WATER-RESOURCES BULLETIN 7
1964

UTAH GEOLOGICAL AND MINERALOGICAL SURVEY
affiliated with
THE COLLEGE OF MINES AND MINERAL INDUSTRIES
University of Utah, Salt Lake City, Utah

GEOLOGY
and
GROUND-WATER RESOURCES
of
THE JORDAN VALLEY

Prepared by
THE UNITED STATES GEOLOGICAL SURVEY
in cooperation with
THE UTAH STATE ENGINEER

Price $3.00

UTAH GEOLOGICAL AND MINERALOGICAL SURVEY

103 Civil Engineering Building
University of Utah
Salt Lake City, Utah 84112

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GEOLOGY AND GROUND-WATER RESOURCES OF THE JORDAN VALLEY, UTAH

by I. Wendell Marine and Don Price
Geologists, U.S. Geological Survey

Gravel deposit at quarry in Sec. 32, T. 1 N., R. 1 E. Similar deposits in the subsurface yield large quantities of water to wells in the Jordan Valley. (Photograph by R. E. Cohenour.)

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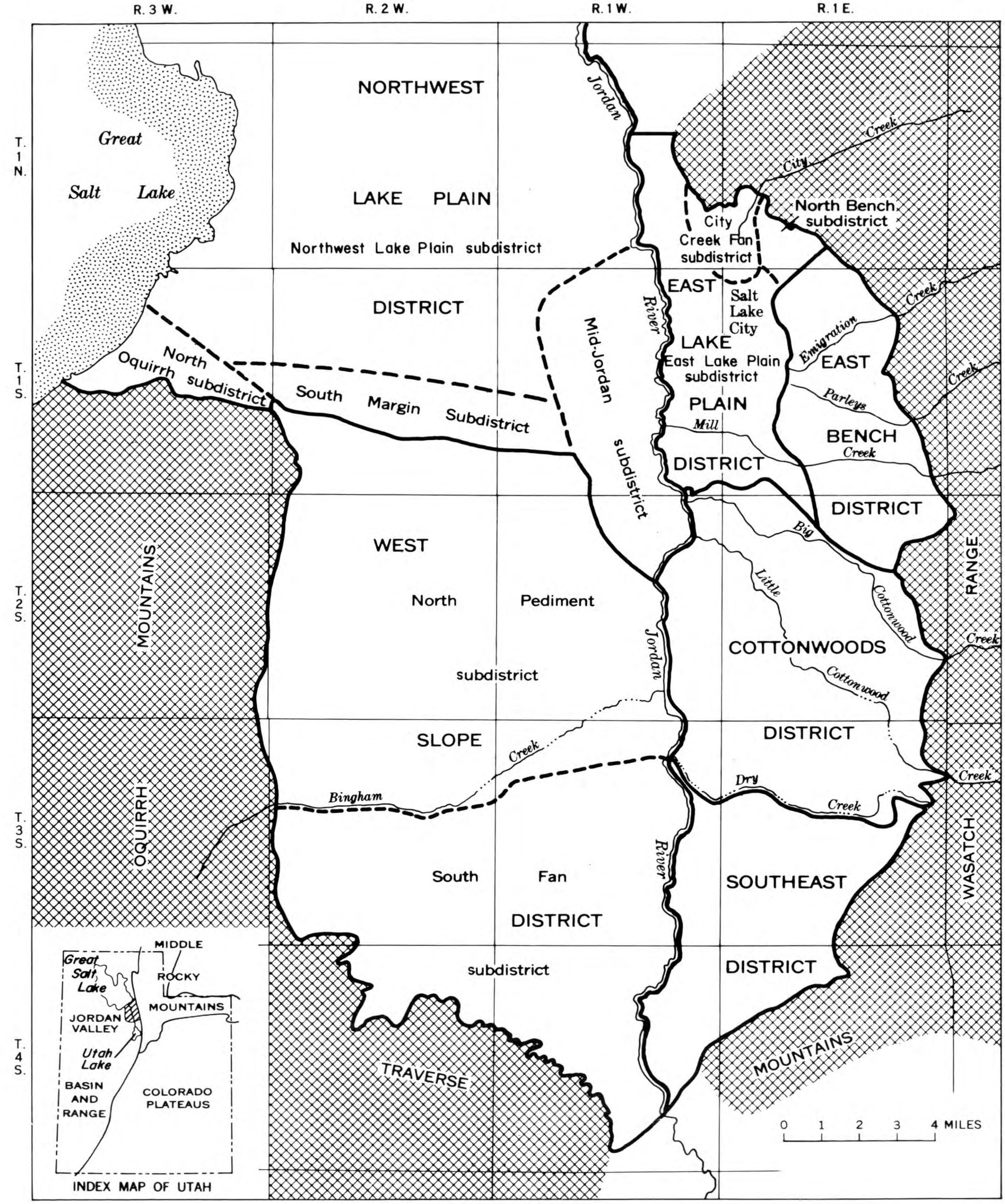

