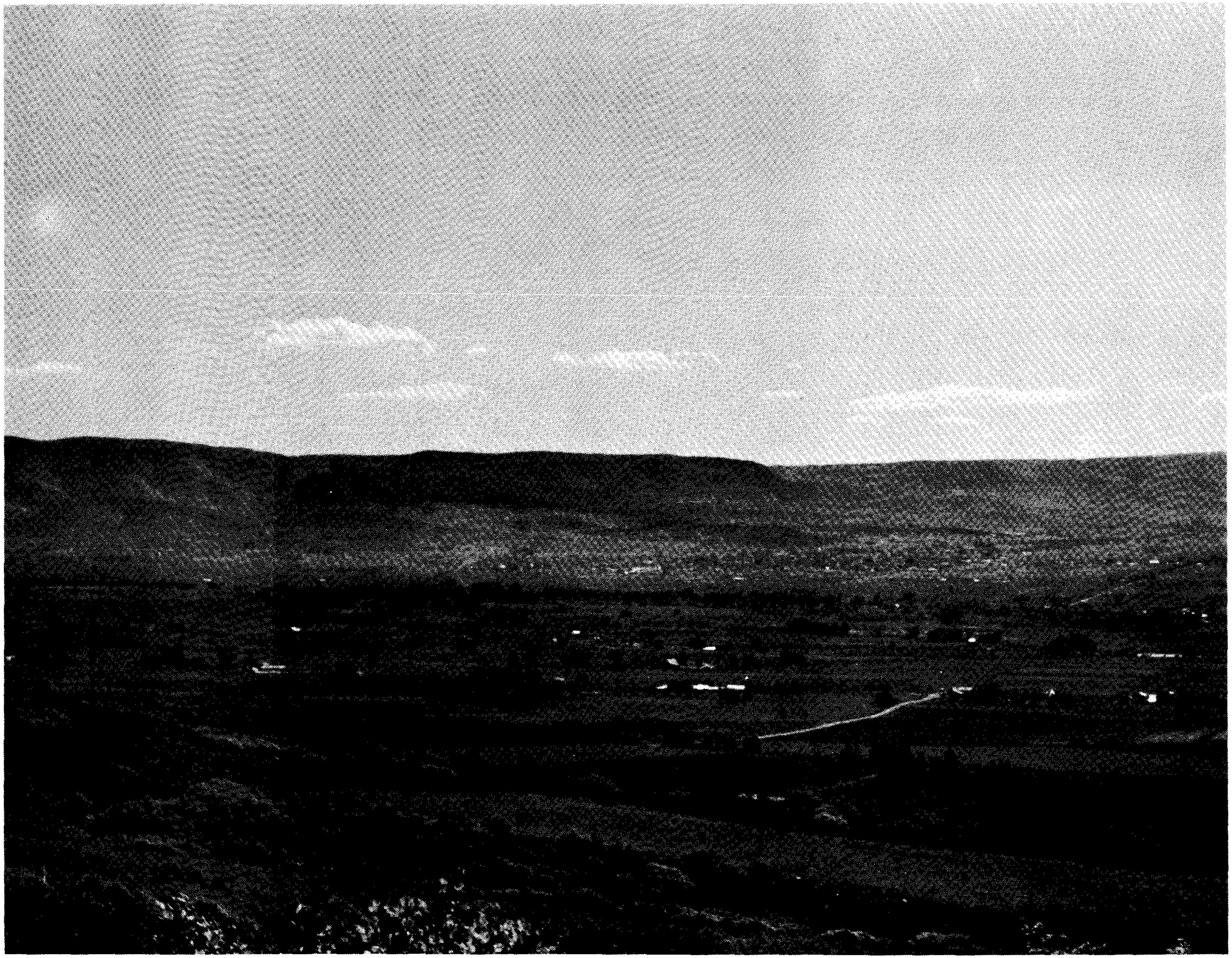

Frontispiece Heber Valley — View looking northeastward from a spur of the Wasatch Range

STATE OF UTAH
DEPARTMENT OF NATURAL RESOURCES

Technical Publication No. 27

# WATER RESOURCES OF THE HEBER-KAMAS-PARK CITY AREA NORTH-CENTRAL UTAH

by
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With a section on

## A GRAVITY AND AEROMAGNETIC SURVEY OF HEBER AND RHODES VALLEYS

by
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Geologist, U. S. Geological Survey

Prepared by the U. S. Geological Survey
In cooperation with
The Utah Department of Natural Resources
Division of Water Rights

1970

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# WATER RESOURCES OF THE HEBER-KAMAS-PARK CITY AREA NORTH-CENTRAL UTAH

by

**C. H. Baker, Jr., Hydrologist**
**U. S. Geological Survey**

## ABSTRACT

The Heber-Kamas-Park City area encompasses about 810 square miles in Wasatch and Summit Counties, in north-central Utah, and includes four mountain valleys—Heber Valley, Rhodes Valley, Parleys Park, and Round Valley—with most of the surrounding watersheds. Parleys Park and most of Rhodes Valley are in the Weber River drainage basin; Heber and Round Valleys are in the Provo River drainage basin.

The Provo River rises in the southwestern Uinta Mountains and flows to Utah Lake. At Deer Creek Dam, on the boundary of the study area, the average annual discharge of the Provo River for the 14-year period 1953-67 was 256,300 acre-feet per year; an additional 33,900 acre-feet per year (average) was diverted for use outside the drainage basin. An average of 68,000 acre-feet of water per year is added to the Provo River by diversion from other drainage basins.

The Weber River has its headwaters in the northwestern Uinta Mountains, and flows to Great Salt Lake. The average discharge of the Weber River below Wanship Dam near the north end of the study area, for the 10-year period 1957-67, was 110,000 acre-feet per year. During that period, an average of 50,600 acre-feet per year was diverted from the drainage basin above Wanship Dam. The surface-water discharge from Parleys Park enters the Weber River below Wanship Dam through East Canyon Creek and Silver Creek; the discharge from Parleys Park averages about 20,000 acre-feet per year.

The consolidated rocks of the Wasatch Range and Uinta Mountains contain large quantities of ground water, mostly in fractures and solution openings, and numerous springs discharge water from the consolidated rocks. Despite the abundance of springs and the fact that mine workings in the Wasatch Range tap large flows of ground water, most wells yield only small supplies of water from the consolidated rocks. The primary permeability of the rocks is low, and wells can produce large yields only if they intersect fractures and solution openings.

Consideration of the water budget for Deer Creek Reservoir, astride the Charleston thrust fault, indicates that there is no net loss of water from the reservoir through the fault. An unbalance of about 17,000 acre-feet of water per year in the water budget for the valley fill in Heber Valley, however, may represent outflow from the valley through the consolidated rocks.

Most of the wells in the area derive water from the unconsolidated alluvial fill in the four valleys. The valley fill consists of a poorly sorted mixture of rock material ranging in size from clay through boulders. There is no evidence to suggest the presence of zones of either very high or very low permeability in any of the valleys; and the valley fill in all the valleys is saturated, generally to within a few feet of the land surface, mostly with unconfined ground water.

Geophysical studies indicate that the valley fill may be as much as 800 feet thick in the deepest parts of Heber Valley and more than 300 feet thick in most of Rhodes Valley. Rocks of Tertiary and Quaternary age are more than 1,600 feet thick in the northern part of Rhodes

Valley, but part of this material is undoubtedly volcanic rocks of Tertiary age rather than unconsolidated alluvial fill. The presence of volcanic rocks and conglomerates of Tertiary age and low density under most of Parleys Park makes it impossible to estimate the thickness of the unconsolidated material by geophysical techniques, but available data suggest a maximum thickness of about 100 feet. Sparse data from well drillers' reports indicate that the alluvial fill in Round Valley is probably only a few tens of feet thick.

The aquifer characteristics of the unconsolidated material in the four valleys are generally similar. The transmissivity ranges from 6,700 to 20,000 $ft^3/d/ft$ (cubic feet per day per foot) in Heber Valley and probably is less in the other valleys. The specific yield is estimated to be 12-15 percent.

In Heber Valley the average annual recharge and discharge is calculated as about 86,000 acre-feet of water. The average annual recharge and discharge in Rhodes Valley is less—about 22,000 acre-feet. Available data for Parleys Park and Round Valley are too scanty to permit calculations of the volume of annual recharge and discharge. The calculated average evapotranspiration is 43,000 acre-feet per year in Parleys Park and 5,000 acre-feet in Round Valley.

An estimated 280,000 acre-feet of water could be recovered by dewatering the upper 100 feet of the aquifer in the unconsolidated deposits in Heber Valley, 310,000 acre-feet could be recovered by dewatering the upper 100 feet in Rhodes Valley, and about 80,000 acre-feet could be recovered by dewatering the unconsolidated deposits in Parleys Park. The ground water in the alluvial fill of the valleys interchanges continuously with water in the streams, however, and none of the aquifers can be dewatered for consumptive use without ultimately reducing streamflow from the area.

The water throughout the area, both surface water and ground water, is generally of good quality, and, with few exceptions, usable for domestic use, livestock, and irrigation. Most of the water is of the calcium bicarbonate type, but calcium sulfate water is present locally in and near shales of Triassic age. Near Midway, in Heber Valley, a group of thermal springs yield water that is too highly mineralized to be desirable for domestic use (although it is suitable for livestock and for irrigation), and locally volcanic rocks of Tertiary age yield water that is too high in iron for many uses.

# INTRODUCTION

This report on the water resources of the Heber-Kamas-Park City area was prepared by the U. S. Geological Survey in cooperation with the Utah Department of Natural Resources, Division of Water Rights. The primary purpose of the report is to provide the Division of Water Rights with the basic hydrologic information needed for the effective administration of water rights in the area.

The study on which this report is based was an overall evaluation of the water resources of the Heber-Kamas-Park City area, and it was made during the period July 1966-December 1968. Principal emphasis in the study was on ground-water resources, because the surface water of the area is fully appropriated, and water for expanded future needs will have to be derived from ground-water sources. The primary purposes of the study were to determine the quantity and quality of ground water available in the area, to determine the relation of ground water to surface water in the area, and to estimate the effects of increased ground-water withdrawals on streamflow from the area.

This report describes the general surface-water hydrology of the study area, evaluates the quantity and quality of ground water available from the several aquifers, and discusses the relationship of ground water to surface water in the area. The basic data on which the interpretations and conclusions in this report are based are included in tables 3-7 in the appendix; the data consist of selected data available for the period prior to July 1966 and of field data gathered from July 1966 to September 1968.

A short report by D. L. Peterson, describing the results of geophysical studies in part of the project area, is included in the appendix.

## Description of the area

The Heber-Kamas-Park City area lies between the Uinta Mountains and the Wasatch Range in Summit and Wasatch Counties, north-central Utah (fig. 1). It includes four mountain valleys—Heber Valley, Rhodes Valley, Parleys Park, and Round Valley—and most of the surrounding drainage area. Although the study area includes about 810 square miles, this study was most concerned with the availability of water in the four valleys (total area about 140 square miles), for it is in the valleys that the population is concentrated and the demand for water is greatest.

About 87 percent of the estimated 8,650 people (1960 census) in the area live in the 16 communities in the valleys, but most of the population are directly or indirectly dependent on agriculture for their livelihood. Dairy farming is the principal source of income in the region, followed by the raising of sheep and beef cattle. The mountains surrounding the valleys furnish summer pasture for livestock, and the irrigated land in the valleys supplies the necessary winter feed. Park City was once the center of a major lead- and silver-mining district, but only two mines in the area were being worked in 1968. Recreational development (for skiing, fishing, and the like) is an increasing contributor to the economy of the area.

The area is approximately bisected by a drainage divide; the northern part, including Parleys Park and most of Rhodes Valley, is drained by the Weber River, and the southern part, including Heber Valley and Round Valley, is drained by the Provo River. These major streams both have their beginnings in the western Uinta Mountains, and both are part of the Great Basin drainage system; the Weber flows north and west to Great Salt Lake, and the Provo flows south and west to Utah Lake.

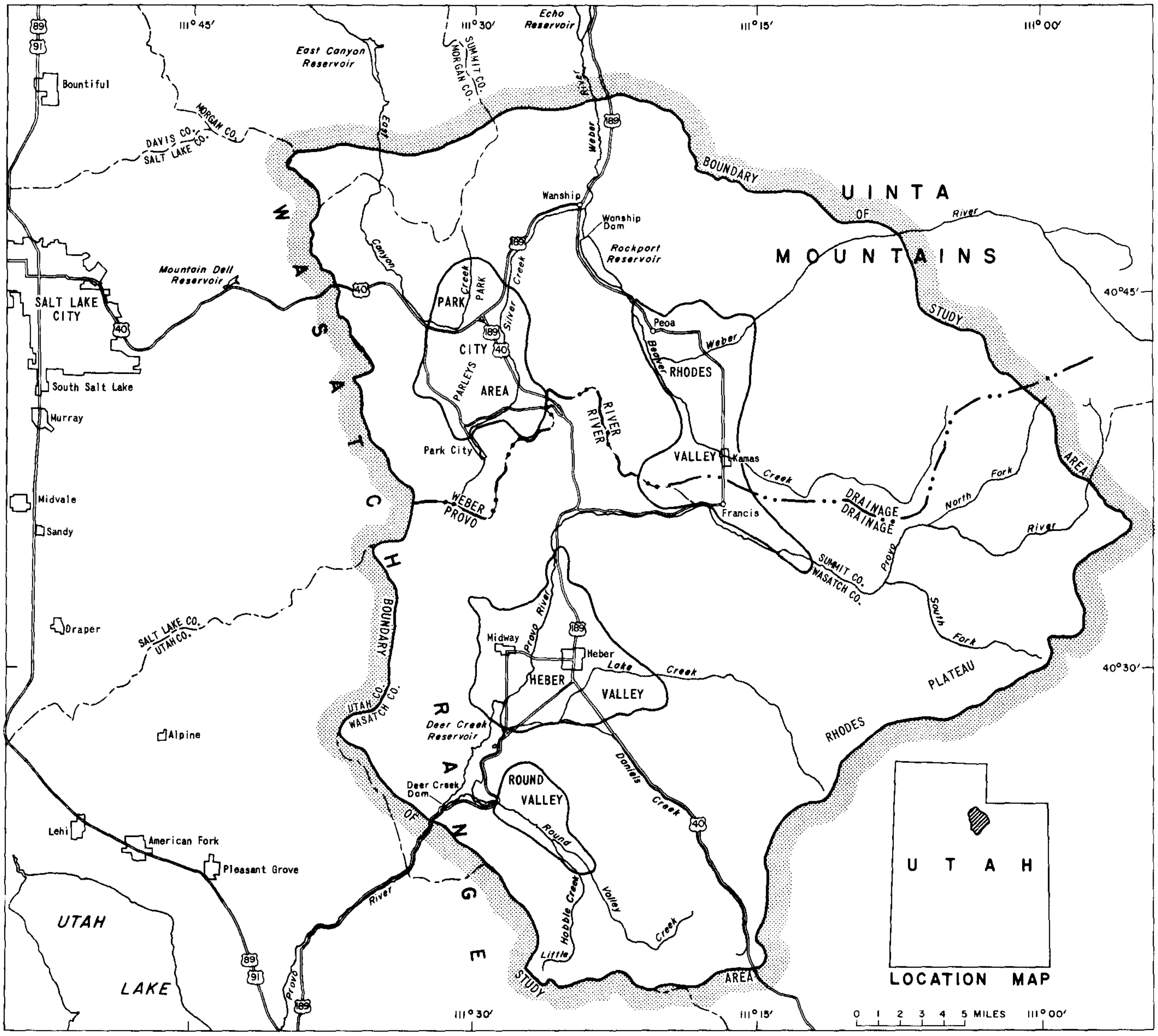


Figure 1.—Map showing the location of the Heber-Kamas-Park City area.

The climate in these mountain valleys is cool but not harsh. Summers are short and cool; winters, although long, are not usually severe. Precipitation varies with the altitude, and most of the precipitation falls during the winter. Although the valleys receive an average of 15-20 inches of precipitation per year, less than 8 inches falls during the period May-September, which includes the growing season. The distribution of normal annual precipitation and normal May-September precipitation are shown on plate 1.

### Previous studies and acknowledgments

Previous hydrologic studies in the area have been confined to the collection of basic data, primarily streamflow records, and to local studies of ground-water and surface-water conditions in connection with reclamation projects. The streamflow records are summarized in reports of the U. S. Geological Survey (1954, 1960, 1961-68, 1963, and 1964), the annual reports of the Provo River Commissioner (1945-68), and the annual reports of the Weber River Commissioner (1929-68). Data collected in connection with various construction and irrigation projects were available from the files of the U. S. Bureau of Reclamation in Provo (Provo River drainage basin) and Ogden (Weber River drainage basin).

Many geologic studies have covered parts of the Heber-Kamas-Park City area, and more information is available on the geology of the Wasatch Range than on that of the Uinta Mountains. In general, however, references to the water-bearing properties of the rocks are few and scanty. The writer has drawn on many sources for the geologic map and descriptions in this report; those sources are listed in the references.

Much of the information on wells and springs in the area came from the files of the Utah State Engineer. Nearly all the subsurface data came from well drillers' reports on file with the State Engineer, and additional information was obtained from well drillers who were working in the area during the time that fieldwork was in progress.

Special thanks are due to the citizens of the area and to the officials of the towns who freely answered many questions about their water supplies and gave permission to measure water levels in their wells.

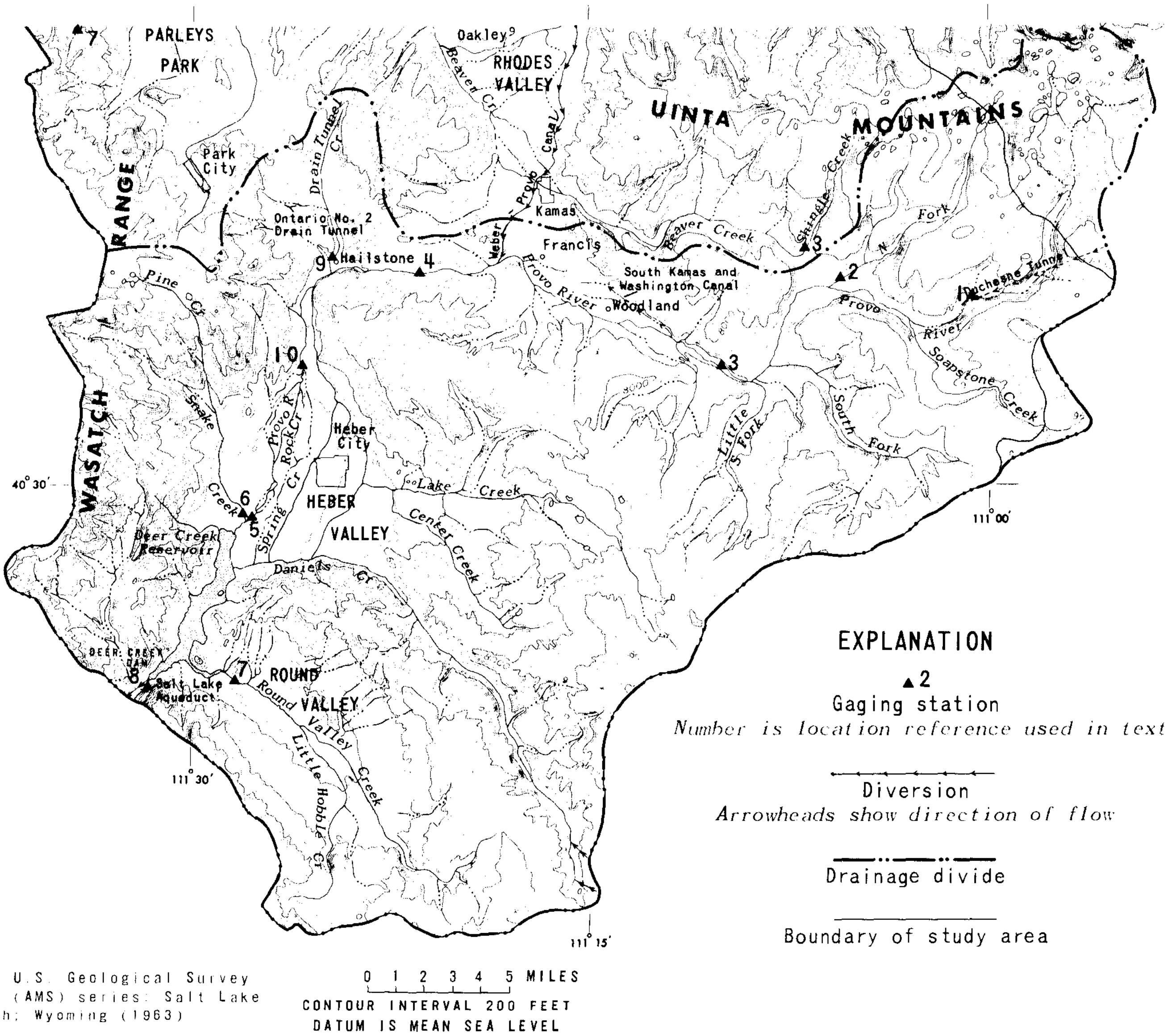
## SURFACE-WATER HYDROLOGY

The Heber-Kamas-Park City area includes parts of the upper drainage basins of two major streams—the Provo River and the Weber River. The discussion of the surface-water hydrology of the area, accordingly, is divided into separate discussions of the two drainage basins.

### Provo River drainage basin

The Provo River rises on the south side of the Uinta Mountains, near the west end of the range, and flows generally westward to the vicinity of Hailstone, in the north end of Heber Valley (fig. 2). From Hailstone, the river flows southwestward through Heber Valley and the narrow lower Provo Canyon to Utah Lake.

At some earlier time, the Provo River near Francis flowed northward through Rhodes Valley and joined the Weber River near Peoa. Both the shape and orientation of Rhodes Valley (fig. 1) and the presence of lineations on the surface of the valley fill north of Francis (almost



Base from U.S. Geological Survey 1:250,000 (AMS) series: Salt Lake City, Utah; Wyoming (1963)

Figure 2.—Map of part of the Provo River drainage system.

invisible from the ground, but clearly evident on aerial photographs) indicate that the upper Provo River was once a northward-flowing stream. At what time the stream changed its course is not know, but it was probably near the end of Pleistocene time, as the lithology and sorting of the alluvial fill near Francis suggest that the material was derived largely from glacial action in the mountains.

Why the stream's course was changed is a more difficult question, but two hypotheses have been suggested.

1. The northern outlet from Rhodes Valley was blocked, and the ponded water rose until it could find an outlet through a pass in the hills on the west side of the valley. Erosion subsequently lowered the outlet to form the narrow upper Provo Canyon.

2. The east fork of the original Provo River (that is, the lower stream), working on a high gradient, lengthened its course by headward erosion and cut through the low divide, thus intercepting and capturing the upper river.

Either of these hypotheses seems to require the presence of a zone of weakness, probably structurally controlled, to permit the carving of the upper Provo Canyon through the hard volcanic rocks in a relatively short time. The writer prefers the second hypothesis, despite the obvious difficulty of rapid headward erosion of a small stream through hard rocks, for the following reasons:

1. The first hypothesis requires ponding of water in Rhodes Valley, and no evidence of such ponding has been found.

2. If the northern outlet of Rhodes Valley were blocked, then when the postulated pond was drained through upper Provo Canyon the Weber River and Beaver Creek should have joined the upper Provo River, but both these streams still flow northward.

### Tributaries, reservoirs, and diversions

The main stem of the Provo River heads in a cluster of rock-basin lakes near the crest of the Uinta Mountains. North Fork, the only large tributary that enters the river from the north, also heads in a group of small lakes near the crest of the range. Soapstone Creek, South Fork, and Little South Fork drain a part of the Rhodes Plateau (fig. 1), which separates the drainage of the Provo River from that of the Duchesne River. All these tributaries enter the Provo River above the gaging station near Woodland, and there are no perennial tributaries between the gaging station and Hailstone.

Drain Tunnel Creek (Ross Creek) enters the Provo River near Hailstone. The creek is intermittent upstream from the mouth of the Ontario No. 2 Drain Tunnel, and it is unlikely that there would be perennial surface inflow to the river without the discharge of the tunnel.

Lake, Center, and Daniels Creeks drain the Rhodes Plateau. The flow of Lake and Center Creeks is now directed to Daniels Creek; Daniels Creek discharges to Deer Creek Reservoir. Snake Creek and its tributary, Pine Creek, are the only perennial streams that flow from the Wasatch Range to the Provo River above Deer Creek Reservoir. Two small tributaries, Rock and Spring Creeks, originate from ground-water discharge in Heber Valley.

Round Valley Creek and its south branch, Little Hobble Creek, drain Round Valley and the surrounding mountains. Round Valley Creek discharges to Deer Creek Reservoir.

Fourteen small rock-basin lakes at the head of the main stem of the river and of North Fork have dams and outlet works, and function as storage reservoirs. The combined regulated capacity of these 14 small reservoirs is about 15,000 acre-feet. In addition, the discharge of the Lake Creek-Center Creek drainage is slightly regulated by several small reservoirs; the storage capacity of these small reservoirs is not reported.

The only major impoundment on the Provo River system is Deer Creek Reservoir. Deer Creek Dam is located at the head of the lower Provo Canyon, and the high-water line of the reservoir forms the southern boundary of Heber Valley. The reservoir effectively controls the discharge of surface water from the Provo River drainage basin in the study area. Deer Creek Reservoir has a storage capacity of 152,560 acre-feet, and provides flood control as well as storage for irrigation and municipal use. Power is generated at the dam.

Deer Creek Dam prevents the movement of ground water out of the study area through the unconsolidated alluvial fill in the river valley. The reservoir lies across a major fault zone, however, and it has been postulated that considerable quantities of water may be lost from the reservoir by subsurface movement along the Charleston and associated Deer Creek thrust faults. The water budget of the reservoir indicates no such loss.

Water storage in Deer Creek Reservoir began in 1940. Nearly all the surface inflow and outflow of the reservoir was measured during the period October 1940-September 1949, so a fairly accurate water budget for the reservoir can be made for that period. The net difference between precipitation on the reservoir surface and adjacent slopes (inflow) and evaporation from the reservoir (outflow) is believed to be small and is neglected in the budget. The measured surface inflow to the reservoir averaged about 192,000 acre-feet per year. The total outflow through the Provo River (the Salt Lake Aqueduct was not completed until 1950) averaged about 227,000 acre-feet per year, an increase of 35,000 acre-feet per year. In addition, about 110,000 acre-feet of water, an average of about 12,000 acre-feet per year, was stored in the reservoir; hence, the total gain (excess of outflow and storage over inflow) was about 47,000 acre-feet per year. The extra 47,000 acre-feet of water per year presumably came from ground-water inflow from the alluvial fill in Heber Valley. There would appear to be no substantial loss of water from the reservoir through the subsurface.

Water is added to the Provo River by diversions from the Weber River (Weber-Provo Canal), the Duchesne River (Duchesne Tunnel), and the Strawberry River system (three small ditches that enter Daniels Creek). Water is diverted from the Provo River through the South Kamas and Washington Canal for irrigation in the south end of Rhodes Valley; some of the diverted water undoubtedly returns to the river as irrigation return flow. Water is also diverted from the basin through the Salt Lake Aqueduct, which carries water from Deer Creek Reservoir to the Jordan Valley for municipal use.

### Discharge

The total discharge of the Provo River above Deer Creek Dam during the 14-year period 1953-67 averaged 290,000 acre-feet per year. Of this amount, about 222,000 acre-feet originated within the drainage basin, and about 68,000 acre-feet was imported from other drainage basins.

The U. S. Geological Survey has operated a gaging station on the Provo River at a point 1,000 feet downstream from Deer Creek Dam since May 1953. The average discharge of the river for 14 years (through water year 1967) was 256,300 acre-feet per year (fig. 3). The average diversion through the Salt Lake Aqueduct during the same period was 21,800 acre-feet per year, hence the total outflow from Deer Creek Reservoir averages about 278,000 acre-feet per year. During the 14-year period 1953-67, an average of about 12,100 acre-feet per year was diverted from the drainage basin through irrigation canals to Rhodes Valley. Thus, the total discharge of surface water from the Provo River drainage basin averages about 290,000 acre-feet per year.

The above total discharge from the drainage basin, however, includes an annual average of about 68,000 acre-feet of water that originates outside the drainage basin and enters the Provo River through interbasin diversions. About 33,500 acre-feet per year is diverted through a tunnel from the Duchesne River, about 31,300 acre-feet per year comes from the Weber River through the Weber-Provo Canal, and about 3,300 acre-feet per year comes from the Strawberry River system through ditches. After deducting these diversions, the total surface outflow from the Provo River drainage basin above Deer Creek Dam averages about 222,000 acre-feet of water per year. (Graphs of the diversions into and out of the basin are shown in fig. 4.)

At present (1968), the U. S. Geological Survey operates four gaging stations on the Provo River and its tributaries above Deer Creek Dam (in addition to the measurements of diversions to the river). Three additional gaging stations were operated during the period 1938-50. The average discharges at these stations for the periods of record are tabulated below.

| Station | Site number in fig. 2 | Period of operation | Years of record | Average discharge (acre-feet per year) |
|---|---|---|---|---|
| 10-1535. Provo River near Kamas | 1 | 1949-67 | 18 | 36,130 |
| 10-1538. North Fork Provo River near Kamas | 2 | 1963-67 | 4 | 30,250 |
| 10-1542. Provo River near Woodland | 3 | 1963-67 | 4 | 178,850 |
| 10-1550. Provo River near Hailstone | 4 | 1950-67 | 17 | 203,000 |
| 10-1555. Provo River near Charleston | 5 | 1938-50 | 12 | 139,000 |
| 10-1560. Snake Creek near Charleston | 6 | 1938-50 | 12 | 33,159 |
| 10-1585. Round Valley Creek near Wallsburg | 7 | 1938-50 | 12 | 9,629 |
| 10-1595. Provo River below Deer Creek Dam | 8 | 1953-67 | 14 | 256,300 |
| – Drain Tunnel Creek near Hailstone[1] | 9 | 1949-67 | 18 | 12,000 |
| – Provo River near Midway[1] | 10 | (2) | | |

[1] Operated by Provo River Commissioner's office.

[2] Irrigation season only.

The Provo River Commissioner's office maintains records of all diversions from the river, and during the irrigation season (May-September) the Commissioner's office operates a gaging station on the river near Midway (site 10, fig. 2). The records for this station are not included in the table, because they cover only a part of each year and are not comparable to the annual averages at other stations.

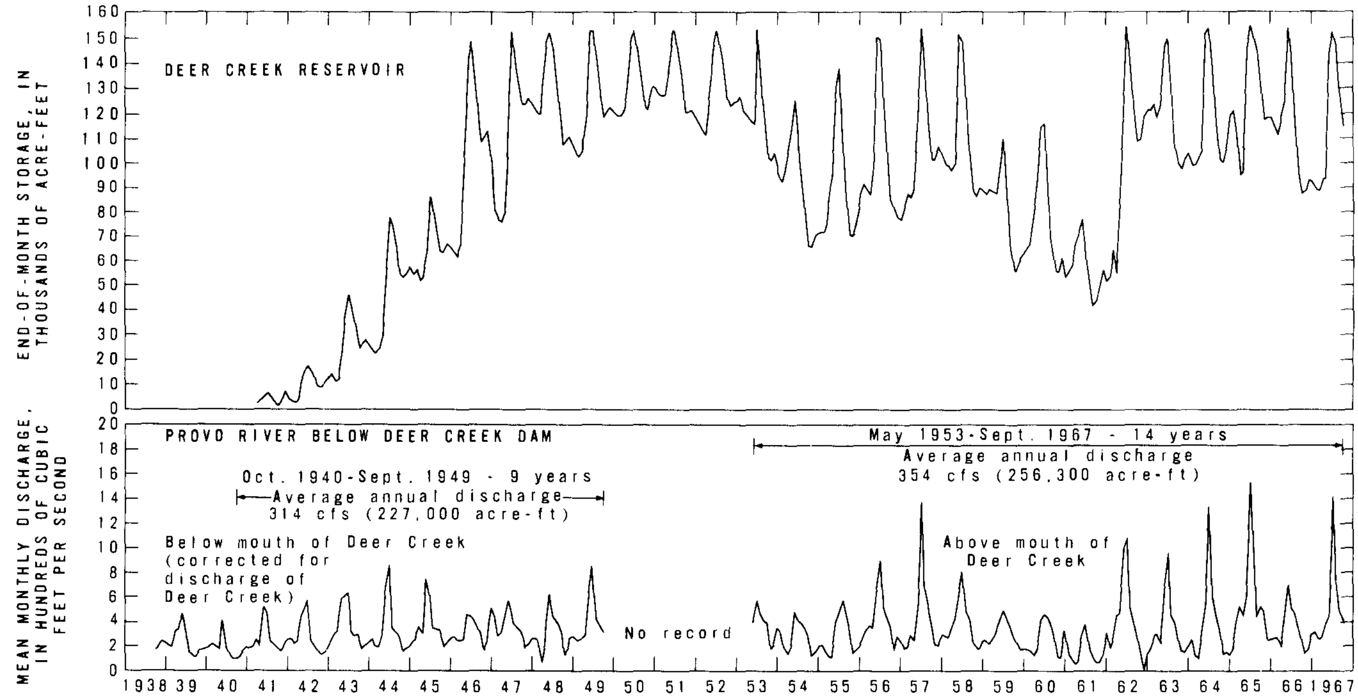


Figure 3.—Graphs of the discharge of the Provo River below Deer Creek Dam and water storage in Deer Creek Reservoir.

The Provo River appears generally to be a gaining stream between the gaging stations at Woodland (site 3, fig. 2) and at Hailstone (site 4, fig. 2). No tributaries other than ephemeral streams enter this reach of the river; but the Weber-Provo Canal discharge is added to the river in this reach, and the South Kamas and Washington Canal diverts from the river in this reach. Taking these factors into account, the average gain in the Provo River in the reach between Woodland and Hailstone, for the period of record at Woodland, is about 18,000 acre-feet per year. The figure cited is for only 4 years of record, however, and may differ from the actual long-term average.

When the records from the Provo River Commissioner's station near Midway are compared with the records from the station near Hailstone (taking into account the many irrigation diversions between the stations and the inflow from Drain Tunnel Creek), the river appears to gain an average of about 6,000 acre-feet per year between the two stations during the irrigation season (May-September).

A more accurate estimate of the gain of water by the river in Heber Valley can be made by comparing records for the stations near Hailstone (site 4, fig. 2) and near Charleston (site 5, fig. 2). The records for the two stations cover different periods of time, but the averages can be compared if they are both representative of the long-term averages for the entire period.

No discharge records for any point on the Provo River above Deer Creek Reservoir cover the entire period 1939-67, but records are available for several other streams that have their headwaters in the same general part of the Uinta Mountains that feeds the Provo River and drain areas of similar precipitation distribution. The discharge records of four of these streams are given on page 12.

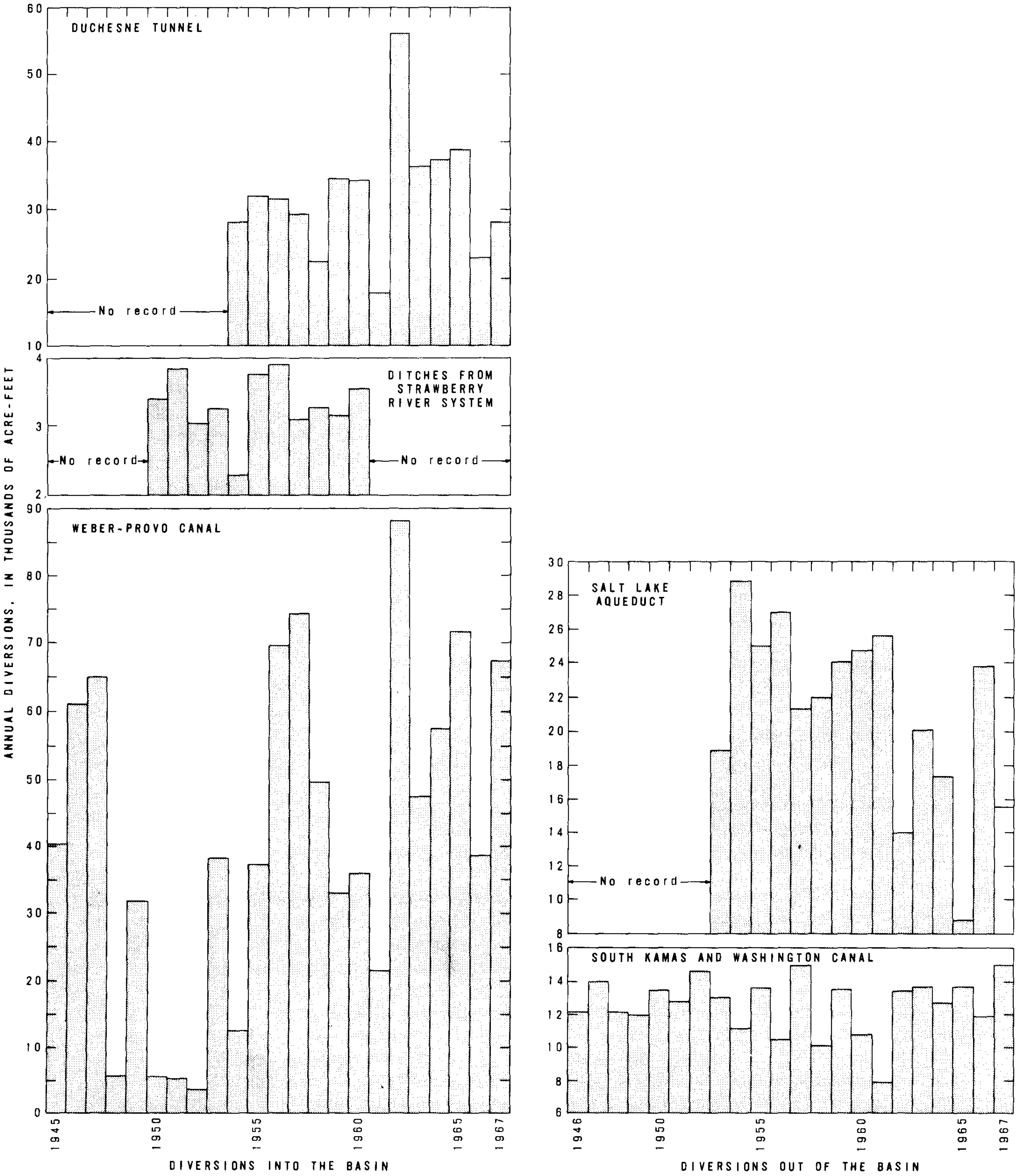


Figure 4.—Graphs of the diversions into and out of the upper Provo River drainage basin.

| Station | Average discharge, in cubic feet per second, for the period: 1939-50 | 1950-67 | 1939-67 |
|---|---|---|---|
| 9-2185. Blacks Fork near Milburne, Wyo. | 156[1] | 156 | 156[1] |
| 9-2775. Duchesne River near Tabiona, Utah | 210 | 179 | 192 |
| 9-2790. Rock Creek near Mountain Home, Utah | 171 | 162 | 164 |
| 10-1285. Weber River near Oakley, Utah | 198 | 205 | 200 |

[1] Record began in 1940.

On none of these streams do the average discharges for the periods 1939-50 and 1950-67 differ by as much as 10 percent from the average for the entire period 1939-67. It appears, then, that the average precipitation over the general area drained by the Provo River was about the same during the two periods, and that the average discharges for the two periods probably are comparable.

The comparison shows that the river gains an average of about 11,000 acre-feet per year in Heber Valley. The average annual gain is calculated as follows:

| | Acre-feet |
|---|---|
| Discharge of Provo River at Charleston | 139,000 |
| Diversions for irrigation between Hailstone and Charleston | + 87,000 |
| Inflow of Drain Tunnel Creek | – 12,000 |
| Net | 214,000 |
| Discharge of Provo River at Hailstone | –203,000 |
| Average annual gain from ground-water inflow in Heber Valley above Deer Creek Reservoir | 11,000 |

The 11,000 acre-feet of ground-water discharge enters the Provo River in several ways. Much of the valley bottom is marshy, and small springs and seeps are common. Two small tributaries of the river—Rock and Spring Creeks—originate from springs in Heber Valley. Probably much of the ground-water discharge enters the river directly as diffuse seepage.

One additional identifiable source of ground-water discharge to the Provo River is infiltration to the Heber City municipal sewage system. During the spring and summer months, when the water table is high, the discharge of the sewage system increases from a winter average of about 300,000 to about 6,500,000 gallons per day (Howard Hurst, Utah State Dept. of Public Health, oral commun., 1968); effluent from the sewage-treatment plant is discharged to Spring Creek.

#### Chemical quality

All surface water from the Provo River drainage basin that was analyzed was chemically suitable for domestic use, as well as for stock and for irrigation, according to the standards recommended by the U. S. Public Health Service (1962). Chemical analyses of nine samples collected prior to this investigation from various surface-water sources in the drainage basin are reported in table 5. The samples were calcium bicarbonate type water and were generally low in dissolved solids.

The relatively high dissolved solids reported for Snake Creek, 442 mg/l (milligrams per liter), is probably due to the inflow of water from thermal springs (p. 21); even a small percentage contribution from that source would suffice to raise the concentration of dissolved solids in the creek water to the observed level.

The concentration of dissolved solids in Little Hobble Creek (346 mg/l) was higher than that of most surface water in the area. However, the sample was taken during a period of very low flow and may represent primarily ground water concentrated by evapotranspiration during the preceding growing season.

