-26-63	-	20	36	664	
		Tw	3,466- 3,480	DST	9-28-63	-	80	36	3,766	
		Kmv	5,518- 5,541	DST	10-12-63	-	600	109	11,643	
(D-15-22) 36dac-1	Texaco Inc.	Je	9,232- 9,349	ST(3)	P 4- -60	-	5,115	534	28,237	
(D-15½-23) 33dca-1	do	Jm-Je	8,630- 8,714	-	P 9- -61	-	5,789	454	34,077	
U(C-4-1) 13dad-1	Gulf Oil Co.	Tgu	4,020- 4,080	DST	4-10-69	-	17	-	23,836	151
		Tgu	5,140- 5,306	DST	4-10-69	-	22	20	17,264	174
U(C-4-4) 13dda-1	Carter Oil Co.	Tgu	3,281- 3,569	DST	2-23-52	-	-	-	1,117	
		Tgu	5,871- 5,935	DST	P 4-11-52	-	16	7.0	4,287	
16aca-1	Friar Oil Co.	Tgu	2,770- 3,350	Tr	P 3- -62	-	8.0	3.0	72,820	
17aca-1	do	Tgu	2,438- 3,582	WT	P 6- 7-62	-	37	-	15,908	
17bcd-1	do	Tgu	2,410- 3,408	RL	11-30-64	-	.0	87	49,139	
U(C-4-5) 8bdd-1	Gulf Oil Co.	Tw	7,366- 8,122	PW	1-12-67	22	56	17	2,750	27
					5- 7-70	-	75	9	2,594	32
10bdd-1	Brinkerhoff Drilling Co.	Tgu	6,335- 6,483	DST	1- 4-72	-	20	16	3,015	24
14dca-1	Friar Oil Co.	Tu	At 915	CP(30)	P 4-19-62	-	10	Trace	9,868	
U(C-6-6) 35bdd-1	Humble Oil and Refining Co.	Tgu	3,190- 3,260	DST	11- -61	-	32	8.0	3,979	

collected from oil and gas wells and tests

(parts per million where P precedes date of collection)

Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Dissolved solids: Determined	Dissolved solids: Sum of constituents	Hardness as $CaCO_3$	Noncarbonate hardness	Sodium-adsorption ratio	Specific conductance (micromhos/cm at 25°C)	pH	Source of analysis
-	-	-	49,128	-	-	-	-	-	-	131,000	-	GS
-	-	-	6,941	-	-	-	-	-	-	21,600	-	GS
-	-	3,300	14,000	-	-	-	280	-	108	-	6.8	GS
-	-	630	76,000	-	-	-	24,000	-	94	-	6.6	GS
-	-	-	4,000	-	-	-	-	-	-	55,900	-	GS
5,910	1,230	464	37,500	0.1	72,700	-	12	0	-	85,000	8.9	GS
5,710	832	917	37,100	.1	72,200	-	16	0	-	82,000	8.8	GS
3,830	856	35	18,600	.1	37,000	-	16	0	-	48,000	8.9	GS
5,940	319	400	21,500	.1	41,800	-	11	0	-	54,000	8.6	GS
561	-	216	17,900	-	-	30,278	8,000	-	-	-	8.2	CGL
488	-	5,100	120	-	-	8,068	-	-	-	-	7.8	CGL
305	-	2,900	5,400	-	-	13,322	-	-	-	-	7.2	CGL
1,110	0	7,000	27,000	-	-	55,461	-	-	-	-	7.6	CGL
425	-	3,580	38,000	-	67,720	67,754	-	-	-	-	7.9	CGL
1,342	600	26	2,549	-	6,840	6,462	-	-	-	-	8.6	CGL
427	36	11,827	37,152	-	-	78,792	-	-	-	-	8.4	CGL
878	-	2,798	41,280	-	-	72,551	-	-	-	98,200	8.1	CGL
647	-	3,728	34,572	-	-	62,456	-	-	-	83,300	8.1	CGL
2,452	72	1,600	2,700	-	-	9,078	-	-	-	12,940	8.4	CGL
2,721	180	130	1,190	-	-	4,832	-	-	-	7,430	8.9	CGL
9,150	8,520	525	45,000	-	98,250	97,937	-	-	-	108,840	9.7	CGL
1,379	216	107	140	-	2,032	1,966	-	-	-	4,000	8.7	CGL
1,440	228	54	296	-	2,486	2,221	-	-	-	3,330	8.8	CGL
1,720	-	3,870	13,100	-	30,480	26,489	-	-	-	40,290	8.0	CGL
1,480	128	14	195	.7	-	1,870	10	0	99	3,080	8.8	GS
1,074	48	145	99	-	1,367	1,941	8	-	88	-	8.9	OL
19	-	481	11,284	-	20,561	19,595	-	-	-	-	4.8	RME
1,220	72	620	3,550	-	7,950	8,562	96	-	-	-	8.7	OL
1,244	0	770	15,762	-	29,410	28,723	1,020	-	-	-	7.8	OL
903	0	308	13,312	-	25,266	23,326	2,600	-	-	-	6.6	OL
464	0	470	11,857	-	23,996	20,452	3,825	-	-	-	6.2	OL
392	0	179	5.1	.1	603	619	34	0	16	942	7.8	GS
2,769	-	10,576	10,900	-	-	35,559	-	-	-	-	7.9	CGL
2,440	300	2,262	380	-	-	6,616	-	-	-	-	8.7	CGL
2,428	300	10	100	-	-	2,822	-	-	-	-	8.9	CGL
606	12	422	4.0	.6	-	1,200	15	0	49	1,820	8.5	GS
375	-	2,900	186	-	-	5,800	-	-	-	-	7.6	OL
1,015	-	2,523	11,000	-	-	26,630	-	-	-	-	6.9	CGL
915	60	1,638	5,600	-	-	12,511	-	-	-	-	-	CGL
311	-	423	17	-	-	1,086	-	-	-	-	7.6	UC
964	264	2,150	140	-	4,714	4,711	-	-	-	-	9.3	CGL
539	0	1,517	18,625	25	33,899	-	1,944	1,496	119	48,900	7.3	GS
366	12	290	32	-	-	818	-	-	-	-	8.7	CGL
149	12	3.0	1,065	-	-	1,966	-	-	-	-	8.4	OL
156	14	7,579	355	-	-	11,986	-	-	-	-	8.6	OL
107	0	5,813	14,981	-	-	33,253	-	-	-	-	7.3	OL
190	-	72	54,000	-	91,800	88,052	-	-	-	-	7.3	CGL
207	-	16	64,000	-	106,800	104,438	-	-	-	-	6.3	CGL
4,355	276	102	34,000	-	-	60,527	-	-	-	-	8.3	CGL
2,086	204	584	25,000	-	-	44,295	-	-	-	-	8.4	CGL
1,550	271	164	380	-	2,758	2,695	-	-	-	-	9.0	OL
1,730	251	79	5,300	-	10,618	10,792	-	-	-	-	8.5	OL
51,240	13,800	347	66,000	-	188,830	178,213	-	-	-	-	9.7	CGL
4,758	7,680	228	12,600	-	39,220	38,796	-	-	-	-	9.6	CGL
23,326	23,217	744	34,553	22	142,790	119,246	360	0	-	-	9.6	GS
1,000	-	1,990	2,390	4.4	-	7,770	209	0	83	11,200	7.8	CGL
1,000	-	1,774	2,300	-	-	7,276	-	-	-	-	7.8	GS
3,221	228	72	2,560	-	-	7,521	-	-	-	-	8.7	CGL
0	9,015	77	3,400	-	22,961	22,915	-	-	-	-	10.2	CGL
5,120	675	58	2,400	-	9,632	9,674	-	-	-	-	8.8	CGL

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

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

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No. 41. Hydrologic reconnaissance of Pilot Valley, Utah and Nevada, by Jerry C. Stephens and J. W. Hood, U.S. Geological Survey, 1973.

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No. 20. Water-quality data for the Flaming Gorge area, Utah and Wyoming, by R. J. Madison, U.S. Geological Survey, 1970.

No. 21. Selected hydrologic data, Cache Valley, Utah and Idaho, by L. J. McGreevy and L. J. Bjorklund, U.S. Geological Survey, 1970.

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*No. 2. Water production from oil wells in Utah, by Jerry Tuttle, Utah State Engineer's Office, 1960.