Figure 1. Index map of the Jordan Valley, Utah, showing ground-water districts and subdistricts.

GEOLOGY AND GROUND-WATER RESOURCES OF THE JORDAN VALLEY, UTAH

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Geologists, United States Geological Survey

ABSTRACT

The Jordan Valley occupies about 400 square miles in the central part of Salt Lake County in north-central Utah. Salt Lake City, the capital of Utah, is in the northeastern part of the valley. The valley is at the eastern margin of the Basin and Range physiographic province, and it is bounded on the northeast, east, south, and west by mountain ranges. The valley is drained by the Jordan River which enters through a water gap in the mountains to the south, flows north, and empties into the Great Salt Lake which forms the northwestern boundary of the valley.

The Jordan Valley has two principal sources of surface water--the Jordan River and six major creeks that enter the east side of the valley from the Wasatch Range. The average annual flow of the Jordan River where it enters the valley is about 267,000 acre-feet, and the average combined annual flow of the six Wasatch creeks is about 140,000 acre-feet. Minor amounts of surface water enter the valley through streams that flow from the Oquirrh Mountains and from short canyons that drain the front of the Wasatch Range. In addition, about 50,000 acre-feet per year is imported into the valley through canals and aquiducts.

The mountains that almost completely enclose the Jordan Valley are composed of rocks that range in age from Precambrian to Recent. In the Wasatch Range to the east of the valley, the rocks include thick sequences of sedimentary rocks of Precambrian, Paleozoic, Mesozoic, and Cenozoic age intruded by granitic rocks of Late Cretaceous or early Tertiary age. The Traverse Mountains to the south consist principally of rocks of the Oquirrh Formation of Pennsylvanian and Permian age and of sedimentary and volcanic rocks of Tertiary age. The part of the Oquirrh Mountains that borders the Jordan Valley to the west is composed of Paleozoic rocks, principally of the Oquirrh Formation, but including Mississippian rocks, and sedimentary, intrusive, and extrusive rocks of Tertiary age.

The Jordan Valley is a graben that has been filling, probably since middle Tertiary time, with detritus which has come mostly from the enclosing mountains but which probably includes windblown material from distant areas. Since the valley was formed it has been inundated from time to time by lakes. The latest series of lakes was of Pleistocene age, and the lakes collectively have been called Lake Bonneville. The deposits associated with Lake Bonneville have largely obliterated the earlier landscape up to an altitude of almost 5,200 feet, the highest shoreline of Lake Bonneville, but many of the large-scale physiographic features are of pre-lake origin. The principal surface features of the Jordan Valley and the processes or agents that formed them are: wave-cut cliffs, wave-cut benches, spits, bars, beaches, lake plains, and deltas formed by <u>lakes</u>; alluvial fans and mud-rock flow deposits, pediments, flood plains, stream terraces, and incised channels formed by <u>streams</u> or <u>running water</u>; dunes and blowouts by <u>wind</u>; moraines by <u>ice</u>; and fault scarps by <u>earth movements</u>.