Water in Deer Creek Reservoir is a mixture of all the surface water and ground water in the drainage basin. The water in the reservoir is fairly well mixed, as shown by the two samples taken at different depths on the same date (9-7-56).

In recent years, concern has been expressed about pollution of the water in the Provo River below Heber City as a result of that city's sewage-treatment problems. The large pickup of water by the sewage lines during the summer (p. 12) overburdens the city treatment plant and makes adequate treatment impossible with the existing facility. Hence, during the summer dilute but virtually untreated sewage is discharged into Spring Creek a short distance from the Provo River. The resulting pollution of Spring Creek is reportedly severe, and the water in Deer Creek Reservoir near the point of inflow of the river may be badly polluted at times. Dilution of the polluted water by the large volume of water in Deer Creek Reservoir has apparently prevented serious pollution of the reservoir as a whole; water diverted from the reservoir is used (after treatment) for municipal supply.

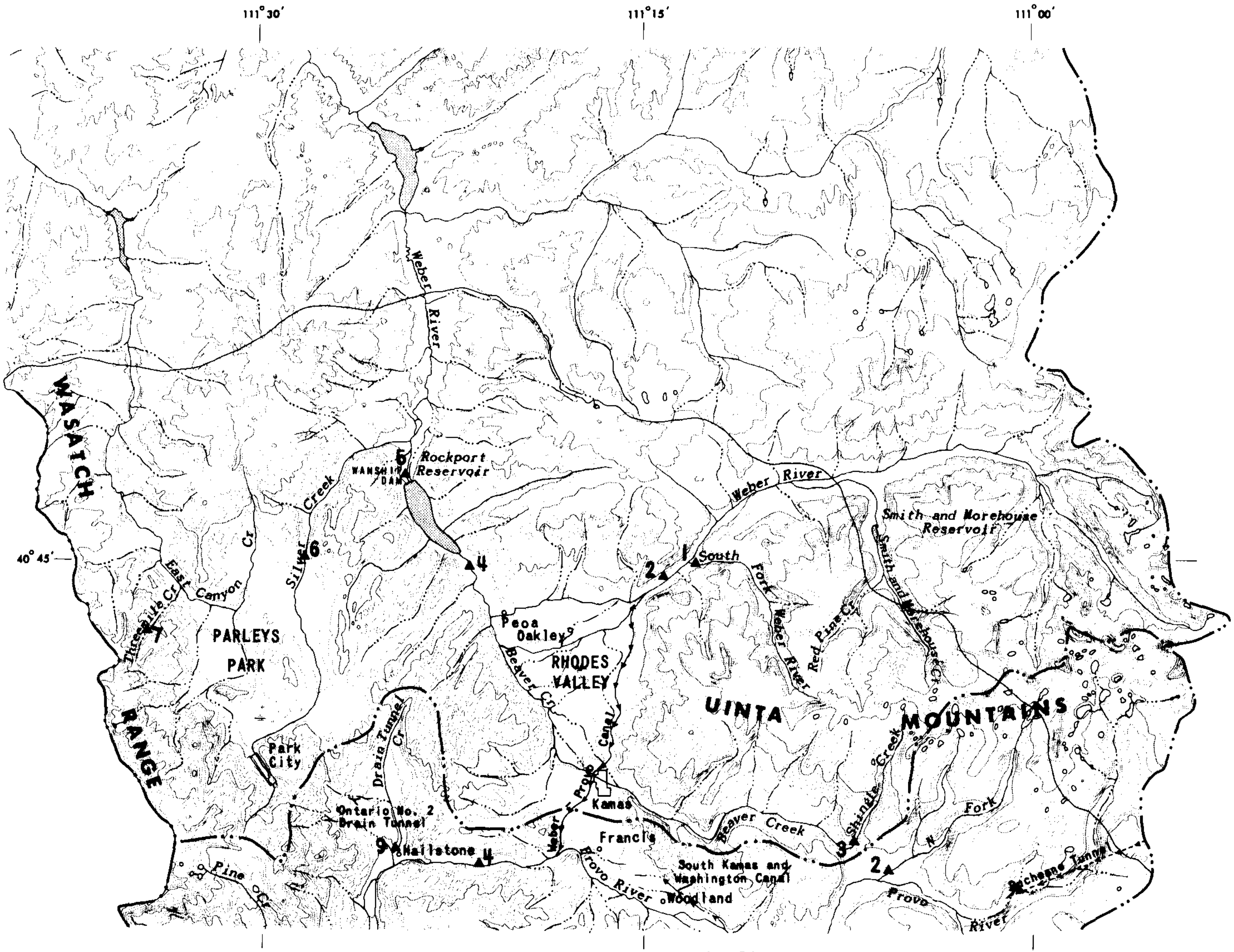
Several solutions to the problem have been suggested. Probably the most desirable course of action would be to locate and seal the leaks in the offending sewer lines. If water can enter the sewage system when the water table is high, sewage can also escape from the lines when the water table is low and may pollute the ground-water body.

### Weber River drainage basin

The Weber River, like the Provo River, has its headwaters in the west end of the Uinta Mountains; but the Weber River drains the northern slopes of the range (fig. 5). The main stem of the river flows roughly westward to Rhodes Valley, turns northward for about 25 miles, and then flows generally northwestward to Great Salt Lake.

#### Tributaries, reservoirs, and diversions

The main stem of the Weber River heads in a group of rock-basin lakes, very near the headwaters of the Provo River. Two major tributaries, Smith and Morehouse Creek and South Fork, also drain the northwestern slopes of the Uinta Mountains. A third major tributary from



Base from U.S. Geological Survey
1:250,000 (AMS) series: Salt Lake
City, Utah; Wyoming (1963)

0 1 2 3 4 5 MILES

CONTOUR INTERVAL 200 FEET
DATUM IS MEAN SEA LEVEL

**EXPLANATION**

▲2
Gaging station
*Number is location reference used in text*

Diversion
*Arrowheads show direction of flow*

Drainage divide

Boundary of study area

Figure 5.—Map of part of the Weber River drainage system.

the Uinta Mountains, Beaver Creek, drains the southwestern slopes of the range. Beaver Creek parallels the course of the Provo River for many miles, then turns northward through Rhodes Valley and joins the Weber River near Peoa.

Two major tributaries enter the Weber River from the southwest and drain parts of the study area. Silver Creek heads in the Wasatch Range southwest of Park City and drains part of Parleys Park; Silver Creek joins the river at Wanship (fig.1). East Canyon Creek drains most of Parleys Park and flows generally northwestward out of the study area and joins the Weber River many miles downstream.

Several small reservoirs near the head of the main stem of the Weber River and near the head of South Fork and one reservoir on Smith and Morehouse Creek have a combined regulated capacity of about 3,400 acre-feet. Wanship Dam, near the north boundary of the study area, impounds water in Rockport Reservoir, which has an active capacity of about 60,900 acre-feet.

Water is diverted from the Weber River just upstream from Oakley into the Weber-Provo Canal, which carries the water out of the basin to the Provo River. Some water is also diverted into the Weber-Provo Canal from Beaver Creek, but no records are kept of the diversions from Beaver Creek.

Water for irrigation in the southern part of Rhodes Valley is diverted into the Weber River basin from the Provo River (South Kamas and Washington Canal). No other water is diverted into the basin unless the water of Shingle Creek is regarded as such a diversion. Early physiographic studies of the region show Shingle Creek as the principal fork of Beaver Creek (Atwood, 1909, fig. 8), and Shingle Creek is shown on most maps as the upper part of the main stem of Beaver Creek. The divide between Shingle Creek and the North Fork Provo River is very low, however, and water from Shingle Creek is easily diverted into North Fork. Such diversions have been alternately made and unmade so many times that there is now considerable uncertainity concerning to which drainage the stream naturally belongs. In most recent reports of surface-water discharge in Utah (U.S. Geol. Survey, 1961-68), Shingle Creek is considered part of the Provo River drainage system, although nearly all the flow goes into Beaver Creek.

### Discharge

The Weber River Commissioner's office has operated a gaging station on the Weber River just downstream from Wanship Dam since the dam was completed in 1957 (see graph, fig. 6). The average discharge of the Weber River at this station for 10 years of record (through water year 1967) was about 110,000 acre-feet per year. The discharge measured at this site does not include the diversions through the Weber-Provo Canal, which have averaged about 50,600 acre-feet per year for the same period. If the diversions to the canal are added to the discharge measured below Wanship Dam, the total outflow from the Weber River basin above Wanship Dam averages about 161,000 acre-feet per year.

At present (1968) the U. S. Geological Survey operates four gaging stations on the Weber River and its tributaries (counting Shingle Creek) above Wanship Dam. The periods of record and average discharges for these stations, the station below Wanship Dam, and three other stations on tributaries of the Weber River that drain the Parleys Park area are tabulated on page 16.

The average annual diversion by the Weber-Provo Canal since its completion in 1931 is less than the average for the 10-year period 1957-67; the long-term average is 32,900 acre-feet per year. The long-term average discharge from the canal to the Provo River is only 31,300 acre-feet

| Station | Site number in fig.5 | Period of operation | Years of record | Average discharge (acre-feet per year) |
|---|---|---|---|---|
| 10-1282. South Fork Weber River near Oakley | 1 | 1964-67 | 3 | 18,090 |
| 10-1285. Weber River near Oakley | 2 | 1904-67 | 63 | 159,300 |
| 10-1293. Weber River near Peoa | 4 | 1957-67 | 10 | 107,100 |
| 10-1295. Weber River below Wanship Dam[1] | 5 | 1957-67 | 10 | 110,000 |
| 10-1300. Silver Creek near Wanship | 6 | 1941-46 | 5 | 5,070 |
| 10-1337. Threemile Creek near Park City | 7 | 1963-67 | 4 | 1,274 |
| 10-1345. East Canyon Creek near Morgan | 8 | 1931-67 | 36 | 35,040 |
| 10-1540. Shingle Creek near Kamas[2] | 3 | 1963-67 | 4 | 11,060 |

[1] Operated by Weber River Commissioner's office.

[2] Numbered as part of the Provo River drainage.

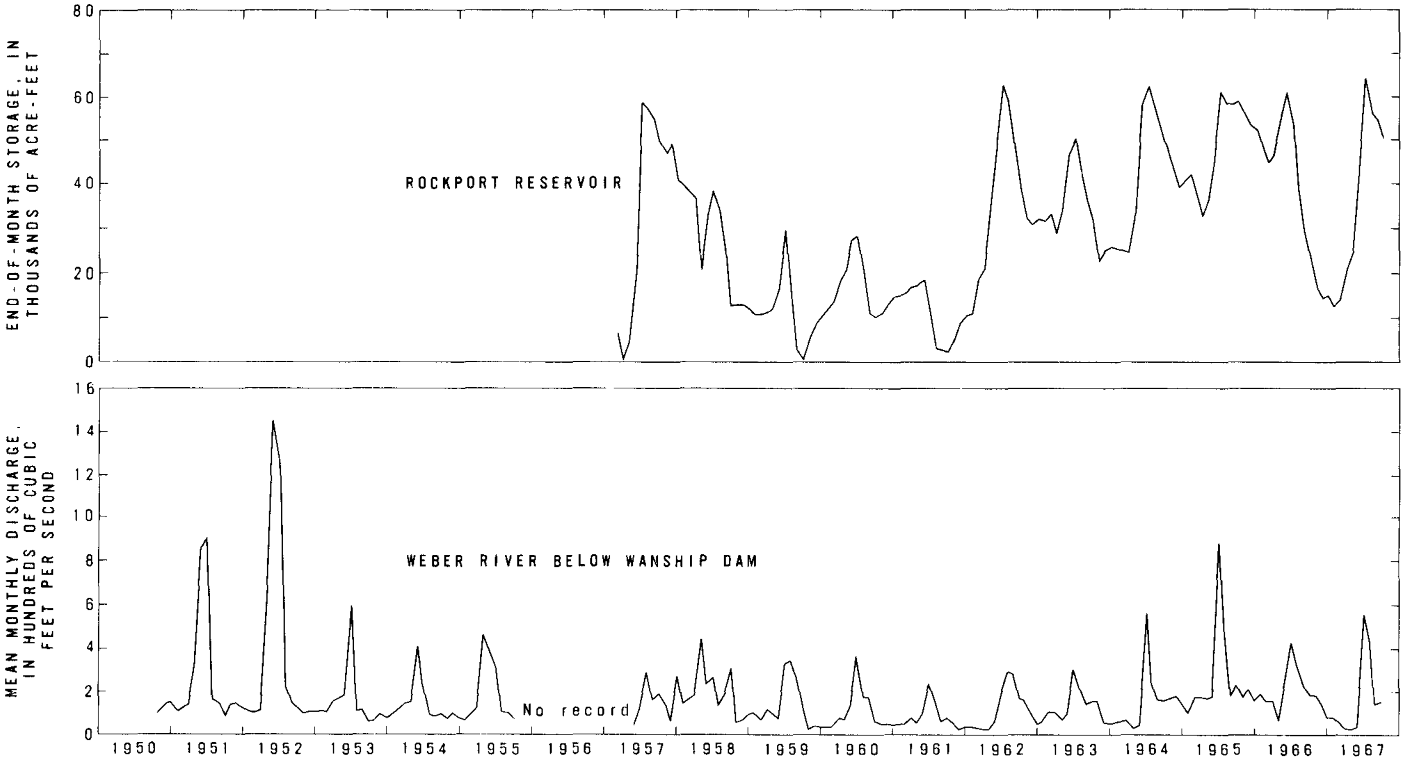


Figure 6.—Graphs of the discharge of the Weber River below Wanship Dam and water storage in Rockport Reservoir.

per year. The difference, an average of 1,600 acre-feet per year, plus any diversions from Beaver Creek, is the conveyance loss of the canal.

The discharge of Beaver Creek is not measured, but the creek enters the Weber River between the stations near Oakley (site 2, fig. 5) and near Peoa (site 4, fig. 5). No other perennial tributaries enter this reach of the river, although the Weber-Provo diversion is taken out: the difference in average discharge at the two stations, adjusted for the canal diversion, should therefore approximate the average discharge of Beaver Creek. Although the average discharge of the Weber River near Oakley for the entire long period of record is 159,300 acre-feet per year, the discharge near Oakley for the period of record available near Peoa is smaller—about 139,000 acre-feet per year. The Weber-Provo Canal diversion (average for the period 50,600 acre-feet per year) is removed from the river below this station, leaving about 88,500 acre-feet per year as the discharge of the main river above the gaging site near Peoa. The average discharge at the station near Peoa, however, is 107,100 acre-feet per year; the river gains 18,600 acre-feet per year (average) between the two stations. Some of the gain is undoubtedly ground-water discharge from the unconsolidated deposits in Rhodes Valley, but most of the gain is the discharge of Beaver Creek; an arbitrary estimate of the contribution from Beaver Creek is about 17,000 acre-feet per year.

The gaging station on East Canyon Creek is many miles downstream from the area of this study; less than half the drainage area of the creek above the gaging station is in the study area. It is probable, therefore, that the average discharge of East Canyon Creek from the study area does not exceed 15,000 acre-feet per year.

#### Chemical quality

All surface water from the Weber River drainage basin that was analyzed was chemically suitable for domestic, stock, and irrigation use. Chemical analyses of seven samples of surface water from the Weber River drainage basin are reported in table 5. All the samples are dilute calcium bicarbonate type water. The most concentrated of the seven samples (445 mg/l) was from Silver Creek at the old Silver King Mine near Park City. The stream at that point almost certainly included ground water discharging from the mine tunnels, which is more concentrated than most surface water in the area.

## GROUND-WATER HYDROLOGY

### Ground water in the consolidated rocks

The consolidated rocks in the Heber-Kamas-Park City area are an important element in the total ground-water system of the area. Springs and wells that discharge water from the consolidated rocks are the principal source of supply for water users in the mountains. Moreover, much of the water that enters the rocks in the mountains either reappears as springs along the margins of the valleys or moves into the unconsolidated valley fill as recharge in the subsurface.

#### Water-bearing units

The consolidated rocks underlying the Heber-Kamas-Park City area range in age from Precambrian to Quaternary. A generalized stratigraphic summary of the consolidated rocks is given in table 1. This is a composite section and nowhere in the area are all the formations present. Plate 2 is a geologic map showing the areal distribution of the various rock units.

The rocks in both the Wasatch Range and the Uinta Mountains have been subjected to considerable deformation and are greatly fractured, faulted, and folded. The most prominent displacement in the area is the Charleston thrust fault, which crosses the south end of Heber Valley. Several smaller thrust faults have been mapped, and high-angle faults of small displacement are numerous. Joints and fractures are ubiquitous, and solution openings are common in the carbonate rocks. These openings and the faults play a major role in controlling the movement of ground water in the area. Small folds are abundantly present, but they exert little influence on ground-water movement

Water moves through the rocks along the abundant fractures, solution openings, and fault planes, and thus any formation may be, at least locally, water bearing. In his report on the Park City Mining District, Boutwell (1912, p. 24) observed that the water in the mines came principally from "the red shale and massive quartzite" (Woodside Formation and Weber Quartzite). Officials of the United Park City Mining Co. agree that most of the water in that company's workings appears in tunnels that penetrate the Weber Quartzite (J. Ivers, Jr., oral commun., 1967).

In 1967, the few wells in the project area that were finished in the consolidated rocks derived their water from only 11 of the more than 30 geologic units under the area. The producing formations were the Quaternary tufa deposits, the Tertiary volcanic rocks, the Knight Conglomerate, the Preuss Sandstone, the Twin Creek Limestone, the Nugget Sandstone, the Chinle Formation, the Ankareh Formation, the Thaynes Formation, the Oquirrh Formation, and the Weber Quartzite. Other units, especially the carbonate rocks of Pennsylvanian, Mississippian, and Devonian age, yield water to springs in the area, and Feltis (1966, p. 14-17) states that in the Uinta Basin, southeast of the study area, some water is obtained from the Park City Formation of Permian age and from the Uinta Formation of Tertiary age. More wells in the study area obtain water from the Tertiary volcanic rocks than from any of the other formations, probably because the volcanic rocks are the shallowest consolidated rocks in the areas where most of the bedrock wells are located.

### Aquifer characteristics

In a broad way, for the purpose of evaluating areal movement of ground water, the highly fractured rocks of the Wasatch Range can be regarded as a single homogeneous aquifer, and the same is probably true of the rocks in the Uinta Mountains. On the small scale involved in selecting sites for the development of water supplies, however, the aquifers are grossly heterogeneous. Information from drillers' tests of wells finished in the consolidated rocks shows that the development of supplies of water sufficient for irrigation, industrial needs, or public supplies from the consolidated rocks depends upon the wells intersecting water-bearing fractures. Even in a fracture system that is properly described as "closely spaced," however, the distance between adjacent fractures may be very large compared to the diameter of a well. Hence, the construction of wells to intercept water moving through fractured rocks tends to be a "hit-or-miss" affair. The large discharge of water from mine tunnels near Park City should not be taken as an indication of the potential yield of wells. Each tunnel drains many miles of workings, whereas a well usually drains a relatively small area. Small supplies, adequate for domestic use in single-family dwellings, can probably be obtained from several of the consolidated rock units.

Drillers' reports of a few wells (table 3) include the results of pumping tests, generally of only a few hours duration. The test results were evaluated by the method of Theis and others (1963) to derive the values of aquifer transmissivity included in table 1.

# Table 1.—Generalized stratigraphic summary of the consolidated rocks of the Heber-Kamas-Park City area

| Age | Formation | Lithology and thickness | Water-bearing properties |
|---|---|---|---|
| Quaternary | Tufa deposits | Calcareous tufa deposited from the water of thermal springs. Nearly pure calcium carbonate. Very porous. Thickness unknown, but locally exceeds 70 feet. | Yields some water to wells. Numerous warm springs flow from tufa deposits, but source of water is probably underlying beds. Tufa apparently is permeable and transmits water readily. |
| Tertiary | Extrusive igneous rocks | Chiefly andesitic pyroclastics with some intercalated flow rocks, includes Keetley Volcanics and Tibble Formation. Thickness uncertain, but reportedly may exceed 1,000 feet. | Yields some water to wells, chiefly in the Parleys Park area, and to numerous small springs. Most of the observed springs are along fractures or contacts. Transmissivity estimated from drillers' reports as about 270 $ft^3/d/ft$. |
| | Intrusive igneous rocks | Includes a few small bodies of basic rocks in the Uinta Mountains and many large masses of granitic rocks in the Wasatch Range. Thickness unknown. | Intrusive rocks yield some water to mine tunnels from fractures, but have little significance as aquifers in the area. |
| | Fowkes Formation | Tuffaceous and limy beds and local conglomeratic lenses. Thickness and stratigraphic relations uncertain. Present only in extreme northwestern part of the study area. | Not known to yield water in the study area. |
| | Uinta Formation | Fluvial and lake deposits. Present only in the extreme south end of the study area. Thickness in the area unknown. | Not known to yield water in the study area, but reportedly supplies some wells locally in the Uinta Basin to the southeast (Feltis, 1966). |
| | Knight Conglomerate | Gray and reddish conglomerate in massive beds, chiefly fluvial. Thickness as much as 2,000 feet. | Yields water to a few wells in the northern part of the study area. Transmissivity probably less than 135 $ft^3/d/ft$. |
| Tertiary and Cretaceous | Wanship Formation of Eardley (1952) | Marine sandstone and shale. Thickness as much as 5,000 feet. | Not known to yield water in the study area. |
| Cretaceous | Echo Canyon Conglomerate of Eardley (1944) | Conglomerate and conglomeratic sandstone and some shale and a few coal beds. Thickness at least 3,100 feet. | Not penetrated by wells in the study area, but supplies a few springs. |
| | Frontier Formation | Nonmarine and marine sandstone, shale, and coal. Thickness more than 2,100 feet. | Not penetrated by wells in the study area. Probable source of a few small springs. |
| | Price River Formation | Conglomerate and shale. Thickness as much as 1,500 feet, but probably less in the study area. Present only in the extreme south end of the area. | Not known to yield water in the study area. |
| | Aspen Shale | Dark gray marine shale. Thickness about 250 feet. | Do. |
| | Kelvin Formation | Continental deposits, predominantly red colored. Thickness about 1,500 feet. | Not penetrated by wells in the study area, but supplies a few springs. |
| Jurassic | Morrison Formation | Continental deposits, locally containing abundant dinosaur remains. Thickness uncertain, perhaps as much as 1,200 feet. | Not known to yield water in the study area. |
| | Preuss Sandstone | Nonmarine siltstone and sandstone. Thickness probably more than 1,000 feet. | Yields small amounts of water to a few wells in the area. Insufficient data to estimate transmissivity. |
| | Twin Creek Limestone | Light-colored splintery limestone. Thickness as much as 2,000 feet. | Yields water to several wells and springs in the area, probably from fractures and solution cavities. Data suggest transmissivity of less than 135 $ft^3/d/ft$. |
| Jurassic(?) and Triassic(?) | Nugget Sandstone | Crossbedded eolian sandstone, generally some shade of red. Thickness as much as 1,200 feet. | Yields water to several wells in the area. Transmissivity generally low (about 65 $ft^3/d/ft$) but locally as high as 335 $ft^3/d/ft$. |
| Triassic | Chinle Formation | Mixed nonmarine sediments, generally red. Thickness uncertain, probably less than 500 feet. | Yields small amounts of water to wells in the Parleys Park area. Transmissivity probably less than 135 $ft^3/d/ft$. |
| | Shinarump Member of the Chinle Formation | Fluvial sandstone and conglomerate. Thickness about 100 feet in the study area. | Not known to yield water in the study area. |
| | Ankareh Formation | Chiefly red siltstone, sandstone, and shale. Thickness more than 1,000 feet. | Yields a little water to wells in the Parleys Park area from sandy beds. Insufficient data to estimate transmissivity. |
| | Thaynes Formation | Calcareous marine sediments. Thickness more than 2,000 feet. | Yields some water to a few wells and springs, largely from fractures and solution openings. Insufficient data to estimate transmissivity. |
| | Woodside Formation | Red siltstone, sandstone, and shale. Thickness about 500 feet. | Reportedly yields water to the mine tunnels in the Park City area from fractures. |
| Permian | Park City Formation | Limestone, phosphorite, cherty siltstone, and shale. Thickness about 1,500 feet. | Not tapped by wells in the study area, but reportedly yields some water in the Uinta Basin (Feltis, 1966). |
| | Diamond Creek Sandstone | Light-colored crossbedded sandstone. Thickness up to 1,000 feet. Present only in the extreme south end of the study area. | Neither of these two formations is sufficiently extensive in the study area to be important as aquifers. No wells in the area tap either formation, but a few small springs in the extreme south end of the area produce water from one or both of these formations. |
| | Kirkman Limestone | Dark-colored, brecciated, thin-bedded limestone. Thickness up to 1,600 feet. Present only in the extreme south end of the study area. | |
| Permian and Pennsylvanian | Oquirrh Formation | Interbedded sandstone and limestone containing some shale and siltstone. Thickness as much as 8,000 feet, but probably less in the study area. Present only south of Heber City. | Yields some water to wells and springs, chiefly from fractures and solution openings. Transmissivity estimated as about 270 $ft^3/d/ft$. |

Table 1.—Generalized stratigraphic summary of the consolidated rocks of the Heber-Kamas-Park City area—continued

| Age | Formation | Lithology and thickness | Water-bearing properties |
|---|---|---|---|
| Pennsylvanian | Weber Quartzite | Chiefly gray crossbedded sandstone. Thickness up to 3,000 feet. | Yields small amounts of water to a few wells. Primary permeability is very low, but reportedly yields large quantities of water from fractures in the mine workings near Park City. Principal source of water in the mines. |
| | Morgan Formation | Red sandstone and shale interfingers with the Weber Quartzite in part. Thickness up to 1,000 feet. | No information on water-bearing properties in the study area, but primary permeability is probably low. |
| | Round Valley Limestone | Light-gray marine limestone. Thickness 250-400 feet. | No wells penetrate the formation in the study area, but it yields water to numerous springs. |
| Pennsylvanian and Mississippian | Manning Canyon Shale | Marine shale, siltstone, claystone, and limestone. Thickness 300-500 feet. | Not penetrated by wells in the area, but supplies a few small springs. |
| Mississippian and Devonian | Mississippian and Devonian rocks undivided | Chiefly marine limestones and dolomites. Thickness from 3,000 to 6,000 feet. | Not penetrated by wells in the area, but yields water from fractures and solution openings to many springs. A major aquifer. |
| Cambrian | Cambrian sedimentary rocks undivided | Chiefly shales and quartzites. Thickness uncertain, probably up to 3,000 feet. | Not known to yield water in the study area. |
| Precambrian | Precambrian rocks undivided | Chiefly metasediments. Thickness unknown. | Water-bearing potential unknown, but probably small. |

### Recharge

In most of the mountainous area, the soil cover is thin and permeable, and rain or snowmelt can infiltrate readily. The rapidity of infiltration into the rocks in the mountains is indicated by the reports that the discharge of the mine tunnels in the Park City area increases noticably during the period of spring snowmelt and runoff. Moreover, observation well (D-2-5)32bad-1, finished in the Tertiary volcanic rocks, shows small rises of water level only a few hours after a rainstorm over the area. The water level in one of the nonflowing thermal springs near Midway (see p. 21) also rises rapidly in response to rain or snowmelt in the mountains.

### Movement

As has been indicated, water moves through the consolidated rocks readily, principally along the abundant zones of fracturing and solution openings. The direction of movement is, in general, downhill from recharge areas in the mountains to discharge areas near the margins of the valleys.

Whether any appreciable amount of water leaves the study area through the consolidated rocks is difficult to ascertain, but an unbalance of 17,000 acre-feet per year in the gound-water budget for Heber Valley is probably due to movement out of the valley through the consolidated rocks. The structural feature most commonly suspected of draining water from the area is the Charleston thrust fault, which passes entirely through the Wasatch Range. Deer Creek Reservoir, on the Provo River, lies directly across the outcrop of the Charleston and associated Deer Creek thrust fault (see pl. 2), and the water budget for Deer Creek Reservoir (see p. 8) indicates that there is no loss of water from the reservoir along the thrust planes. Because there is no detectable movement of water from Deer Creek Reservoir down the Charleston thrust fault, it is probable that no significant amount of ground water leaves the study area along the fault.

### Discharge

The principal manmade discharge of water from the consolidated rocks in the area is through the extensive mine workings in the vicinity of Park City (fig. 7). The amount of water discharged by the few small-capacity wells that penetrate the consolidated rocks is only a very small part of the total discharge. Natural discharge is through numerous springs, mostly around the margins of the valleys, and through direct infiltration into the unconsolidated deposits in the valleys.

The total discharge from mine tunnels is estimated as at least 50 cfs (cubic feet per second) or 36,000 acre-feet per year. The discharge of the Spiro Tunnel, near Park City, was reported in 1935 as about 15 cfs and "a rather steady flow" for several years (G. H. Taylor, written commun., 1935). The flow of Drain Tunnel Creek, which consists principally of the discharge of the Ontario No. 2 Drain Tunnel, is measured at a weir about 5 miles downstream from the mouth of the tunnel (fig. 2). The losses to evapotranspiration between the tunnel mouth and the weir probably equal or exceed any gains from ground-water discharge to the stream. The average discharge of Drain Tunnel Creek is 15.9 cfs (18 years of record). The drainage from the Mayflower Mine enters Drain Tunnel Creek downstream from the above-mentioned weir; in 1967-68 the discharge of the Mayflower Mine drainage was estimated as about one-half that of Drain Tunnel Creek at the weir. Smaller amounts of water are discharged from other tunnels in the area.

The water discharged from the Alliance Tunnel (quantity unknown) provides the municipal supply for Park City; the discharge from the other tunnels is used for irrigation in Parleys Park and Heber Valley.

A large but undetermined amount of water is discharged from the consolidated rocks through numerous springs. In 1968, the Utah State Engineer's records included claims to water from about 250 springs that discharge water from the consolidated rocks. The springs are nearly all associated with fractures or solution openings. The largest springs in the area flow from solution openings in the limestones of Pennsylvanian and Mississippian age. For example, three springs near the mouth of Snake Creek Canyon discharged about 13 cfs from the limestones during the summer of 1967.

An unusual hydrologic feature of Heber Valley is a group of thermal springs near the town of Midway. Although the springs are located on the Snake Creek alluvial fan, and are underlain in part by alluvium, their source is deep seated and they represent discharge from the consolidated rocks. A more detailed discussion of the thermal springs has been given elsewhere (Baker, 1968), and they will be described only briefly here.

Most of the thermal springs do not flow and are known locally as "hot pots." The typical hot pots are small pools of warm water that occupy shallow depressions in the tops of mounds of calcareous tufa (fig. 8). Seventeen hot pots in the area have been examined by the writer. Four of the hot pots are artificially discharged to supply water to swimming pools at resorts, 2 pots occasionally overflow, and the other 11 discharge water at the land surface only by evaporation, although some thermal water may be discharged into the valley fill in the subsurface.

The temperature of the water in the 13 pots without artificial discharge ranges from 12° to 34°C (54°-94°F), and the highest temperatures are in the 2 pots that occasionally overflow. Water temperature in the 4 pots that are artificially discharge ranges from 38° to 40°C (100°-104°F). Addition of heated water from below to many of the pots is very slow, and the water of a few pots is lower than that properly classified as "thermal."

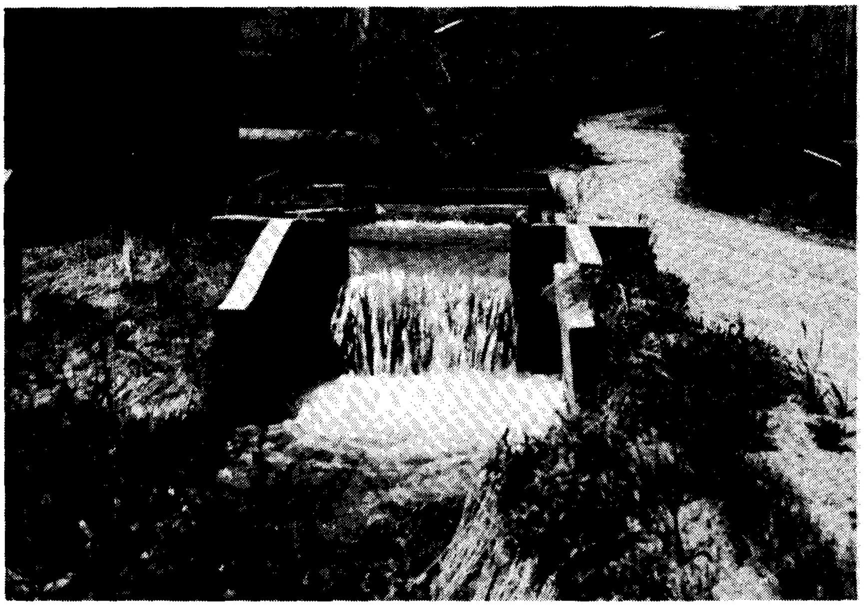


Figure 7.—Water discharging from the Spiro Tunnel near Park City. Water moves from the tunnel mouth to this drainage ditch through the pipe in the background. Discharge is about 15 cubic feet per second.

Figure 8.—Typical hot pot near Midway. View looking east from a point about 7 feet above the ground. The opening is about 9 feet in diameter and the top of the rim is about 5 feet above the road in the upper left corner of the photograph. Water level is about 1.5 feet below the rim.

In addition to the hot pots, at least 7 thermal springs in the area flow perennially. The discharge of these springs ranges from a few gallons per minute to about 3 cfs; the total discharge of the 7 springs in 1967 was about 7 cfs. The water temperature of the 7 flowing springs ranges from 30° to 46°C (86°-144°F).

### Chemical quality

Nearly all tne nonthermal water from the consolidated rocks is suitable for domestic use according to the standards of the U. S. Public Health Service (1962); the exception is some water from the volcanic rocks that is high in iron. All the water is hard to very hard, and many residents of the area use ion-exchange type softeners in their domestic water systems. Water from the hot pots is too mineralized to be desirable for domestic use, and plentiful supplies of better water are available from the springs that furnish the public supply of Midway. Even water from the hot pots is used by livestock; and, according to the criteria established by the U. S. Department of Agriculture (U.S. Salinity Lab. Staff, 1954), all water from the consolidated rocks in the area is suitable to use for irrigation. Although water from the hot pots is in the high salinity hazard class for irrigation, it can be used for salt-tolerant crops on the premeable and well-drained soils in Heber Valley.

Samples of water for chemical analysis were collected from 28 springs, wells, and tunnels that tap the consolidated rocks; the analyses are included in table 5. The locations from which the samples were collected and diagrammatic representations of the concentrations of the principal dissolved solids in some of the samples are shown on plate 3. Four kinds of water can be distinguished from four general sources in the consolidated rocks. Figure 9 illustrates average analyses of samples of the four kinds of water.

Water from the sandstones and limestones of Jurassic age and older is represented by diagram 1 (fig. 9). The water is of calcium magnesium bicarbonate type and is not highly mineralized; the concentration of dissolved solids in 13 samples from these formations ranged from 104 to 488 mg/l. Most samples were hard according to the classification of the U. S. Geological Survey (more than 120 mg/l hardness), and many samples were in the very hard range (more than 180 mg/l). The concentration of silica was low; the samples ranged from 8.2 to 25 mg/l, but most were below 20 mg/l. The percentages of sulfate and chloride were low (each less than 20 percent of the total anions), and chloride was generally slightly lower than sulfate.

Diagram 2 (fig. 9) is typical of water from the shales of Triassic age; 1 sample was collected from a spring, 1 from a well, and 3 from mine drain tunnels. The water is of calcium sulfate type, and generally more concentrated than that from the limestones and sandstones. The concentration of dissolved solids in 5 samples ranged from 218 to 691 mg/l. All samples were in the very hard range; the hardness of 2 samples exceeded 300 mg/l. Concentrations of silica ranged from 6.3 to 21 mg/l.

Water from the volcanic rocks is represented by diagram 3 (fig. 9). The volcanic rocks yield calcium bicarbonate type water; the concentrations of 5 samples ranged from 249 to 1,020 mg/l. Four samples were in the very hard range, but water from the volcanic rocks was generally softer than water from the shales. Concentrations of silica were much higher in these samples than in water from other sources in the area. The silica concentration ranged from 22 to 52 mg/l, but only 1 sample was below 30 mg/l. The relative concentrations of sulfate and chloride in these waters was also distinctive; the samples contained from 3 to 5 times as much chloride as sulfate. The volcanic rocks are the only consolidated rocks in the area that yield water containing

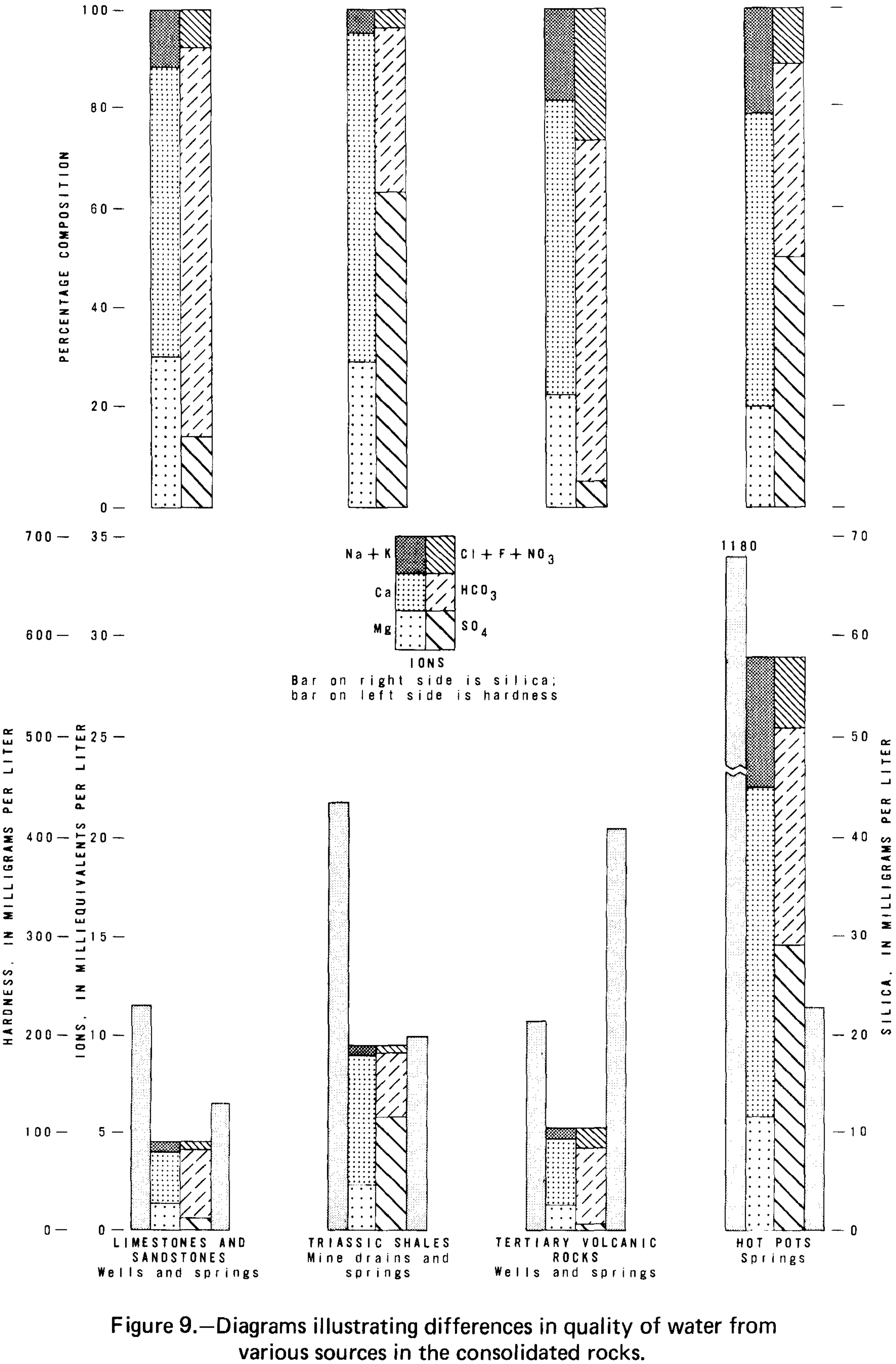


Figure 9.—Diagrams illustrating differences in quality of water from various sources in the consolidated rocks.

substantially more chloride than sulfate. One sample was very high in iron (34 mg/l), but this seems to be a local condition; the few other analyses indicate little or no iron in solution.

Water from the hot pots is a calcium sulfate bicarbonate type (diagram 4, fig. 9), and is by far the most mineralized water in the area. Concentrations of dissolved solids in 10 samples of the thermal water ranged from 1,650 to 2,160 mg/l, and total hardness ranged from 960 to 1,270 mg/l. The water is saturated with respect to calcium carbonate at normal temperatures and pressures; calcium carbonate precipitates from samples that are allowed to stand for a few days exposed to the atmosphere.

### Ground water in the unconsolidated deposits

The principal source of water to wells in the Heber-Kamas-Park City area is the unconsolidated alluvial fill in the major valleys. Unconsolidated deposits in the mountains have little significance as aquifers. The stratigraphy, lithology, and water-bearing characteristics of the unconsolidated deposits are summarized in table 2. The areal distribution of the various units is shown on plate 2.