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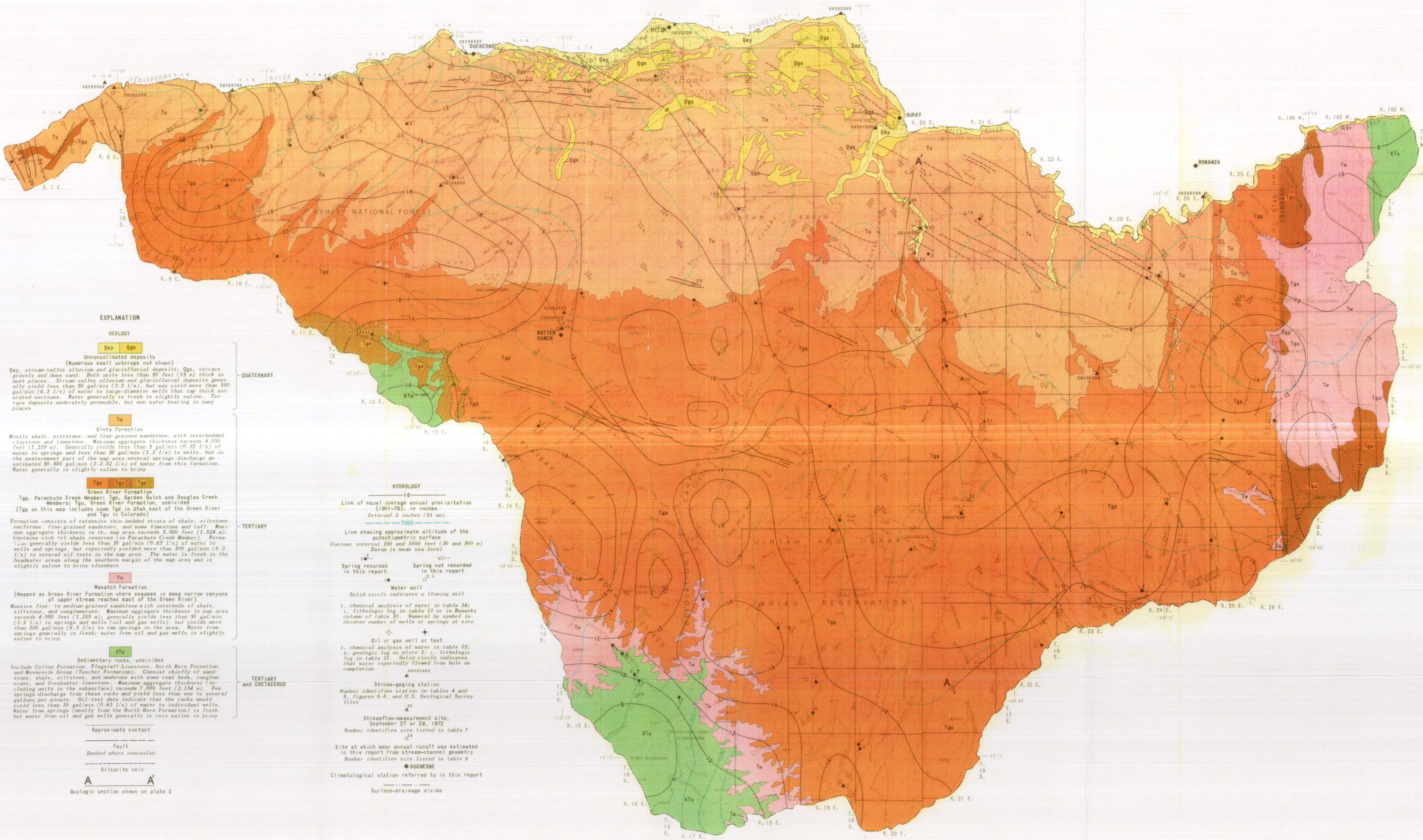
No. 19. Ground-water hydrology of southern Cache Valley, Utah, by L. P. Beer, 1967.

No. 20. Fluvial sediment in Utah, 1905-65, A data compilation by J. C. Mundorff, U.S. Geological Survey, 1968.

No. 21. Hydrogeology of the eastern portion of the south slopes of the Uinta Mountains, Utah, by L. G. Moore and D. A. Barker, U.S. Bureau of Reclamation, and James D. Maxwell and Bob L. Bridges, Soil Conservation Service, 1971.

No. 22. Bibliography of U.S. Geological Survey water-resources reports for Utah, compiled by Barbara A. LaPray, U.S. Geological Survey, 1972.