Among the most impressive aspects of the landscape of the Jordan Valley are the deposits and erosional features of Lake Bonneville. Tremendous embankment deposits of gravel and sand are at the mouths of many canyons and at the Jordan Narrows. Sharp shorelines of Lake Bonneville are etched in bedrock and in pre-Lake Bonneville alluvial fans alike all around the valley. The most prominent shorelines are the Bonneville, ranging from about 5,135-5,180 feet, and the Provo at about 4,800 feet.

Alluvial deposits were laid down in the valley both before and after Lake Bonneville. On the west side of the valley the Tertiary deposits that have been pedimented by later erosion are principally stream or mudflow deposits. All over the valley minor stream activity since Lake Bonneville time has scarred or obscured older deposits.

In a few areas dunes have developed from wind activity, and glacial deposits occur in the vicinity of Little Cottonwood Canyon.

The earth movements that originally formed the valley have continued into comparatively recent times and have formed scarps in the unconsolidated deposits of the valley. The most prominent of the faults showing late movement is the East Bench fault which is marked by a scarp that reaches a height of 80 feet in the unconsolidated deposits in the northeastern part of the valley. The west-facing scarp of the East Bench fault, together with the east-facing scarps of the Jordan Valley fault zone delineate an inner graben within the Jordan Valley.

The complex varieties of deposits in the Jordan Valley have been the basis for dividing the valley into ground-water districts and subdistricts, which have been delimited on the surface by geomorphic features that reflect the subsurface geology. These districts and subdistricts, named in general for their principal geomorphic feature, are: East Bench; East Lake Plain, subdivided into the East Lake Plain, City Creek Fan, and North Bench subdistricts; Cottonwoods; Southeast; West Slope, subdivided into the South Fan and North Pediment subdistricts; and Northwest Lake Plain, subdivided into the Northwest Lake Plain, North Oquirrh, South Margin, and Mid-Jordan subdistricts. Pertinent geologic and hydrologic data for the districts and subdistricts are summarized in the following table:

District and subdistrict	Physiography	Material	Deposits		Gravel in intervals in drillers' logs (away from boundaries) (percent)	Specific capacity (gallons per minute per foot) of drawdown	Dissolved solids (parts per million)			Discharge by wells in 1957 (acre-feet)	Storage in water-table areas in top 100 feet below 1958 water level (acre-feet)
			Type	Approximate thickness (away from boundaries) (feet)			Minimum	Average	Maximum1/		
East Bench	Pediments and alluvial fans overlain in some places by lake-shore features.	Boulders and clay with some gravel and silt, mostly reddish brown. Sandstone, siltstone, and limestone of Mesozoic age in pediment areas.	Mud-rock flows and ephemeral stream deposits.	0-700	50-100	0.1-135	320	602	774	4,200	95,000
East Lake Plain:											
East Lake Plain	Lake plain overlain in some places by alluvial fans or abandoned flood plains.	Blue-gray clay with discontinuous gravel lenses.	Lake-bottom sediments.	>1,000 in most places.	<25	0.9-15	251	490	764	17,000	13,000
City Creek Fan	Alluvial fan	Boulders and gravel.	Alluvial-fan deposits.	500	50-100	28-410	253	530	761		18,000
North Bench	Bajada overlain by lake-shore features.	Boulders, gravel, and clay.	Mud-rock flow deposits.	2/	2/	2/	2/	2/	2/		2/
Cottonwoods	Large lake-shore features cut by abandoned stream channels.	Gravel interlayered with clay.	Alluvial fans of perennial streams interlayered with lake bottom and delta deposits.	>1,000	Mostly 50-100, but <25 in the north and south-central parts.	6-200; largest in the eastern part.	75	253	718	18,000	160,000