Table 2.—Generalized description of the unconsolidated deposits in the Heber-Kamas-Park City area

| Age | Unit | Lithology and thickness | Water-bearing properties |
|---|---|---|---|
| Quaternary | Younger alluvium | Poorly sorted mixture of material ranging in size from clay to boulders. All beds appear to be lenticular and discontinuous. Thickness ranges from 0 to about 1,000 feet. Underlies the valley floors of Heber Valley, Rhodes Valley, Parleys Park, and Round Valley and forms low terraces along the margins of Heber and Rhodes Valleys. The two units cannot be distinguished lithologically; the terraces are mapped as older alluvium and the valley floors as younger alluvium, but older alluvium probably also underlies the valley floors. | These deposits form the best and most productive aquifers in the study area. Water-table conditions predominate. Hydraulic conductivity ranges from 20 to 50 $ft^3/d/ft^2$; estimated specific yield ranges from 12 to 15 percent. Most wells and many springs in the study area yield water from these deposits. |
|  | Older alluvium |  |  |
|  | Landslide deposits | Unsorted material ranging from clay through boulders. Thickness unknown. Present only in a few isolated areas of the mountains. | Hydrologic properties unknown, but the scattered small deposits have no hydrologic significance in the area. |
|  | Glacial deposits | Includes outwash deposits, morainal deposits, and glacially striated bare ground. Present in the higher elevations of both the Wasatch Range and the Uinta Mountains. | The small areas of sorted outwash undoubtedly store and transmit some ground water, but the glacial deposits as a whole have no significance as aquifers in the study area. |
| Tertiary(?) | Older high-level gravel surfaces of uncertain age | Planed surfaces underlain by thin deposits of gravel. Thickness uncertain. Present only in southeastern part of study area. | No data concerning hydrologic characteristics, but not significant as an aquifer in the study area. |

### Heber Valley

Heber Valley, on the Provo River, is the largest of the four valleys included in the study area (pl. 1 and fig. 1). The valley floor is roughly triangular in plan and has an area of about 44 square miles. The Provo River enters the valley at the northern apex of the triangle and flows out near the southwestern apex. Three small tributaries of the Provo River—Lake, Center, and Daniels Creeks—enter the valley near the southeastern apex, and a fourth tributary, Snake Creek, enters about midway on the western side of the valley. The valley floor is thickly blanketed with unconsolidated debris, and each of the tributary streams has built a substantial alluvial fan at the mouth of its canyon.

Two wells in Heber Valley that pass through the entire thickness of unconsolidated material reached consolidated rocks at depths of about 310 feet. Geophysical studies, however, indicate that the maximum thickness of the unconsolidated deposits may exceed 800 feet locally (see appendix, p. 57). The material is poorly sorted, and because there are no well-defined beds of material of very low or very high permeability, the unconsolidated valley fill can be treated as a single, essentially homogeneous, water-table aquifer.

*Aquifer characteristics.*—The calculated hydraulic conductivity of the aquifer in Heber Valley is about 50 $ft^3/day/ft^2$ (cubic feet of water per day per square foot), and the transmissivity is in the range of 6,700-20,000 $ft^3/day/ft$. These values were calculated using values of specific capacity of wells obtained from drillers' tests and using the value for ground-water accretion to Deer Creek Reservoir calculated on page 8. Conventional aquifer tests were not made because the valley contains no large-capacity wells.

Drillers' reports for 35 wells in the valley include the results of pumping or bailing tests, generally of 2 hours duration or less (table 3). The specific capacities determined from these tests ranged from 0.2 to 25 gpm (gallons per minute) per foot of drawdown. Because the specific capacity of a well is greatly influenced by the well construction—thickness of aquifer penetrated and open to the well, method of finish, method and amount of development, and a host of other factors—as well as the duration of the test, the largest specific capacities are probably most indicative of the potential of the aquifer. The largest specific capacities of wells in Heber Valley (25 gpm per foot of drawdown) were used to calculate the aquifer transmisivity by the method of Theis and others (1963); the calculated transmissivity was about 6,700 $ft^3/day/ft$.

The calculated ground-water accretion to Deer Creek Reservoir is 47,000 acre-feet per year (p. 8). Using Darcy's law in the form:

$$T = 119.4\ Q/IL$$

where Q is the ground-water discharge (47,000 acre-feet per year), I is the slope of the water table near the reservoir (0.02 foot per foot), and L is the length of the reservoir shoreline adjacent to the valley fill (13,900 feet), the transmissivity, T, is calculated as about 20,000 $ft^3/day/ft$.

The specific yield of the aquifer material was estimated from drillers' logs as follows: Each logged material was assigned a value of specific yield and this value was multiplied by the percent of the total depth logged as that material; the resulting figure was the weighted specific yield for the given material in that hole. The weighted specific yields of all the materials reported in each log were summed to give the average specific yield of all the material drilled. The values of specific yield assigned to the various materials reported by the drillers were values that have been determined largely by hydrologists in other areas and the interpretation of drillers' terms followed the schemes summarized by Johnson (1967, tables 17 and 24).

The specific yield of the upper 30 feet of the aquifer material was estimated from 20 logs; the values of specific yield ranged from 8 to 20 percent and averaged about 14 percent. The specific yield of the total thickness of material penetrated was estimated from 17 logs of the deepest wells in the valley. The total depths of the wells ranged from 100 to 225 feet and averaged 144 feet; the values of specific yield ranged from 7 to 21 percent and averaged about 12 percent. Accordingly, the value of 14 percent (for the upper 30 feet of the material) was used to compute annual recharge, and the value of 12 percent (for the total thickness of the valley fill) was used to compute the amount of water in recoverable storage in the aquifer.

*Ground-water budget.*—The ground-water budget for the valley fill in Heber Valley is summarized as follows:

| | Acre-feet |
|---|---|
| Recharge: | |
| Irrigation water and precipitation on the valley floor | 56,000 |
| Subsurface inflow | 30,000 |
| Total recharge: | 86,000 |
| Discharge: | |
| Net evapotranspiration loss (evapotranspiration less precipitation) | 11,000 |
| To Deer Creek Reservoir | 47,000 |
| To Provo River | 11,000 |
| Subsurface outflow | 17,000 |
| Total discharge: | 86,000 |

The derivation of each of these values is explained in the following sections on recharge and discharge.

In the calculations of recharge and discharge (both in Heber Valley and in Rhodes Valley) the assumption is made that precipitation on the valley floor is entirely consumed by evapotranspiration. This assumption is, of course, an oversimplification; some of the precipitation reaches the water table as recharge and some runs off as surface water. The calculated totals for both recharge and discharge are not affected by the simplification.

*Recharge.*—The unconsolidated deposits in Heber Valley are recharged by precipitation on the valley floor; by infiltration of surface water, especially water spread over the land for irrigation; and by subsurface inflow from the surrounding consolidated rocks. The amount of recharge derived from the infiltration of precipitation is small and probably occurs primarily during the spring period of snowmelt. Direct infiltration of water from the Provo River is also small; most of the time the Provo River through Heber Valley is a gaining stream and removes water from the aquifer rather than adding water to it.

The infiltration of irrigation water is the major source of recharge to the valley fill. Most of the valley bottom is irrigated, and because the infiltration rate is rapid, each application of irrigation water adds considerable recharge to the aquifer.

The average annual recharge in Heber Valley is somewhat more than the average annual change in storage, but the difference between annual change in storage and annual recharge probably is not great. Hence, the average annual change in storage can be used as the budget estimate for average annual recharge.

The average annual change in storage in the water-table aquifer is equal to the product of the annual change in saturated thickness, the specific yield of the aquifer material, and the area of the aquifer.

Water levels in about 25 wells in all parts of Heber Valley were measured by various agencies, and were reported by the Provo River Commissioner, during the period 1945-60. The Commissioners' reports distinguish four subareas or divisions of the valley. The four divisions, their approximate areas, and the average annual change of saturated thickness in each division for the period 1945-60 (from the Provo River Commissioners' Annual Reports) are tabulated below:

| Division | Area (acres) | Average annual change in saturated thickness (feet) |
|---|---|---|
| Above irrigation | 3,000 | 4.97 |
| Midvalley | 21,000 | 25.58 |
| Lower valley | 3,200 | 13.52 |
| River bottom lands | 800 | 7.58 |

The estimated average specific yield of the upper 30 feet of the aquifer materials is 14 percent; if that estimate and the tabulated figures are used in the equation, the computed average annual change in storage in the unconsolidated deposits in Heber Valley is 86,000 acre-feet.

The principal sources of recharge to the valley fill, as stated earlier, are infiltration of irrigation water and subsurface inflow from the consolidated rocks. Neglecting minor sources of recharge, the approximate contribution from each of the principal sources can be calculated from the following data:

The total amount of water diverted for irrigation in Heber Valley each year is reported by the Provo River Commissioner; the average for the period 1945-60 was 87,000 acre-feet per year.

The average amount of water required by crops in the valley during the irrigation season (May-September) can be calculated by the Blaney-Criddle method (Blaney and Criddle, 1962). Using data published by the Utah State Engineer's office (Criddle and others, 1962) for hay and mixed pastures in Heber Valley, the crop water requirement is calculated as 43,000 acre-feet per irrigation season.

Part of the water required by the crops will be furnished by precipitation during the growing season. Using data from the May-September precipitation map of Utah (U. S. Weather Bur., 1963), the precipitation on the valley floor during the irrigation season is calculated as 12,000 acre-feet.

So the contribution to recharge, in acre-feet, from irrigation is:

| | |
|---|---|
| Water diverted for irrigation | 87,000 |
| Plus precipitation | +12,000 |
| Total: | 99,000 |
| Less crop water requirements | –43,000 |
| Difference (available for recharge): | 56,000 |

And the contribution from subsurface inflow, in acre-feet, is:

| | |
|---|---|
| Total recharge | 86,000 |
| Less recharge from irrigation | –56,000 |
| Difference (recharge from subsurface inflow): | 30,000 |

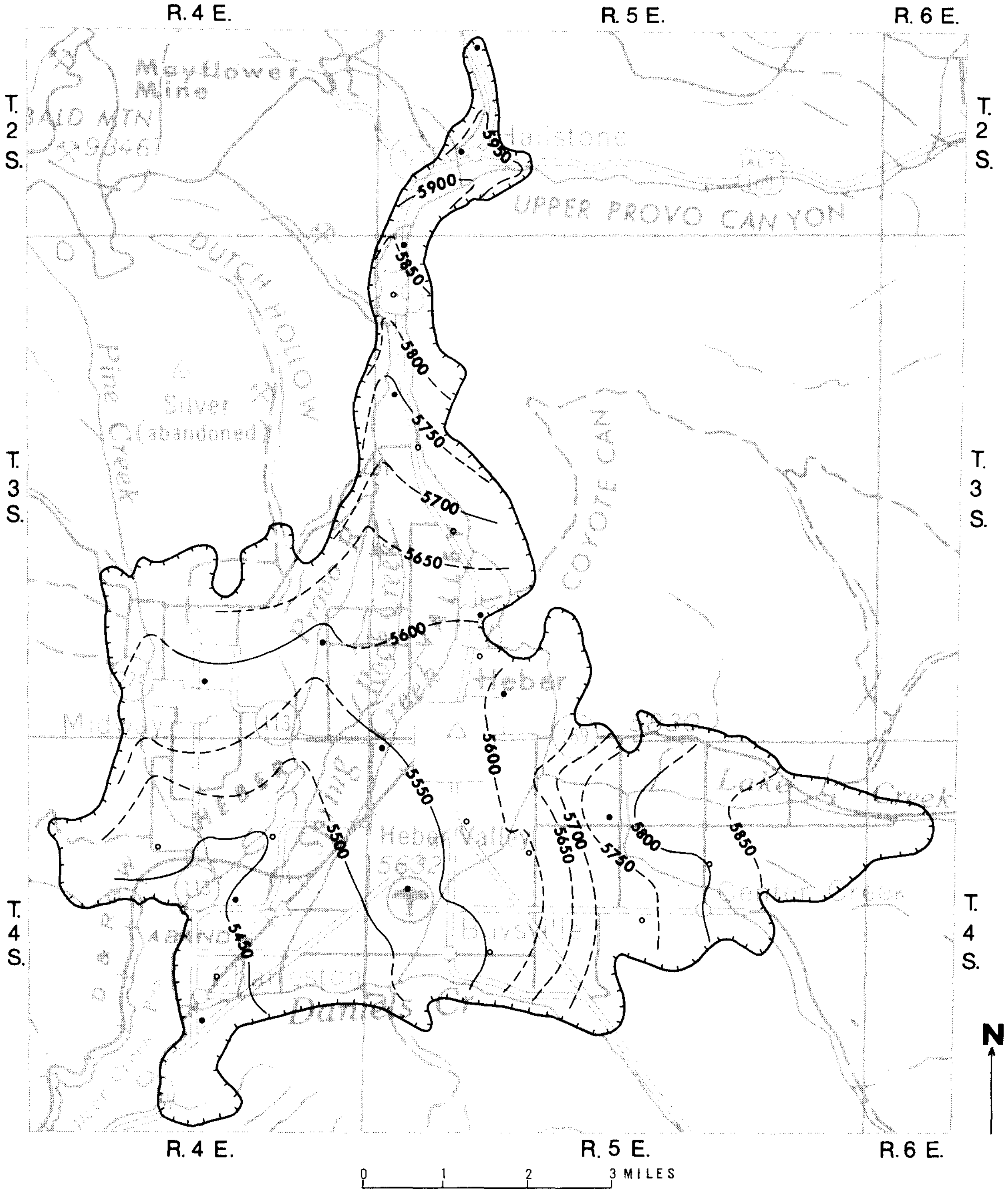
*Movement.*—The direction of ground-water movement through the unconsolidated deposits in Heber Valley is shown by the water-table map (fig. 10). In general, the direction of movement is toward the Provo River and downvalley. During periods of peak stream discharge, the direction of movement in the immediate vicinity of the river probably would be reversed.

The water-table map indicates that Snake Creek, like the Provo River, is generally a gaining stream in Heber Valley. The three tributaries from the east (Lake, Center, and Daniels Creeks), however, are losing streams. The coarse-grained fan deposits across which these streams flow as they enter the valley are at altitudes well above the main valley floor, and the water table is several tens of feet below the surface of the fans (fig. 11). The increased depth to water in the area of these alluvial fans reflects the higher altitude of the land surface; the slope of the water table beneath the fans is about the same as the slope of the water table elsewhere in the valley (fig. 10).

*Water-level fluctuations.*—The water level in wells in Heber Valley fluctuates in response to the seasonal recharge-discharge cycle (figs. 11 and 12 and table 7). Generally the water table is highest in late May or early June and gradually declines through the summer, fall, and winter. The lowest level of the year is commonly reached in February or March, shortly before the spring thaw. With the coming of the thaw and the heavy spring runoff, the water table rises rapidly, and again reaches a high in May or June. This seasonal rise and fall of the water level is illustrated by the graph of well (D-4-4)14abb-1 (fig. 12).

Man's activities have somewhat altered the cycle in Heber Valley. One effect is the intermittent addition of recharge by irrigation during the growing season. In well (D-4-4)23bcc-1 (fig. 13), the smooth summer decline of the water level is interrupted by many small but rapid rises, each resulting from the rapid infiltration of irrigation water applied to nearby fields. A second effect of man's activities is shown by the same graph—near Deer Creek Reservoir the water level in the aquifer is controlled by the water level in the reservoir (fig. 13). Except for the minor fluctuations from irrigation during the growing season, the graph of the water level in the well is a subdued image of the graph of the water level in the reservoir.

Comparison of the long-term graphs with the graph of departure from normal precipitation at Heber (fig. 12) shows that the aquifer is in a state of equilibrium, with recharge



Base from U.S. Geological Survey
1:250,000 (AMS) series: Salt Lake
City, Utah; Wyoming (1963)

EXPLANATION

– – – – – 5600 ————

Water-level contour

*Dashed where approximate. Contour interval 50 feet. Datum is mean sea level*

●

Observation well

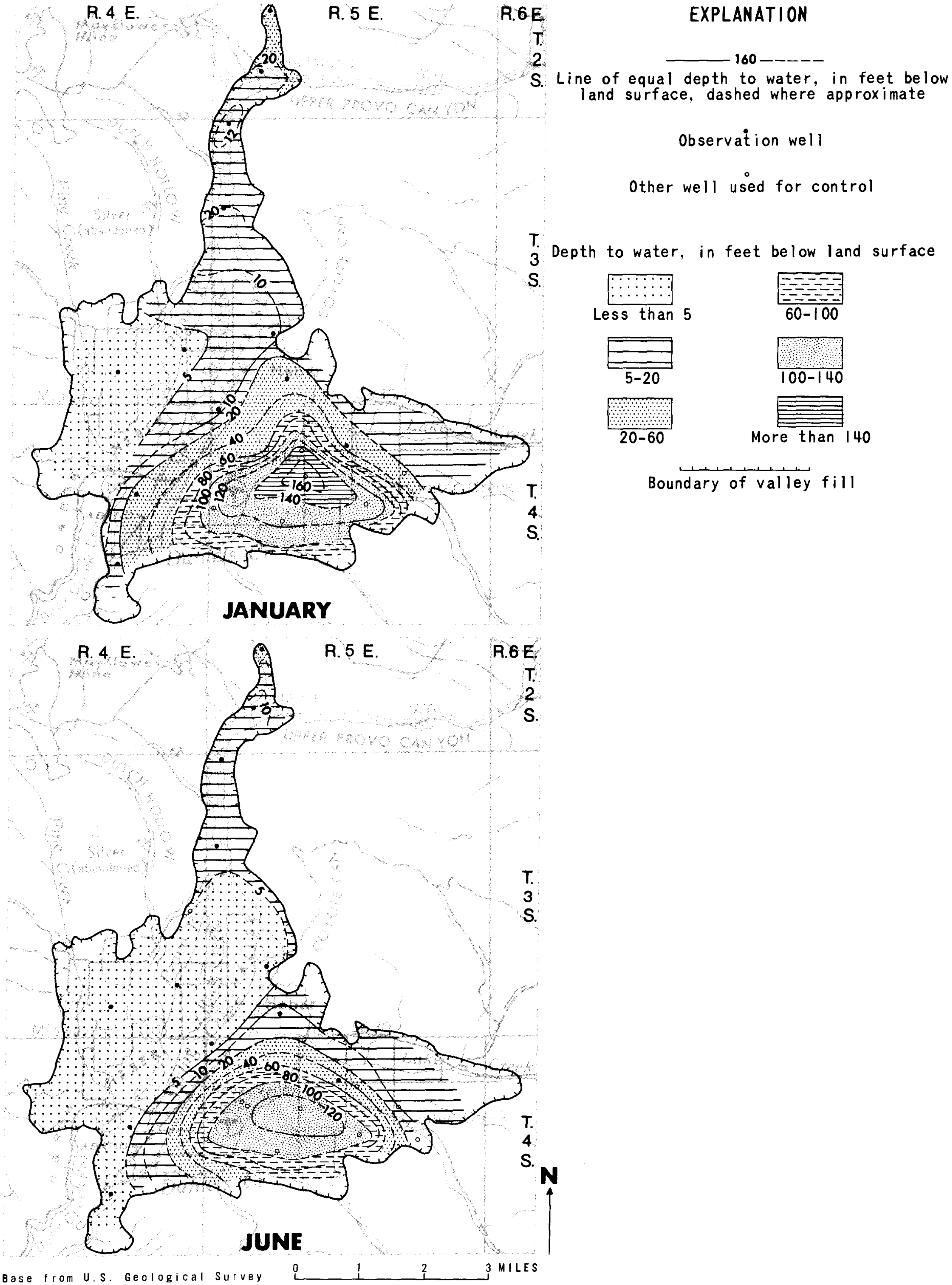
○

Other well used for control

ⵊⵊⵊⵊⵊⵊⵊⵊⵊⵊ

Boundary of valley fill

Figure 10.—Map of Heber Valley showing water-level contours in September 1967.



Base from U.S. Geological Survey
1:250,000 (AMS) series: Salt Lake
City, Utah; Wyoming (1963)

Figure 11.—Maps of Heber Valley showing depths to water in January 1967 (near seasonal low) and June 1967 (near seasonal high).

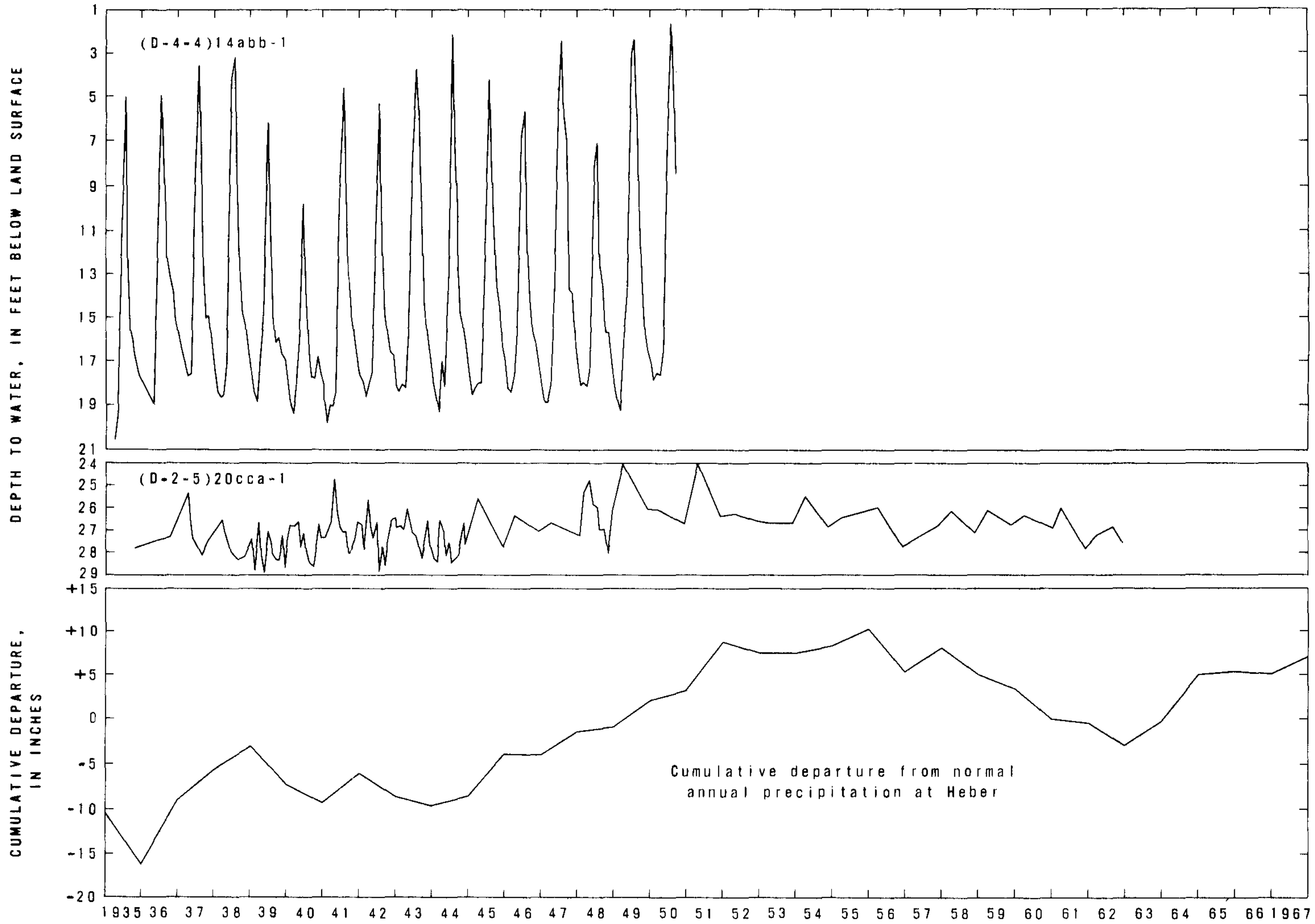


Figure 12.—Water levels in selected wells in Heber Valley and cumulative departure from the 1931-60 normal annual precipitation at Heber.

about balanced by discharge. Very wet or very dry years are reflected by unusually high or low water levels, but the peaks of each graph cluster about an average line, and there is no indication of a significant long-term change in water levels in Heber Valley.

*Storage.*—The total volume of water in storage in an aquifer can be calculated by multiplying the total volume of the aquifer by the total porosity of the aquifer material, but such a figure is of little value, because part of the water in an aquifer is held tightly by molecular forces and cannot be recovered. The recoverable water in storage, that is, the volume of water that can be removed from storage by wells, is equal to the product of the volume of the aquifer and the specific yield of the aquifer materials. It is difficult to get an accurate estimate of the total volume of alluvial fill in a valley, but the volume of water theoretically recoverable from the upper 100 feet of the aquifer can be calculated.

Available information on the thickness of the valley fill in Heber Valley indicates that it extends at least 50 feet below the water table under most of the valley and at least 100 feet below the water table under at least two-thirds of the valley. The average specific yield of the aquifer material to a depth of 100 feet is estimated as 12 percent. Using these figures, the volume of water theoretically recoverable from dewatering 100 feet of the unconsolidated deposits in Heber Valley is calculated thus:

28,000 acres x 50 feet x 12 percent = 170,000 acre-feet (approximately) for the upper 50 feet and;

28,000 acres x 50 feet x 0.66 x 12 percent = 110,000 acre-feet (approximately) for the next 50 feet;

total 170,000 + 110,000 = 280,000 acre-feet.

The statement that 280,000 acre-feet of water is theoretically recoverable from the upper 100 feet of valley fill in Heber Valley should not be construed to mean that it is practicable, under present conditions, to recover all, or any substantial part, of that amount. The calculated 280,000 acre-feet of water could be removed only by dewatering the upper 100 feet of the aquifer. However, the ground water in the valley fill and the surface water in the Provo River and its tributaries are two parts of a system that is presently in dynamic equilibrium. Efforts to dewater any part of the aquifer would, of course, upset that equilibrium, and would have far-reaching effects on the system. This point is discussed in greater detail on pages 46-47.

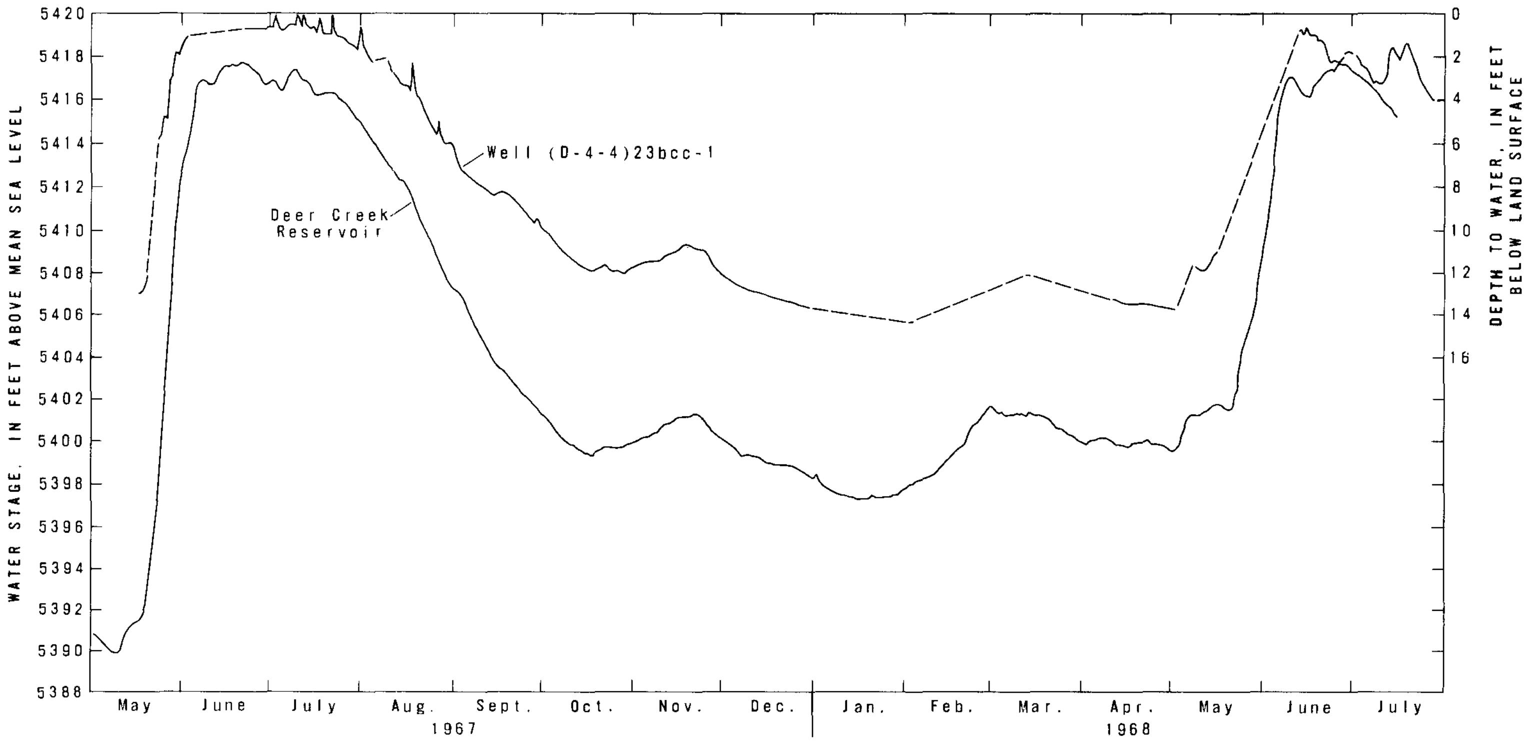


Figure 13.—Water levels in well (D-4-4)23bcc-1, near the south end of Heber Valley, and water stage in Deer Creek Reservoir.

*Discharge.*—Ground water is discharged from the unconsolidated deposits in Heber Valley by pumping from wells, by evapotranspiration, by effluent seepage, and probably by subsurface outflow through the surrounding consolidated rocks.

The total volume of water pumped from wells in the valley is very small, and there have been no drastic changes in irrigation practice for many years; hence the long-term recharge-discharge regimen is fairly stable and should be in balance. The average annual discharge, therefore, should be about 86,000 acre-feet per year.

The total evapotranspiration from Heber Valley, calculated by the Blaney-Criddle method (Blaney and Criddle, 1962) is about 81,000 acre-feet per year. (evaporation from Deer Creek Reservoir is not included in this amount). Part of the evapotranspiration loss is the crop water requirement and is supplied by irrigation water and summer precipitation (p. 28); and according to the assumption made on page 27, part of the loss will be supplied by the winter precipitation. The net evapotranspiration loss from the ground-water body, therefore, is calculated as follows:

| | Acre-feet |
|---|---|
| Total evapotranspiration | 81,000 |
| Less crop water requirement (irrigation water and May-September precipitation) | −43,000 |
| Less October-April precipitation | −27,000 |
| Net evapotranspiration loss of ground water | 11,000 |

Ground-water discharge by effluent seepage includes the accretion to Deer Creek Reservoir (47,000 acre-feet per year, p. 8) and the discharge to the Provo River (11,000 acre-feet per year, p. 12). Ground-water discharge to the Provo River apparently occurs throughout the length of the river in the valley.

The total discharge from the foregoing calculations is 69,000 acre-feet per year, or 17,000 acre-feet less than the average annual recharge. No direct evidence of subsurface discharge from the valley fill has been found, but this unbalance in the recharge-discharge calculation may indicate such subsurface discharge.

Thus the average annual discharge, in acre-feet, from the unconsolidated deposits is:

| | |
|---|---|
| Net evapotranspiration loss | 11,000 |
| To Deer Creek Reservoir | 47,000 |
| To Provo River | 11,000 |
| Subsurface outflow | 17,000 |
| Total discharge | 86,000 |

*Chemical Quality.*—All the water sampled from the unconsolidated deposits in Heber Valley was chemically suitable for domestic use, according to the standards of the U. S. Public Health Service, although 2 samples of sulfate type water and 1 sample of mixed type were somewhat above the optimum in dissolved solids, and all samples were hard to very hard. The water is satisfactory for stock or for irrigation.

Chemical analyses of 10 samples of water from the unconsolidated deposits in Heber Valley are reported in table 5. The locations from which the samples were collected and diagrammatic representations of the concentrations of the principal dissolved solids in some of the samples are shown on plate 3.

Seven of the 10 samples were calcium bicarbonate type water, with dissolved solids ranging from 187 to 446 mg/l. The hardness of the 7 samples ranged from 144 to 324 mg/l, in the hard to very hard range. Silica concentration ranged from 12 to 43 mg/l; the samples that were high in silica came from the east side of the valley, where the rocks forming the valley wall are predominantly volcanic.

Two of the 10 samples were calcium sulfate water, and both contained more dissolved solids than the calcium bicarbonate water. One of these samples came from a well at the north end of the valley, very near the outcropping of the Triassic shales, and the water was similar to that found in the shales (diagram 2, fig. 9). The concentration of dissolved solids of this sample was 727 mg/l and the hardness was 464 mg/l. The other sample of sulfate type water came from a well near Midway. That well taps a layer of gravel overlain by tufa, and the water is similar to water from the hot pots, but more dilute. The sample contained 1,160 mg/l dissolved solids, and the hardness was 770 mg/l.

One of the 10 samples was a calcium bicarbonate sulfate type water. That sample came from a shallow dug well in the tufa deposits near Midway, and the water appears to be a mixture of hot pot type water and the dilute calcium bicarbonate type water commonly found in the valley fill. The concentration of dissolved solids in the sample was 661 mg/l and the hardness was 434 mg/l.

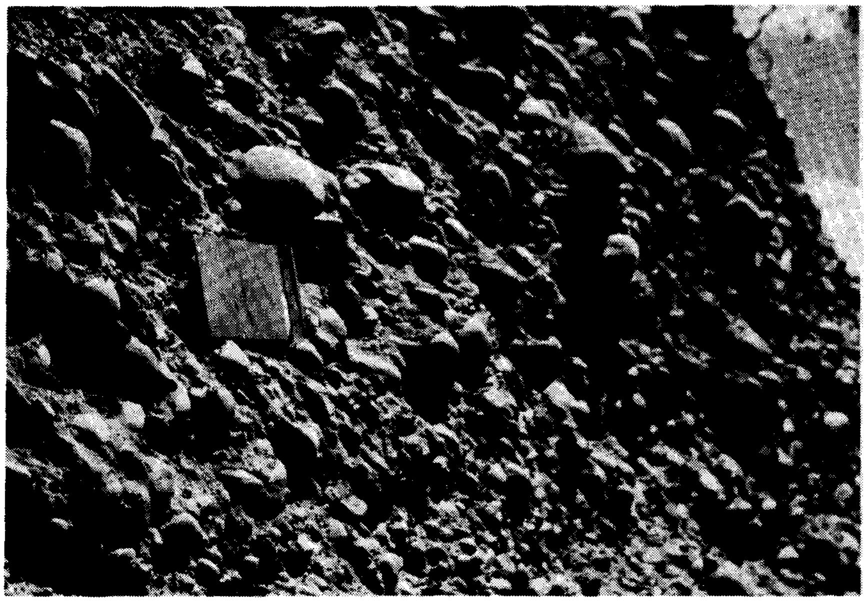
### Rhodes Valley

Rhodes Valley, the second largest of the four valleys in the study area, is nearly rectangular in plan, with the long axis of the rectangle oriented about north-south (pl. 1 and fig. 1). The area of the valley floor is about 39 square miles. The Weber River flows westward across the north end of the valley, entering and leaving through narrow canyons. The principal drainage of the valley is by Beaver Creek, which enters the valley from the east near the south end, flows northwestward, and joins the Weber River where that stream leaves the valley. At the south end, Rhodes Valley terminates in a bluff that overlooks the Provo River.

The alluvial fill deposited in Rhodes Valley by the Provo River (see p. 5-7) is probably more than 300 feet thick under most of the valley. In addition, a sizeable alluvial fan has been formed where the Weber River enters the valley, and smaller fans mark the mouths of Beaver Creek Canyon and Hoyt Canyon.

When the upper Provo River changed course, the stream entrenched itself in its former valley floor. Thus nearly 100 feet of unconsolidated material is exposed in the north side of the Provo Canyon at the south end of Rhodes Valley (fig. 14a). The material is poorly sorted and only weakly stratified (fig. 14b).

a. View looking northwest from the bottom of the Provo River valley. Bluff is about 90 feet high. Old slump scar visible on right side of photograph.



b. Closeup view showing lack of sorting and poor stratification. Clipboard is 6 inches wide.

Figure 14.—Valley fill at the south end of Rhodes Valley exposed by entrenchment of the Provo River.

The unconsolidated deposits in Rhodes Valley are saturated to within a few feet of the land surface with unconfined ground water. As in Heber Valley, the entire valley fill can be treated as a single water-table aquifer, because neither continuous zones of very high or very low permeability nor areas of artesian conditions are evident.

*Aquifer characteristics.*—Data from drillers' tests of 17 wells in Rhodes Valley (table 3) yield specific capacities of wells ranging from 0.1 gpm per foot of drawdown to 13 gpm per foot of drawdown. The largest values of specific capacity suggest an aquifer transmissivity of about 3,500 $ft^3/d/ft$.

Aquifer tests have not been performed in Rhodes Valley proper, but tests were conducted by the U. S. Bureau of Reclamation in a well at a damsite in Weber Canyon, a few miles upstream from Rhodes Valley and just outside the study area. Data obtained by the Bureau from 3 pumping tests and 2 recovery tests were analyzed by the writer; the calculated transmissivity was about 5,400 $ft^3/d/ft$. The aquifer at the test site is 247 feet thick, giving a calculated hydraulic conductivity of about 22 $ft^3/d/ft^2$—only about one-half that calculated for the valley fill in Heber Valley.

The value of specific yield calculated from the data obtained by the Bureau of Reclamation was about 12 percent. Specific yield was also calculated from drillers' logs of 15 wells in Rhodes Valley by the method used for Heber Valley. The wells ranged in depth from 33 to 78 feet and averaged 68 feet; the estimated values of specific yield averaged about 15 percent, both for the upper 20 feet and for the total thickness penetrated.

*Recharge.*—The unconsolidated deposits in Rhodes Valley are recharged primarily by the infiltration of irrigation water. Some additional recharge comes from the direct infiltration of snowmelt and by subsurface inflow from the surrounding consolidated rocks; probably little or no recharge is received from summer rains.

Records of water-level fluctuations are available for only a few wells in Rhodes Valley. Records for about 10 wells in the valley, for various periods before 1950, indicate an average annual change in saturated thickness of about 4 feet in the southern three-fourths of the valley and about 12 feet in the northern one-fourth. This average change in saturated thickness, with an area of 39 square miles (about 25,000 acres) and a specific yield of 15 percent gives an average annual change in storage of about 22,000 acre-feet of water; hence the minimum average annual recharge is 22,000 acre-feet per year. This value is used as an estimate of the annual recharge in the water-budget study.

The amounts of recharge contributed from irrigation water and from other sources were calculated for Rhodes Valley as they were for Heber Valley. Calculation by the Blaney-Criddle method (Blaney and Criddle, 1962) gives an average crop water requirement for Rhodes Valley of about 40,000 acre-feet per irrigation season. The average total irrigation diversion is about 44,000 acre-feet; the average precipitation on the valley floor during the irrigation season is about 13,000 acre-feet. Thus the amount of recharge from irrigation water is:

| | Acre-feet |
|---|---|
| Total irrigation diversion | 44,000 |
| Precipitation | +13,000 |
| Total | 57,000 |
| Less crop water requirement | –40,000 |
| Difference (available for recharge) | 17,000 |
| Total recharge | 22,000 |
| Less recharge from irrigation | –17,000 |
| Difference (recharge from other sources, primarily subsurface inflow) | 5,000 |

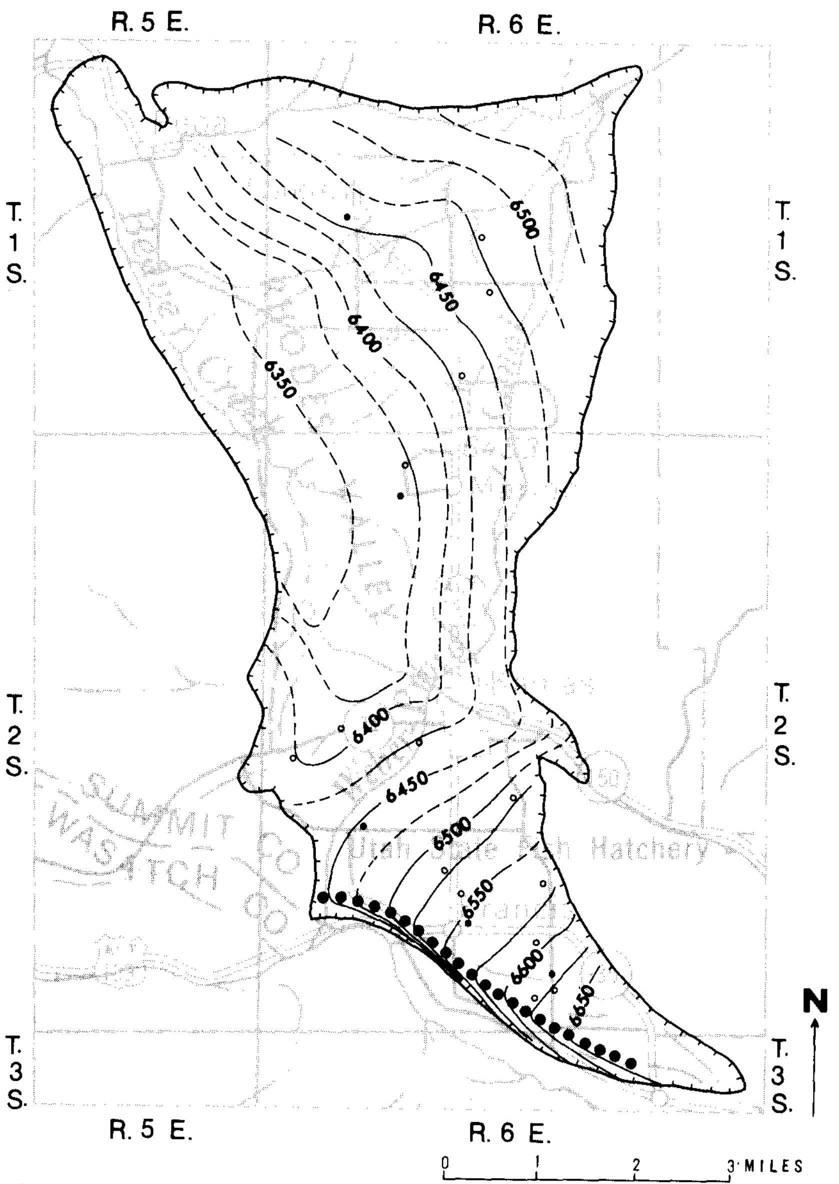
*Movement.*—In most of Rhodes Valley, ground water moves toward Beaver Creek (fig. 15); in the north end of the valley, in the vicinity of the Weber River, ground water moves toward the river.