EXPLANATION

GEOLOGY

Qay | Qgs

Unconsolidated deposits
(Numerous small outcrops not shown)

Qay, stream-valley alluvium and glaciofluvial deposits; Qgs, terrace gravels and dune sand. Both units less than 50 feet (15 m) thick in most places. Stream-valley alluvium and glaciofluvial deposits generally yield less than 50 gal/min (3.2 l/s), but may yield more than 100 gal/min (6.3 l/s) of water to large-diameter wells that tap thick saturated sections. Water generally is fresh to slightly saline. Terrace deposits moderately permeable, but non water bearing in many places

QUATERNARY

Tu

Uinta Formation

Mostly shale, siltstone, and fine-grained sandstone, with interbedded claystone and limestone. Maximum aggregate thickness exceeds 4,000 feet (1,219 m). Generally yields less than 5 gal/min (0.32 l/s) of water to springs and less than 20 gal/min (1.3 l/s) to wells, but in the westernmost part of the map area several springs discharge an estimated 50-500 gal/min (3.2-32 l/s) of water from this formation. Water generally is slightly saline to briny

Tgp | Tgu | Tgd

Green River Formation
Tgp, Parachute Creek Member; Tgd, Garden Gulch and Douglas Creek Members; Tgu, Green River Formation, undivided
(Tgp on this map includes some Tgd in Utah east of the Green River and Tgu in Colorado)

Formation consists of extensive thin-bedded strata of shale, siltstone, marlstone, fine-grained sandstone, and some limestone and tuff. Maximum aggregate thickness in the map area exceeds 5,000 feet (1,524 m). Contains rich oil-shale reserves (in Parachute Creek Member). Formation generally yields less than 10 gal/min (0.63 l/s) of water to wells and springs, but reportedly yielded more than 100 gal/min (6.3 l/s) to several oil tests in the map area. The water is fresh in the headwater areas along the southern margin of the map area and is slightly saline to briny elsewhere

Tw

Wasatch Formation
(Mapped as Green River Formation where exposed in deep narrow canyons of upper stream reaches east of the Green River)

Massive fine- to medium-grained sandstone with interbeds of shale, siltstone, and conglomerate. Maximum aggregate thickness in map area exceeds 4,000 feet (1,219 m); generally yields less than 50 gal/min (3.2 l/s) to springs and wells (oil and gas wells), but yields more than 100 gal/min (6.3 l/s) to two springs in the area. Water from springs generally is fresh; water from oil and gas wells is slightly saline to briny

TERTIARY

KTu

Sedimentary rocks, undivided

Include Colton Formation, Flagstaff Limestone, North Horn Formation, and Mesaverde Group (Tuscher Formation). Consist chiefly of sandstone, shale, siltstone, and mudstone with some coal beds, conglomerate, and freshwater limestone. Maximum aggregate thickness (including units in the subsurface) exceeds 7,000 feet (2,134 m). Few springs discharge from these rocks and yield less than one to several gallons per minute. Oil-test data indicate that the rocks would yield less than 10 gal/min (0.63 l/s) of water to individual wells. Water from springs (mostly from the North Horn Formation) is fresh, but water from oil and gas wells generally is very saline to briny

TERTIARY and CRETACEOUS

Approximate contact

Fault
Dashed where concealed

Gilsonite vein

A A′

Geologic section shown on plate 2

HYDROLOGY

16

Line of equal average annual precipitation (1941-70), in inches
Interval 2 inches (51 mm)

7000

Line showing approximate altitude of the potentiometric surface
Contour interval 100 and 1000 feet (30 and 300 m)
Datum is mean sea level

2 C

Spring recorded in this report

3

Spring not recorded in this report

C, L

Water well
Solid circle indicates a flowing well

C, chemical analysis of water in table 14; L, lithologic log in table 11 or in Remarks column of table 10. Numeral by symbol indicates number of wells or springs at site

Oil or gas well or test

C, chemical analysis of water in table 15; G, geologic log on plate 2; L, lithologic log in table 11. Solid circle indicates that water reportedly flowed from hole on completion

09302000

Stream-gaging station
Number identifies station in tables 4 and 5, figures 6-8, and U.S. Geological Survey files

35

Streamflow-measurement site, September 27 or 28, 1972
Number identifies site listed in table 7

28

Site at which mean annual runoff was estimated in this report from stream-channel geometry
Number identifies site listed in table 6