Southeast	Lake-shore features; in south, dissected pediment.	Gravel, sand, and clay.	Lake and alluvial-fan deposits.	>1,150 in places.	<25->50	0.4-1,800	255	3/	1,390	110	2/
West Slope:											
South Fan	Gentle eastward slope overlain by lake-shore features; pediments near mountains.	Boulders, gravel, sand, and clay.	Alluvial-fan deposits.	200-500	>25; >50 in most places.	0.2-113	365	643	4/1,240	7,000	150,000
North Pediment	do.	Tertiary clay, silt, and limestone.	Lake-bottom sediments.	>1,400 in places.	<25	<3					170,000
Northwest Lake Plain:											
Northwest Lake Plain	Lake plain overlain in places by flood plains.	Clay with thin sand lenses.	Lake-bottom sediments.	>3,600 in places.	0	Low	492	1,640	3,600	44,000	5/
Mid-Jordan	do.	Sand and gravel interlayered with clay.	Channel, flood plain, and lake deposits.	Unknown but >775.	<25- >50	<20	244	356	508		5/
South Margin	do.	Sand, gravel, and clay.	Lake-bottom sediments underlain by gravel of unknown origin.	500 in places.	25-50	12-20	840	1,150	1,510		5/
North Oquirrh	do.	Blue lake clay underlain by coarse angular gravel.	Lake deposit underlain by talus or brecciated bedrock.	150-800	25-50	22-750	2,485	6,861	10,800		5/
								Total	(rounded)	90,000	600,000

1/ Excluded from this column are maxima caused by isolated contamination or isolated occurrences of thermal water.

2/ Not calculated because of insufficient data.

3/ Not meaningful.

4/ Exclusive of general contamination of beds less than 300 feet deep by Jordan River water in the area where this is used for irrigation.

5/ Little or no water-table area.

Ground water occurs in the Jordan Valley under artesian (confined) and water-table (unconfined) conditions. The confined water is mostly in the lower parts of the valley, and it constitutes the bulk of the ground-water resource. Much of the recharge area for the artesian basin is along the benchlands on the side of the valley, and here the ground water is unconfined.

Recharge to the ground-water reservoir in the Jordan Valley comes from at least seven sources: (1) seepage from irrigated lands, (2) seepage directly from precipitation, (3) seepage from creek channels, (4) subsurface bedrock springs, (5) underflow from mountain canyons, (6) underflow from Utah Valley through the Jordan Narrows, and (7) seepage from irrigation canals.

The varied deposits in the Jordan Valley have in part caused different methods of well construction to be used in different areas. Dug wells have been constructed principally on the benchlands where they tap perched water bodies and supply water mostly for domestic use. Jetted wells of small diameter (less than 6 inches) penetrate the finer-grained materials in the valley lowlands. Many of the jetted wells flow, and most of the water is used for domestic purposes. About 7,700 jetted wells were in use in the Jordan Valley in 1958. Most large-diameter (6 to 24 inches) wells are drilled by the cable-tool method, and records were obtained for 186 wells of this type in the valley in 1958. The water from these wells is used for municipal, industrial, irrigation, and air-conditioning purposes.

The visible discharge of ground water in the Jordan Valley in 1957 was about 270,000 acre-feet. About 55,000 acre-feet was discharged from large-diameter wells and about 35,000 acre-feet from small-diameter and dug wells. Discharge in the Northwest Lake Plain district, largely for industrial use, accounted for almost half of the total discharge from wells. Springs and seeps that flow into the Jordan River and its tributaries discharged about 180,000 acre-feet, and other springs and seeps discharge about 3,000 acre-feet. The amount of ground water discharged by evapotranspiration and underflow to the Great Salt Lake was not determined.

The quantity of ground water in storage in the Jordan Valley was calculated on the basis of estimates of specific yield obtained from the study of drilling samples from 42 wells. It is estimated that 600,000 acre-feet of water is stored in the upper 100 feet of saturated permeable sediments in those areas of the East Bench, East Lake Plain, Cottonwoods, and West Slope districts in which the ground water is under water-table conditions. No estimate was made for the amount of water in storage in the Southeast district because of insufficient data and in the Northwest Lake Plain district because the ground water in all of this district is essentially under artesian conditions.