In the south end of Rhodes Valley, near the bluff overlooking the Provo River, some ground water moves toward the bluff and the Provo River. The ground-water divide, separating water that moves toward the Weber River from water that moves toward the Provo River, is only a short distance north of the bluff (fig. 15). Apparently the divide can exist so near the bluff because of the difference between lateral and vertical permeability of the aquifer. The bedding, like the land surface, slopes gently northward from the edge of the bluff. Hence water moving northward to the Weber River and Beaver Creek moves laterally through the beds, but water moving toward the Provo River moves vertically across the beds. The lateral permeability of alluvial deposits is commonly greater than the vertical permeability. It is calculated that if water has equal opportunity to move in either direction from the ground-water divide, and if the ratio of lateral to vertical permeability is 140 to 1—within the range reported for bedded deposits (Bennett and others, 1967, p. G53)—the divide will be stable at about the position indicated in figure 15.

*Water-level fluctuations.*—Graphs of three wells in Rhodes Valley that have been measured since 1938 are shown in figure 16. All three graphs show the annual fluctuations that are typical of water-table aquifers in permeable valley-fill material that is irrigated with diverted surface water. The well at Oakley, in the north end of the valley, fluctuates through a much greater range than either of the two wells farther south. Although there is considerable variation between the highest or lowest water levels in adjacent years, there is no marked long-term departure from the average high or low. The graphs indicate a relatively stable recharge-discharge relation, with little evidence of long-term net change.

*Storage.*—The total volume of water theoretically recoverable from storage in the upper 100 feet of valley fill in Rhodes Valley can be calculated by the same method used for Heber Valley. If the saturated valley fill is at least 50 feet thick under the entire valley, and at least 100 feet thick under two-thirds of the valley, then the recoverable water in storage is:

25,000 acres x 50 feet x 15 percent = 190,000 acre-feet (approximately) for the upper 50 feet; and



Base from U.S. Geological Survey
1:250,000 (AMS) series: Salt Lake
City, Utah; Wyoming (1963)

**EXPLANATION**

——— 6500 – – – –
Water level contour
*Dashed where approximate. Contour interval 25 feet. Datum is mean sea level*

●
Observation well

○
Other well used for control

●●●●●
Ground-water divide

Boundary of valley fill

Figure 15.—Map of Rhodes Valley showing water-level contours in September 1966.

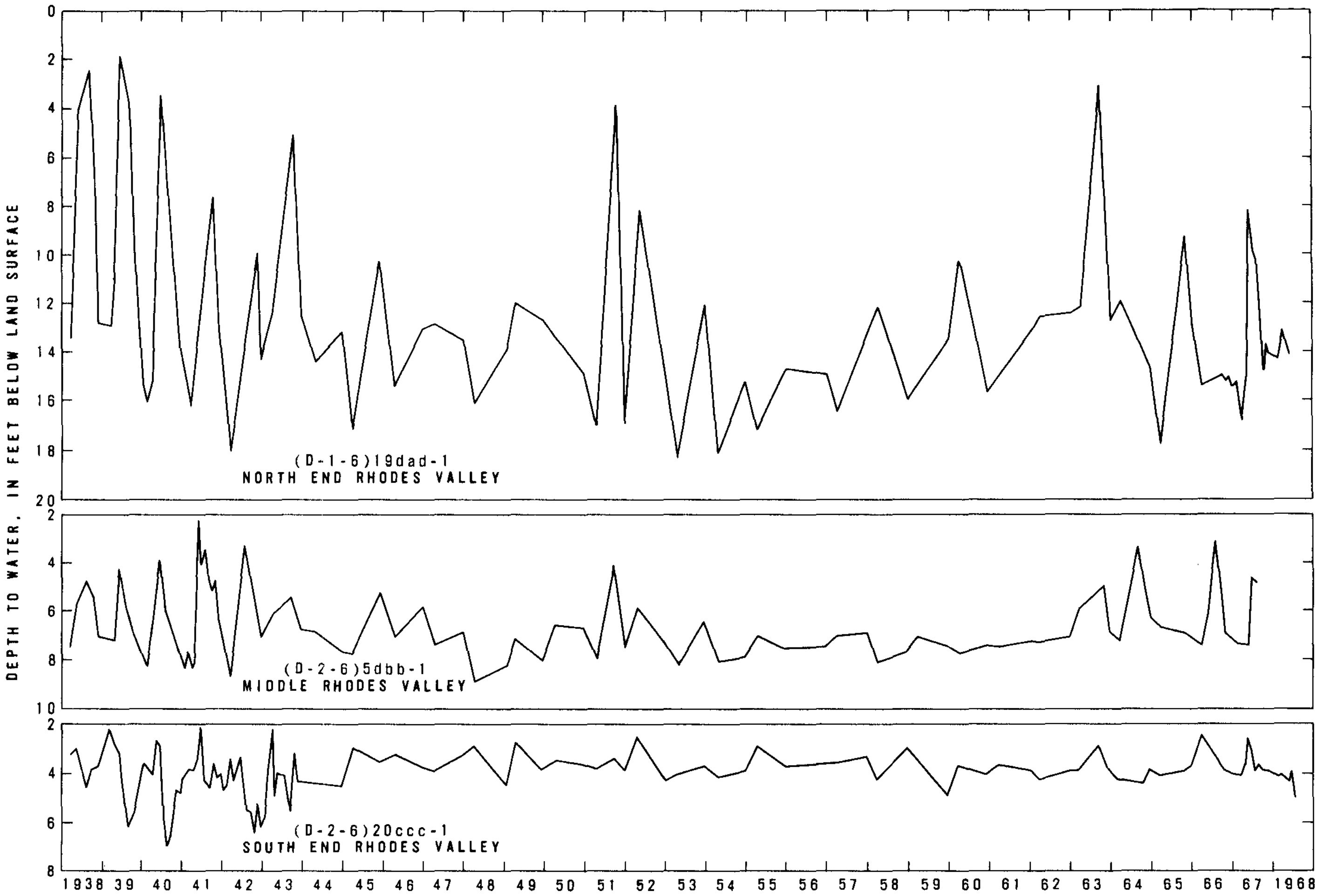


Figure 16.—Graphs of water levels in selected wells in Rhodes Valley.

25,000 acres x 50 feet x 0.66 x 15 percent = 120,000 acre-feet (approximately) for the lower 50 feet;

Total: 190,000 + 120,000 = about 310,000 acre-feet.

*Discharge.*—Ground water is discharged from the unconsolidated deposits in Rhodes Valley by evapotranspiration and by seepage into Beaver Creek, Weber River, and Provo River. Because the hydrologic regimen in the valley is stable, the minimum long-term average annual discharge probably is about equal to the minimum average annual recharge of 22,000 acre-feet.

The net annual evapotranspiration loss of ground water, in acre-feet, from Rhodes Valley is calculated as follows:

| | |
|---|---|
| Total evapotranspiration (Blaney-Criddle method) | 72,000 |
| Less crop water requirement (irrigation and May-September precipitation, from page 37) | –40,000 |
| Less October-April precipitation from precipitation map, pl. 2) | –22,000 |
| Net evapotranspiration loss of ground water: | 10,000 |

Long-term discharge records of the streams traversing the valley, from which ground-water discharge by effluent seepage could be calculated, are not available. Most of the valley bottom bordering Beaver Creek is marshy and contains abundant springs and seeps; most of the ground-water discharge to streams probably goes to Beaver Creek. A few springs are found in the bluff overlooking the Provo River, and the Provo is generally a gaining stream in the reach between the gaging stations near Woodland and near Hailstone (p. 10). The estimated minimum average annual discharge to Beaver Creek, Weber River, and Provo River is 12,000 acre-feet per year.

*Chemical quality.*—Chemical analyses of two samples of water from wells that tap the unconsolidated deposits in Rhodes Valley are reported in table 5. Both samples were dilute calcium bicarbonate type water. One sample, from a well near the south end of the valley and very near an outcropping of the Tertiary volcanic rocks, contained 289 mg/l dissolved solids. This water was relatively high in silica (40 mg/l) and contained about equal concentrations of sulfate and chloride (14 and 13 mg/l, respectively). The water is evidently affected by recharge from the nearby volcanic rocks.

The second sample of water was from a well near the north end of the valley, distant from the volcanic rocks. This water contained 205 mg/l of dissolved solids, was low in silica (5.5 mg/l), and contained about four times as much sulfate as chloride (13 and 3.9 mg/l, respectively). Subsurface recharge that affects this water comes from the sandstones and limestones of Jurassic age and older.

These two samples are probably typical of the water from the unconsolidated deposits in Rhodes Valley. The water, although hard, is quite suitable for domestic, livestock, and irrigation use.

### Parleys Park

Parleys Park is the name given to the broad, gently rolling flat north of Park City (see pl. 1 and fig. 1). A ridge of low hills, extending east-northeast from Quarry Mountain, divides the south end of the park into two arms. The narrow eastern arm is the valley of Silver Creek, which heads in Empire Canyon south of Park City, flows around the east side of Quarry Mountain, continues northeast, and joins the Weber River about 2 miles north of Wanship Dam. The wider western arm and the broad flat north and west of the hills drains to East Canyon Creek. East Canyon Creek rises in the mountains north of Parleys Park and flows through the northern part of the park, collecting the water of several small streams that flow generally northward through the park. The creek then turns northward through a narrow canyon and joins the Weber River about 20 miles north of Parleys Park.

Unconsolidated deposits cover only about 21 square miles of Parleys Park along Silver and East Canyon Creeks and in the flats northwest of Quarry Mountain (pl. 2); the rest of the park is underlain by consolidated rocks, principally the Tertiary volcanic rocks and the Knight Conglomerate. Little information is available about the thickness of the unconsolidated deposits. The contact between the unconsolidated material and the underlying volcanic rocks or Knight Conglomerate is difficult to recognize in boreholes, and drillers often fail to recognize the contact. The differences in density between the unconsolidated deposits and the underlying material are too small to give conclusive results by gravity methods. The best information available suggests a maximum thickness of about 100 feet and an average thickness of about 60 feet.

The unconsolidated deposits in Parleys Park, as in Heber Valley and Rhodes Valley, consist of a poorly sorted mixture of material ranging in size from clay to cobbles. There appear to be no well-defined beds of material of very high or very low permeability, and no indications of the existence of artesian conditions. The unconsolidated deposits are saturated to within a few feet of the land surface with unconfined ground water.

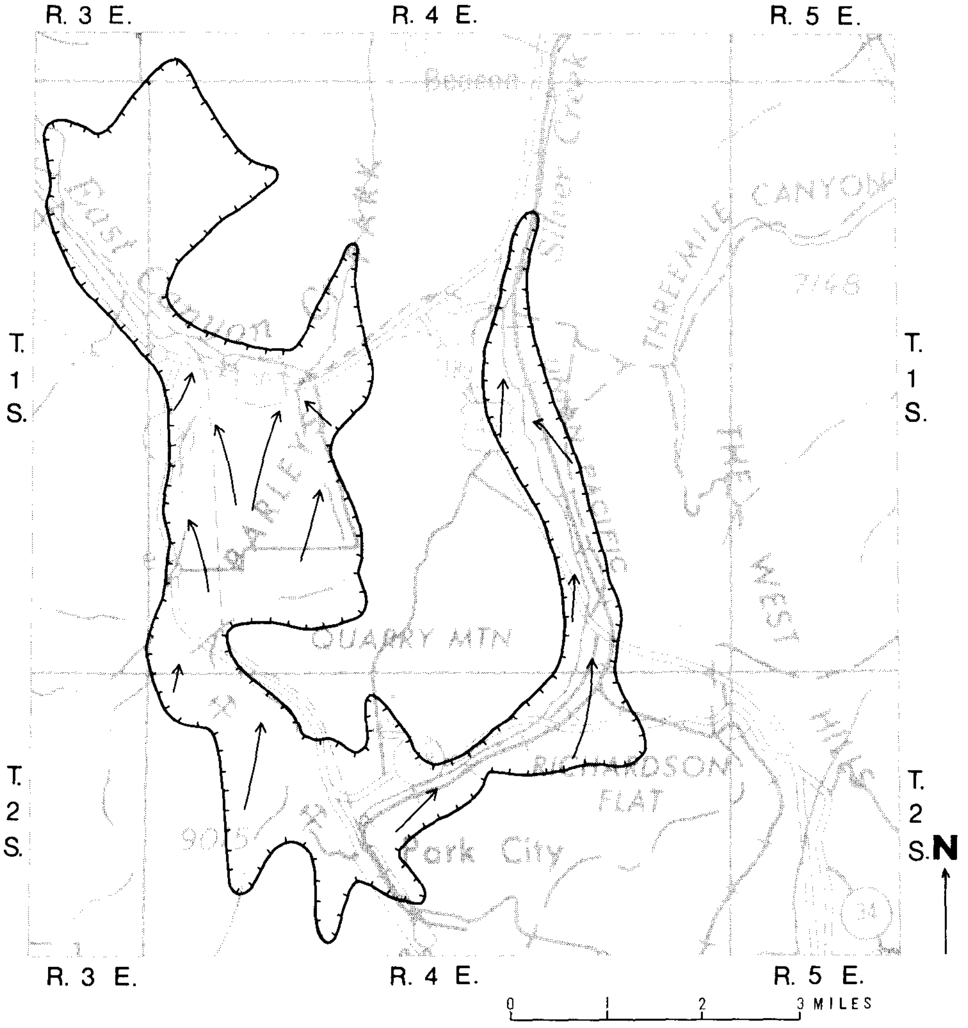
There are very few wells in the unconsolidated deposits of Parleys Park to provide a basis for estimating the transmissivity and specific yield of the aquifer. The specific capacity of one well is reported as 20 gpm per foot of drawdown; such a specific capacity suggests an aquifer transmissivity of about 4,670 $ft^3/d/ft$. The aquifer at the well location is about 100 feet thick, giving an estimated hydraulic conductivity of about 50 $ft^3/d/ft^2$—about the same as the value derived for similar material in Heber Valley. The few drillers' logs available are not suitable for calculating specific yield by the method used in Heber Valley and Rhodes Valley; however, an estimate of 15 percent, based on the values derived in the other areas, is probably in the right range.

Recharge to the unconsolidated deposits in Parleys Park comes primarily from the direct infiltration of precipitation on the park and runoff from the surrounding mountains, and secondarily from subsurface inflow through the consolidated rocks. Available data on the annual range of water-level fluctuations are too scanty to permit a direct estimate of the average annual recharge. The probable minimum recharge is indicated by the estimated evapotranspiration (see below).

The inferred direction of ground-water movement in Parleys Park is shown in figure 17. Water in the eastern arm of the park moves toward Silver Creek and down the valley. In the western arm of the park, ground water moves generally northward toward East Canyon Creek. Each of the small tributaries of East Canyon Creek that crosses the park is a gaining stream, however, and locally ground water moves toward each of these streams.

The water-level fluctuations in well (D-1-4)31bdb-1 were observed from 1936 to 1948; the well was destroyed in 1948. Well (D-1-4)31adb-1 was monitered by an automatic water-level recorder that was installed in October 1966 and operated intermittently through 1968. Graphs of water levels in these wells are shown in figure 18. The short-term record of well (D-l-4)31adb-1 shows annual fluctuations of more than 17 feet, but the longer record of well (D-l-4)31bdb-1 shows no substantial long-term change in the position of the water table.

Any calculation of the amount of water available from storage in the unconsolidated deposits of Parleys Park can be only a rough estimate. The maximum depth to water recorded in well (D-1-4)31adb-1 was nearly 20 feet; if the average thickness of the unconsolidated deposits is 60 feet, the average saturated thickness (when the water table is lowest) is about 40 feet. If the



Base from U.S. Geological Survey
1:250,000 (AMS) series: Salt Lake
City, Utah; Wyoming (1963)

EXPLANATION

→ Approximate direction of ground-water movement

Boundary of unconsolidated deposits

Figure 17.—Map of Parleys Park showing approximate direction of ground-water movement through the unconsolidated deposits.

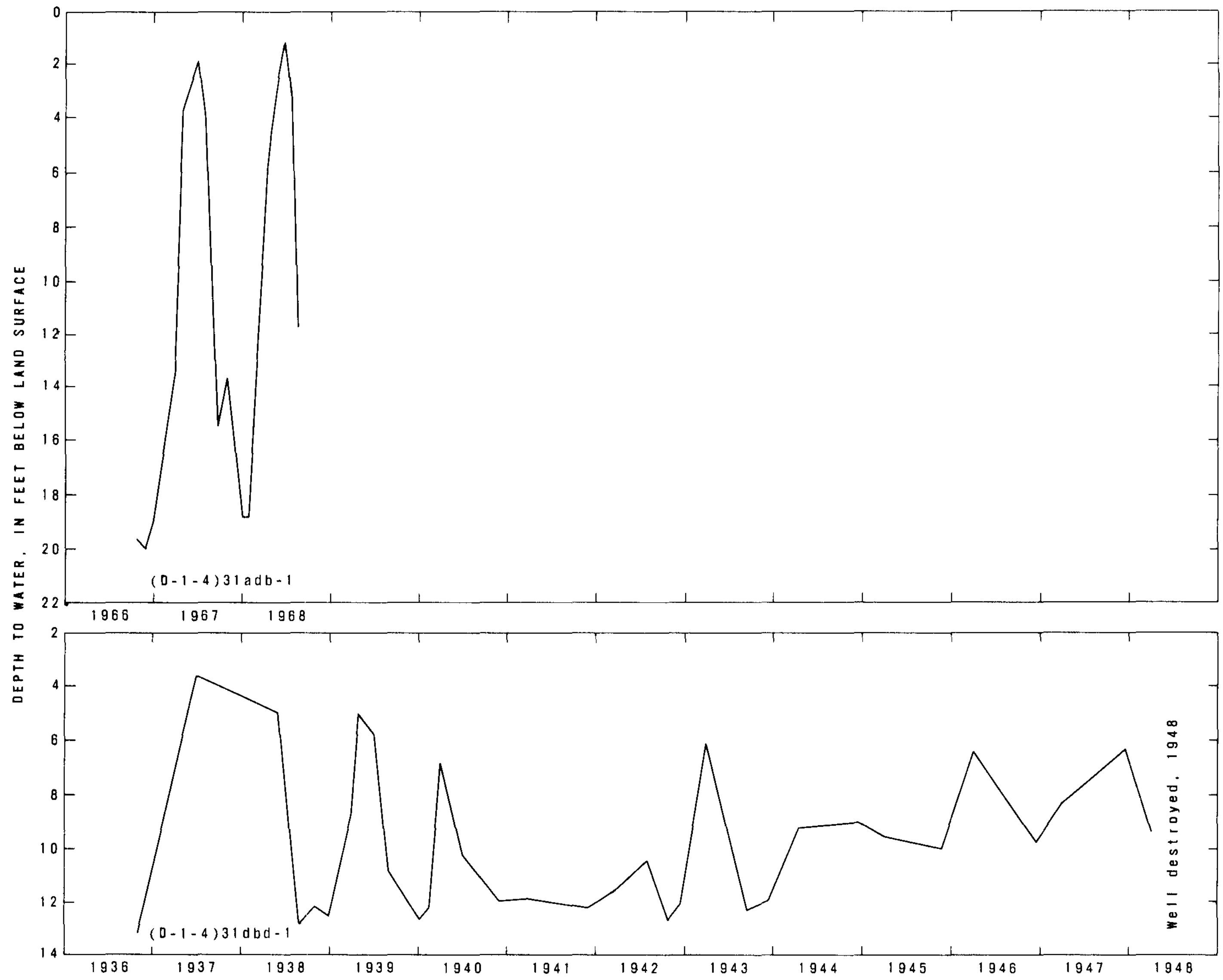


Figure 18.—Graphs of water levels in wells tapping the unconsolidated deposits in Parleys Park.

saturated thickness is 40 feet, the area 21 square miles (about 13,000 acres), and the specific yield 15 percent, the volume of recoverable water in storage is about 80,000 acre-feet. As in the other calculations of storage, this volume of water is theoretically recoverable by dewatering the aquifer; dewatering the aquifer, however, may not be practicable in the foreseeable future.

The combined discharge from wells and discrete springs in the unconsolidated deposits in Parleys Park is small. Large seeps or marshy areas are common in the park, however, especially during the summer months; and these areas discharge large quantities of ground water by evapotranspiration. The total evapotranspiration from the park is calculated by the Blaney-Criddle method as 43,000 acre-feet per year based on air temperatures measured at Park City during the period 1921-50. Ground water is also discharged directly to Silver Creek and to East Canyon Creek and its tributaries; all the streams in the park appear to be gaining streams most of the year. It is possible that water also moves from the unconsolidated deposits into the consolidated rocks at the north end of the park.

It is believed that all water in the unconsolidated deposits in Parleys Park is suitable for domestic, stock, or irrigation use. Analyses of two samples of water from the unconsolidated deposits in Parleys Park are reported in table 5. One sample, from a well near the north end of the park, was a calcium bicarbonate type water and contained 338 mg/l of dissolved solids; the hardness was 261 mg/l. The second sample was from a well on the south side of Quarry Mountain, very near an outcropping of Triassic rocks. Water from this well was a calcium sulfate bicarbonate type. The dissolved solids in this sample was 527 mg/l and the hardness was 398 mg/l. These two samples probably indicate the kind of water to be expected from the unconsolidated deposits in Parleys Park.

### Round Valley

A roughly oval depression, about 7 miles long and 4 miles wide, in the overthrust (upper) block of the Charleston thrust fault south of Heber Valley, is called Round Valley (pl. 1 and fig. 1). Unlike the other valleys described, the valley floor in Round Valley is decidedly bowlshaped. The total area covered by alluvium is about 20 square miles.

Two drillers' logs for wells in Round Valley are available. The log for well (D-5-4)12bba-1 reports unconsolidated material to 45 feet, the total depth of the well. The other log, for well (D-5-4)13acd-1, indicates rock at 38 feet. Thus it appears that the alluvial fill in Round Valley is only a few tens of feet thick.

Such alluvial fill as there is in Round Valley, however, is saturated to within a few feet of the land surface with unconfined ground water. Because of the virtual absence of wells, no evaluation of aquifer characteristics is possible, but it is likely that the hydraulic conductivity and specific yield of the unconsolidated deposits here is similar to those of the other valleys in the studyarea—about50 $ft^3/d/ft^2$ and 15 percent, respectively.

Water probably enters the alluvial fill in Round Valley primarily through the infiltration of precipitation on the valley floor and runoff from the surrounding slopes, and secondarily through the infiltration of irrigation water. About 2,580 acres of land in the valley are irrigated with water from Round Valley Creek and from a few springs. There may also be some subsurface inflow from the surrounding Oquirrh Formation.

Ground water in the unconsolidated deposits of Round Valley moves generally toward Round Valley Creek and downvalley. Water is discharged into the creek and into the atmosphere by evapotranspiration. The calculated evapotranspiration from the irrigated land and a few acres of marshy bottom lands is 5,000 acre-feet per year. In addition, about 3,300 acres on the lower slopes of the valley are partly covered with such plants as greasewood and rabbitbrush, which use some ground water. The average discharge to Round Valley Creek is not known.

Chemical analyses of water from two springs that discharge from the unconsolidated deposits in the valley are reported in table 5. Both samples were dilute calcium bicarbonate type water (dissolved solids less than 300 mg/l). Both were very hard but were otherwise quite suitable for domestic use as well as for livestock and for irrigation.

# GROUND-WATER SURFACE-WATER RELATIONSHIPS

A primary purpose of this study was to evaluate the relation of ground water to surface water in the area and to estimate the effects of increased ground-water withdrawals on streamflow from the area.

From the preceding discussions, it is apparent that the ground water in the valley fill and the surface water in the streams that traverse the valleys are intimately related. A part of the ground-water discharge in each valley goes into the streams and a part of the recharge to the aquifer in each valley is derived from surface water. Thus the ground water and the surface water are two parts of a hydrologic system that is in approximate balance, and any changes in the present pattern of water use would change the balance of the system. Any increase in withdrawal of water from the system would ultimately be reflected in decreased stream discharge.

Use of ground water in the valleys could be increased, however, with only minimal effects on streamflow. Water that is consumed by evapotranspiration in the marshy bottom lands could be salvaged for other uses by lowering the water table locally and drying up the marshes. Because most of the marshy bottom land is irrigated and maintained as wet meadows, these areas were not distinguished from other croplands in the evapotranspiration calculations given elsewhere in this report, and no estimate of the amount of water that may be salvageable is given. Most of the marshy areas are very near the streams, so careful planning and thorough site investigation would be required to minimize the effect on streamflow of lowering the water table.

Moreover, the effects on streamflow of increased withdrawal of ground water from the valley fill would not necessarily be immediate nor pronounced. When water is pumped from an aquifer bordering a stream, part of the water withdrawn from the aquifer is diverted from the stream, either by increasing recharge from the stream or by decreasing discharge to the stream. The percentage of the water pumped from a well that is diverted from the stream is related to the transmissivity and specific yield of the aquifer, the distance of the well from the stream, and the duration of pumping.

A graphical method developed by Theis and Conover (1963) can be used to estimate the percentage of the water pumped from a well that is diverted from a nearby stream for any combination of aquifer coefficients, distance between well and stream, and duration of pumping. The following examples are given for Heber Valley, assuming an aquifer transmissivity of 10,000 $ft^3/d/ft$ (p. 26) and a specific yield of 12 percent (p. 26).

If a well in Heber Valley 1,000 feet from the Provo River were pumped continuously throughout the irrigation season (120-150 days), 85 percent of the water pumped at the end of the season would be water diverted from the river. If the well were 1 mile from the river, however, only about 30 percent of the water pumped at the end of 150 days would be water diverted from the river, and only about 50 percent of the withdrawal at the end of 1 year would be diverted from the river. The diversion from the river would be in the form of a decrease in the rate of ground-water discharge to the river.

That part of the pumped water not immediately diverted from the river would be withdrawn from storage in the aquifer. When pumping ceased, the rate of ground-water discharge to the river would not increase to the pre-pumping rate until the water removed from storage in the aquifer had been replaced. Ultimately, all the water removed from the aquifer and used consumptively will have been diverted from the stream.

From the foregoing, it can be seen that it is not possible to remove ground water from the valley fill for consumptive use without affecting streamflow. It is possible, however, to make more effective use of the water resources by "borrowing" water from ground-water storage during periods of peak demand and "paying back" (in diminished streamflow) during periods of low demand. The details of such a water-management plan are beyond the scope of this report. Detailed studies for such a plan should include tests to determine the aquifer coefficients at the proposed pumping site; the aquifer coefficients given in this report for the valley as a whole may not be applicable to a particular site.

The preceding discussion concerns withdrawals of ground water for increased consumptive use. Virtually all the irrigable land in the valleys is already irrigated, however, from surface-water sources. Pumping ground water to replace surface water for irrigation would not be an increase in consumptive use. Indeed, such a practice would doubtless save water, because evaporation losses from canals would be reduced. The cost of constructing wells and operating pumps, however, would increase the cost of water to the irrigator.

Outside the valleys, in the areas underlain by consolidated rocks, the low flow of the streams is sustained by ground-water discharge, and increased withdrawal of ground water would decrease the natural discharge. Existing methods of estimating the effects of pumping wells on nearby streams, however, are not applicable to the consolidated rocks; therefore, no quantitative estimates of the effect of increased withdrawal of ground water from the consolidated rocks can be made.

## SELECTED REFERENCES

Atwood, W. W., 1909, Glaciation of the Uinta and Wasatch Mountains: U. S. Geol. Survey Prof. Paper 61.

Baker, A. A., 1964, Geology of the Aspen Grove quadrangle, Utah: U. S. Geol. Survey Geol. Quad. Map GQ-239.

Baker, A. A., Calkins, F. C., Crittenden, M. D., Jr., and Bromfield, C. S., 1966, Geologic map of the Brighton quadrangle, Utah: U. S. Geol. Survey Geol. Quad. Map GQ-534.

Baker, A. A., and Crittenden, M. D., Jr., 1961, Geology of the Timpanogos Cave quadrangle, Utah: U. S. Geol. Survey Geol. Quad. Map GQ-132.

Baker, C. H., Jr., 1968, Thermal springs near Midway, Utah: U. S. Geol. Survey Prof. Paper 600-D, p. D63-D70.

Bennett, G. D., Rehman, A., Sheikh, I. A., and Ali, S., 1967, Analysis of aquifer tests in the Punjab region of West Pakistan: U. S. Geol. Survey Water-Supply Paper 1608-G.

Blaney, H. F. and Criddle, W. D., 1962, Determining consumptive use and irrigation water requirements: Agr. Res. Service Tech. Bull. 1275.

Boutwell, J. M., 1912, Geology and ore deposits of the Park City District, Utah: U. S. Geol. Survey Prof. Paper 77.

Bromfield, C. S., Baker, A. A., and Crittenden, M. D., Jr., 1967, Geologic map of the Heber quadrangle, Wasatch and Summit Counties, Utah: U. S. Geol. Survey open-file rept.

Calkins, F. C. and Butler, B. S., 1943, Geology and ore deposits of the Cottonwood-American Fork area, Utah. U. S. Geol. Survey Prof. Paper 201.

Connor, J. G., Mitchell, C. G., and others, 1958, A compilation of chemical quality data for ground and surface waters in Utah: Utah State Engineer Tech. Pub. 10.

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

Crittenden, M. D., Jr., Calkins, F. C., and Sharp, B. J., 1966, Geologic map of the Park City West quadrangle Utah: U. S. Geol. Survey Geol. Quad. Map GQ-535.

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

Feltis, R. D., 1966, Water from bedrock in the Colorado Plateau of Utah: Utah State Engineer Tec. Pub. 15.

Gilbert, G. K., 1928, Studies of basin-range structure: U. S. Geol. Survey Prof. Paper 153.

Hem, J. D., 1959, Study and interpretation of the chemical characteristics of natural water: U. S. Geol. Survey Water-Supply Paper 1473.

Intermountain Association of Petroleum Geologists, 1959, Guidebook to the geology of the Wasatch and Uinta Mountains transition area, 10th Annual Field Conference: Salt Lake City, Utah.

........................1964, Guidebook to the geology and mineral resources of the Uinta Basin—Utah's hydrocarbon storehouse, 13th Annual Field Conference: Salt Lake City, Utah.

Johnson, A. I., 1967, Specific yield—Compilation of specific yields for various materials: U. S. Geol. Survey Water-Supply Paper 1662-D.

Provo River Commissioner, 1945-68, Annual reports of the Provo River distribution system: Provo, Utah (duplicated).

Schultz, A. R., 1918, A geologic reconnaissance of the Uinta Mountains, northern Utah, with special reference to phosphate, *in* Contributions to economic geology: U. S. Geol. Survey Bull. 690-C, p. 31-94.

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

Theis, C. V., Brown, R. H., and Meyer, R. R., 1963, Estimating the transmissibility of aquifers from the specific capacity of wells, *in* Methods of determining permeability, transmissibility, and drawdown: U. S. Geol. Survey Water-Supply Paper 1536-I, p. 331-341.

Theis, C. V., and Conover, C. S., 1964, Chart for determination of the percentage of pumped water being diverted from a stream or drain, *in* Shortcuts and special problems in aquifer tests: U. S. Geol. Survey Water-Supply Paper 1545-C, p. C106-C109.

U. S. Geological Survey, 1954, Compilation of records of surface waters of the United States through September 1950, Colorado River Basin, Part 9: U. S. Geol. Survey Water-Supply Paper 1313.

........................1960, Compilation of records of surface waters of the United States through September 1950, the Great Basin, Part 10: U. S. Geol. Survey Water-Supply Paper 1314.

........................1961-68, Water resources data for Utah, Part 1, Surface-water records: Water Resources Div.

........................1963, Compilation of records of surface waters of the United States, October 1950 to September 1960, the Great Basin, Part 10: U. S. Geol. Survey Water-Supply Paper 1734.

........................1964, Compilation of records of surface waters of the United States, October 1950 to September 1960, Colorado River Basin, Part 9: U. S. Geol. Survey Water-Supply Paper 1733.

U. S. Public Health Service, 1962, Drinking water standards: Public Health Service Pub. 956.

U. S. Salinity Laboratory Staff, 1954, Diagnosis and improvement of saline and alkaline soils: U. S. Dept. Agriculture Handb. 60.

U. S. Weather Bureau, 1963, Normal annual and May-September precipitation (1931-60) for the State of Utah: Map of Utah, scale 1:500,000.

Weber River Commissioner, 1929-68, Annual reports of the Weber River distribution system: Ogden, Utah (duplicated).

# APPENDIX

### Well- and spring-numbering system

The system of numbering wells and springs in Utah is based on the cadastral land-survey system of the U. S. Government. The number, in addition to designating the well or spring, describes its position in the land net. By this system, the State is divided into four quadrants by the Salt Lake Base Line and Meridian, and these quadrants are designated by the uppercase letters A, B, C, and D, indicating the northeast, northwest, southwest, and southeast quadrants, respectively. Numbers designating the township and range (in that order) follow the quadrant letter, and all three are enclosed in parentheses. The number after the parentheses indicates the section, and is followed by three lowercase[1] letters indicating the quarter section, the quarter-quarter section, and the quarter-quarter-quarter section (generally 10 acres); the letters a,b,c, and d indicate, respectively, the northeast, northwest, southwest, and southeast quarters of each subdivision. The number after the letters is the serial number of the well or spring within the 10-acre tract; the letter "S" preceding the serial number denotes a spring. Springs that cannot be located accurately to the nearest 10-acre tract are indicated by the letter "S" following one or two lowercase letters and are assigned no serial number. Thus (D-3-4)32cca-1 designates the first well constructed or visited in the NE¼SW¼SW¼ sec. 32, T. 3 S., R. 4 E.; and (D-3-4)32b-S indicates a spring known only to be in the northwest quarter of the same section. The numbering system is illustrated in figure 19.

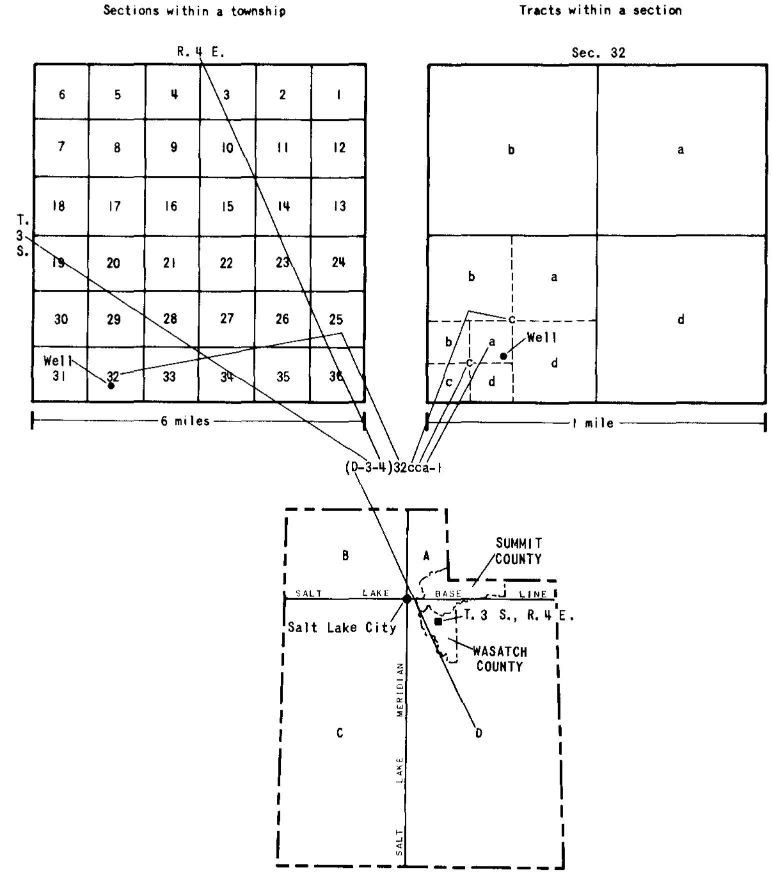


Figure 19.—Well- and spring-numbering system used in Utah.

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[1] In the basic-data tables in this report, which are computed printouts, these letters are uppercase.

## Units and terminology

Some of the terms used in this report and the units in which some parameters are expressed represent a departure from earlier practice. These new terms and units are described in the following paragraphs.

The *hydraulic conductivity* of a material is the ability of the material to transmit water and was formerly called the field coefficient of permeability. Hydraulic conductivity in this report is expressed in cubic feet of water per day per square foot of cross-sectional area ($ft^3/d/ft^2$), rather than in gallons per day per square foot. One cubic foot is about 7½ gallons.

Similarly, the ability of an aquifer as a whole to transmit water is the *transmissivity* of the aquifer and replaces the older term coefficient of transmissibility. Transmissivity is given in cubic feet of water per day per foot of aquifer width ($ft^3/d/ft$) rather than in gallons per day per foot. Note that hydraulic conductivity is a property of the aquifer material, whereas transmissivity is a property of the aquifer as a whole. The figure for transmissivity is equal to the product of the figure for hydraulic conductivity of the aquifer material and the saturated thickness of the aquifer.

The water temperatures in the text and tables are given in degrees Celsius (°C) rather than in degrees Fahrenheit (°F). In the text, the equivalent temperatures in °F are given in parentheses. The reader who is not familiar with the Celsius scale may find the following table useful for converting temperature data from the tables of basic data to the more familiar Fahrenheit scale.

TEMPERATURE-CONVERSION TABLE

For conversion of temperature in degrees Celsius (°C) to degrees Fahrenheit (°F). Conversions are based on the equation, $°F = 1.8°C + 32$; temperatures in °F are rounded to nearest degree. Underscored equivalent temperatures are exact equivalents. For temperature conversions beyond the limits of the table, use the equation given, and for converting from °F to °C, use $°C = 0.5556\ (°F - 32)$. The equations say, in effect, that from the freezing point (O°C, 32°F) the temperature rises (or falls) 5°C for every rise (or fall) of 9°F.

| °C | °F | °C | °F | °C | °F | °C | °F | °C | °F | °C | °F | °C | °F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -20 | -4 | -10 | 14 | 0 | 32 | 10 | 50 | 20 | 68 | 30 | 86 | 40 | 104 |
| -19 | -2 | -9 | 16 | +1 | 34 | 11 | 52 | 21 | 70 | 31 | 88 | 41 | 106 |
| -18 | 0 | -8 | 18 | 2 | 36 | 12 | 54 | 22 | 72 | 32 | 90 | 42 | 108 |
| -17 | +1 | -7 | 19 | 3 | 37 | 13 | 55 | 23 | 73 | 33 | 91 | 43 | 109 |
| -16 | 3 | -6 | 21 | 4 | 39 | 14 | 57 | 24 | 75 | 34 | 93 | 44 | 111 |
| -15 | 5 | -5 | 23 | 5 | 41 | 15 | 59 | 25 | 77 | 35 | 95 | 45 | 113 |
| -14 | 7 | -4 | 25 | 6 | 43 | 16 | 61 | 26 | 79 | 36 | 97 | 46 | 115 |
| -13 | 9 | 13 | 27 | 7 | 45 | 17 | 63 | 27 | 81 | 37 | 99 | 47 | 117 |
| -12 | 10 | -2 | 28 | 8 | 46 | 18 | 64 | 28 | 82 | 38 | 100 | 48 | 118 |
| -11 | 12 | -1 | 30 | 9 | 48 | 19 | 66 | 29 | 84 | 39 | 102 | 49 | 120 |

Chemical analyses throughout this report are expressed in milligrams per liter (mg/l) rather than in parts per million (ppm). For water having a total concentration of dissolved solids of less than about 7,000 mg/l (which includes all water in the area described in this report), milligrams per liter can be considered equivalent to parts per million. Milliequivalents per liter (meq/l) are calculated by dividing the concentration in milligrams per liter by the combining weight of the ion; for graphical presentation, milliequivalents per liter is a more convenient unit than milligrams per liter.