DUCHESNE

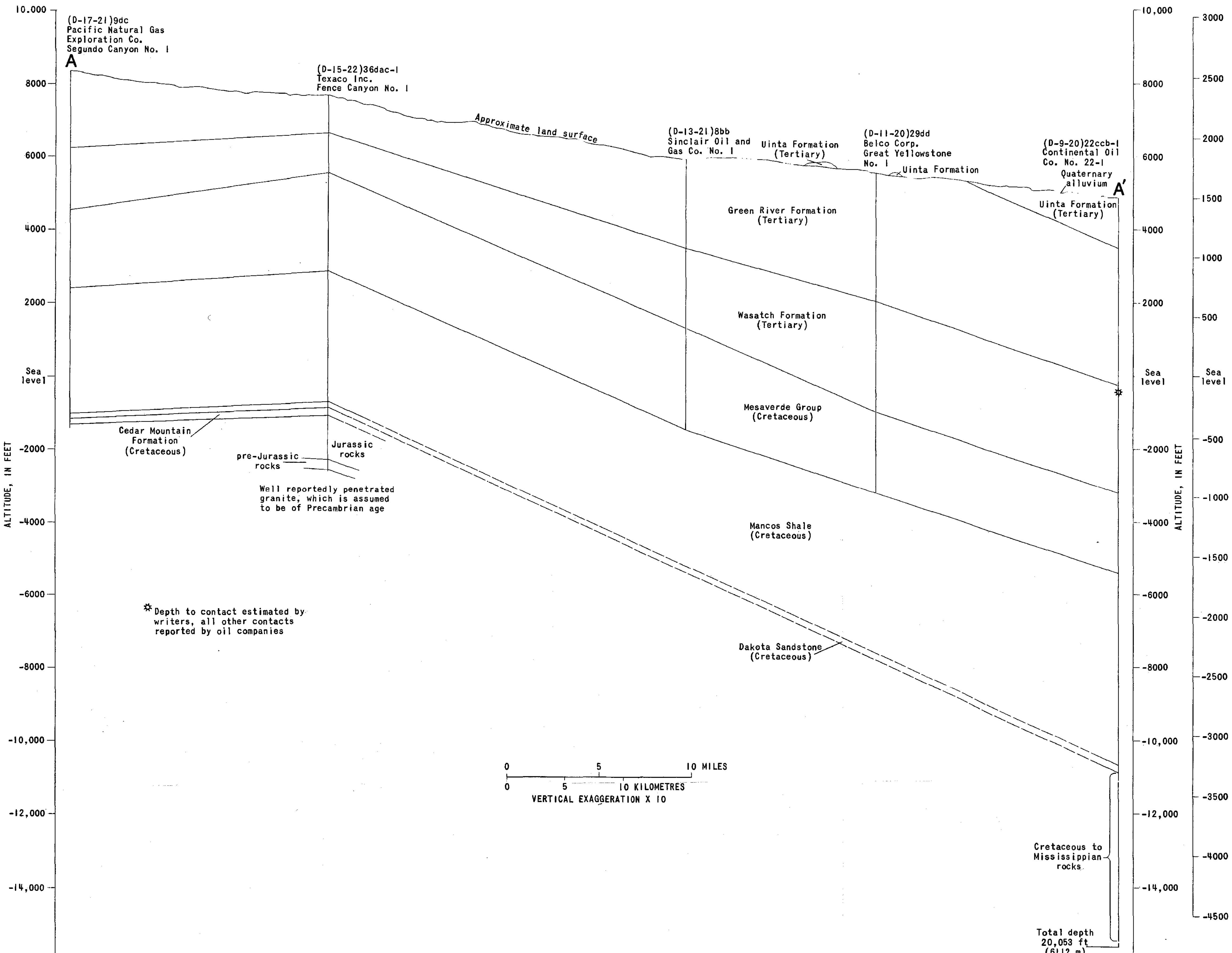
Climatological station referred to in this report

Surface-drainage divide

Base from U.S. Geological Survey 1:250,000 series: Grand Junction, 1962; Price, 1962; Salt Lake City, 1963; and Vernal, 1965

Hydrology by Don Price and Louise L. Miller, 1973. Geology in Utah after Stokes (1964), modified from data in Cashion and Donnell (1974); in Colorado after Burbank and others (1935). Average annual precipitation from Fields and Adams (1975)

Hydrogeologic map of the southern Uinta Basin, Utah and Colorado



Generalized geologic section A-A' of part of the southern Uinta Basin, Utah and Colorado
(See pl. 1 for location of section.)