The quality of ground water in the East Bench and East Lake Plain districts is satisfactory for most uses, but the water is hard. Ground water in the Cottonwoods district contains less dissolved solids than does ground water in other areas of the valley. Some water in the Southeast district is highly mineralized. Ground water in the West Slope district is satisfactory for most uses, although the concentration of dissolved minerals is increased by seepage of industrial waste water and in areas where fields are irrigated by water diverted from the Jordan River. The Northwest Lake Plain district is divided into five areas on the basis of differences in chemical quality of the ground water. One of these areas coincides with the Mid-Jordan subdistrict, but the other areas do not coincide with the other ground-water subdistricts. Water in the Mid-Jordan subdistrict is usable for most purposes; but in the other areas of the Northwest Lake Plain district the content of dissolved minerals in the ground water is such that the water can be used only for selected purposes.

The temperature of ground water in the Jordan Valley is mostly between 52° and 60°F. Ground water in large areas in the Southeast district and the Northwest Lake Plain district has temperatures that exceed 60°F., and in smaller areas in both districts the temperatures exceed 70°F. The areas of warmer water are associated with faults, principally along the Wasatch Front, the north end of the Oquirrh Mountains, and the north slope of the Traverse Mountains, but also along the Jordan Valley fault zone that forms the west side of the Jordan Valley graben near the center of the valley.

INTRODUCTION

Location and Hydrologic Setting of the Area

The Jordan Valley occupies about 400 square miles in the central part of Salt Lake County, in north-central Utah (fig. 1). Salt Lake City, the capital and largest city of Utah, lies in the northeast part of the Jordan Valley.

The Jordan Valley is in the Basin and Range physiographic province, adjacent to the boundary that separates this province from the Rocky Mountain province on the east. The valley is bounded on the east by the Wasatch Range, on the south by the Traverse Mountains, on the west by the Oquirrh Mountains, and on the north by the Great Salt Lake and a low east-west salient of the Wasatch Range. The boundaries of the area investigated are shown in figures 1 and 11.

The Jordan Valley, which is a structural graben, receives water from the Jordan River and the high mountains that border most of the valley. The Jordan River drains Utah Lake, which is in Utah Valley, south of the Traverse Mountains. Utah Lake, in turn, receives water principally during periods of snowmelt from major streams that drain the Uinta Mountains and the Wasatch Range east of Utah Valley. Much of the water from the bordering mountains enters the Jordan Valley during periods of snowmelt as surface water. The streams flow across deposits of coarse unconsolidated material at the edges of the valley, however, and some of the melt water sinks into the ground. This water recharges the vast ground-water basin that consists of unconsolidated deposits of gravel, sand, silt, and clay underlying most of the valley.

The Jordan Valley ground-water basin has been divided into six districts: East Lake Plain, East Bench, Cottonwoods, Southeast, West Slope, and Northwest Lake Plain.

The division was made on the basis of geology, the water-bearing properties of the deposits, and the quality of the ground water. These districts, and the subdistricts into which some districts are further divided, are shown in figures 1 and 11, and they are discussed in detail in the section on ground water.

Purpose and Scope of the Investigation

The principal supplies of water for Salt Lake City and other communities and rural areas of the Jordan Valley come from surface-water sources; but as the population of the valley has grown, more and more water users have sought new or supplemental supplies of water from the ground. In order to provide for the orderly development of the ground-water reservoir of the valley, the Utah State Engineer in 1956 initiated a cooperative investigation with the U. S. Geological Survey which had for its objectives: (1) division of the Jordan Valley ground-water basin into hydrologic units on which the administration and development of ground water could be based, (2) evaluation of the potential development of the hydrologic units, and (3) determination of the status of ground-water development at the time of the study.