# A GRAVITY AND AEROMAGNETIC SURVEY OF HEBER AND RHODES VALLEYS, UTAH

BY

**D. L. Peterson**
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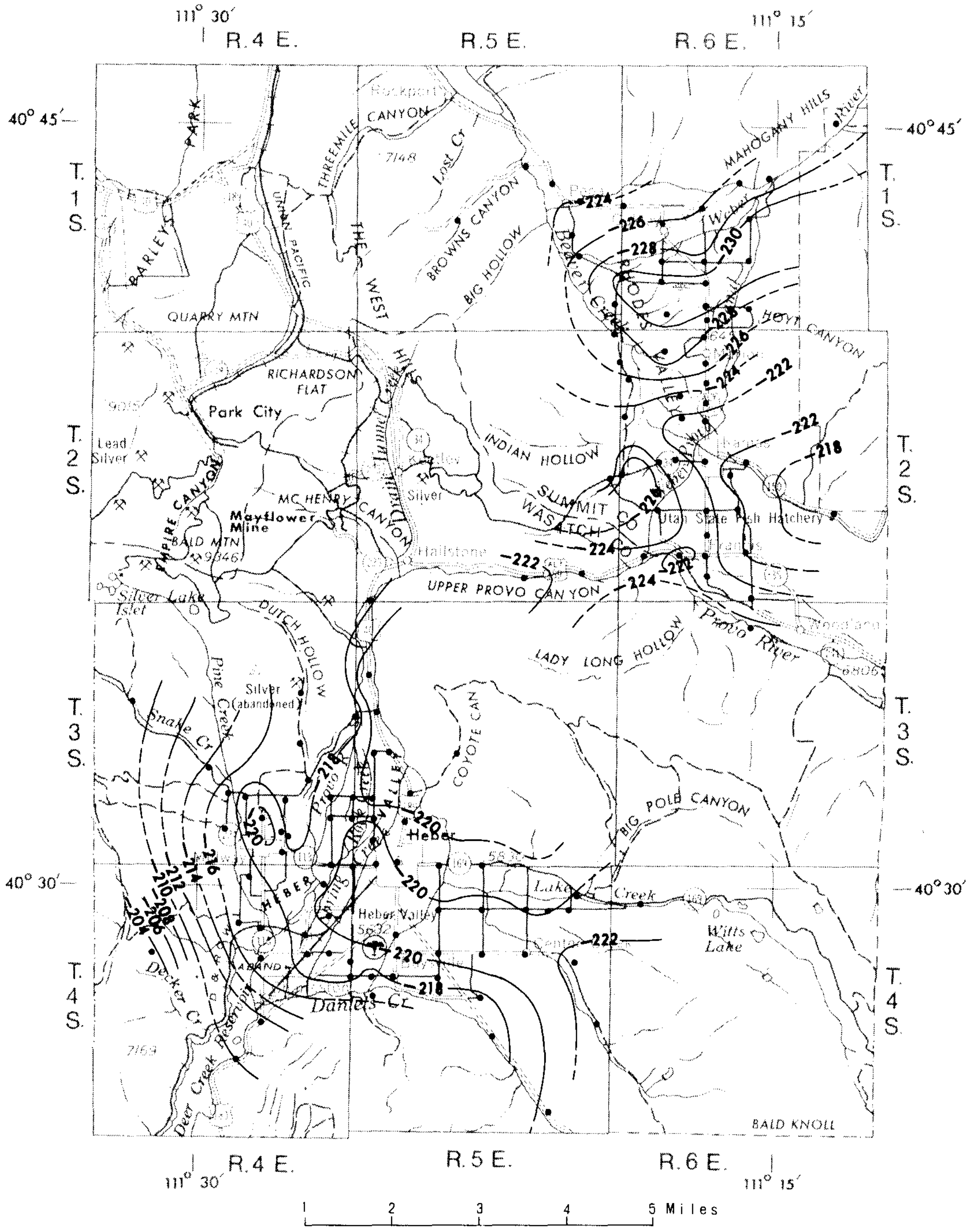
A gravity survey was made in Heber and Rhodes Valleys to aid in determining the approximate thickness of valley fill and to help interpret bedrock configuration. Observations were made at about 130 locations in the valleys and at a few locations in the nearby Wasatch Range and Uinta Mountains with a Worden gravimeter with a sensitivity of about 0.5 milligal per scale division. Horizontal and vertical positions for most of the observations were taken from benchmarks and other points of known elevations located on U. S. Geological Survey 1:24,000 scale topographic maps. Elevations for 23 observations were determined by altimetry. Two altimeters were read at points easily recognized on topographic maps and the average of the two readings was used in the computations. Loops were made from points of known elevation. The readings were corrected for changes in air density and are considered accurate to within 10 feet.

A density of 2.67 grams per cubic centimeter was assumed in reducing the data to the complete Bouguer anomaly. Theoretical gravity was computed from the International formula. The observed gravity values were referenced to base station WU 29 at Liberty Park, Salt Lake City, Utah (Behrendt and Woollard, 1961). Terrain corrections were computed through zone K using Hayford-Bowie templates (Swick, 1942) for 44 stations. Terrain corrections for the remaining stations were interpolated from a contour map of the 44 terrain correction values. The relative accuracy of complete Bouguer gravity values thus obtained is about 0.5 milligal, except for gravity stations with elevations determined by altimetry which may be in error by 1.0 milligal.

An unpublished Master's thesis, "A regional gravity survey of the back valleys of the Wasatch Mountains and adjacent areas in Utah, Idaho, and Wyoming," by Robert P. Quitzau reports on gravity observations in this area made by students at the University of Utah. Dr. Kenneth L. Cook made a copy of this thesis available to the U. S. Geological Survey. None of the gravity data from the thesis were used in preparing the maps presented here, but the data were useful in designing the gravity survey, interpolating terrain corrections, and defining the regional gravity field.

The complete Bouguer gravity map (fig. 20) shows an eastward decrease in the regional gravity field which is interpreted as being related mainly to features of greater extent than the local valleys. An assumed regional gravity field was determined by contouring gravity values for stations on or near exposures of pre-Tertiary bedrock. A residual Bouguer gravity map (fig. 21) was perpared by removing the assumed regional gravity field from the Bouguer gravity map.

The residual Bouguer gravity map shows a 4-milligal low in Heber Valley and an 8-milligal low in Rhodes Valley. The low in Heber Valley is approximately coextensive with the valley with the lowest values in the southwest. The steeper gravity gradients along the west and south edges of Heber Valley may reflect faulting. Faulting has been mapped along the south edge of the valley (Stokes, 1964). The closed gravity low in Rhodes Valley is confined to the northern half of the valley and is bounded by steep gradients, which may reflect faults. In the southern half of Rhodes Valley there is an area of low gravity values continuing south beyond the area of the survey.



Base from U.S. Geological Survey 1:250,000 (AMS) series: Salt Lake City, Utah; Wyoming (1963)

Geophysical interpretation by D. L. Peterson

## EXPLANATION

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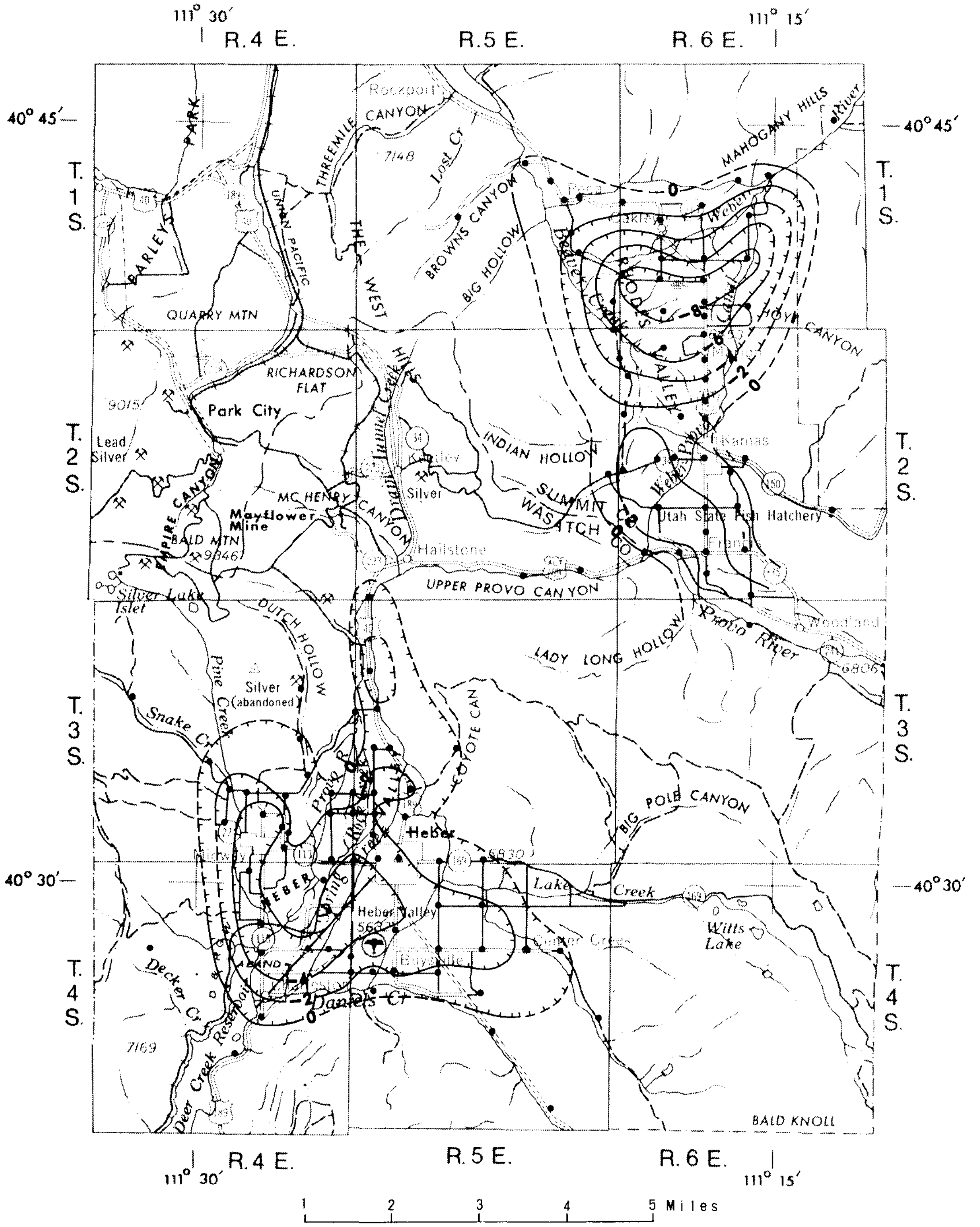
Gravity contour
*Dashed where approximately located. Contour interval 2 milligals. Hachured contours indicate areas of low gravity closure*

●
Gravity station

Figure 20.—Complete Bouguer gravity map.



Base from U.S. Geological Survey 1:250,000 (AMS) series: Salt Lake City, Utah; Wyoming (1963)

Geophysical interpretation by D. L. Peterson

## EXPLANATION

————-8—————

Gravity contour

*Dashed where approximately located. Contour interval 2 milligals. Hachured contours indicate areas of low gravity closure*

●

Gravity station

Figure 21.—Residual Bouguer gravity map.

A contour map of the thickness of the low density rock that would produce the residual gravity anomaly in Heber and Rhodes Valleys (fig. 22) was perpared by making an iterative three-dimensional solution with a digital computer (Cordell and Henderson, 1968). In this analysis the computer input is the residual Bouguer gravity data and a density contrast of 0.5 g per $cm^3$, which was assumed to exist between the low density material underlying the valleys and the more dense pre-Tertiary rocks in the bordering mountains, and the requirement that the low density mass extend to the surface of observation. The solution is a mass distribution that will produce the measured gravity anomalies. In figure 22 some minor adjustments of the lines have been made to make the low density mass distribution consistent with exposures of bedrock.

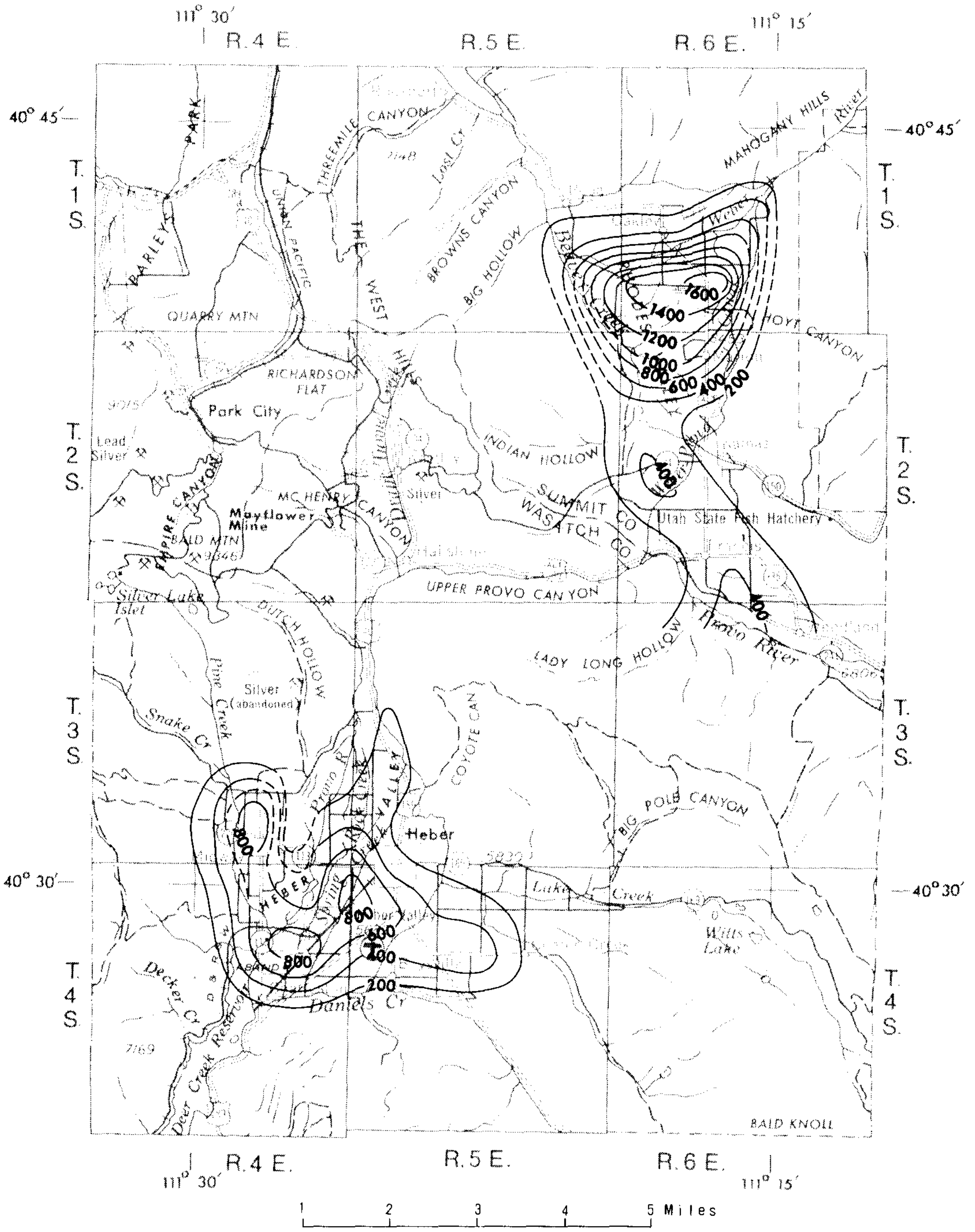
An irregular thickness of low density material underlies Heber Valley. Three areas of closure, where the maximum thickness is 800 feet or more, are indicated. In the western half of the valley there is a bedrock ridge which plunges to the south between the towns of Midway and Heber City. This ridge is exposed at the surface near the northeast corner of Midway. A shallow trough of low density material extends northward up the Provo River for about 3 miles. The computed model is generally consistent with the sediment thickness data revealed by drill holes in Heber Valley indicating that the assumed density contrast is approximately correct.

The computed model indicates that the northern half of Rhodes Valley is underlain by low density material with a miximum thickness of about 1,600 feet. The model shows the bedrock bottom of the valley sloping steeply towards the center in all directions. A trough of low density material 300-400 feet thick extends south beneath the town of Francis. No drill hole data are available in Rhodes Valley to confirm the computer model.

An aeromagnetic map (fig. 23) of the area was taken from a survey flown in 1965 (Meuschke and Kirby, 1966). Total intensity magnetic measurements were made with a fluxgate magnetometer mounted in a tailboom on a Convair aircraft. Flight lines were north-south, 2 miles apart and at 11,000 feet barometric elevation.

No magnetic evidence of igneous rock underlying Heber Valley is apparent; however, a small but significant magnetic anomaly was observed over northern Rhodes Valley and is strong evidence that igneous rock underlies this part of the valley. The magnetic anomaly in the area of the thickest low density material indicates that part of the low density material is volcanic rock. Tertiary extrusive rocks are present to the west (Stokes, 1964), and may be the source of the anomaly in the valley. Because the density of the volcanic rock is probably higher than that of the sediments producing the gravity low in Heber Valley and the southern part of Rhodes Valley, the actual thickness of low density material in northern Rhodes Valleyis probably greater than the thickness indicated on the model.

The high amplitude magnetic positive anomaly in the mountains northwest of Heber Valley is related to Tertiary granitoid rocks (Stokes, 1964). The magnetic data suggests an eastward extension of the anomaly along the north side of the valley. The gradient along the south side of the extension corresponds with the north edge of the gravity low and may define the northern limit of the valley.



Base from U.S. Geological Survey
1:250,000 (AMS) series: Salt Lake
City, Utah; Wyoming (1963)

Geophysical interpretation
by D. L. Peterson

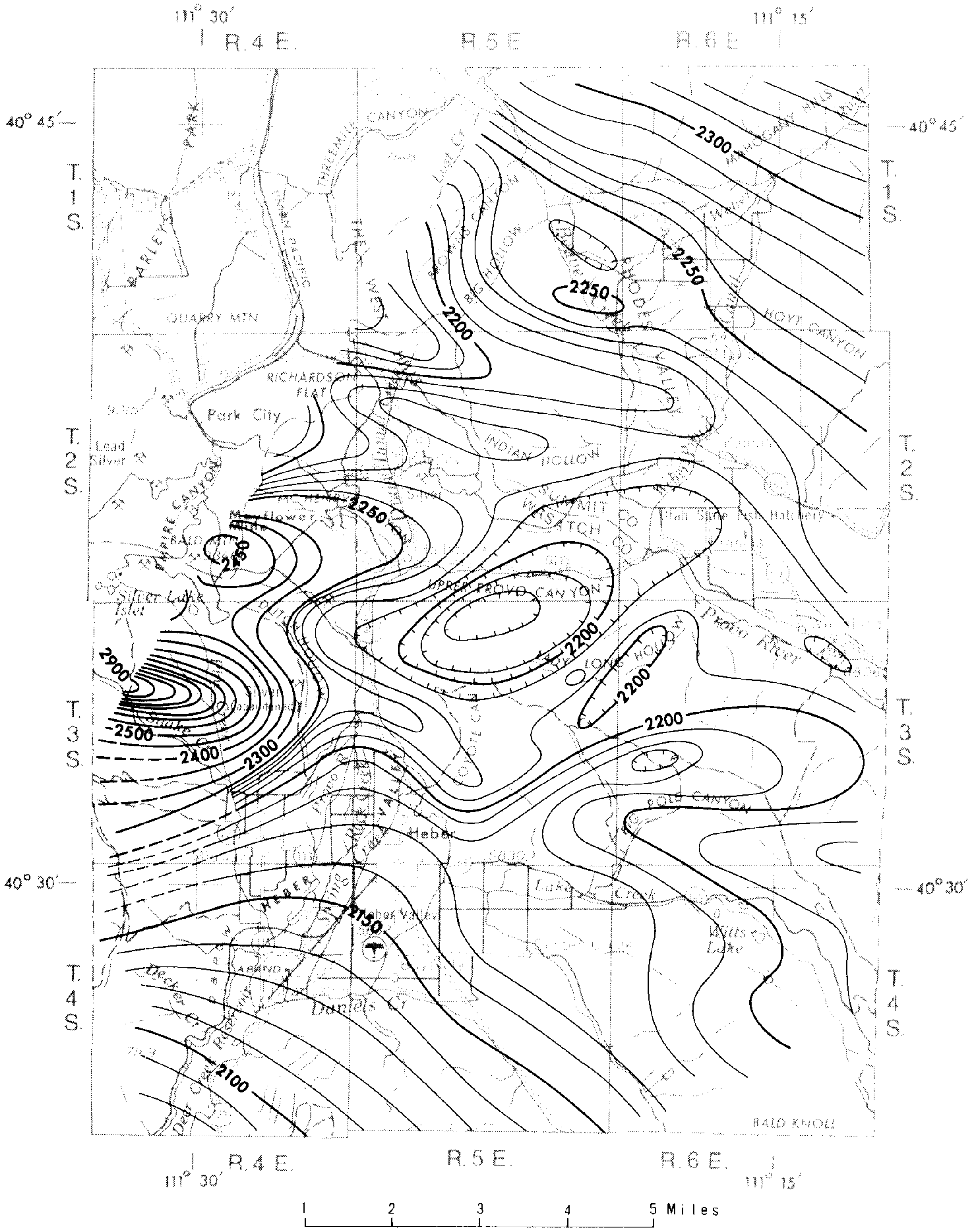
## EXPLANATION

——— **800** - - - - -

Lines of equal thickness of rock

*Dashed where approximately located.*
*Interval 200 feet*

Figure 22.—Map showing thickness of low-density rock.



Base from U.S. Geological Survey 1:250,000 (AMS) series: Salt Lake City, Utah; Wyoming (1963)

Aeromagnetic survey flown 11,000 feet barometric elevation, 1965. Geophysical interpretation by D. L. Peterson

## EXPLANATION

2450

Magnetic contour

*Showing total intensity magnetic field of the earth in gammas relative to arbitrary datum. Hachured to indicate closed areas of lower magnetic intensity; dashed where data are incomplete. Contour interval 10 and 50 gammas*

Figure 23.—Total intensity aeromagnetic map.

# REFERENCES

Behrendt, J. C., and Woollard, G. P., 1961, An evaluation of the gravity control network in North America: Geophysics, v. 26, no. 1, p. 57-76.

Cordell, L., and Henderson, R. G., 1968, Iterative three-dimensional solution of gravity anomaly data using a digital computer: Geophysics, v. 33, no. 4, p. 596-601.

Crittenden, M. D., Jr., Wallace, C. A., and Sheridan, M. J., 1967, Mineral resources of the High Uintas primitive area, Utah: U. S. Geol. Survey Bull. 1230-I.

Meuschke, J. L., and Kirby, J. R., 1966, Aeromagnetic map of Hayden Peak and vicinity, Uinta Mountains, Utah: U. S. Geol. Survey open-file rept.

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

Swick, C. H., 1942, Pendulum gravity measurements and isostatic reductions: U. S. Coast and Geod. Survey Spec. Pub. 232, 82 p.

# BASIC DATA

# Table 3.—Records of selected wells

LOCATION. SEE TEXT FOR DESCRIPTION OF WELL-NUMBERING SYSTEM.

TYPE OF WELL. B, BORED; C, DRILLED (CABLE TOOL); D, DUG; H, DRILLED (HYDRAULIC ROTARY).

CASING FINISH. C, POROUS CONCRETE; O, OPEN END ONLY; W, SHORED (DUG WELLS); X, OPEN HOLE.

WATER-BEARING MATERIAL. A, ALLUVIUM; C, CONGLOMERATE; J, VOLCANIC TUFF; JJ, FRACTURED VOLCANIC ROCKS; JL, FRACTURED LIMESTONE; RB, RED SHALE; RV, RED SANDSTONE; V, SANDSTONE; Y, CLAYEY GRAVEL; BG, SANDY GRAVEL; BW, SANDY SILTSTONE.

AQUIFER. OA, UNCONSOLIDATED VALLEY FILL; OL, TERTIARY VOLCANIC ROCKS; 1P, KNIGHT CONGLOMERATE; 4P, PREUSS SANDSTONE; 4V, TWIN CREEK LIMESTONE; 4W, NUGGET SANDSTONE; 5E, ANKAREH FORMATION; 2G, CHINLE FORMATION; 7C, OQUIRRH FORMATION; 9Z, WEBER QUARTZITE.

WATER LEVEL. DEPTH TO WATER BELOW LAND SURFACE UNLESS INDICATED BY +, HEAD ABOVE LAND SURFACE, OR F, WELL FLOWS BUT HEAD NOT DETERMINED. REPORTED WATER LEVELS ARE INDICATED BY R, MEASURED LEVELS BY M.

TYPE OF LIFT. C, CENTRIFUGAL; J, JET; N, NONE; S, SUBMERGIBLE; T, TURBINE.

PRODUCTION. SOURCE OF YIELD AND DRAWDOWN DATA SHOWN BY D, FROM DRILLER'S REPORT, OR R, REPORTED BY OTHER THAN DRILLER.

USE OF WATER. USE REPORTED IN 1966-67. H, DOMESTIC; I, IRRIGATION; N, INDUSTRIAL; P, PUBLIC SUPPLY; S, STOCK; T, TEST HOLE (WATER UNUSED); U, UNUSED.

OTHER DATA AVAILABLE. C, CHEMICAL ANALYSIS GIVEN IN THIS REPORT; D, DRILLER'S LOG AVAILABLE; K, SPECIFIC CONDUCTANCE OF WATER AVAILABLE; W, PERIODIC WATER-LEVEL MEASUREMENTS GIVEN IN THIS REPORT. NUMBERS REFER TO FOOTNOTES AT END OF TABLE.

| LOCATION | OWNER | DATE DRILLED (YEAR) | TYPE OF WELL | DEPTH OF WELL (FT) | CASING DIAMETER (IN) | CASING FINISH | WATER BEARING FORMATION MATERIAL | WATER BEARING FORMATION AQUIFER | ALTITUDE OF LAND SURFACE (FT) | WATER LEVEL (FT) | DATE MEASURED | PRODUCTION TYPE OF LIFT | PRODUCTION YIELD (GPM) | PRODUCTION DRAW DOWN (FT) | USE OF WATER | OTHER DATA AVAILABLE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SUMMIT COUNTY | | | | | | | | | | | | | | | | |
| (A- 1- 4) | | | | | | | | | | | | | | | | |
| 33DBB-1 | L LUKENBACK | 1965 | H | 364 | 4 | P | C | 1P | 6,980 | 40 R | 7-65 | | | | H | D 1 |
| (A- 1- 5) | | | | | | | | | | | | | | | | |
| 5DBC-1 | | 1964 | C | 210 | 10 | P | C | 1P | 5,910 | 7 | 9-64 | | 15 | 40 | H | |
| 20ABC-1 | | 1962 | C | 115 | 8 | X | JL | 4V | 5,910 | 5 R | | | 35 | 40 | H | D 1 |
| (D- 1- 3) | | | | | | | | | | | | | | | | |
| 10AAB-1 | HILLCO CORP | 1966 | C | 441 | 12 | P | JL | 4V | 6,640 | 100 | 1-66 | S | 20 | 300 | P | C D 1 |
| 10AAD-1 | EVERET DEBENHAM | 1965 | H | 152 | 4 | P | JL | 4V | 6,520 | 28 R | 8-65 | S | | | H | D |
| 10ACD-1 | C RONNOW | 1961 | C | 65 | 6 | X | JL | 4V | 6,520 | 24 R | 9-61 | | 10 | 41 | H | D |
| 10ADA-1 | JAMES SORENSON | 1964 | C | 75 | 6 | P | JL | 4V | 6,840 | 2 R | 6-64 | | 30 D | 20 | H | D |
| 10CDB-1 | TIMBERLINE INC | 1964 | C | 400 | 16 | P | JL | 4V | 6,650 | 38 R | 11-64 | | 50 D | 171 | P | D 1 |
| 12CBA-1 | DAN WRIGHT | 1967 | C | 160 | 6 | P | BW | 5E | 6,300 | 13 R | 8-67 | S | 30 D | 20 | H | |
| 12CBD-1 | JAMES KILBY | | C | 189 | 8 | P | BW | 5E | 6,290 | 30 R | 12-66 | S | 90 | 100 | H | C D |
| 13ADB-1 | ROBERT MCCOMB | 1965 | C | 250 | 6 | P | RB | 2G | 6,330 | 48 R | 8-65 | S | | | H | D |
| (D- 1- 4) | | | | | | | | | | | | | | | | |
| 4BBC-1 | P A SNELL | 1967 | C | 326 | 6 | O | JJ | OL | 6,870 | 3 R | 10-27 | S | 20 D | 125 | H | D |
| 4CCD-1 | ROBERT BURNS JR | 1967 | C | 258 | 6 | P | JJ | OL | 6,570 | 19 R | 3-67 | S | 7 D | 115 | H | |
| 4DBC-1 | ROBERT BURNS | 1967 | C | 205 | 6 | P | JJ | OL | 6,620 | 97 R | 1-67 | S | 15 D | 195 | H | |
| 10CBD-1 | JOSEPH STANTON | 1963 | H | 238 | 4 | P | JJ | OL | 6,580 | | | N | | | U | D 1 |
| 10DBB-1 | ALLEN LEWIS | 1962 | H | 260 | 4 | P | JJ | OL | 6,620 | 138 M | 12-62 | N | | | U | D |
| 16AAD-1 | ALLEN LEWIS | 1964 | C | 668 | 10 | P | JJ | OL | 6,440 | F R | 12-64 | S | 175 D | 235 | H | D 1 2 |
| 16DCA-1 | U S R COMM | 1955 | C | 202 | 6 | O | JJ | OL | 6,470 | 127 R | 12-55 | | 10 D | 30 | H | C D |
| 17BBB-1 | G T FLINDERS | 1950 | C | 127 | 6 | X | JL | 4V | 6,620 | 12 R | 9-60 | S | 13 D | 0 | H | C D 1 |
| 19BBC-1 | A L MARCHANT | 1947 | C | 67 | 6 | X | Y | OA | 6,480 | 33 R | 4-47 | | 40 D | 18 | H | D |
| 19BCA-1 | U S R COMM | 1947 | C | 48 | 4 | X | A | OA | 6,430 | | | | | | H | C D |
| 20DDB-1 | LELAND FLINDERS | 1966 | C | 98 | 6 | P | JJ | OL | 6,410 | 25 R | 11-66 | S | 15 D | 40 | H | |
| 21AAA-1 | MACART INVESTCO | 1964 | C | 554 | 10 | P | JJ | OL | 6,580 | 80 R | 10-64 | | 100 D | 120 | H | D 1 |
| 21BCB-1 | MACART INVES CO | 1964 | H | 400 | 4 | P | JJ | OL | 6,390 | 65 R | 7-64 | N | | | U | |
| 29CCC-1 | GEORGE STAHLE | 1947 | C | 48 | 4 | X | A | OA | 6,430 | 25 M | 10-66 | N | | | S | D 3 |
| 31AAC-1 | DALE DURRANT | 1959 | H | 72 | 6 | O | Y | 4W | 6,430 | 11 R | 5-59 | J | | | H | C D |
| 31ADB-1 | GEORGE STAHLE | | D | 22 | 24 | W | A | OA | 6,430 | M | 10-66 | N | | | U | W |
| 31BDB-1 | T JOHNSON | 1886 | D | 20 | 42 | W | A | OA | 6,610 | 13 R | 10-36 | N | | | U | W 4 |
| 32BBC-1 | GEORGE STAHLE | 1948 | H | 50 | 6 | X | A | OA | 6,550 | 23 R | 1-48 | T | | | H | D |
| (D- 1- 5) | | | | | | | | | | | | | | | | |
| 4DCC-1 | R D SIDDOWAY | 1948 | C | 40 | 6 | O | A | OA | 6,070 | 15 R | 6-48 | | 30 D | 0 | H | K |
| 5ADA-1 | W GIBBONS | 1948 | C | 30 | 6 | O | A | OA | 6,030 | 23 R | 6-48 | J | 30 D | 0 | H | K |
| 5ADD-1 | M GIBBONS | 1948 | C | 66 | 6 | O | A | OA | 6,020 | 22 R | 7-48 | | 30 D | 4 | H | D |
| 10BBA-1 | S S CLUFF | 1949 | C | 58 | 6 | O | A | OA | 6,070 | 5 R | 6-49 | | 30 D | 25 | H | D |
| 14DCA-1 | H L COOK | 1967 | C | 300 | 10 | P | | 4W | 6,160 | 5 R | 1-67 | N | 100 D | 80 | N | C |
| (D- 1- 6) | | | | | | | | | | | | | | | | |
| 17CCA-1 | ROBERT MATHESON | 1964 | C | 128 | 4 | P | RV | 4P | 6,600 | 60 R | 8-64 | | 10 D | 80 | H | D |
| 19DAD-1 | P WOOLSTENHULME | 1880 | D | 35 | 60 | W | A | OA | 6,470 | 15 | 9-66 | N | | | U | W |
| 28BBA-1 | JACK HOLLAND | 1963 | C | 70 | 4 | P | A | OA | 6,490 | 12 R | 9-63 | | | | H | D |
| 28BCC-1 | JOHN MITCHELL | | D | 45 | 48 | W | A | OA | 6,480 | 12 R | | J | | | H | C |
| 28BDD-1 | JOHN SIMPSON | 1949 | C | 57 | 6 | O | A | OA | 6,490 | 14 M | 9-49 | J | | | H | K D |

# Table 3.—Records of selected wells—continued

| LOCATION | OWNER | DATE DRILLED (YEAR) | TYPE OF WELL | DEPTH OF WELL (FT) | CASING DIAMETER (IN) | CASING FINISH | WATER BEARING FORMATION MATERIAL | WATER BEARING FORMATION AQUIFER | ALTITUDE OF LAND SURFACE (FT) | WATER LEVEL (FT) | DATE MEASURED | PRODUCTION TYPE OF LIFT | PRODUCTION YIELD (GPM) | DRAW DOWN (FT) | USE OF WATER | OTHER DATA AVAILABLE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (D- 1- 6) | | | | | | | | | | | | | | | | |
| 28CAA-1 | RENO GIBBONS | 1917 | | 15 | 12 | | A | OA | 6,480 | 14 M | 11-66 | N | | | U | |
| 28CCC-1 | HOWARD BUTTERS | 1951 | C | 52 | 6 | O | A | OA | 6,440 | 3 R | 9-51 | J | | | H | D |
| 29ADD-1 | EARL SNYDER | 1949 | C | 46 | 6 | O | A | OA | 6,460 | 15 R | 12-49 | | 30 D | 8 | H | D |
| 29DAA-1 | DWIGHT KING | 1960 | C | 56 | 6 | X | A | OA | 6,460 | 9 R | 5-60 | | | | H | D |
| 29DDD-1 | RUSS ROBERTSON | 1955 | C | 45 | 6 | O | A | OA | 6,440 | 8 R | 4-55 | T | | | H | K D |
| 33BCC-1 | WILLIAM COSSEY | 1950 | C | 69 | 6 | O | A | OA | 6,460 | 30 R | 9-50 | | 30 D | 0 | H | D |
| (D- 2- 4) | | | | | | | | | | | | | | | | |
| 2CBA-1 | MARK CORNABY | 1962 | H | 222 | 6 | P | JJ | OL | 6,720 | 55 R | 8-62 | S | | | H | D |
| 2CBD-1 | RAY WORTLEY | 1964 | H | 220 | 4 | P | JJ | OL | 6,640 | 42 | 5-64 | S | | | H | D 1 |
| 4CDD-1 | L D S CHURCH | | D | 30 | 24 | W | A | OA | 6,750 | | | C | | | H | |
| 4CDD-2 | LDS CHURCH | 1967 | C | 115 | 8 | P | BW | 5F | 6,750 | 32 R | 9-67 | S | 35 D | 4 | H | K |
| 4DCC-1 | L D S CHURCH | | D | 33 | 24 | W | A | OA | 6,750 | 23 M | 10-66 | C | | | H | C |
| 9BAA-1 | VERA SORENSEN | 1962 | H | 40 | 4 | P | A | OA | 6,740 | 25 R | 12-62 | C | | | H | |
| (D- 2- 5) | | | | | | | | | | | | | | | | |
| 24ADD-1 | J EDWARD URE | 1955 | C | 58 | 6 | O | A | OA | 6,440 | 20 R | 4-55 | | | | H | K D |
| (D- 2- 6) | | | | | | | | | | | | | | | | |
| 3BBB-1 | ALICE MCNEIL | 1949 | C | 60 | 3 | O | A | OA | 6,680 | 35 R | 3-49 | | | | H | D |
| 5ACC-1 | F W LARSEN | 1950 | C | 29 | 6 | O | A | OA | 6,380 | 14 R | 2-50 | J | 14 D | 0 | H | K D |
| 5DBB-1 | BURTON PETERSON | | D | 10 | 10 | O | A | OA | 6,375 | 7 | 9-66 | N | | | U | W |
| 5DBB-2 | HAROLD CLEGG | 1951 | D | 30 | 12 | O | A | OA | 6,380 | 2 | | J | | | H | K |
| 18ADD-1 | MRS L RUSSELL | 1950 | C | 78 | 6 | O | A | OA | 6,380 | 18 R | 1-50 | J | 30 D | 0 | H | C D |
| 18DDC-1 | ILE RUSSELL | 1947 | C | 20 | 6 | O | A | OA | 6,410 | 5 R | 7-47 | | 40 D | 5 | H | K D |
| 19ABA-1 | ANTHON GINES | 1950 | C | 30 | 6 | O | A | OA | 6,410 | 2 R | 7-50 | | 30 D | 18 | H | D |
| 19ABC-1 | JOHN LAMBERT | 1947 | C | 67 | 6 | X | V | 97 | 6,410 | 6 R | 4-47 | S | 40 D | 0 | H | K D 1 |
| 19BAC-1 | JOHN LAMBERT | 1964 | C | 50 | 12 | P | A | OA | 6,420 | 8 R | 11-64 | S | 60 D | 10 | S | K D |
| 19BCC-1 | J EDWARD URE | 1964 | C | 110 | 8 | P | JJ | OL | 6,460 | 25 R | 10-64 | S | 32 D | 65 | S | K D 1 |
| 20ABB-1 | ALBERT WAGSTAFF | 1951 | C | 21 | 6 | O | A | OA | 6,440 | 2 R | 4-51 | J | 20 D | 0 | H | K D |
| 20BAA-1 | A L WAGSTAFF | 1947 | C | 42 | 6 | O | A | OA | 6,440 | 2 R | 6-47 | J | 40 D | 3 | H | |
| 20BDA-1 | RAY LAMBERT | 1949 | C | 46 | 6 | O | A | OA | 6,460 | 6 R | 11-49 | | 30 D | 0 | H | |
| 20CCC-1 | WALDEN LAMBERT | 1893 | D | 10 | 30 | W | A | OA | 6,460 | 4 | 9-67 | N | | | U | W |
| 20CCC-2 | WALDEN LAMBERT | 1947 | C | 36 | 6 | O | A | OA | 6,460 | 6 R | 4-47 | C | 40 D | 4 | H | K D |
| 21DCA-1 | R GOODWORTH | 1948 | C | 47 | 6 | P | A | OA | 6,540 | 19 R | 1-48 | J | | | H | D |
| 21DDC-1 | WAYNE PRESCOTT | 1949 | C | 72 | 6 | O | A | OA | 6,550 | 27 R | 12-49 | J | 36 D | 0 | H | D |
| 25CAB-1 | ROBERT COCKRELL | 1965 | C | 76 | 6 | P | A | OA | 6,900 | 30 R | 6-65 | | 30 D | 10 | H | |
| 25DBB-1 | W SAUNDERS | 1964 | C | 105 | 6 | P | A | OA | 6,850 | 80 R | 7-64 | S | 15 D | 0 | H | |
| 26AAD-1 | GRANT WOODWARD | | C | 56 | 6 | P | A | OA | 6,800 | 12 | 10-65 | S | 25 D | 40 | H | |
| 26BAB-1 | B W HERMANSON | 1966 | C | 47 | | P | A | OA | 6,800 | 7 R | 8-66 | S | 75 D | 2 | H | |
| 27CCC-1 | ELVIN PRESCOTT | 1948 | C | 55 | 4 | O | A | OA | 6,610 | 39 R | 10-48 | J | | | H | D |
| 28BBC-1 | LEO PAGE | 1947 | C | 43 | 7 | P | A | OA | 6,530 | 5 R | 3-47 | | | | H | D |
| 28CCB-1 | JOHN KIRKHAM | 1947 | C | 33 | 6 | O | A | OA | 6,550 | 5 R | 7-47 | N | | | U | D |
| 28CCC-1 | FARREL ATKINSON | 1924 | D | 28 | 24 | C | A | OA | 6,570 | 15 M | 8-66 | N | | | U | |
| 28CCC-2 | ALFONSO MCNIEL | | D | 30 | 24 | C | A | OA | 6,570 | 14 M | 8-66 | N | | | U | W |
| 28DDC-1 | MELVIN KIRKHAM | 1947 | C | 43 | 6 | O | A | OA | 6,590 | 5 R | 7-47 | J | | | H | D |
| 29ADA-1 | ELLIS THOMAS | 1890 | D | 11 | 48 | W | A | OA | 6,530 | 4 M | 8-66 | J | | | H | K |
| 29DDD-1 | PARLEY MITCHELL | 1925 | D | 30 | 72 | W | A | OA | 6,560 | | | N | | | U | |
| 33AAA-1 | L M CRITTENDEN | 1955 | C | 59 | 6 | O | A | OA | 6,570 | | | J | | | U | |
| 33AAA-2 | R CRITTENDEN | 1958 | C | 55 | 6 | O | A | OA | 6,610 | 25 R | 5-58 | N | 30 | 10 | U | D |
| 33ADA-1 | EARL WOODWARD | 1960 | H | 60 | 6 | O | A | OA | 6,630 | 18 R | 2-60 | N | 10 D | 7 | U | D |
| 33BBB-1 | ALICE MCNIEL | 1948 | C | 60 | 4 | O | A | OA | 6,580 | 15 | 10-48 | N | | | U | D |
| 33DAA-1 | ALBERT SIMMONS | 1950 | H | 64 | 6 | O | A | OA | 6,630 | 16 R | 6-50 | N | 30 D | 7 | U | D |
| 33DBD-1 | R J PRESCOTT | 1950 | H | 86 | 6 | O | A | OA | 6,640 | 8 R | 6-50 | N | 30 | 17 | U | D |
| 34BCB-1 | C F MCNIEL | 1948 | C | 73 | 3 | O | A | OA | 6,630 | 13 R | 9-48 | | | | U | D |
| 34BCC-1 | T W MCNIEL | 1949 | C | 33 | 4 | O | A | OA | 6,640 | 22 | 9-66 | N | | | U | W |
| 34CBC-1 | GEORGE SPADER | 1947 | C | 62 | 6 | O | A | OA | 6,640 | 40 R | 12-47 | J | 30 D | 0 | H | K D |
| 34CBC-2 | DOYLE SIMMONS | 1950 | H | 69 | 6 | O | A | OA | 6,640 | 7 M | 8-66 | N | 25 D | 17 | U | D |
| | WASATCH COUNTY | | | | | | | | | | | | | | | |
| (D- 2- 5) | | | | | | | | | | | | | | | | |
| 6CDB-1 | SAN FRANCISCO C | 1965 | H | 260 | 4 | P | J | OL | 6,620 | 94 R | 11-65 | S | | | H | C D |
| 20BCB-1 | NEW PARK MNG CO | 1944 | C | 140 | 6 | P | J | OL | 6,080 | 20 R | 3-44 | N | 11 D | 40 | U | D 1 |
| 20CCA-1 | LEE BROTHERS | | D | 29 | 24 | W | A | OA | 6,021 | 25 M | 9-66 | N | | | U | W |
| 31ADA-1 | HARRY H MORRIS | 1956 | C | 34 | 6 | P | A | OA | 5,840 | 8 R | 10-56 | C | 50 | | H | C D |
| 32BAD-1 | UTAH PANDL CO | 1943 | C | 103 | 8 | X | J | OL | 5,965 | 33 M | 9-66 | N | | | U | D W 1 5 |
| 32BBC-1 | MORRIS BROTHERS | 1899 | D | 20 | 30 | W | A | OA | 5,950 | 11 M | 8-66 | N | | | U | W |
| 32BBC-2 | LDS CHURCH | 1950 | C | 150 | 7 | X | J | OL | 5,950 | 12 R | 3-50 | J | | | I | D 1 |
| 32BBC-3 | LDS CHURCH | 1958 | C | 175 | 8 | P | J | OL | 5,950 | 24 R | 12-58 | J | | | H | P D |
| (D- 3- 4) | | | | | | | | | | | | | | | | |
| 24ACC-1 | EMER WILSON | 1964 | C | 100 | 6 | O | A | OA | 5,630 | 9 R | | J | 30 D | 25 | H | K D |
| 25ADD-1 | MERRIL REESE | 1949 | C | 32 | 6 | O | A | OA | 5,580 | 2 R | 9-49 | | 30 D | 0 | H | K D |
| 25DCC-1 | U S B R | 1961 | B | 8 | 2 | O | A | OA | 5,554 | 3 M | 7-66 | | | | U | W |
| 26DBA-1 | LEROY KOHLER | 1934 | D | 19 | 48 | X | A | OA | 5,600 | 13 M | 7-66 | R | | | S | C |
| 35ABC-1 | E H WATKINS | | D | 21 | 24 | W | A | OA | 5,610 | 2 M | 9-66 | N | | | U | W |
| 35DAB-1 | ABRAHAMNEERINGS | 1960 | H | 94 | 6 | P | BG | OA | 5,530 | 58 R | 1-60 | S | | | H | C D I |