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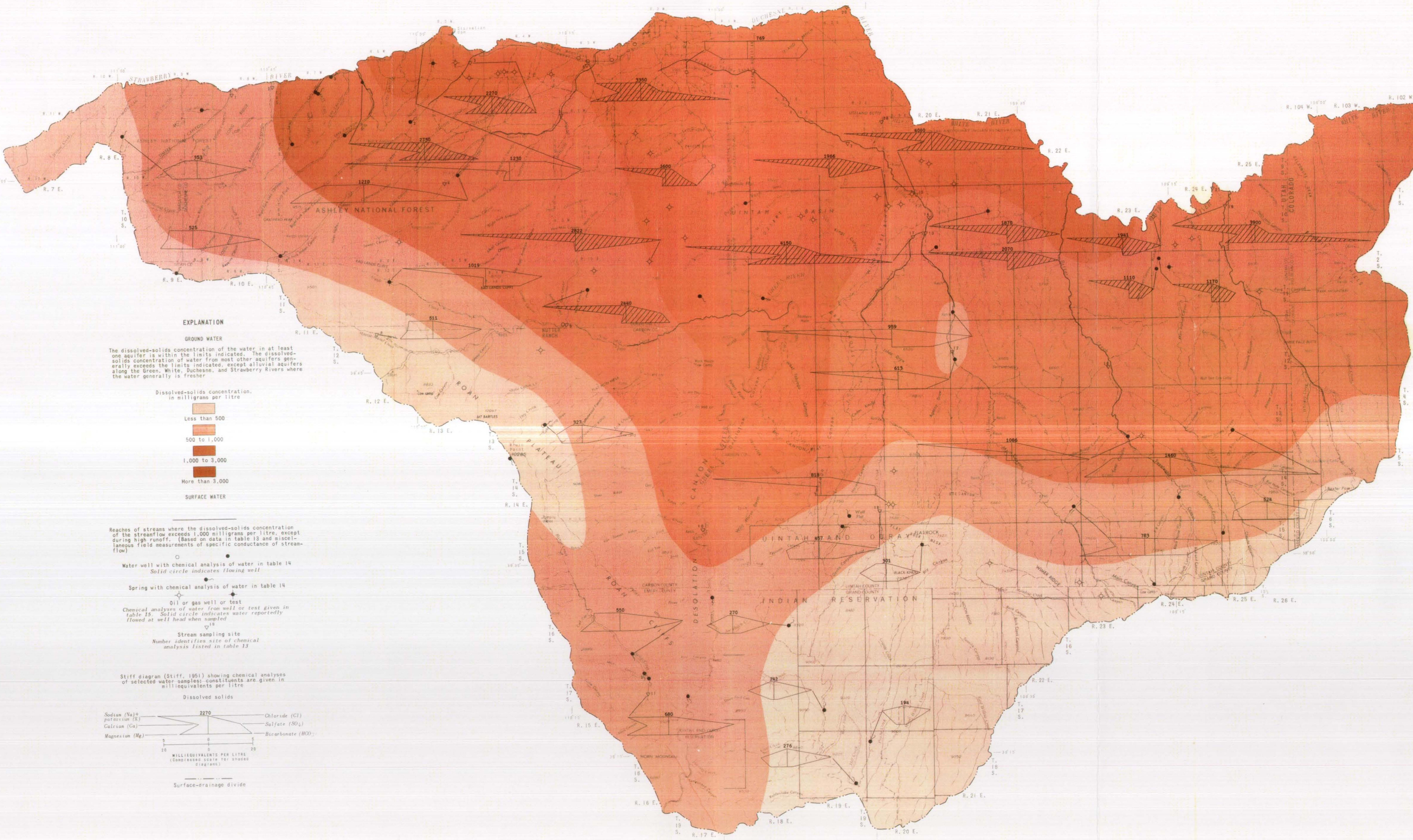

Base from U.S. Geological Survey 1:250,000 series: Grand Junction, 1962; Price, 1962; Salt Lake City, 1963; and Vernal, 1965

Compiled by Don Price and Louise L. Miller, 1973

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Map showing general chemical quality of water and location of sampling sites in the southern Uinta Basin, Utah and Colorado