# Table 3.—Records of selected wells—continued

| LOCATION | OWNER | DATE DRILLED (YEAR) | TYPE OF WELL | DEPTH OF WELL (FT) | CASING | | WATER BEARING FORMATION | | ALTITUDE OF LAND SURFACE (FT) | WATER LEVEL (FT) | DATE MEASURED | PRODUCTION | | | USE OF WATER | OTHER DATA AVAILABLE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | DIAMETER (IN) | FINISH | MATERIAL | AQUIFER | | | | TYPE OF LIFT | YIELD (GPM) | DRAW DOWN (FT) | | |
| (D- 3- 5) | | | | | | | | | | | | | | | | |
| 6BAB-1 | HOWARD JENSEN | 1915 | | 8 | 6 | O | A | OA | 5,860 | 7 M | 7-66 | N | | | U | W |
| 6BAB-2 | HOWARD JENSEN | 1958 | C | 53 | 6 | X | A | OA | 5,860 | 9 R | 12-58 | J | | | H | C D |
| 6CBD-1 | WILLIAM JORDAN | 1960 | C | 60 | 6 | X | J | OL | 5,820 | 18 R | 1-60 | C | | | H | D |
| 7CDC-1 | HEBER CITY CORP | 1940 | C | 88 | 4 | P | A | OA | 5,750 | 6 | 9-66 | C | | | U | D W |
| 18DBB-1 | ISAAC BAUM | 1952 | C | 36 | 6 | P | A | OA | 5,710 | 6 R | 4-52 | C | 50 D | 4 | H | D |
| 19AAB-1 | JOHN MOULTON | 1955 | C | 83 | 6 | O | A | OA | 5,690 | 43 R | 4-55 | J | 8 D | 22 | H | D |
| 19ADD-1 | A D MACEWAN | 1961 | H | 80 | 6 | O | A | OA | 5,680 | 30 R | 7-61 | | 10 D | 10 | H | C |
| 20CCB-1 | WELBY YOUNG | 1918 | D | 36 | 36 | W | A | OA | 5,640 | | | C | | | H | |
| 29BDB-1 | C FITZGERALD | 1957 | H | 52 | 6 | O | A | OA | 5,630 | 10 R | 5-57 | S | 15 D | 4 | H | D |
| 29BDC-1 | THOMAS KEELING | 1948 | C | 48 | 6 | O | A | OA | 5,620 | 12 R | 9-48 | | 30 D | 12 | H | D |
| 29CAB-1 | BROWN KEELING | 1960 | C | 42 | 6 | X | A | OA | 5,600 | 15 R | 11-60 | C | 12 D | 20 | H | K D |
| 29CAB-2 | LESLIE NORTH | 1950 | C | 48 | 6 | P | A | OA | 5,600 | 10 R | 10-50 | J | 75 D | 10 | H | D |
| 29CAC- 1 | ALBERT NORTH | | D | 15 | 48 | W | A | OA | 5,608 | 3 | 9-66 | N | | | U | W |
| 29CDB-1 | DESERET VAN GAS | 1962 | C | 95 | 6 | X | L | 4V | 5,590 | 20 R | 10-62 | | 25 D | 75 | H | D |
| 32ACC-1 | U S B R | 1961 | B | 24 | 2 | O | A | OA | 5,570 | 14 M | 7-66 | | | | | |
| 32BBA-1 | VERNON PRICE | 1950 | C | 80 | 6 | P | J | OL | 5,600 | 12 R | 10-50 | | 50 D | 38 | H | D |
| 32CCA-1 | CARL GREER | 1960 | H | 72 | 6 | X | A | OA | 5,590 | 12 R | 9-60 | | 20 D | 28 | H | D |
| 34DDD-1 | W J BOND | 1963 | H | 300 | 6 | P | V | 4W | 6,000 | 70 R | 10-63 | S | | | H | K D |
| (D- 4- 4) | | | | | | | | | | | | | | | | |
| 10BDA-1 | RUSSEL WOLPOLE | 1964 | H | 76 | 6 | X | A | OA | 5,460 | 20 R | 7-64 | T | 30 D | 60 | H | K D |
| 11AAA-1 | WALTER WEBSTER | 1949 | C | 59 | 6 | O | A | OA | 5,460 | 8 R | 10-49 | | | | S | D |
| 11DCC-1 | LEO WERNERTON | 1900 | D | 20 | 30 | O | A | OA | 5,470 | 12 | 8-66 | N | | | U | |
| 11DCD-1 | LESTER GREEN | 1914 | D | 26 | 30 | O | A | OA | 5,470 | 14 | 8-66 | N | | | U | |
| 11DCD-2 | GRANT WINTERTON | 1916 | D | 27 | 30 | O | A | OA | 5,470 | 15 | 8-66 | N | | | U | |
| 11DDC-1 | JOSEPH LLOYD | 1891 | D | 28 | 48 | W | A | OA | 5,490 | 17 M | 8-66 | | | | U | W |
| 12BBC-1 | N BESENDORFER | 1896 | D | 18 | 36 | W | A | OA | 5,470 | | | N | | | U | |
| 13CBA-1 | IVAN ANDERSON | 1961 | C | 100 | 8 | X | A | OA | 5,540 | R | 4-61 | S | 36 D | 10 | N | C D |
| 13CBC-1 | JACK ANDERSON | 1964 | C | 110 | 6 | P | A | OA | 5,530 | | | J | | | H | K D |
| 14AAB-1 | LINDON MAXFIELD | 1901 | D | 29 | 24 | O | A | OA | 5,490 | | | C | | | S | |
| 14ABB-1 | NORMAN EDWARDS | 1916 | D | 15 | 36 | W | A | OA | 5,470 | | | N | | | U | |
| 14ABB-2 | CHARLOTTE BROWN | | D | 24 | 36 | W | A | OA | 5,457 | 17 M | 5-37 | N | | | U | W 6 |
| 14BBC-1 | C EDWARDS | 1899 | D | 16 | 48 | W | A | OA | 5,430 | 11 | | N | | | U | |
| 14CCC-1 | CHARLESTON TOWN | 1934 | C | 325 | 10 | P | A | OA | 5,430 | | | S | | | P | 2 |
| 14CDB-1 | CALVIN PROBST | | D | 34 | 48 | W | A | OA | 5,450 | 29 | 8-66 | N | | | U | |
| 15ADA-1 | R MAXFIELD | 1885 | D | 22 | 48 | W | A | OA | 5,420 | 14 M | 8-66 | C | | | U | |
| 22AAA-1 | W S WRIGHT | 1915 | D | 19 | 30 | W | A | OA | 5,420 | 14 | 8-66 | N | | | U | |
| 23BAB-1 | H F PRICE | 1896 | D | 34 | 36 | W | A | OA | 5,450 | 26 | 8-66 | N | | | U | |
| 23BBB-1 | JOHN JACOBSON | 1896 | D | 25 | 48 | W | A | OA | 5,430 | 17 | 8-66 | C | | | H | |
| 23BBB-2 | L W FARNSWORTH | 1905 | D | 25 | 36 | W | A | OA | 5,430 | | | C | | | H | |
| 23BBB-3 | MILL NORTH | | D | 26 | 36 | O | A | OA | 5,430 | 18 | 8-66 | N | | | U | |
| 23BCC-1 | CLARK WEBSTER | 1917 | D | 19 | 24 | O | A | OA | 5,420 | 12 M | 8-66 | N | | | U | W |
| 27ACB-1 | PROVO RIVER WUA | 1963 | C | 119 | 8 | P | A | OA | 5,410 | 16 R | 5-63 | S | 20 D | 40 | H | D |
| (D- 4- 5) | | | | | | | | | | | | | | | | |
| 1CAD-1 | CHASE CROOK | | D | 16 | | W | A | OA | 6,100 | 12 R | | C | | | H | |
| 2DCC-1 | CALVIN CROOK | 1948 | C | 43 | 6 | O | A | OA | 6,000 | 18 R | 10-48 | S | 30 D | 0 | H | K D |
| 3CCC-1 | RONALD MCDONALD | 1960 | C | 67 | 6 | O | A | OA | 5,800 | | | | 9 D | 20 | H | D |
| 4AAC-1 | GEORGE HOLMES | 1900 | D | 40 | 48 | X | JL | 4V | 5,780 | 25 M | 8-66 | J | | | H | K W |
| 4BBB-1 | J F MOUNTFORD | 1957 | C | 86 | 6 | O | A | OA | 5,680 | 16 R | 10-57 | S | 30 D | 10 | H | D |
| 4DDC-1 | G CHRISTENSEN | 1948 | C | 63 | 6 | X | A | OA | 5,800 | 30 R | 9-48 | J | 30 D | 0 | H | D |
| 4DDD-1 | LEROY MAIR | 1960 | C | 50 | 6 | P | A | OA | 5,800 | 16 M | 9-66 | J | 20 D | 10 | H | D W |
| 5CCC-1 | JOE ROZZELLE | 1952 | C | 135 | 6 | O | A | OA | 5,630 | 60 R | 12-52 | S | | | H | C D |
| 5DDD-1 | DON BARKER | 1959 | C | 198 | 6 | O | A | OA | 5,630 | 153 R | 1-59 | S | 10 D | 10 | H | D |
| 6BBA-1 | USBR | 1961 | B | 4 | 2 | O | A | OA | 5,545 | 3 M | 7-66 | N | | | U | W |
| 6BCB-1 | DERIAL MOULTON | 1948 | H | 85 | 6 | O | A | OA | 5,530 | 24 R | 10-48 | S | 30 D | 36 | H | K D |
| 7AAC-1 | FERRIS CLEGG | 1955 | C | 152 | 6 | O | A | OA | 5,630 | 112 R | 1-55 | | | | H | C D |
| 7ADA-1 | JAY SIMPSON | 1961 | C | 158 | 6 | O | A | OA | 5,650 | 110 R | 9-61 | J | | | H | C D |
| 7CAD-1 | HEBER CITY CORP | 1949 | C | 155 | 6 | O | A | OA | 5,610 | 70 R | 7-49 | T | | | H | D |
| 8ADA-1 | CHARLES YEATES | 1955 | C | 200 | 6 | P | A | OA | 5,700 | 175 R | 3-55 | S | 6 D | 21 | H | K D |
| 9AAD-1 | CALVIN GILES | 1953 | H | 59 | 6 | X | A | OA | 5,700 | 12 R | 10-53 | | 9 D | 4 | H | D |
| 9ABA-1 | L CHRISTENSEN | 1953 | H | 60 | 6 | O | A | OA | 5,780 | 17 | 8-66 | J | 14 D | 4 | H | K D |
| 10ADA-1 | RUSSEL WALL | 1953 | H | 50 | 6 | X | A | OA | 5,870 | 10 R | 10-53 | C | 10 D | 5 | H | D |
| 10BAB-1 | W BINGGELI | 1961 | C | 74 | 6 | O | A | OA | 5,850 | 40 | 4-61 | | | | H | D |
| 10DDC-1 | O C HAYCOCK | 1960 | C | 56 | 6 | P | A | OA | 6,080 | 9 R | 6-60 | | 7 D | 30 | H | D |
| 11CBB-1 | GLEN BURGENER | 1967 | C | 70 | 6 | P | A | OA | 5,820 | 13 R | 4-67 | | 25 D | 15 | H | D |
| 11CDC-1 | DAVID IVIE | 1947 | C | 34 | 6 | P | A | OA | 5,950 | | | | | | H | D |
| 14AAC-1 | ROBERT CLYDE | 1964 | C | 104 | 6 | P | A | OA | 6,030 | 12 R | 4-64 | J | 20 D | 20 | H | C D |
| 14BBA-1 | RETTA BINGGELI | 1959 | C | 50 | 6 | O | A | OA | 5,940 | 8 R | 4-59 | | 10 D | 5 | H | D |
| 15AAB-1 | J E MCDONALD | 1949 | D | 15 | 10 | C | A | OA | 5,900 | | | | | | H | D |
| 15BAB-1 | THEON SWEAT | 1961 | C | 164 | 6 | O | A | OA | 5,850 | 122 M | 8-66 | S | 15 D | 2 | S | K D |
| 17BDD-1 | LDS CHURCH | 1962 | C | 330 | 8 | P | A | OA | 5,770 | 120 R | 3-62 | S | 30 D | 60 | H | D |
| 18BBC-1 | H L COOK | 1960 | C | 190 | 6 | P | A | OA | 5,600 | 109 M | 1-60 | S | | | H | D |
| (D- 5- 4) | | | | | | | | | | | | | | | | |
| 12ADD-1 | NILE GIVENS | | D | 9 | 48 | C | A | OA | 5,600 | 6 M | 8-66 | C | | | H | K |
| 12BBA-1 | KARLSON | 1952 | C | 60 | 6 | O | A | OA | 5,560 | | | J | | | H | |
| (D- 5- 5) | | | | | | | | | | | | | | | | |
| 19ABB-1 | A RAY EAKINS | 1890 | D | 40 | 48 | W | A | OA | 5,680 | | | C | | | H | |

1. DRILLER'S LOG GIVEN IN THIS REPORT.
2. ORIGINALLY DRILLED TO 194 FEET, CAVED.
3. USED AS OBSERVATION WELL 1938-49, DESTROYED.
4. ORIGINALLY DRILLED TO 206 FEET, CAVED.
5. USED AS OBSERVATION WELL 1915-50, DESTROYED.

# Table 4.—Records of selected springs

LOCATION. SEE TEXT FOR DESCRIPTION OF SPRING-NUMBERING SYSTEM.
AQUIFER. 0A, UNCONSOLIDATED VALLEY FILL; 0L, TERTIARY VOLCANIC ROCKS; 4V, TWIN CREEK LIMESTONE; 4W, NUGGET SANDSTONE, 5T, THAYNES FORMATION; 7V, ROUND VALLEY LIMESTONE; 8J OR 8N, MISSISSIPPIAN LIMESTONE; 9Z, WEBER QUARTZITE.
DISCHARGE. SOURCE OF DISCHARGE DATA SHOWN BY M, MEASURED; E, ESTIMATED; R, REPORTED.
USE OF WATER. C, COMMERCIAL; H, DOMESTIC; I, IRRIGATION; N, INDUSTRIAL; P, PUBLIC SUPPLY; R, RECREATIONAL; S, STOCK; U, UNUSED.
OTHER DATA AVAILABLE. C, CHEMICAL ANALYSIS IN TABLE 5; K, SPECIFIC CONDUCTANCE AVAILABLE; NUMBERS REFER TO FOOTNOTES AT END OF TABLE.

| LOCATION | NAME OR OWNER | ALTITUDE (FEET) | AGE OF AQUIFER | DISCHARGE (GPM) | DATE MEASURED | TEMP (°C) | USE OF WATER | OTHER DATA AVAILABLE |
|---|---|---|---|---|---|---|---|---|
| SUMMIT COUNTY | | | | | | | | |
| (D- 1- 3) | | | | | | | | |
| 11CCCS-1 | TWO MILE SPRING | | 5T | | | | H | C |
| 25DDBS-1 | L D S CHURCH | 6,880 | 4W | 100 E | JUNE 1968 | | I | |
| 36AADS-1 | L D S CHURCH | 6,700 | 4V | 1,300 E | JUNE 1968 | 11 | I | K |
| (D- 1- 4) | | | | | | | | |
| 30BCAS-1 | L D S CHURCH | 6,470 | 4W | 150 E | JUNE 1968 | 11 | S | K |
| 33AAAS-1 | | 6,790 | 0L | 50 E | JUNE 1968 | 21 | S | K |
| 34DCDS-1 | | 6,750 | 0L | 350 E | JUNE 1968 | 12 | | K |
| 35ADAS-1 | HOMER SPRING | 6,590 | 0L | 6 E | SEPT. 1967 | 13 | S | K |
| (D- 1- 5) | | | | | | | | |
| 20DCAS-1 | | 6,720 | 0L | 4 E | OCT. 1967 | 9 | S | K |
| 31DBDS-1 | | 6,850 | 0L | 300 E | JUNE 1968 | 11 | S | K |
| (D- 1- 6) | | | | | | | | |
| 34CCAS-1 | MARION WTRWKS | 6,780 | 9Z | 900 E | | | P | |
| (D- 2- 4) | | | | | | | | |
| 4DCAS-1 | DORITY SPRING | 6,740 | 4W | 700 E | | 13 | I | C |
| 9CBBS-1 | A E JENKINS | | 0A | | | | H | |
| 13BCBS-1 | | 6,740 | 5T | 10 E | AUG. 1967 | 12 | U | K |
| 15DCAS-1 | | 7,160 | 9Z | 150 E | JUNE 1968 | 12 | S | K |
| 22ABCS-1 | | 7,300 | 9Z | 100 E | JUNE 1968 | 12 | | K |
| (D- 2- 6) | | | | | | | | |
| 5BC S- | HELMA WHERRITT | 6,380 | 0A | 2,200 M | MAY 1968 | 11 | S | K |
| 5CBBS-1 | EDWARD PETERSON | 6,380 | 0A | 15 E | MAY 1968 | 10 | S | K |
| 26BBDS-1 | CEDAR FORK SPR | | 9Z | | | 11 | N | P |
| 32ABBS-1 | | 6,410 | 0A | 200 F | SEPT. 1967 | 10 | S | K |
| WASATCH COUNTY | | | | | | | | |
| (D- 2- 5) | | | | | | | | |
| 5CCDS-1 | | 6,550 | 0L | 200 E | SEPT. 1967 | 10 | S | C |
| 17BCAS-1 | | 6,200 | 0L | 10 E | SEPT. 1967 | 11 | S | K |
| 17CDAS-1 | | 6,280 | 0L | 250 E | SEPT. 1967 | 12 | P | K |
| 29CADS-1 | | | 0L | 50 R | | 5 | U | |
| 33ADAS-1 | BERG SPRING | | 0L | 3,000 R | | | | |
| (D- 3- 4) | | | | | | | | |
| 21BBBS-1 | EPPERSON SPRING | | 8J | 5,900 R | | 12 | I | C |
| 21DCDS-1 | GERBER SPRING | 5,870 | 7V | 1,600 E | | 11 | P | K |
| 22BCCS-1 | MAHOGANY SPRING | 5,890 | 8N | 3,200 E | | | I | |
| 26CCAS-1 | EUGENE PAYNE | 5,650 | | 50 E | | 39 | M | C |
| 27ABAS-1 | WARM DITCH SPR | 5,740 | | 1,250 M | AUG. 1967 | 1 | I | K |
| 27ABBS-1 | JOE DEAN HUBER | 5,750 | | 125 M | AUG. 1967 | 1 | H | K |
| 27BAAS-1 | | 5,850 | | 3 M | | 7 | I | C |
| 27BADS-1 | | 5,735 | | 150 E | SEPT. 1966 | 4 | U | C |
| 27BDDS-1 | HOMESTEAD INC | 5,755 | | 175 E | | 3 | R | |
| 27CBDS-1 | | 5,751 | | | | 29 | U | C |
| 27CBDS-2 | | 5,765 | | | | 31 | U | C |
| 27CBDS-3 | | 5,757 | | 1 E | | 28 | U | C |
| 28ACCS-1 | | 6,040 | 9Z | 4 M | SEPT. 1967 | 8 | U | |
| (D- 3- 5) | | | | | | | | |
| 32BADS-1 | HATCH SPRING | 5,590 | 0A | 1,400 E | JUNE 1968 | 10 | I | K |
| (D- 4- 4) | | | | | | | | |
| 2CBBS-1 | UTAH F AND G | 5,460 | 0A | 6,200 E | | | N | C |
| 10CCDS-1 | STATE PARK COMM | 5,460 | 4W | 1,300 E | JUNE 1968 | 12 | S | K |
| (D- 4- 5) | | | | | | | | |
| 4AABS-1 | HEBER CITY CORP | | 4V | 1,200 E | | | P | |
| (D- 5- 5) | | | | | | | | |
| 17ABCS-1 | WALLSBURG TOWN | 5,960 | 0A | 300 E | JUNE 1968 | 13 | I | C |
| 18ACAS-1 | N DITCH IRR CO | 5,675 | 0A | 1,800 E | JUNE 1968 | 11 | I | K |
| 28DCDS-1 | MAPLE SPRING | 6,160 | 0A | 500 E | JUNE 1968 | 11 | I | C |
| 33ACBS-1 | WALLSBURG TOWN | 6,190 | 0A | 1,300 E | JUNE 1968 | 10 | P | K |

1. SEASONAL, FLOWS ONLY IN SPRING.
2. ALSO SUPPLIES DOMESTIC WATER FOR TWO HOUSES.
3. LARGE AREA OF SEEPS, DISCHARGE IS TOTAL.
4. ABOUT 500 GPM TO WASATCH STATE PARK FOR IRRIGATION AND DOMESTIC USE.
5. ABOUT 700 GPM USED FOR IRRIGATION.
6. ''HOT POT''.
7. THERMAL SPRING.
8. REPORTED DISCHARGE IS MEAN FOR 1966-67.
9. DISCHARGE GIVEN IS REPORTED AVERAGE.

# Table 5.—Chemical analyses of selected water samples

(SAMPLES COLLECTED PRIOR TO 1958 ARE REPORTED BY CONNOR, MITCHELL, AND OTHERS, 1958)

LOCATION. SEE TEXT FOR WELL- AND SPRING-NUMBERING SYSTEM.

AQUIFER. 0A, UNCONSOLIDATED VALLEY FILL; 0L, TERTIARY VOLCANIC ROCKS; 4V, TWIN CREEK LIMESTONE; 4W, NUGGET SANDSTONE; 5E, ANKAREH FORMATION; 5T, THAYNES FORMATION; 8J, MISSIPPIAN LIMESTONE; 9Z, WEBER QUARTZITE.

SODIUM AND POTASSIUM. AN ENTRY OF C FOR POTASSIUM INDICATES THAT SODIUM AND POTASSIUM ARE CALCULATED AND REPORTED AS SODIUM.

AGENCY MAKING ANALYSIS. BR, U.S. BUREAU OF RECLAMATION; GS, U.S. GEOLOGICAL SURVEY; PH, UTAH STATE DEPARTMENT OF PUBLIC HEALTH; SL, SALT LAKE CITY CORPORATION.

| | | | | MILLIGRAMS PER LITER | | | | | | | | | | | | | | | DISSOLVED SOLIDS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LOCATION | AQUIFER | DATE OF COLLECTION | TEMPERATURE (°C) | SILICA ($SIO_2$) | IRON (FE) | CALCIUM (CA) | MAGNESIUM (MG) | SODIUM (NA) | POTASSIUM (K) | BICARBONATE ($HCO_3$) | CARBONATE ($CO_3$) | SULFATE ($SO_4$) | CHLORIDE (CL) | FLUORIDE (F) | NITRATE ($NO_3$) | BORON (B) | CA,MG HARDNESS (AS $CACO_3$) | NONCARBONATE HARDNESS | DETERMINED | CALCULATED | SPECIFIC CONDUCTANCE (MICROMHOS PER CM AT 25°C) | SAR | PH | AGENCY MAKING ANALYSIS |
| SUMMIT COUNTY -- GROUND WATER | | | | | | | | | | | | | | | | | | | | | | | | |
| WELLS | | | | | | | | | | | | | | | | | | | | | | | | |
| (D- 1- 3)10AAB 1 | 4V | 12-19-66 | | 19 | .00 | 72 | 26 | 36 | 2.0 | 320 | | 65 | 38 | .8 | .7 | .13 | 266 | 24 | 428 | | 645 | .9 | 7.7 | PH |
| (D- 1- 3)12CBD 1 | 5E | 10-13-66 | | 12 | .53 | 79 | 20 | 28 | 2.0 | 305 | | 62 | 22 | .5 | .2 | .22 | 280 | 30 | 392 | | 625 | .7 | 7.4 | PH |
| (D- 1- 4)16DCA 1 | 0L | 5-24-63 | | 32 | .07 | 52 | 16 | 22 | 2.4 | 185 | | 15 | 43 | .2 | 3.9 | .13 | 195 | 43 | 315 | | 443 | .7 | 7.8 | PH |
| (D- 1- 4)17BBB 1 | 4V | 1- 2-63 | | 12 | .09 | 54 | 19 | 12 | 1.5 | 203 | | 46 | 13 | .2 | 9.1 | .09 | 214 | 48 | 276 | | 450 | .4 | 8. | PH |
| (D- 1- 4)19BCA 1 | 0A | 5-24-63 | | 9.0 | .03 | 84 | 12 | 17 | .8 | 270 | | 25 | 30 | .1 | 1.1 | .11 | 261 | 40 | 338 | | 520 | .4 | 7.8 | PH |
| (D- 1- 4)31AAC 1 | 4W | 5- 9-68 | 9 | 17 | | 26 | 9.7 | 6.8 | .4 | 125 | 0 | 4.5 | 7.1 | .1 | 2.4 | .00 | 105 | 2 | 141 | 135 | 227 | .3 | 7.0 | GS |
| (D- 1- 5)14DCA 1 | 4W | 11-16-66 | 10 | 18 | | 69 | 27 | 17 | C | 280 | 0 | 62 | 17 | | 1.0 | | 262 | 52 | 356 | 349 | 568 | .4 | 7.7 | GS |
| (D- 1- 6)28BCC 1 | 0A | 5- 9-68 | 13 | 5.5 | | 57 | 11 | 2.0 | .5 | 210 | 0 | 13 | 3.9 | .2 | .7 | .00 | 188 | 16 | 205 | 197 | 352 | .1 | 7.4 | GS |
| (D- 2- 4) 4DCC 1 | 0A | 5- 9-68 | 8 | 12 | | 111 | 30 | 7.9 | 1.9 | 216 | 0 | 209 | 15 | .2 | 7.7 | .01 | 398 | 221 | 527 | 501 | 742 | .2 | 7.4 | GS |
| (D- 2- 6)18ADD 1 | 0A | 5- 9-68 | 10 | 40 | | 53 | 14 | 21 | 2.9 | 242 | 0 | 14 | 13 | .3 | 3.8 | .02 | 190 | 0 | 289 | 281 | 439 | .7 | 7.2 | GS |
| SPRINGS | | | | | | | | | | | | | | | | | | | | | | | | |
| 1/(A- 1- 5)30CC S | | 2-15-51 | | 46 | | 77 | 9.5 | 22 | C | 254 | | 3.5 | 45 | .2 | 3.8 | | 233 | 25 | 322 | | | .6 | | PH |
| (D- 1- 3)11CCCS 1 | 5T | 5-28-63 | | 6.3 | | 55 | 14 | 3.8 | .6 | 204 | 1 | 14 | 10 | .1 | .0 | .00 | 195 | 28 | 218 | | 348 | .1 | 8. | PH |
| 1/(D- 1- 5)13A S | | 9-20-50 | | 18 | | 58 | 26 | 15 | C | 306 | | 22 | 7.3 | .2 | .5 | | 251 | 0 | 308 | | | .4 | | PH |
| 1/(D- 1- 6)16 S | | 2-21-51 | | 9.3 | | 30 | 12 | 13 | C | 171 | | 7.0 | 4.3 | .2 | .5 | | 124 | 16 | 186 | | | .5 | | PH |
| (D- 2- 4) 4DCAS 1 | 4W | 9-13-67 | 8 | 14 | | 109 | 23 | 5.8 | 1.0 | 212 | | 190 | 10 | .3 | 2.1 | .02 | 368 | 194 | 479 | | 688 | .1 | 7.4 | GS |
| (D- 2- 4) 8 S | | 3- 9-51 | | 10 | | 64 | 12 | 9.8 | C | 181 | | 71 | 3.6 | .3 | 1.3 | | 207 | 58 | 256 | | | .3 | | PH |
| 1/(D- 2- 4) 9CBBS 1 | 0A | 6-19-63 | | 8.5 | | 40 | 15 | .5 | .5 | 162 | 1 | 15 | 10 | .1 | .4 | .12 | 162 | 29 | 170 | | 282 | | 6.0 | PH |
| (D- 2- 6)26BBDS 1 | 9Z | 11-14-62 | 12 | | | | | .7 | C | 278 | | 7.0 | 4.5 | | 1.4 | | 241 | 13 | 236 | | 448 | | 7.3 | GS |
| (D- 3- 6) 3 S | | 2-21-51 | | 25 | | 14 | 8.1 | 12 | C | 103 | | 3.7 | 4.8 | .1 | .5 | | 69 | 15 | 104 | | | .3 | | PH |
| 1/(D- 3- 7)17 S | | 6- 7-40 | | 8.2 | | 55 | 12 | 11 | C | 229 | | 6.8 | 12 | .1 | | | 187 | 0 | 261 | | | .3 | | PH |
| TUNNELS | | | | | | | | | | | | | | | | | | | | | | | | |
| SPIRO TUNNEL | | 8-15-67 | 8 | 15 | | 116 | 47 | 5.4 | 1.7 | 168 | | 344 | 4.2 | .4 | .1 | .02 | 484 | 346 | 691 | | 870 | .1 | 7.4 | GS |
| (D-2-4)28 UNNAMED TUNNEL | | 11- 4-46 | | 21 | | 87 | 30 | 5.5 | 2.3 | 143 | | 219 | 4.0 | .4 | .1 | | 340 | 222 | 472 | | 647 | .1 | | GS |
| ONTARIO DRAIN TUNNEL | | 8-15-67 | 9 | 19 | | 91 | 14 | 5.8 | 1.0 | 130 | | 162 | 9.9 | .6 | .1 | .04 | 284 | 177 | 405 | | 548 | .1 | 7.3 | GS |
| SUMMIT COUNTY -- SURFACE WATER | | | | | | | | | | | | | | | | | | | | | | | | |
| WEBER RIVER NEAR OAKLEY | | 10-31-52 | | | | 42 | 11 | 6.4 | .4 | 197 | | 12 | 3.1 | | | | 150 | 12 | 183 | | 318 | .2 | | BR |
| DO | | 2-11-54 | | 5.9 | | 46 | 13 | 2.3 | .4 | 187 | | 17 | 2.1 | .1 | .1 | | 168 | 15 | 178 | | 319 | .1 | | GS |
| WEBER-PROVO CANAL | | 2-11-54 | | 14 | | 44 | 12 | 4.6 | 1.9 | 188 | | 12 | 4.1 | .3 | .1 | | 159 | 5 | 186 | | 322 | | | GS |
| WEBER RIVER NEAR PEOA | | 8- 0-38 | | 12 | | 43 | 5.7 | 2.5 | .5 | 179 | | 19 | 2.0 | | | | 130 | 17 | 167 | | | .1 | | SL |
| CRANDALL CREEK | | 10-26-56 | | | | 78 | 14 | 13 | 2.0 | 286 | | 29 | 13 | .2 | | | 252 | 17 | 309 | | 508 | .4 | | BR |
| SILVER CREEK | | 4- 5-35 | | 18 | | 86 | 28 | 5.2 | 3.0 | 173 | | 194 | 6.6 | | | | 331 | 189 | 445 | | | .1 | | SL |
| 2/EAST CANYON CREEK | | 8- 8-51 | | 13 | | 72 | 16 | 13 | 2.6 | 261 | | 34 | 16 | .2 | 2.0 | | 246 | 32 | 296 | | 502 | .4 | | GS |

## Wasatch County—Ground Water

| | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WELLS | | | | | | | | | | | | | | | | | | | | | | | | |
| (D- 2- 5) 6CDB 1 | OL | 5-17-67 | 9 | 39 | 3/34 | 81 | 19 | 30 | 2.9 | 246 | 0 | 29 | 85 | .4 | 2.4 | .2 | 282 | 80 | 459 | 444 | 688 | .8 | 7.9 | GS |
| (D- 2- 5)31ADA 1 | OA | 5-17-67 | 8 | 20 | | 144 | 25 | 20 | 3.1 | 188 | 0 | 224 | 84 | .9 | 15 | .0 | 464 | 310 | 727 | 628 | 951 | .4 | 7.6 | GS |
| (D- 2- 5)32BBC 2 | OL | 6- 8-50 | | 22 | .10 | 130 | 24 | 15 | C | 245 | | 139 | 60 | .0 | 31 | | 425 | 224 | 632 | | | .3 | | PH |
| (D- 3- 4)26DBA 1 | OA | 5-17-67 | 12 | 17 | | 118 | 34 | 37 | 7.0 | 314 | 0 | 219 | 34 | 1.1 | 3.6 | .16 | 434 | 177 | 661 | 625 | 951 | .6 | 8.0 | GS |
| (D- 3- 4)35DAB 1 | OA | 5-17-67 | 15 | 19 | | 220 | 54 | 66 | 15 | 500 | 0 | 424 | 62 | 2.2 | 1.3 | .36 | 770 | 360 | 1.160 | 1.110 | 1.530 | 1.0 | 7.8 | GS |
| (D- 3- 5) 6BAB 2 | OA | 8-15-67 | 16 | 14 | | 42 | 9.7 | 4.4 | 1.5 | 128 | 0 | 44 | 5.2 | .3 | .1 | .03 | 144 | 39 | 187 | 184 | 303 | .2 | 7.1 | GS |
| (D- 3- 5)19ADD 1 | OA | 5-17-67 | 13 | 43 | | 48 | 13 | 13 | 3.2 | 200 | 0 | 26 | 6.2 | .4 | 1.4 | .02 | 172 | 8 | 265 | 252 | 373 | .4 | 7.9 | GS |
| (D- 4- 4)13CBA 1 | OA | 8-17-67 | 13 | 12 | | 56 | 18 | 4.7 | .3 | 232 | 0 | 18 | 7.3 | .2 | 5.4 | .00 | 212 | 22 | 229 | 236 | 405 | .1 | 7.5 | GS |
| (D- 4- 5) 5CCC 1 | OA | 5-20-66 | | 30 | .06 | 52 | 10 | 7.0 | 1.0 | 182 | | 16 | 11 | .2 | 12 | .05 | 170 | 21 | 234 | | 370 | .2 | 7.5 | PH |
| (D- 4- 5) 7AAC 1 | OA | 7-30-63 | | 24 | .08 | 59 | 10 | 6.4 | 2.2 | 209 | | 13 | 10 | .1 | 8.6 | .07 | 190 | 19 | 268 | | 367 | .2 | 7.25 | PH |
| (D- 4- 5) 7ADA 1 | OA | 8-17-67 | 12 | 29 | | 75 | 17 | 8.2 | .8 | 292 | 0 | 17 | 7.8 | .2 | 5.9 | .00 | 256 | 17 | 302 | 305 | 497 | .2 | 7.5 | GS |
| (D- 4- 5)14AAC 1 | OA | 8-17-67 | 16 | 43 | | 89 | 26 | 31 | 1.7 | 376 | 0 | 38 | 35 | .5 | 4.0 | .05 | 324 | 16 | 446 | 451 | 705 | .7 | 7.9 | GS |
| SPRINGS | | | | | | | | | | | | | | | | | | | | | | | | |
| (D- 2- 5) 5CCDS 1 | OL | 9-13-67 | 14 | 52 | | 40 | 11 | 15 | 4.6 | 164 | 0 | 8.8 | 28 | .2 | .9 | .04 | 144 | 10 | 249 | 242 | 347 | .5 | 7.7 | GS |
| (D- 2- 5)29CADS 1 | OL | 9-13-67 | 14 | 33 | | 198 | 50 | 33 | .7 | 228 | 0 | 512 | 32 | .7 | .3 | .03 | 700 | 513 | 1.020 | 972 | 1.250 | .5 | 7.7 | GS |
| (D- 3- 4)21BBBS 1 | RJ | 7-29-63 | | 13 | | 97 | 30 | 24 | 2.1 | 359 | | 96 | 17 | .2 | .0 | .16 | 365 | 71 | 488 | | 760 | .5 | 7.9 | PH |
| (D- 3- 4)21DCDS 1 | 7V | 9-12-68 | | 7.0 | | 61 | 30 | 7.3 | 1.1 | 292 | 0 | 39 | 7.0 | .6 | 2.0 | .03 | 275 | 36 | 290 | 299 | 522 | .2 | 7.3 | GS |
| (D- 3- 4)26CCAS 1 | (4/) | 9-28-66 | 39 | 23 | | 331 | 68 | 114 | 25 | 674 | 0 | 661 | 108 | 2.2 | .1 | .67 | 1.110 | 553 | 1.730 | 1.670 | 2.200 | 1.5 | 7.3 | GS |
| (D- 3- 4)27AAAS 1 | (4/) | 9-13-67 | 45 | 27 | | 345 | 83 | 148 | 16 | 644 | 0 | 742 | 132 | 2.5 | .4 | .64 | 1.200 | 672 | 1.910 | 1.810 | 2.410 | 1.9 | 7.5 | GS |
| (D- 3- 4)27BADS 1 | (4/) | 9-28-66 | 39 | 28 | | 389 | 73 | 151 | 31 | 728 | 0 | 820 | 138 | 2.5 | .1 | .79 | 1.270 | 673 | 2.040 | 1.990 | 2.560 | 1.8 | 7.3 | GS |
| (D- 3- 4)27BADS 1 | (4/) | 5-16-67 | 40 | 28 | | 361 | 88 | 152 | 32 | 696 | 0 | 853 | 140 | 3.1 | .0 | .83 | 1.260 | 689 | 2.060 | 2.000 | 2.490 | 1.9 | 7.8 | GS |
| (D- 3- 4)27CBDS 1 | (4/) | 9-28-66 | 29 | 21 | | 353 | 72 | 125 | 28 | 716 | 0 | 702 | 115 | 2.1 | .1 | .70 | 1.180 | 589 | 1.940 | 1.770 | 2.330 | 1.6 | 7.4 | GS |
| (D- 3- 4)27CBDS 1 | (4/) | 5-16-67 | 29 | 22 | | 228 | 95 | 130 | 28 | 476 | 0 | 719 | 115 | 2.3 | .1 | .71 | 960 | 570 | 1.650 | 1.570 | 2.280 | 1.8 | 7.8 | GS |
| (D- 3- 4)27CBDS 1 | (4/) | 5-23-67 | 30 | | | | | | | | | | | | | | 0 | 0 | | | 2.280 | | | GS |
| (D- 3- 4)27CBDS 2 | (4/) | 9-28-66 | 29 | 19 | | 329 | 70 | 111 | 25 | 686 | 0 | 643 | 103 | 2.2 | .1 | .64 | 1.110 | 545 | 1.710 | 1.640 | 2.180 | 1.4 | 7.7 | GS |
| (D- 3- 4)27CBDS 2 | (4/) | 5-15-67 | 32 | 17 | | 279 | 74 | 114 | 26 | 572 | 0 | 611 | 105 | 2.4 | .0 | .64 | 1.000 | 531 | 1.630 | 1.510 | 2.120 | 1.6 | 7.9 | GS |
| (D- 3- 4)27CBDS 3 | (4/) | 5-16-67 | 28 | 21 | | 329 | 88 | 163 | 33 | 584 | 0 | 805 | 150 | 2.7 | .0 | .80 | 1.180 | 701 | 1.980 | 1.880 | 2.610 | 2.1 | 7.7 | GS |
| (D- 4- 4) 2CBBS 1 | OA | 12- 7-62 | 14 | | | | | 36 | C | 348 | | 223 | 30 | | 2.6 | | 464 | 199 | 682 | | 994 | .7 | 7.7 | GS |
| (D- 4- 5) 4AABS 1 | 4V | 3- 3-48 | | 25 | | 49 | 12 | 5.0 | C | 185 | | 10 | 11 | .3 | .0 | | 170 | 18 | 215 | | | .2 | | PH |
| (D- 5- 5)17ABCS 1 | OA | 5-13-41 | 5/13 | 13 | | 65 | 18 | 13 | C | 246 | | 41 | 14 | .0 | | | 238 | 36 | 298 | | | .4 | | PH |
| (D- 5- 5)28DCDS 1 | OA | 5-13-41 | 5/11 | 9.2 | | 43 | 18 | 8.8 | C | 210 | | 16 | 8.0 | .1 | | | 182 | 0 | 217 | | | | | PH |
| WASATCH COUNTY -- SURFACE WATER | | | | | | | | | | | | | | | | | | | | | | | | |
| PROVO RIVER NEAR HEBER | | 10-19-55 | | 22 | | 57 | 13 | 5.2 | | 140 | | 85 | 6 | | .2 | | 196 | 81 | | 257 | 401 | .2 | | GS |
| SNAKE CREEK | | 4-27-49 | | 14 | | 94 | 26 | 23 | C | 282 | | 124 | 21 | | 1.5 | | 342 | 111 | | 442 | 698 | .5 | | GS |
| DANIEL'S CREEK | | 5-14-47 | | | | 16 | 4.0 | 5.5 | C | 70 | | 8.2 | 1 | | 1.5 | | 56 | 0 | | 71 | 123 | .3 | | GS |
| ROUND VALLEY CREEK | | 4-27-49 | | 11 | | 37 | 7.9 | 6.2 | C | 140 | | 13 | 6 | | 2.5 | | 125 | 10 | | 153 | 252 | .2 | | GS |
| LITTLE HOBBLE CREEK | | 11- 9-56 | | | | 70 | 26 | 17 | 2.3 | 306 | | 24 | 21 | | | | 282 | 31 | 346 | | 581 | .4 | | BR |
| DEER CREEK RESERVOIR | | 9- 6-51 | | 17 | | 42 | 8 | 8 | C | 146 | | 84 | 6 | | | | 137 | 17 | 255 | | | .3 | | SL |
| SURFACE | | 9- 7-56 | | 8.1 | | 49 | 11 | 9.0 | 1.9 | 162 | | 48 | 7.8 | .1 | 1.3 | | 168 | 35 | 215 | | 375 | .3 | | GS |
| DEPTH 80 FEET | | 9- 7-56 | | 9.1 | | 42 | 9.2 | 6.2 | 2.1 | 136 | | 40 | 6.2 | | 1.8 | | 144 | 32 | 180 | | 301 | .2 | | GS |
| AT THE OUTLET | | 2- 2-56 | | 16 | | 64 | 17 | 15 | 3.6 | 195 | | 72 | 16 | .7 | 1.6 | | 230 | 70 | 304 | | 490 | .4 | | GS |

1. LOCATION IS REPORTED AND UNCERTAIN. SPRING IS NOT LISTED ON TABLE 4 OR SHOWN ON PLATE 1.
2. SAMPLING SITE IS OUTSIDE THE STUDY AREA AND NOT SHOWN ON PLATE 1.
3. IN SOLUTION AT TIME OF ANALYSIS.
4. THERMAL SPRING -- WATER-BEARING FORMATION IS TUFA DEPOSITS SURROUNDING THE SPRINGS, BUT WATER RISES FROM AN UNIDENTIFIED SOURCE AT DEPTH.
5. TEMPERATURE MEASURED 5-16-68.

# Table 6.—Drillers' logs of selected wells and test holes

Altitudes are in feet above mean sea level for land surface at well; determined for interpolation from topographic maps.
Thickness in feet.
Depth in feet below the land surface.
Stratigraphy by Claud H. Baker, Jr.

| Material | Thickness | Depth |
|---|---|---|
| SUMMIT COUNTY | | |
| (A-1-4)33dbb-1. Log by Intermountain Drilling Corp., 1965. Alt. 6,980 ft. | | |
| Topsoil | 7 | 7 |
| Sandstone [Nugget Sandstone] | 11 | 18 |
| Limestone, hard | 3 | 21 |
| Sandstone | 22 | 43 |
| Cemented rocks | 122 | 165 |
| Silt [siltstone(?)] | 45 | 210 |
| Sand [sandstone(?)] | 25 | 235 |
| Silt and sand (siltstone and sandstone) | 110 | 345 |
| Reddish hardpan [Chinle Formation(?)] | 19 | 364 |
| (A-1-15)20abc-1. Log by J. H. Peterson, 1962. Alt. 5,910 ft. | | |
| Surface soil | 6 | 6 |
| Boulders | 17 | 23 |
| Clay and gravel, gray | 10 | 33 |
| Clay, gray, hard | 16 | 49 |
| Clay, blue and gray, with some limestone [Twin Creek Limestone] | 6 | 55 |
| Clay, blue and gray, hard | 27 | 82 |
| Limestone, broken | 33 | 115 |
| (D-1-3)10aab-1. Log by J. G. Lee, 1966. Alt. 6,640 ft. | | |
| Boulders and clay | 79 | 79 |
| Conglomerate | 91 | 170 |
| Limestone [Twin Creek Limestone] | 25 | 195 |
| Shale | 16 | 211 |
| Limestone | 35 | 246 |
| Shale with streaks of limestone | 146 | 392 |
| Conglomerate [fractured limestone(?)] | 44 | 436 |
| Shale | 5 | 441 |
| (D-1-3)10cdb-1. Log by J. G. Lee, 1964. Alt. 6,650 ft. | | |
| Topsoil | 1 | 1 |
| Boulders | 49 | 50 |
| Limestone [Twin Creek Limestone] | 133 | 183 |
| Shale and limestone | 217 | 400 |
| (D-1-3)13adb-1. Log by Intermountain Drilling Corp., 1965. Alt. 6,330 ft. | | |
| Clay and cobbles | 5 | 5 |
| Clay and sand | 10 | 15 |
| Sand | 10 | 25 |
| (D-1-3)13adb-1 - continued | | |
| Clay and gravel, red [Chinle Formation(?)] | 6 | 31 |
| Clay, red | 49 | 80 |
| Gravel | 10 | 90 |
| Clay, red | 23 | 113 |
| Gravel | 1 | 114 |
| Clay, red | 104 | 218 |
| Gravel | 7 | 225 |
| Clay, red | 25 | 250 |
| (D-1-4)10cbd-1. Log by E. C. Osborne, 1963. Alt. 6,580 ft. | | |
| Soil | 5 | 5 |
| Sand and gravel | 9 | 14 |
| Clay and silt | 67 | 81 |
| Silt, sand, and gravel | 13 | 94 |
| Andesite, red and gray [Tertiary rocks] | 144 | 238 |
| (D-1-4)16aad-1. Log by J. S. Lee, 1964. Alt. 6,440 ft. | | |
| Topsoil | 3 | 3 |
| Clay, brown | 9 | 12 |
| Sand, fine | 1 | 13 |
| Clay, gray | 37 | 50 |
| Clay, sandy and gravelly, brown [weathered Tertiary volcanic rocks(?)] | 112 | 162 |
| Clay, red, sticky | 29 | 191 |
| Clay and gravel | 19 | 210 |
| Clay, red, sticky | 10 | 220 |
| Clay and gravel, red | 30 | 250 |
| Clay, brown, sticky | 15 | 265 |
| Clay and gravel | 15 | 280 |
| Clay, red and brown | 10 | 290 |
| Clay and gravel | 10 | 300 |
| Clay, red, sticky | 8 | 308 |
| Boulders and gravel, hard | 3 | 311 |
| Clay, red, sticky | 9 | 320 |
| Clay and gravel, brown | 14 | 334 |
| Gravel, some clay | 6 | 340 |
| Clay, brown, sticky | 8 | 348 |
| Hard rock | 7 | 355 |
| Clay and gravel, brown, sticky | 13 | 368 |
| Clay, red | 22 | 390 |
| Clay, brown | 10 | 400 |
| Conglomerate [Knight Conglomerate] | 40 | 440 |
| Clay, brown | 10 | 450 |
| Conglomerate | 14 | 464 |
| Conglomerate, sandy | 204 | 668 |
| (D-1-4)17bbb-1. Log by M. A. Gale, 1950. Alt. 6,620 ft. | | |
| Topsoil | 2 | 2 |
| Clay and gravel, red | 25 | 27 |
| Clay and shale gravel, cream colored | 7 | 34 |
| Shale, limy; and limestone [Twin Creek Limestone] | 41 | 75 |
| Sandstone | 1 | 76 |
| Limy shale, as above | 51 | 127 |
| (D-1-4)21aaa-1. Log by J. G. Lee, 1964. Alt. 6,580 ft. | | |
| Topsoil | 12 | 12 |
| Andesite [Tertiary volcanic rocks] | 211 | 223 |
| Quartzite and red shale | 37 | 260 |
| Andesite | 27 | 287 |
| Porphyry | 197 | 484 |
| Shale, red [Woodside Shale] | 7 | 491 |
| Shale, blue | 2 | 493 |
| Shale, red | 61 | 554 |
| (D-2-4)2cbd-1. Log by E. C. Osborne, 1964. Alt. 6,640 ft. | | |
| Soil | 3 | 3 |
| Clay | 16 | 19 |
| Andesite [Tertiary volcanic rocks] | 40 | 59 |
| Clay, moist | 6 | 65 |
| Andesite, red | 82 | 147 |
| Andesite, gray | 63 | 210 |
| Shale, red [Ankareh Formation] | 6 | 216 |
| Sandstone, gray | 4 | 220 |
| (D-2-6)19abc-1. Log by J. H. Turner, 1947. Alt. 6,410 ft. | | |
| Old well [alluvial fill] | 29 | 29 |
| Clay, yellow | 6 | 35 |
| Sand, brown | 3 | 38 |
| Sandstone, gray; water bearing [Weber Quartzite] | 29 | 67 |
| (D-2-6)19bcc-1. Log by Lester Binning, 1964. Alt. 6,460 ft. | | |
| Clay | 10 | 10 |
| Clay and sand | 15 | 25 |
| Sand | 5 | 30 |
| Clay and gravel, hard | 10 | 40 |
| Porphyry [Tertiary volcanic rocks] | 35 | 75 |
| Porphyry and clay | 35 | 110 |
| WASATCH COUNTY | | |
| (D-2-5)20bcb-1. Log by A. Lyons, 1944. Alt. 6,080 ft. | | |
| Andesite, light gray to yellow [Tertiary volcanic rocks] | 90 | 90 |
| Altered andesite, with serpentine and chlorite | 10 | 100 |
| Clay, blue, sticky; altered andesite; water | 40 | 140 |
| (D-2-5)32bad-1. Log by T. J. Burkhart and J. S. Lee, 1943. Alt. 5,965 ft. | | |
| Surface fill | 36 | 36 |
| Boulders and gravel | 10 | 46 |
| Andesite lava [Tertiary volcanic rocks] | 150 | 196 |
| Shale [Ankareh Formation(?)] | 10 | 206 |
| (D-2-5)32bbc-2. Log by J. H. Peterson, 1950. Alt. 5,850 ft. | | |
| Surface fill | 16 | 16 |
| (D-2-5)32bbc-2 - continued | | |
| Gravel, boulders, and clay | 29 | 45 |
| Porphyry [Tertiary volcanic rocks] | 100 | 145 |
| Quartz | 5 | 150 |
| (D-3-4)35dab-1. Log by J. G. Lee, 1960. Alt. 5,530 ft. | | |
| Topsoil | 5 | 5 |
| "Volcanic ash and cinders" [tufa] | 65 | 70 |
| Gravel | 16 | 86 |
| Limestone [tufa] | 6 | 92 |
| Sand and gravel | 2 | 94 |

# Table 7.—Water levels in selected observation wells

(D-1-4)31ADB-1. UNUSED DUG WELL IN ALLUVIUM.AUTOMATIC WATER LEVEL RECORDER INSTALLED OCTOBER 28, 1966. MEASUREMENTS ARE NOON LEVELS FROM RECORDER CHARTS.
HIGHEST WATER LEVEL 1.18 BELOW LSD, JUNE 13, 1968,
DRY, WATER LEVEL NOT MEASUREABLE, JAN. 10, 1967.
RECORDS AVAILABLE 1966-68.

| DATE | WATER LEVEL | DATE | WATER LEVEL | DATE | WATER LEVEL | DATE | WATER LEVEL |
|---|---|---|---|---|---|---|---|
| OCT. 28, 1966 | 19.69 | JULY 5, 1967 | 1.53 | FEB. 1, 1968 | 19.80 | JUNE 13, 1968 | 1.18 |
| NOV. 14 | 19.97 | JULY 19 | 4.89 | MAR. 12 | 18.73 | JULY 8 | 2.45 |
| DEC. 15 | 19.62 | AUG. 21 | 7.63 | APR. 9 | 6.40 | JULY 16 | 4.31 |
| JAN. 10, 1967 | D | SEP. 28 | 12.27 | APR. 14 | 5.70 | AUG. 13 | 11.76 |
| MAR. 20 | 18.95 | OCT. 5 | 15.38 | APR. 21 | 4.99 | AUG. 20 | 11.08 |
| APR. 1 | 8.60 | OCT. 20 | 14.45 | APR. 28 | 4.56 | AUG. 27 | 12.03 |
| APR. 20 | 3.83 | NOV. 7 | 13.69 | MAY 5 | 5.24 | SEP. 2 | 14.62 |
| MAY 14 | 5.15 | JAN. 9, 1968 | 19.82 | MAY 12 | 3.22 | SEP. 12 | 20.29 |
| JUNE 27 | 1.88 | JAN. 20 | 20.25 | MAY 19 | 3.09 | | |

(D-1-6)19DAD-1. UNUSED DUG WELL IN ALLUVIUM.
HIGHEST WATER LEVEL 1.87 BELOW LSD, JUNE 22, 1939,
LOWEST WATER LEVEL 18.30 BELOW LSD, APR. 3, 1953.
RECORDS AVAILABLE 1938-60, 1962-66.

| DATE | WATER LEVEL | DATE | WATER LEVEL | DATE | WATER LEVEL | DATE | WATER LEVEL |
|---|---|---|---|---|---|---|---|
| MAR. 21, 1960 | 10.28 | MAR. 6, 1963 | 13.16 | DEC. 10, 1964 | 14.68 | SEP. 13, 1966 | 14.98 |
| NOV. 31 | 15.60 | AUG. 30 | 3.10 | MAR. 8, 1965 | 17.66 | OCT. 12 | 15.15 |
| JAN. 12, 1962 | 13.01 | DEC. 7 | 12.64 | OCT. 18 | 9.20 | NOV. 14 | 15.03 |
| MAR. 8 | 12.53 | MAR. 4, 1964 | 11.92 | DEC. 13 | 12.89 | DEC. 15 | 15.37 |
| DEC. 18 | 13.41 | OCT. 20 | 10.08 | MAR. 16, 1966 | 15.34 | | |

(D-2-6)5DBB-1. UNUSED DUG WELL IN ALLUVIUM.
HIGHEST WATER LEVEL 2.28 BELOW LSD, JUNE 4, 1941,
DRY, WATER LEVEL NOT MEASUREABLE, FEB. 1, 1968, MAY 8, 1968.
RECORDS AVAILABLE 1938-62, 1964.

| DATE | WATER LEVEL | DATE | WATER LEVEL | DATE | WATER LEVEL | DATE | WATER LEVEL |
|---|---|---|---|---|---|---|---|
| MAR. 21, 1960 | 7.80 | MAR. 8, 1965 | 7.21 | JAN. 10, 1967 | 7.34 | OCT. 11, 1967 | 6.91 |
| NOV. 30 | 7.43 | JULY 27 | 3.38 | MAR. 20 | 7.41 | NOV. 9 | 7.08 |
| MAR. 21, 1961 | 7.55 | OCT. 18 | 5.11 | APR. 12 | 6.85 | FEB. 1, 1968 | 7D4 |
| JAN. 12, 1962 | 7.3 J | DEC. 13 | 6.28 | MAY 17 | 6.14 | MAY 8 | 7D4 |
| MAR. 8 | 7.3 J | MAR. 16, 1966 | 6.62 | JUNE 12 | 4.20 | JUNE 6 | 4.63 |
| DEC. 18 | 7.05 | SEP. 13 | 6.83 | JULY 19 | 3.13 | JULY 16 | 4.80 |
| MAR. 4, 1964 | 5.9 J | OCT. 12 | 6.87 | AUG. 21 | 4.76 | AUG. 13 | 4.06 |
| OCT. 20 | 4.99 | NOV. 14 | 7.02 | SEP. 28 | 5.93 | SEP. 12 | 4.17 |
| DEC. 10 | 6.93 | DEC. 15 | 7.11 | | | | |

(D-2-6)20CCC-1. UNUSED DUG WELL IN ALLUVIUM.
HIGHEST WATER LEVEL 2.20 BELOW LSD, JUNE 14, 1941,
LOWEST WATER LEVEL 6.86 BELOW LSD, AUG. 20, 1940.
RECORDS AVAILABLE 1938-68.

| DATE | WATER LEVEL | DATE | WATER LEVEL | DATE | WATER LEVEL | DATE | WATER LEVEL |
|---|---|---|---|---|---|---|---|
| MAR. 21, 1960 | 3.71 | OCT. 20, 1964 | 4.41 | DEC. 15, 1966 | 3.97 | OCT. 11, 1967 | 3.92 |
| NOV. 30 | 4.04 | DEC. 10 | 3.93 | JAN. 10, 1967 | 4.03 | NOV. 9 | 3.91 |
| MAR. 21, 1961 | 3.66 | MAR. 8, 1965 | 4.08 | MAR. 20 | 4.14 | FEB. 1, 1968 | 4.16 |
| JAN. 12, 1962 | 3.91 | JULY 27 | 3.97 | APR. 15 | 3.65 | MAR. 12 | 4.02 |
| MAR. 8 | 4.27 | OCT. 18 | 3.87 | MAY 17 | 2.63 | MAY 8 | 4.33 |
| DEC. 18 | 3.91 | DEC. 13 | 3.71 | JUNE 12 | 3.10 | JUNE 6 | 3.99 |
| MAR. 6, 1963 | 3.93 | MAR. 16, 1966 | 2.45 | JULY 19 | 3.98 | JULY 16 | 4.97 |
| AUG. 30 | 2.89 | SEP. 13 | 3.71 | AUG. 21 | 3.65 | AUG. 13 | 4.10 |
| DEC. 9 | 3.80 | OCT. 12 | 3.83 | SEP. 28 | 3.87 | SEP. 12 | 4.54 |
| MAR. 4, 1964 | 4.28 | NOV. 14 | 3.90 | | | | |

## Table 7.—continued

(D-2-6)28CCC-2. UNUSED DUG WELL IN ALLUVIUM.
HIGHEST WATER LEVEL 6.58 BELOW LSD, JULY 1, 1967,
LOWEST WATER LEVEL 28.39 BELOW LSD, FEB. 1, 1968.
RECORDS AVAILABLE 1966-68.

| DATE | WATER LEVEL | DATE | WATER LEVEL | DATE | WATER LEVEL | DATE | WATER LEVEL |
|---|---|---|---|---|---|---|---|
| OCT. 24, 1966 | 22.59 | MAY 15, 1967 | 25.41 | DEC. 1, 1967 | 24.17 | JUNE 19, 1968 | 10.52 |
| NOV. 1 | 23.21 | JUNE 1 | 18.00 | DEC. 15 | 26.03 | JUNE 26 | 19.99 |
| NOV. 15 | 24.67 | JUNE 15 | 13.04 | JAN. 1, 1968 | 25.75 | JULY 3 | 10.22 |
| DEC. 15 | 25.20 | JULY 1 | 6.58 | FEB. 1 | 28.39 | JULY 10 | 10.55 |
| JAN. 10, 1967 | 26.51 | JULY 12 | 9.49 | MAR. 12 | 24.02 | JULY 17 | 8.65 |
| FEB. 1 | 26.79 | AUG. 1 | 10.40 | APR. 1 | 22.31 | JULY 24 | 7.74 |
| FEB. 15 | 27.10 | AUG. 21 | 13.24 | APR. 9 | 22.39 | JULY 31 | 8.81 |
| MAR. 1 | 27.17 | SEP. 1 | 10.48 | APR. 21 | 25.99 | AUG. 13 | 7.86 |
| MAR. 15 | 24.21 | OCT. 1 | 13.20 | MAY 5 | 24.91 | AUG. 20 | 8.62 |
| APR. 1 | 24.37 | OCT. 15 | 19.83 | MAY 19 | 19.31 | AUG. 27 | 11.02 |
| APR. 15 | 24.27 | NOV. 1 | 22.20 | JUNE 2 | 12.99 | SEP. 3 | 13.08 |
| MAY 1 | 25.58 | NOV. 15 | 23.32 | JUNE 12 | 9.74 | SEP. 12 | 12.27 |

(D-2-6)34BCC-1. UNUSED DRILLED WELL IN ALLUVIUM.
HIGHEST WATER LEVEL 2.25 BELOW LSD, AUG. 30, 1963,
DRY, WATER LEVEL NOT MEASUREABLE, MAR. 20, 1967, APR. 12, 1967, FEB. 1, 1968, MAR. 14, 1968,
MAY 8, 1968.
RECORDS AVAILABLE 1963-68.

| DATE | WATER LEVEL | DATE | WATER LEVEL | DATE | WATER LEVEL | DATE | WATER LEVEL |
|---|---|---|---|---|---|---|---|
| AUG. 30, 1963 | 2.25 | SEP. 13, 1966 | 22.17 | MAY 17, 1967 | 33.42 | FEB. 1, 1968 | 34D2 |
| OCT. 20, 1964 | 23.44 | OCT. 12 | 25.17 | JUNE 12 | 18.23 | MAR. 14 | 34D2 |
| DEC. 10 | 29.81 | NOV. 14 | 29.83 | JULY 19 | 14.59 | MAY 8 | 34D2 |
| MAR. 8, 1965 | 32.34 | DEC. 15 | 31.30 | AUG. 21 | 19.19 | JUNE 6 | 14.99 |
| JULY 27 | 4.34 | JAN. 10, 1967 | 33.19 | SEP. 28 | 23.65 | JULY 16 | 18.73 |
| OCT. 18 | 23.33 | MAR. 20 | 34D2 | OCT. 11 | 27.18 | AUG. 13 | 10.17 |
| DEC. 13 | 25.01 | APR. 12 | 34D2 | NOV. 9 | 29.94 | SEP. 12 | 6.50 |
| MAR. 16, 1966 | 33.60 | | | | | | |

(D-2-5)20CCA-1. UNUSED DUG WELL IN ALLUVIUM.
HIGHEST WATER LEVEL 20.70 BELOW LSD, APR. 17, 1952,
LOWEST WATER LEVEL 29.00 BELOW LSD, NOV. 7, 1949, DEC. 16, 1952.
RECORDS AVAILABLE 1936-68.

| DATE | WATER LEVEL | DATE | WATER LEVEL | DATE | WATER LEVEL | DATE | WATER LEVEL |
|---|---|---|---|---|---|---|---|
| MAR. 21, 1960 | 26.04 | OCT. 20, 1964 | 26.07 | DEC. 15, 1966 | 25.17 | OCT. 11, 1967 | 25.23 |
| NOV. 30 | 27.70 | DEC. 10 | 26.13 | JAN. 10, 1967 | 25.21 | NOV. 9 | 25.26 |
| MAR. 21, 1961 | 26.29 | MAR. 8, 1965 | 25.49 | MAR. 20 | 24.73 | FEB. 1, 1968 | 25.81 |
| JAN. 12, 1962 | 25.85 | OCT. 18 | 25.90 | APR. 12 | 24.39 | MAR. 12 | 24.66 |
| MAR. 8 | 24.99 | DEC. 13 | 25.59 | MAY 17 | 24.02 | MAY 8 | 24.98 |
| DEC. 18 | 26.82 | MAR. 16, 1966 | 23.55 | JUNE 12 | 24.17 | JUNE 6 | 25.33 |
| MAR. 6, 1963 | 26.17 | SEP. 13 | 24.88 | JULY 19 | 24.31 | JULY 16 | 25.50 |
| AUG. 30 | 25.80 | OCT. 12 | 25.02 | AUG. 21 | 24.29 | AUG. 13 | 24.78 |
| DEC. 9 | 26.50 | NOV. 14 | 25.11 | SEP. 28 | 24.57 | SEP. 12 | 24.90 |
| MAR. 4, 1964 | 26.18 | | | | | | |

Table 7.—continued

(D-2-5)32BAD-1. UNUSED DRILLED WELL IN TERTIARY VOLCANIC ROCKS. AUTOMATIC WATER-LEVEL RECORDER INSTALLED SEPTEMBER 29, 1966. MEASUREMENTS ARE NOON LEVELS FROM RECORDER CHARTS.
HIGHEST WATER LEVEL 28.45 BELOW LSD, JUNE 5, 1968,
LOWEST WATER LEVEL 35.41 BELOW LSD, FEB. 18, 1968.
RECORDS AVAILABLE 1966-68.

| DATE | WATER LEVEL | DATE | WATER LEVEL | DATE | WATER LEVEL | DATE | WATER LEVEL |
|---|---|---|---|---|---|---|---|
| SEP. 22, 1966 | 33.00 | MAR. 19, 1967 | 31.27 | AUG. 27, 1967 | 31.45 | MAR. 24, 1968 | 32.50 |
| OCT. 2 | 32.33 | MAR. 26 | 31.70 | SEP. 3 | 31.71 | MAR. 31 | 33.10 |
| OCT. 9 | 32.50 | APR. 2 | 31.88 | SEP. 10 | 30.92 | APR. 7 | 31.92 |
| OCT. 16 | 33.32 | APR. 9 | 32.07 | SEP. 17 | 32.34 | APR. 14 | 32.03 |
| OCT. 23 | 34.29 | APR. 16 | 32.40 | OCT. 1 | 32.52 | APR. 21 | 32.07 |
| OCT. 30 | 34.61 | APR. 23 | 32.50 | OCT. 8 | 31.48 | APR. 28 | 32.35 |
| NOV. 6 | 34.76 | APR. 30 | 32.61 | OCT. 15 | 32.92 | MAY 5 | 29.79 |
| NOV. 13 | 34.43 | MAY 7 | 31.87 | OCT. 22 | 34.17 | MAY 12 | 30.24 |
| NOV. 20 | 34.83 | MAY 14 | 31.23 | OCT. 29 | 35.15 | MAY 19 | 30.44 |
| NOV. 27 | 34.96 | MAY 21 | 30.06 | NOV. 9 | 30.20 | MAY 26 | 29.76 |
| DEC. 4 | 34.35 | MAY 28 | 30.25 | NOV. 12 | 30.93 | JUNE 2 | 29.25 |
| DEC. 5 | 33.23 | JUNE 4 | 31.47 | NOV. 19 | 32.23 | JUNE 5 | 28.45 |
| DEC. 18 | 33.51 | JUNE 11 | 30.92 | NOV. 26 | 32.94 | JUNE 9 | 29.60 |
| DEC. 25 | 34.36 | JUNE 18 | 30.30 | DEC. 3 | 33.54 | JUNE 16 | 30.56 |
| JAN. 1, 1967 | 34.99 | JUNE 25 | 30.37 | DEC. 9 | 33.74 | JUNE 23 | 30.31 |
| JAN. 8 | 35.24 | JULY 2 | 30.02 | FEB. 4, 1968 | 35.19 | JULY 16 | 29.06 |
| JAN. 15 | 35.27 | JULY 9 | 29.42 | FEB. 11 | 35.31 | JULY 23 | 28.91 |
| JAN. 22 | 35.07 | JULY 16 | 31.39 | FEB. 18 | 35.41 | JULY 30 | 29.05 |
| JAN. 29 | 34.62 | JULY 23 | 31.32 | FEB. 25 | 33.57 | AUG. 6 | 30.03 |
| FEB. 5 | 33.98 | JULY 30 | 32.13 | MAR. 3 | 32.51 | AUG. 13 | 29.96 |
| FEB. 26 | 34.21 | AUG. 6 | 32.14 | MAR. 12 | 31.88 | AUG. 20 | 29.83 |
| MAR. 5 | 33.11 | AUG. 21 | 30.81 | MAR. 17 | 31.78 | SEP. 12 | 31.43 |
| MAR. 12 | 31.92 | | | | | | |

(D-2-5)32BBC-1. UNUSED DUG WELL IN ALLUVIUM.AUTOMATIC WATER LEVEL RECORDER INSTALLED OCTOBER 10, 1966. MEASUREMENTS ARE NOON LEVELS FROM RECORDER CHARTS.
HIGHEST WATER LEVEL 4.19 BELOW LSD, AUG. 11, 1968,
DRY, WATER LEVEL NOT MEASURABLE, FEB. 17, 1967, JAN. 9, 1968.
RECORDS AVAILABLE 1966-68.

| DATE | WATER LEVEL | DATE | WATER LEVEL | DATE | WATER LEVEL | DATE | WATER LEVEL |
|---|---|---|---|---|---|---|---|
| AUG. 17, 1966 | 11.13 | APR. 9, 1967 | 11.98 | AUG. 27, 1967 | 9.60 | JUNE 11, 1968 | 8.59 |
| SEP. 13 | 6.89 | APR. 16 | 12.98 | SEP. 3 | 6.39 | JUNE 16 | 6.25 |
| OCT. 10 | 10.40 | APR. 23 | 15.04 | SEP. 10 | 6.86 | JUNE 23 | 4.70 |
| OCT. 17 | 14.74 | APR. 30 | 16.92 | SEP. 17 | 8.61 | JUNE 30 | 6.08 |
| OCT. 23 | 17.03 | MAY 7 | 17.45 | SEP. 24 | 7.92 | JULY 7 | 5.62 |
| OCT. 30 | 17.77 | MAY 14 | 16.82 | OCT. 1 | 13.50 | JULY 14 | 6.60 |
| NOV. 6 | 16.68 | MAY 28 | 7.60 | OCT. 8 | 8.56 | JULY 21 | 9.31 |
| NOV. 13 | 18.40 | JUNE 5 | 7.48 | OCT. 15 | 12.74 | JULY 28 | 4.78 |
| NOV. 20 | 18.92 | JUNE 13 | 6.31 | OCT. 22 | 15.44 | AUG. 4 | 9.58 |
| JAN. 15, 1967 | 19.30 | JULY 16 | 8.38 | OCT. 29 | 16.40 | AUG. 11 | 4.19 |
| FEB. 17 | D | JULY 23 | 7.25 | NOV. 5 | 18.22 | AUG. 18 | 9.23 |
| MAR. 20 | 11.49 | AUG. 6 | 4.37 | JAN. 9, 1968 | 1907 | AUG. 25 | 10.50 |
| MAR. 26 | 11.75 | AUG. 13 | 8.22 | MAR. 12 | 16.28 | SEP. 12 | 4.95 |
| APR. 2 | 11.66 | AUG. 20 | 7.85 | MAY 8 | 5.13 | | |

(D-3-4)25DCC-1. BORED OBSERVATION HOLE IN ALLUVIUM. MEASUREMENTS BEFORE 1966 BY U. S. BUREAU OF RECLAMATION.
HIGHEST WATER LEVEL 1.01 BELOW LSD, JUNE 12, 1967,
LOWEST WATER LEVEL 3.70 BELOW LSD, AUG. 1, 1961, JAN. 25, 1962.
RECORDS AVAILABLE 1961-63, 1966-68.

| DATE | WATER LEVEL | DATE | WATER LEVEL | DATE | WATER LEVEL | DATE | WATER LEVEL |
|---|---|---|---|---|---|---|---|
| AUG. 1, 1961 | 3.7 | MAY 11, 1962 | 2.3 | NOV. 26, 1962 | 3.1 | JUNE 12, 1967 | 1.01 |
| AUG. 23 | 3.6 | MAY 31 | 2.2 | JAN. 7, 1963 | 3.6 | JULY 19 | 2.23 |
| SEP. 14 | 3.1 | JUNE 18 | 2.0 | FEB. 6 | 3.0 | AUG. 21 | 2.64 |
| OCT. 19 | 2.5 | JULY 3 | 2.1 | MAR. 4 | 2.7 | SEP. 28 | 2.59 |
| NOV. 24 | 2.6 | JULY 19 | 2.5 | APR. 1 | 2.8 | OCT. 11 | 2.66 |
| DEC. 29 | 3.5 | JULY 31 | 2.6 | JULY 28, 1966 | 2.93 | MAY 8, 1968 | 1.50 |
| JAN. 25, 1962 | 3.7 | AUG. 9 | 2.1 | SEP. 13 | 2.89 | JUNE 6 | 1.98 |
| FEB. 26 | 3.1 | AUG. 24 | 2.4 | OCT. 12 | 2.97 | JULY 16 | 2.07 |
| MAR. 29 | 2.3 | SEP. 7 | 3.0 | NOV. 14 | 3.17 | AUG. 13 | 1.08 |
| APR. 24 | 3.2 | OCT. 16 | 3.1 | MAY 17, 1967 | 2.87 | SEP. 12 | 1.37 |

## Table 7.—continued

(D-3-4)35ABC-1. UNUSED DUG WELL IN ALLUVIUM.
HIGHEST WATER LEVEL 0.74 BELOW LSD, SEP. 12, 1968,
LOWEST WATER LEVEL 4.51 BELOW LSD, DEC. 9, 1963.
RECORDS AVAILABLE 1938-68.

| DATE | WATER LEVEL | DATE | WATER LEVEL | DATE | WATER LEVEL | DATE | WATER LEVEL |
|---|---|---|---|---|---|---|---|
| MAR. 21, 1960 | 1.23 | MAR. 4, 1964 | 3.97 | NOV. 14, 1966 | 2.06 | NOV. 9, 1967 | 3.41 |
| NOV. 30 | 4.28 | OCT. 20 | 3.68 | MAR. 20, 1967 | 3.39 | MAR. 12, 1968 | 0.94 |
| MAR. 21, 1961 | 1.18 | DEC. 10 | 4.00 | APR. 12 | 3.13 | APR. 12 | 3.13 |
| JAN. 12, 1962 | 3.14 | MAR. 8, 1965 | 3.11 | MAY 17 | 2.27 | MAY 8 | 1.46 |
| MAR. 8 | 2.14 | OCT. 18 | 1.69 | JUNE 12 | 1.09 | JUNE 6 | 1.19 |
| DEC. 18 | 3.52 | DEC. 13 | 2.09 | JULY 19 | 1.53 | JULY 16 | 1.21 |
| MAR. 6, 1963 | 2.48 | MAR. 16, 1966 | 2.27 | AUG. 21 | 3.13 | AUG. 13 | 1.18 |
| AUG. 30 | 3.04 | SEP. 13 | 2.27 | SEP. 28 | 2.13 | SEP. 12 | 0.74 |
| DEC. 9 | 4.51 | OCT. 12 | 1.83 | OCT. 11 | 2.82 |  |  |

(D-3-5)6BAB-1. UNUSED DRILLED WELL IN ALLUVIUM.
HIGHEST WATER LEVEL 1.62 BELOW LSD, JUNE 6, 1968,
LOWEST WATER LEVEL 7.74 BELOW LSD, FEB. 1, 1968.
RECORDS AVAILABLE 1966-68.

| DATE | WATER LEVEL | DATE | WATER LEVEL | DATE | WATER LEVEL | DATE | WATER LEVEL |
|---|---|---|---|---|---|---|---|
| JULY 28, 1966 | 7.33D | MAR. 20, 1967 | 6.41D | SEP. 28, 1967 | 7.10D | MAY 8, 1968 | 3.80 |
| SEP. 13 | 6.37D | APR. 20 | 5.12D | OCT. 11 | 7.23D | JUNE 6 | 1.62 |
| OCT. 12 | 7.18D | MAY 17 | 3.19D | NOV. 9 | 7.13D | JULY 16 | 4.63 |
| NOV. 14 | 7.73D | JUNE 12 | 5.23D | FEB. 1, 1968 | 7.74D | AUG. 13 | 3.51 |
| DEC. 15 | 7.47D | JULY 19 | 6.87D | MAR. 12 | 6.27 | SEP. 12 | 6.21 |
| JAN. 10, 1967 | 7.53D | AUG. 21 | 6.54D |  |  |  |  |

(D-3-5)7CDC-1. UNUSED DRILLED WELL IN ALLUVIUM.
HIGHEST WATER LEVEL 3.17 BELOW LSD, JUNE 6, 1968,
LOWEST WATER LEVEL 23.89 BELOW LSD, MAR. 20, 1967.
RECORDS AVAILABLE 1966-68.

| DATE | WATER LEVEL | DATE | WATER LEVEL | DATE | WATER LEVEL | DATE | WATER LEVEL |
|---|---|---|---|---|---|---|---|
| SEP. 13, 1966 | 6.23 | APR. 20, 1967 | 20.19 | SEP. 28, 1967 | 10.03 | MAY 8, 1968 | 4.93 |
| OCT. 12 | 12.18 | MAY 17 | 7.48 | OCT. 11 | 19.08 | JUNE 6 | 3.17 |
| NOV. 14 | 17.44 | JUNE 12 | 5.55 | NOV. 9 | 18.17 | JULY 16 | 5.18 |
| DEC. 15 | 18.79 | JULY 19 | 6.19 | FEB. 1, 1968 | 19.93 | AUG. 13 | 4.67 |
| JAN. 10, 1967 | 19.63 | AUG. 21 | 8.84 | MAR. 12 | 20.69 | SEP. 12 | 6.68 |
| MAR. 20 | 23.89 |  |  |  |  |  |  |

(D-3-5)29CAC-1 UNUSED DUG WELL IN ALLUVIUM.
HIGHEST WATER LEVEL 0.61 BELOW LSD, JULY 24, 1942,
LOWEST WATER LEVEL 10.92 BELOW LSD, MAR. 9, 1942.
RECORDS AVAILABLE 19 .

| DATE | WATER LEVEL | DATE | WATER LEVEL | DATE | WATER LEVEL | DATE | WATER LEVEL |
|---|---|---|---|---|---|---|---|
| MAR. 21, 1960 | 9.71 | OCT. 20, 1964 | 5.19 | DEC. 15, 1966 | 8.67 | NOV. 9, 1967 | 8.23 |
| NOV. 30 | 7.10 | DEC. 10 | 7.00 | JAN. 10, 1967 | 8.84 | FEB. 1, 1968 | 9.74 |
| MAR. 21, 1961 | 8.62 | MAR. 8, 1965 | 9.74 | MAR. 20 | 9.83 | MAR. 12 | 10.11 |
| JAN. 12, 1962 | 10.41 | JULY 27 | 1.21 | APR. 12 | 9.07 | APR. 12 | 9.07 |
| MAR. 8 | 8.48 | OCT. 18 | 5.30 | MAY 17 | 7.16 | MAY 8 | 5.90 |
| DEC. 18 | 8.16 | DEC. 13 | 1.89 | JUNE 12 | 4.02 | JUNE 6 | 2.68 |
| MAR. 6, 1963 | 10.79 | MAR. 16, 1966 | 4.67 | JULY 19 | 7.13 | JULY 16 | 1.57 |
| AUG. 30 | 3.49 | SEP. 16 | 2.72 | AUG. 21 | 3.14 | AUG. 13 | 2.01 |
| DEC. 9 | 7.59 | OCT. 12 | 7.83 | SEP. 28 | 4.27 | SEP. 12 | 2.79 |
| MAR. 4, 1964 | 10.60 | NOV. 16 | 8.18 | OCT. 11 | 4.93 |  |  |

## Table 7.—continued

(D-3-5)32ACC-1. BORED OBSERVATION HOLE IN ALLUVIUM. MEASUREMENTS BEFORE 1966 BY U. S. BUREAU OF RECLAMATION.
HIGHEST WATER LEVEL 10.17 BELOW LSD, MAY 17, 1967,
DRY, WATER LEVEL NOT MEASUREABLE, NOV. 24, 1961, JAN. 25, 1962, FEB. 23, 1962, MAR. 29, 1962, APR. 24, 1962, FEB. 6, 1963, MAR. 4, 1963, APR. 2, 1963, MAR. 20, 1967, MAY 8, 1968.
RECORDS AVAILABLE 1961-63, 1966-68.

| DATE | WATER LEVEL | DATE | WATER LEVEL | DATE | WATER LEVEL | DATE | WATER LEVEL |
|---|---|---|---|---|---|---|---|
| AUG. 3, 1961 | 23.7 | MAY 29, 1962 | 18.9 | FEB. 6, 1963 | 24D8 | JULY 19, 1967 | 12.04 |
| AUG. 23 | 24.2 | JUNE 18 | 15.7 | MAR. 4 | 24D8 | AUG. 21 | 16.68 |
| SEP. 14 | 22.8 | JUNE 29 | 15.0 | APR. 2 | 24D8 | SEP. 28 | 18.85 |
| OCT. 19 | 21.3 | JULY 18 | 14.1 | JULY 20, 1966 | 13.91 | OCT. 11 | 21.19 |
| NOV. 24 | 24D8 | JULY 30 | 14.7 | SEP. 13 | 19.81 | NOV. 19 | 23.43 |
| DEC. 29 | 24.7 | AUG. 9 | 13.9 | OCT. 12 | 20.03 | MAR. 12, 1968 | 24.34 |
| JAN. 25, 1962 | 24D8 | AUG. 23 | 15.1 | NOV. 14 | 21.17 | MAY 8 | 24D8 |
| FEB. 23 | 24D8 | SEP. 6 | 16.6 | MAR. 20, 1967 | 24D8 | JUNE 6 | 16.59 |
| MAR. 29 | 24D8 | OCT. 4 | 20.1 | APR. 20 | 18.65 | JULY 16 | 13.17 |
| APR. 24 | 24D8 | NOV. 26 | 23.6 | MAY 17 | 10.17 | AUG. 13 | 11.24 |
| MAY 10 | 24.5 | JAN. 4, 1963 | 24.7 | JUNE 12 | 11.28 | SEP. 12 | 15.35 |

(D-4-4)11DCD-1. UNUSED DUG WELL IN ALLUVIUM.AUTOMATIC WATER LEVEL RECORDER INSTALLED OCTOBER 10, 1966. MEASUREMENTS ARE NOON LEVELS FROM RECORDER CHARTS.
HIGHEST WATER LEVEL 4.72 BELOW LSD, JULY 19, 1967,
LOWEST WATER LEVEL 23.22 BELOW LSD, APR. 23, 1967.
RECORDS AVAILABLE 19 .

| DATE | WATER LEVEL | DATE | WATER LEVEL | DATE | WATER LEVEL | DATE | WATER LEVEL |
|---|---|---|---|---|---|---|---|
| AUG. 10, 1966 | 17.28 | JAN. 15, 1967 | 21.81 | MAY 14, 1967 | 16.47 | NOV. 19, 1967 | 16.45 |
| SEP. 13 | 17.45 | JAN. 22 | 21.97 | MAY 21 | 13.26 | NOV. 26 | 16.83 |
| OCT. 10 | 17.34 | JAN. 29 | 22.09 | MAY 25 | 11.85 | DEC. 3 | 17.10 |
| OCT. 23 | 18.33 | FEB. 5 | 22.20 | JULY 19 | 4.72 | FEB. 1, 1968 | 20.45 |
| OCT. 30 | 17.99 | FEB. 19 | 22.51 | AUG. 2 | 4.99 | FEB. 11 | 20.91 |
| NOV. 6 | 17.91 | FEB. 26 | 22.70 | AUG. 6 | 5.68 | FEB. 18 | 21.22 |
| NOV. 13 | 18.17 | MAR. 5 | 22.78 | AUG. 13 | 5.55 | FEB. 25 | 21.35 |
| NOV. 20 | 18.50 | MAR. 12 | 21.92 | AUG. 21 | 5.95 | MAR. 12 | 21.46 |
| NOV. 27 | 18.87 | MAR. 19 | 22.07 | SEP. 30 | 15.69 | MAR. 18 | 19.61 |
| DEC. 4 | 19.22 | MAR. 26 | 22.50 | OCT. 8 | 16.53 | MAY 10 | 20.06 |
| DEC. 11 | 19.59 | APR. 2 | 22.80 | OCT. 15 | 18.13 | JUNE 12 | 6.44 |
| DEC. 18 | 20.21 | APR. 9 | 23.05 | OCT. 22 | 18.57 | JULY 16 | 8.48 |
| DEC. 25 | 20.88 | APR. 16 | 23.15 | OCT. 29 | 16.60 | AUG. 13 | 7.16 |
| JAN. 1, 1967 | 21.31 | APR. 23 | 23.22 | NOV. 9 | 15.38 | SEP. 12 | 6.23 |
| JAN. 8 | 21.62 | APR. 30 | 22.49 |  |  |  |  |

(D-4-4)23BCC-1. UNUSED DUG WELL IN ALLUVIUM.AUTOMATIC WATER LEVEL RECORDER INSTALLED MAY 16, 1967. MEASUREMENTS ARE NOON LEVELS FROM RECORDER CHARTS.
HIGHEST WATER LEVEL 0.02 BELOW LSD, JULY 2, 1967,
LOWEST WATER LEVEL 18.21 BELOW LSD, MAR. 20, 1967.
RECORDS AVAILABLE 1966-68.

| DATE | WATER LEVEL | DATE | WATER LEVEL | DATE | WATER LEVEL | DATE | WATER LEVEL |
|---|---|---|---|---|---|---|---|
| DEC. 10, 1960 / | 12.87 | APR. 10, 1968 | 13.33 | JUNE 19, 1968 | 1.28 | JULY 24, 1968 | 2.42 |
| DEC. 17, 1967 | 13.19 | APR. 21 | 13.54 | JUNE 26 | 2.25 | JULY 31 | 4.07 |
| DEC. 24 | 13.44 | APR. 28 | 13.69 | JULY 3 | 2.16 | AUG. 7 | 3.09 |
| DEC. 30 | 13.65 | MAY 8 | 11.62 | JULY 10 | 3.30 | AUG. 13 | 4.89 |
| FEB. 1, 1968 | 12.35 | MAY 16 | 11.04 | JULY 17 | 1.97 | SEP. 12 | 7.90 |
| MAR. 12 | 12.14 | JUNE 12 | 0.88 |  |  |  |  |

## Table 7.—continued

(D-4-5)4AAC-1. DUG DOMESTIC WELL IN TWIN CREEK LIMESTONE.
HIGHEST WATER LEVEL 19.64 BELOW LSD, DEC. 15, 1966,
LOWEST WATER LEVEL 39.27 BELOW LSD, MAY 17, 1967.
RECORDS AVAILABLE 1966-68.

| DATE | WATER LEVEL | DATE | WATER LEVEL | DATE | WATER LEVEL | DATE | WATER LEVEL |
|---|---|---|---|---|---|---|---|
| AUG. 2, 1966 | 24.91B | MAR. 20, 1967 | 34.14B | SEP. 28, 1967 | 38.44B | MAY 8, 1968 | 30.37B |
| SEP. 13 | 30.42B | APR. 20 | 36.53B | OCT. 11 | 36.69B | JUNE 6 | 30.16 |
| OCT. 12 | 26.17B | MAY 17 | 39.27B | NOV. 9 | 38.17B | JULY 16 | 31.18B |
| NOV. 14 | 37.28B | JUNE 12 | 24.14B | FEB. 1, 1968 | 39.23B | AUG. 13 | 30.06 |
| DEC. 15 | 19.64B | JULY 19 | 29.83B | MAR. 12 | 37.41B | SEP. 12 | 32.28B |
| JAN. 10, 1967 | 21.20B | AUG. 21 | 27.16B | | | | |

(D-4-5)4DDD-1. DRILLED DOMESTIC WELL IN ALLUVIUM.
HIGHEST WATER LEVEL 15.68 BELOW LSD, SEP. 13, 1966,
LOWEST WATER LEVEL 45.64 BELOW LSD, MAR. 4, 1964.
RECORDS AVAILABLE 1964-68.

| DATE | WATER LEVEL | DATE | WATER LEVEL | DATE | WATER LEVEL | DATE | WATER LEVEL |
|---|---|---|---|---|---|---|---|
| MAR. 21, 1960 | 36.44 | OCT. 20, 1964 | 24.13 | JAN. 10, 1967 | 38.76 | NOV. 9, 1967 | 29.81 |
| NOV. 30 | 29.84 | DEC. 10 | 35.31 | MAR. 20 | 42.12B | FEB. 1, 1968 | 39.94B |
| MAR. 21, 1961 | 40.37 | MAR. 8, 1965 | 40.79 | APR. 12 | 34.10 | MAR. 12 | 37.42 |
| JAN. 12, 1962 | 45.45 | OCT. 18 | 20.38 | MAY 17 | 35.86 | APR. 12 | 34.10 |
| MAR. 8 | 45.10 | DEC. 13 | 28.37 | JUNE 12 | 43.23B | MAY 8 | 24.63A |
| DEC. 18 | 45.26 | MAR. 16, 1966 | 39.24 | JULY 19 | 45.54A | JUNE 6 | 21.27 |
| MAR. 6, 1963 | 41.47 | SEP. 13 | 15.68B | AUG. 21 | 38.82 | JULY 16 | 33.27A |
| AUG. 30 | 19.60 | OCT. 12 | 27.27 | SEP. 28 | 28.84 | AUG. 13 | 31.17B |
| DEC. 9 | 32.06 | NOV. 14 | 43.18A | OCT. 11 | 37.20B | SEP. 12 | 34.31A |
| MAR. 4, 1964 | 45.64 | DEC. 15 | 36.42 | | | | |

(D-4-5)16BBA-1. BORED OBSERVATION HOLE IN ALLUVIUM. MEASUREMENTS BEFORE 1966 BY U. S. BUREAU OF RECLAMATION.
HIGHEST WATER LEVEL 1.00 BELOW LSD, JULY 2, 1962,
LOWEST WATER LEVEL 9.70 BELOW LSD, APR. 1, 1963.
RECORDS AVAILABLE 1961-63, 1966-68.

| DATE | WATER LEVEL | DATE | WATER LEVEL | DATE | WATER LEVEL | DATE | WATER LEVEL |
|---|---|---|---|---|---|---|---|
| AUG. 2, 1961 | 9.0 | JUNE 18, 1962 | 1.7 | APR. 1, 1963 | 9.7 | AUG. 21, 1967 | 3.63 |
| AUG. 24 | 9.0 | JULY 2 | 1.0 | JULY 29, 1966 | 3.42 | SEP. 28 | 4.18 |
| SEP. 27 | 8.6 | JULY 19 | 1.8 | SEP. 13 | 5.54 | OCT. 11 | 5.65 |
| OCT. 19 | 8.6 | JULY 31 | 1.3 | OCT. 12 | 6.17 | NOV. 9 | 6.83 |
| NOV. 24 | 9.4 | AUG. 9 | 1.6 | NOV. 14 | 6.84 | FEB. 1, 1968 | 6.97 |
| DEC. 29 | 9.4 | AUG. 24 | 2.5 | DEC. 15 | 6.92 | MAR. 12 | 6.94 |
| JAN. 25, 1962 | 9.4 | SEP. 7 | 2.7 | JAN. 10, 1967 | 7.01 | MAY 8 | 6.69 |
| FEB. 23 | 4.3 | OCT. 16 | 4.4 | MAR. 20 | 6.97 | JUNE 6 | 1.76 |
| MAR. 29 | 8.2 | NOV. 26 | 7.2 | APR. 20 | 6.14 | JULY 16 | 2.24 |
| APR. 24 | 9.2 | JAN. 7, 1963 | 8.5 | MAY 17 | 5.60 | AUG. 13 | 1.13 |
| MAY 11 | 3.2 | FEB. 6 | 9.3 | JUNE 12 | 1.10 | SEP. 12 | 1.47 |
| MAY 31 | 1.7 | MAR. 4 | 9.5 | JULY 19 | 2.17 | | |

# PUBLICATIONS OF THE UTAH DEPARTMENT OF NATURAL RESOURCES, DIVISION OF WATER RIGHTS

(*)—Out of Print

## TECHNICAL PUBLICATIONS

No. 1. Underground leakage from artesian wells in the Flowell area, near Fillmore, Utah, by Penn Livingston and G. B. Maxey, U. S. Geological Survey, 1944.

No. 2. The Ogden Valley artesian reservoir, Weber County, Utah, by H. E. Thomas, U. S. Geological Survey, 1945.

*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.

*No. 5. Ground water in the East Shore area, Utah: Part I, Bountiful District, Davis County, Utah, by H. E. Thomas and W. B. Nelson, U. S. Geological Survey, in Utah State Eng. 26th Bienn. Rept., p. 53-206, pls. 1-2, 1948.

*No. 6. Ground water in the Escalante Valley, Beaver, Iron, and Washington Counties, Utah, by P. F. Fix, W. B. Nelson, B. E. Lofgren, and R. G. Butler, U. S. Geological Survey, in Utah State Eng. 27th Bienn. Rept., p. 107-210, pls. 1-10, 1950.

No. 7. Status of development of selected ground-water basins in Utah, by H. E. Thomas, W. B. Nelson, B. E. Lofgren, and R. G. Butler, U. S. Geological Survey, 1952.

*No. 8. Consumptive use of water and irrigation requirements of crops in Utah, by C. O. Roskelly and Wayne D. Criddle, 1952.

No. 8. (Revised) Consumptive use and water requirements for Utah, by W. D. Criddle, K. Harris, and L. S. Willardson, 1962.

No. 9. Progress report on selected ground water basins in Utah, by H. A. Waite, W. B. Nelson, and others, U. S. Geological Survey, 1954.

No. 10. A compilation of chemical quality data for ground and surface waters in Utah, by J. G. Connor, C. G. Mitchell, and others, U. S. Geological Survey, 1958.

No. 11. Ground water in northern Utah Valley, Utah: A progress report for the period 1948-63, by R. M. Cordova and Seymour Subitzky, U. S. Geological Survey, 1965.

No. 12. Reevaluation of the ground-water resources of Tooele Valley, Utah, by Joseph S. Gates, U. S. Geological Survey, 1965.

*No. 13. Ground-water resources of selected basins in southwestern Utah, by G. W. Sandberg, U. S. Geological Survey, 1966.

No. 14. Water-resources appraisal of the Snake Valley area, Utah and Nevada, by J. W. Hood and F. E. Rush, U. S. Geological Survey, 1966.

No. 15. Water from bedrock in the Colorado Plateau of Utah, by R. D. Feltis, U. S. Geological Survey, 1966.

No. 16. Ground-water conditions in Cedar Valley, Utah County, Utah, by R. D. Feltis, U. S. Geological Survey, 1967.

No. 17. Ground-water resources of northern Juab Valley, Utah, by L. J. Bjorklund, U. S. Geological Survey, 1968.

No. 18. Hydrologic reconnaissance of Skull Valley, Tooele County, Utah, by J. W. Hood and K. M. Waddell, U. S. Geological Survey, 1968.

No. 19. An appraisal of the quality of surface water in the Sevier Lake basin, Utah, by D. C. Hahl and J. C. Mundorff, U. S. Geological Survey, 1968.

No. 20. Extensions of streamflow records in Utah, by J. K. Reid, L. E. Carroon, and G. E. Pyper, U. S. Geological Survey, 1969.

No. 21. Summary of maximum discharges in Utah streams, by G. L. Whitaker, U. S. Geological Survey, 1969.

No. 22. Reconnaissance of the ground-water resources of the upper Fremont River valley, Wayne County, Utah, by L. J. Bjorklund, U. S. Geological Survey, 1969.

No. 23. Hydrologic reconnaissance of Rush Valley, Tooele County, Utah, by J. W. Hood, Don Price, and K. M. Waddell, U. S. Geological Survey, 1969.

No. 24. Hydrologic reconnaissance of Deep Creek valley, Tooele and Juab Counties, Utah, and Elko and White Pine Counties, Nevada, by J. W. Hood and K. M. Waddell, U. S. Geological Survey, 1969.

No. 25. Hydrologic reconnaissance of Curlew Valley, Utah and Idaho, by E. L. Bolke and Don Price, U. S. Geological Survey, 1969.

No. 26. Hydrologic reconnaissance of the Sink Valley area, Tooele and Box Elder Counties, Utah, by Don Price and E. L. Bolke, U. S. Geological Survey, 1969.

## WATER CIRCULAR

No. 1. Ground water in the Jordan Valley, Salt Lake County, Utah, by Ted Arnow, U. S. Geological Survey, 1965.

No. 2. Ground water in Tooele Valley, Utah, by J. S. Gates and O. A. Keller, U. S. Geological Survey, 1970.

## BASIC-DATA REPORTS

No. 1. Records and water-level measurements of selected wells and chemical analyses of ground water, East Shore area, Davis, Weber, and Box Elder Counties, Utah, by R. E. Smith, U. S. Geological Survey, 1961.

No. 2. Records of selected wells and springs, selected drillers' logs of wells, and chemical analyses of ground and surface waters, northern Utah Valley, Utah County, Utah, by Seymour Subitzky, U. S. Geological Survey, 1962.

No. 3. Ground-water data, central Sevier Valley, parts of Sanpete, Sevier, and Piute Counties, Utah, by C. H. Carpenter and R. A. Young, U. S. Geological Survey, 1963.

No. 4. Selected hydrologic data, Jordan Valley, Salt Lake County, Utah, by I. W. Marine and Don Price, U. S. Geological Survey, 1963.

No. 5. Selected hydrologic data, Pavant Valley, Millard County, Utah, by R. W. Mower U. S. Geological Survey, 1963.

*No. 6. Ground-water data, parts of Washington, Iron, Beaver, and Millard Counties, Utah, by G. W. Sandberg, U. S. Geological Survey, 1963.

No. 7. Selected hydrologic data, Tooele Valley, Tooele County, Utah, by J. S. Gates, U. S. Geological Survey, 1963.

No. 8. Selected hydrologic data, upper Sevier River basin, Utah, by C. H. Carpenter, G. B. Robinson, Jr., and L. J. Bjorklund, U. S. Geological Survey, 1964.

No. 9. Ground-water data, Sevier Desert, Utah, by R. W. Mower and R. D. Feltis. U. S. Geological Survey, 1964.

No. 10. Quality of surface water in the Sevier Lake basin, Utah, by D. C. Hahl and R. E. Cabell, U. S. Geological Survey, 1965.

No. 11. Hydrologic and climatologic data, collected through 1964, Salt Lake County, Utah by W. V. Iorns, R. W. Mower, and C. A. Horr, U. S. Geological Survey, 1966.

No. 12. Hydrologic and climatologic data, 1965, Salt Lake County, Utah, by W. V. Iorns, R. W. Mower, and C. A. Horr, U. S. Geological Survey, 1966.

No. 13. Hydrologic and climatologic data, 1966, Salt Lake County, Utah, by A. G. Hely, R. W. Mower, and C. A. Horr, U. S. Geological Survey, 1967.

No. 14. Selected hydrologic data, San Pitch River drainage basin, Utah, by G. B. Robinson, Jr., U. S. Geological Survey, 1968.

No. 15. Hydrologic and climatologic data, 1967, Salt Lake County, Utah, by A. G. Hely, R. W. Mower, and C. A. Horr, U. S. Geological Survey, 1968.

No. 16. Selected hydrologic data, southern Utah and Goshen Valleys, Utah, by R. M. Cordova, U. S. Geological Survey, 1969.

No. 17. Hydrologic and climatologic data, 1968, Salt Lake County, Utah, by A. G. Hely, R. W. Mower, and C. A. Horr, U. S. Geological Survey, 1969.

No. 18. Quality of surface water in the Bear River basin, Utah, Wyoming, and Idaho, by K. M. Waddell, U. S. Geological Survey, 1970.

No. 19. Daily water-temperature records for Utah streams, 1944-68, by G. L. Whitaker, U. S. Geological Survey, 1970.

## INFORMATION BULLETINS

*No. 1. Plan of work for the Sevier River Basin (Sec. 6, P. L. 566), U. S. Department of Agriculture, 1960.

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

No. 3. Ground-water areas and well logs, central Sevier Valley, Utah, by R. A. Young, U. S. Geological Survey, 1960.

*No. 4. Ground-water investigations in Utah in 1960 and reports published by the U. S. Geological Survey or the Utah State Engineer prior to 1960, by H. D. Goode, U. S. Geological Survey, 1960.

No. 5. Developing ground water in the central Sevier Valley, Utah, by R. A. Young and C. H. Carpenter, U. S. Geological Survey, 1961.

*No. 6. Work outline and report outline for Sevier River basin survey, (Sec. 6, P.L. 566), U. S. Department of Agriculture, 1961.

No. 7. Relation of the deep and shallow artesian aquifers near Lynndyl, Utah, by R. W. Mower, U. S. Geological Survey, 1961.

No. 8. Projected 1975 municipal water-use requirements, Davis County, Utah, by Utah State Engineer's Office, 1962.

No. 9. Projected 1975 municipal water-use requirements, Weber County, Utah, by Utah State Engineer's Office, 1962.

No. 10. Effects on the shallow artesian aquifer of withdrawing water from the deep artesian aquifer near Sugarville, Millard County, Utah, by R. W. Mower, U. S. Geological Survey, 1963.

No. 11. Amendments to plan of work and work outline for the Sevier River basin (Sec. 6, P.L. 566), U. S. Department of Agriculture, 1964.

No. 12. Test drilling in the upper Sevier River drainage basin, Garfield and Piute Counties, Utah, by R. D. Feltis and G. B. Robinson, Jr., U. S. Geological Survey, 1963.

No. 13. Water requirements of lower Jordan River, Utah, by Karl Harris, Irrigation Engineer, Agricultural Research Service, Phoenix, Arizona, prepared under informal cooperation approved by Mr. William W. Donnan, Chief, Southwest Branch (Riverside, California) Soil and Water Conservation Research Division, Agricultural Research Service, U.S.D.A. and by Wayne D. Criddle, State Engineer, State of Utah, Salt Lake City, Utah, 1964.

*No. 14. Consumptive use of water by native vegetation and irrigated crops in the Virgin River area of Utah, by Wayne D. Criddle, Jay M. Bagley, R. Keith Higginson, and David W. Hendricks, through cooperation of Utah Agricultural Experiment Station, Agricultural Research Service, Soil and Water Conservation Branch, Western Soil and Water Management Section, Utah Water and Power Board, and Utah State Engineer, Salt Lake City, Utah, 1964.

No. 15. Ground-water conditions and related water-administration problems in Cedar City Valley, Iron County, Utah, February, 1966, by Jack A. Barnett and Francis T. Mayo, Utah State Engineer's Office.

No. 16. Summary of water well drilling activities in Utah, 1960 through 1965, compiled by Utah State Engineer's Office, 1966.

No. 17. Bibliography of U. S. Geological Survey Water Resources Reports for Utah, compiled by Olive A. Keller, U. S. Geological Survey, 1966.

No. 18. The effect of pumping large-discharge wells on the ground-water reservoir in southern Utah Valley, Utah County, Utah, by R. M. Cordova and R. W. Mower, U. S. Geological Survey 1967.

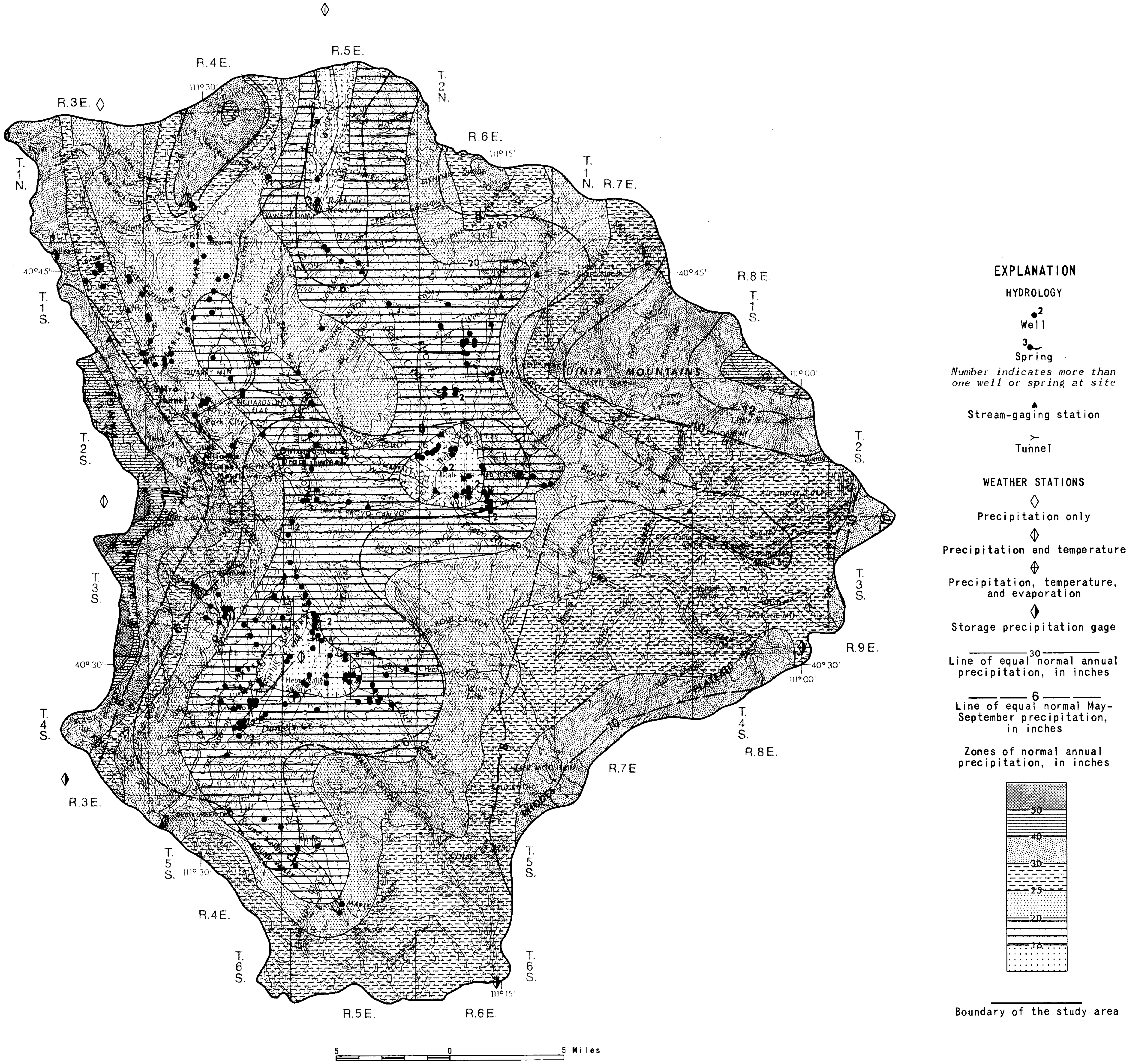
No. 19. Ground-water hydrology of southern Cache Valley, Utah, by L. P. Beer, 1967.

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

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

STATE OF UTAH
DEPARTMENT OF NATURAL RESOURCES

TECHNICAL PUBLICATION NO. 27
PLATE 1 1970



5 0 5 Miles

5 0 5 Kilometers

CONTOUR INTERVAL 200 FEET
DATUM IS MEAN SEA LEVEL

Base from U.S. Geological Survey
1:250,000 (AMS) series: Salt Lake
City, Utah; Wyoming (1963)

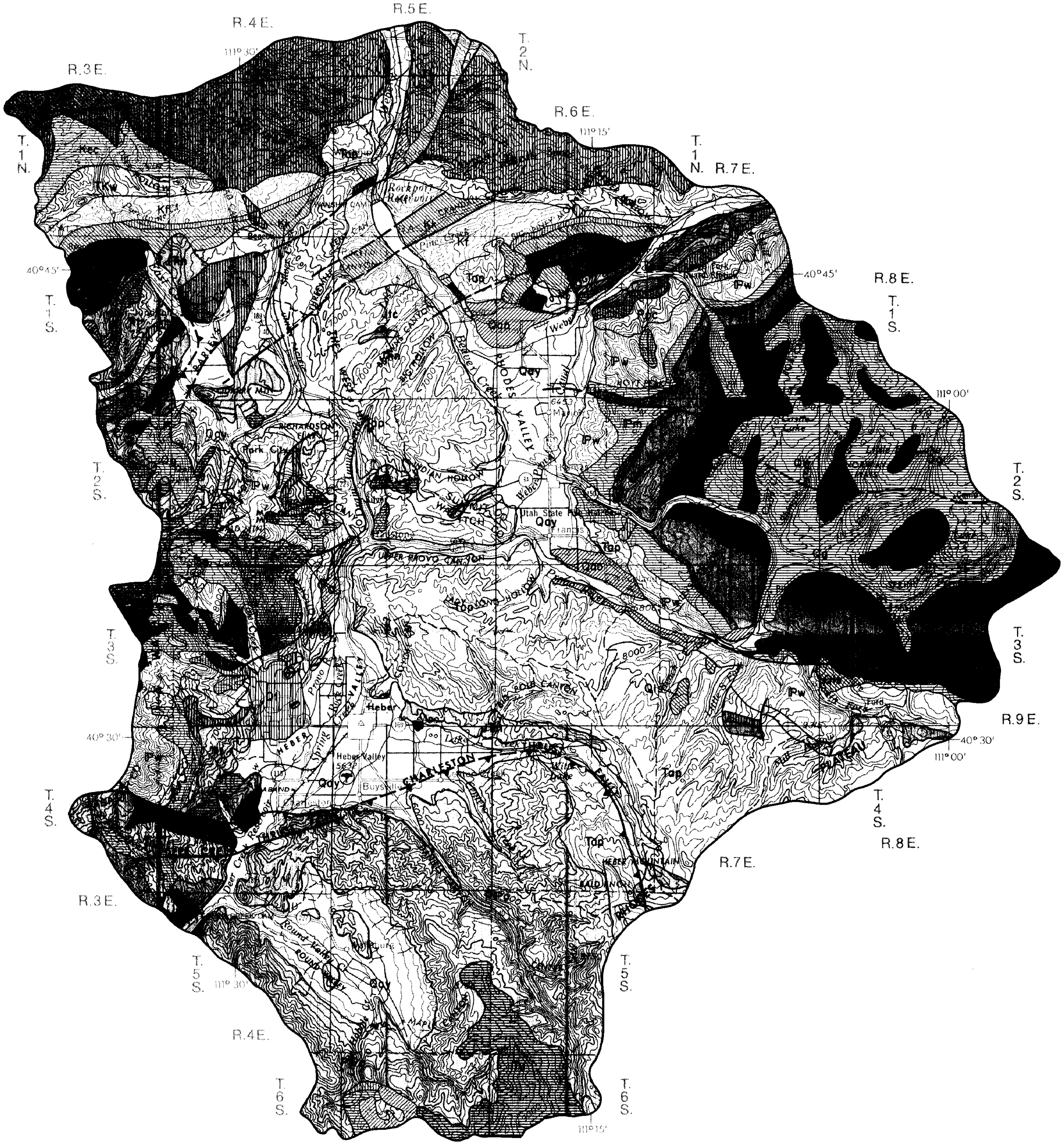
Hydrology by C. H. Baker, Jr., 1969
Precipitation data from U.S. Weather
Bureau, 1963

MAP OF THE HEBER-KAMAS-PARK CITY AREA, NORTH-CENTRAL UTAH, SHOWING LOCATIONS OF WELLS, SPRINGS, STREAM-GAGING STATIONS, AND WEATHER STATIONS AND NORMAL MAY-SEPTEMBER PRECIPITATION

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

STATE OF UTAH
DEPARTMENT OF NATURAL RESOURCES

TECHNICAL PUBLICATION NO. 27
PLATE 2 1970



5 0 5 Miles
5 0 5 Kilometers
CONTOUR INTERVAL 200 FEET
DATUM IS MEAN SEA LEVEL

Base from U.S. Geological Survey 1:250,000 (AMS) series: Salt Lake City, Utah; Wyoming (1963)

## EXPLANATION

(See table 1 or 2 for discussion of the water-bearing properties of each formation)

**QUATERNARY**

Qay
Relatively younger alluvial fill in active stream valleys

Qao ▨ Qls ▤ Qg ▨ Qt ▥
Older Quaternary rocks
Qao, *relatively older alluvium on terraces adjoining major valleys*
Qls, *landslides and other masses displaced chiefly by gravity*
Qg, *glacial deposits*
Qt, *tufa deposits*

**TERTIARY**

Tgs
Older high-level gravel surfaces of uncertain age

Tap Tig ▤ Tib ▥
Igneous rocks
Tap, *extrusive igneous rocks, chiefly andesite pyroclastics*
Tig, *granitic intrusive bodies*
Tib, *basic intrusive bodies*

■ ■
Tf, Fowkes Formation
Tu, Uinta Formation

▥
Knight Conglomerate

**TERTIARY–CRETACEOUS**

TKw
Wanship Formation of Eardley (1952)

**CRETACEOUS**

Kec
Echo Canyon Conglomerate of Eardley (1944)

Kf
Frontier Formation

Kpr
Price River Formation

Ka
Aspen Shale

Kk
Kelvin Formation

**JURASSIC**

■
Morrison Formation

■
Preuss Sandstone

■
Twin Creek Limestone

**JURASSIC–TRIASSIC**

J̄Rn
Nugget Sandstone

**TRIASSIC**

■
R̄c, Chinle Formation
R̄cs, Shinarump Member of Chinle Formation

■
Ankareh Formation

■
Thaynes Formation

■
Woodside Formation

**PERMIAN**

Ppc
Park City Formation

■
Diamond Creek Sandstone

■
Kirkman Limestone

**PERMIAN–PENNSYLVANIAN**

■
Oquirrh Formation

**PENNSYLVANIAN**

IPw
Weber Quartzite

IPm
Morgan Formation

IPrv
Round Valley Limestone

**PENNSYLVANIAN–MISSISSIPPIAN**

■
Manning Canyon Shale

**MISSISSIPPIAN**

■
Mississippian rocks undivided

**DEVONIAN**

■
Devonian rocks undivided

**CAMBRIAN**

■
Cambrian sedimentary rocks undivided

**PRECAMBRIAN**

■
Precambrian rocks undivided

———
Contact

——— — — —
High-angle fault
*Dashed where inferred*

—▲——▲——▲—
Thrust fault
*Teeth on overriding block, dashed where inferred*

———
Boundary of the study area

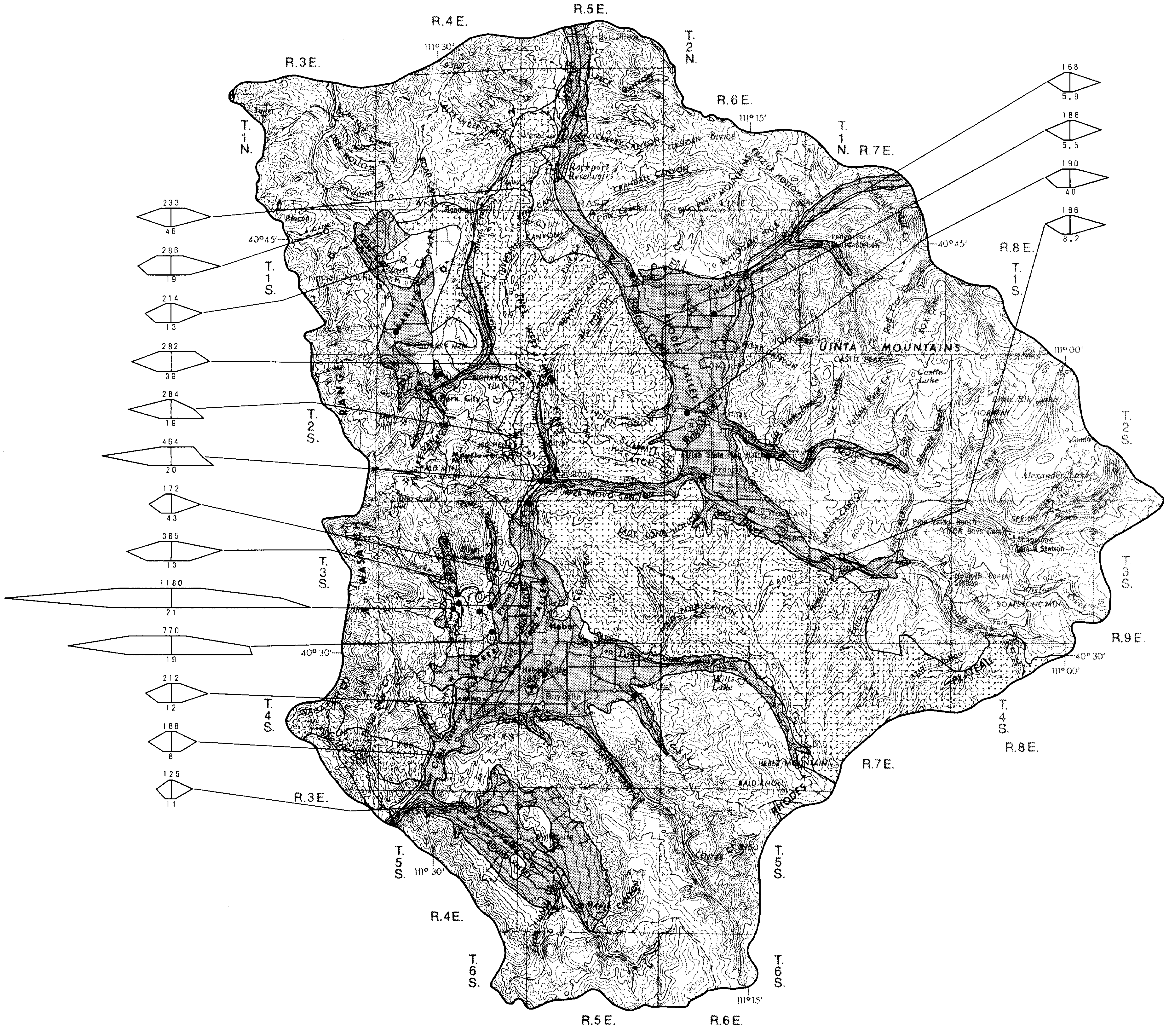
Geology after Baker and Crittenden (1961); Baker (1964); Stokes (1964); Baker, Calkins, Crittenden, and Bromfield (1966); Crittenden, Calkins, and Sharp (1966); and Bromfield, Baker, and Crittenden (1968).

# GENERALIZED GEOLOGIC MAP OF THE HEBER-KAMAS-PARK CITY AREA, NORTH-CENTRAL UTAH

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

STATE OF UTAH
DEPARTMENT OF NATURAL RESOURCES

TECHNICAL PUBLICATION NO. 27
PLATE 3 1970



5 0 5 Miles
5 0 5 Kilometers
CONTOUR INTERVAL 200 FEET
DATUM IS MEAN SEA LEVEL

Base from U.S. Geological Survey
1:250,000 (AMS) series: Salt Lake
City, Utah; Wyoming (1963)

## EXPLANATION

⬚ Area where most wells and springs yield water from volcanic rocks of Tertiary age

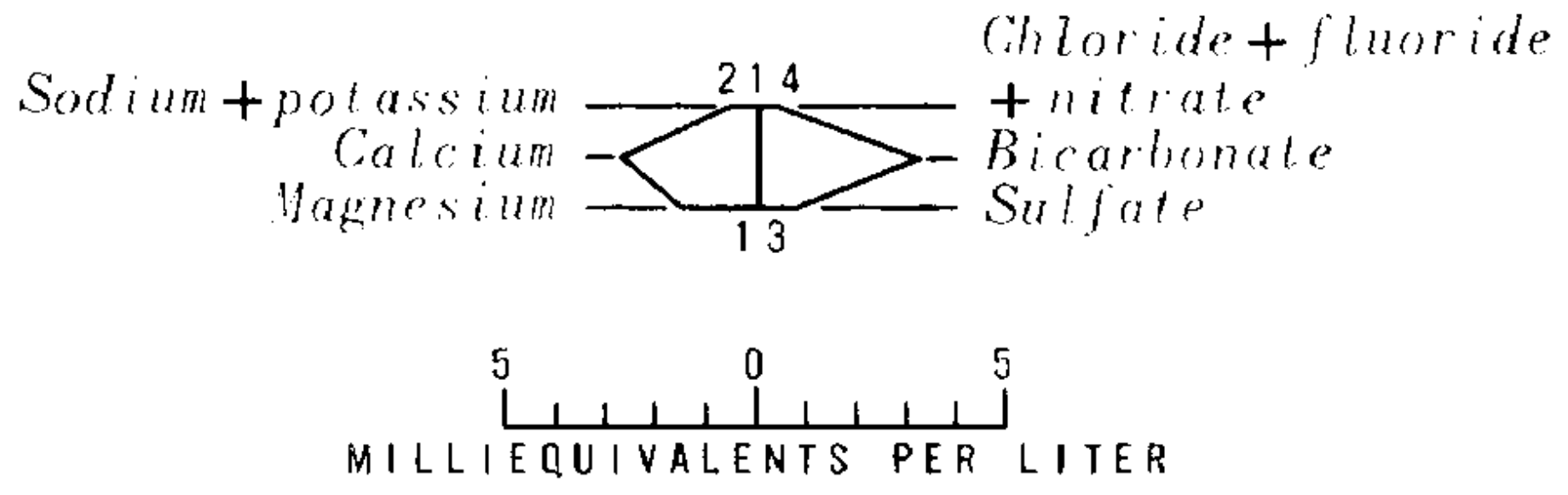
☐ Area where most wells and springs yield water from other consolidated rocks, mostly pre-Tertiary sedimentary rocks

▨ Area of tufa deposits associated with hot springs; all springs are thermal and most wells yield water from the tufa

▩ Area where most wells and springs yield water from Quaternary alluvial deposits

● ○ Well 3●~ ○~ Spring △ Stream ▶– ≻– Tunnel

*Solid symbols indicate sites sampled during the present study; open symbols indicate sites sampled before this study began. Number by spring symbol indicates more than one spring at site*



*Diagrams show concentrations of cations and anions, in milliequivalents per liter, for representative analyses of water. Figure above each diagram indicates calcium magnesium hardness, in milligrams per liter; figure below indicates silica, in milligrams per liter*

Boundary of the study area

Hydrology by C. H. Baker, Jr., 1969

# MAP OF THE HEBER-KAMAS-PARK CITY AREA, NORTH-CENTRAL UTAH, SHOWING LOCATIONS FROM WHICH WATER SAMPLES WERE COLLECTED FOR CHEMICAL ANALYSIS AND SELECTED WATER-QUALITY DATA