I. W. Marine and Don Price completed the fieldwork for the investigation in December 1958 and the laboratory work in May 1959. G. F. Harmon assisted in the field during the summers of 1956 and 1957. H. D. Goode contributed numerous ideas and valuable assistance during the preparation of the manuscript.

Methods of Study

The project began with the collection of basic data, including records of wells and springs, streamflow records, geologic data, and water samples for chemical analyses. In addition, water levels were measured periodically in 170 wells and 3 wells were equipped with automatic water-level recording gages. These data were integrated with similar data obtained during previous investigations. Much of the basic data (including records for 565 wells and springs, chemical analyses for 56 surface sources, chemical analyses for 296 wells and springs, and logs for 64 wells were released as a separate report (Marine and Price, 1963) and are not included as such in this report.

Much of the effort of the investigation was directed toward the discovery and the delimitation of aquifers. The methods used involved geologic, hydraulic, and chemical studies. The geologic studies included the use of: (1) peg models, (2) cross sections, (3) gravel-percentage maps, (4) mechanical analysis of drilling samples, (5) analysis of the source of sediments present in the valley fill, and (6) qualitative evaluation of drillers' logs. The hydraulic studies included the use of: (1) graphs of the depths of small-diameter wells, (2) graphs of the relation of water pressure to well depth, (3) changes in piezometric surface, (4) deep well current-meter investigations, (5) well-interference tests, and (6) a specific-capacity map. The chemical studies included: (1) evaluation of analyses of water, (2) evaluation of influence of geologic processes and conditions on water quality, and (3) evaluation of influence of water use and development on water quality.

The division of the valley into ground-water districts and sub-districts was based primarily on the evaluation of drillers' logs and on the specific capacities of wells and secondarily on chemical quality of water and gravel-percentage studies. The analysis of drilling samples, the determination of the source of sediments present in the valley fill, the depths of small-diameter wells, the relation of water level to well depth, and current-meter investigations in wells were helpful in understanding ground-water conditions in the Jordan Valley.

The yields of small-diameter wells were obtained from records of the Utah State Engineer and the yields of large-diameter wells were measured, abstracted from well owners' records, or estimated from personal interviews with well owners and others.

Previous Investigations

The first investigation of ground water in the Jordan Valley was completed by G. B. Richardson of the U. S. Geological Survey in 1906. The report (Richardson, 1906) includes information concerning geology, ground-water conditions, and wells, and it contains maps showing the depth to ground water and the area of flowing wells. A second investigation was made from 1931 to 1935, and the report (Taylor and Leggette, 1949) includes many well records and discussions of the occurrence of ground water, recharge and discharge conditions, chemical quality of water, and the fluctuations of water levels. Lofgren (1952) discussed the status of ground-water development in the Jordan Valley as of 1951; M. E. Hunt (written communication, 1956) described political and technical aspects of the utilization of ground water in Utah using Jordan Valley as an example; and Jerry Tuttle (written communication, 1957) reported on the history of development of ground water in Jordan Valley. Water-level measurements for selected observation wells in the Jordan Valley have been published since 1935 by the U. S. Geological Survey in its Water-Supply Paper series.

Reports have been prepared on the geology of the three mountain ranges bordering the Jordan Valley. Granger and others (1952) reported on the Wasatch Range; R. E. Marsell (written communication, 1932) and Pitcher (1957) reported on the Traverse Mountains; and Gilluly (1932), Slentz (1955), and Cook (1961) reported on the Oquirrh Mountains and foothills. The unconsolidated deposits in the Jordan Valley are discussed in reports by Lofgren (written communication, 1947), Jones and Marsell (1955), and Eardley and others (1957).

Great Salt Lake, into which the Jordan Valley drains, has in itself been the subject of numerous investigations which date back to 1833. Woolley and Marsell (1946) have prepared a selective bibliography of the most significant reports. Peck (1954) made a hydrometeorological study of the lake. Fluctuations of the lake stage are published annually by the U. S. Geological Survey in its report on surface-water records of Utah.

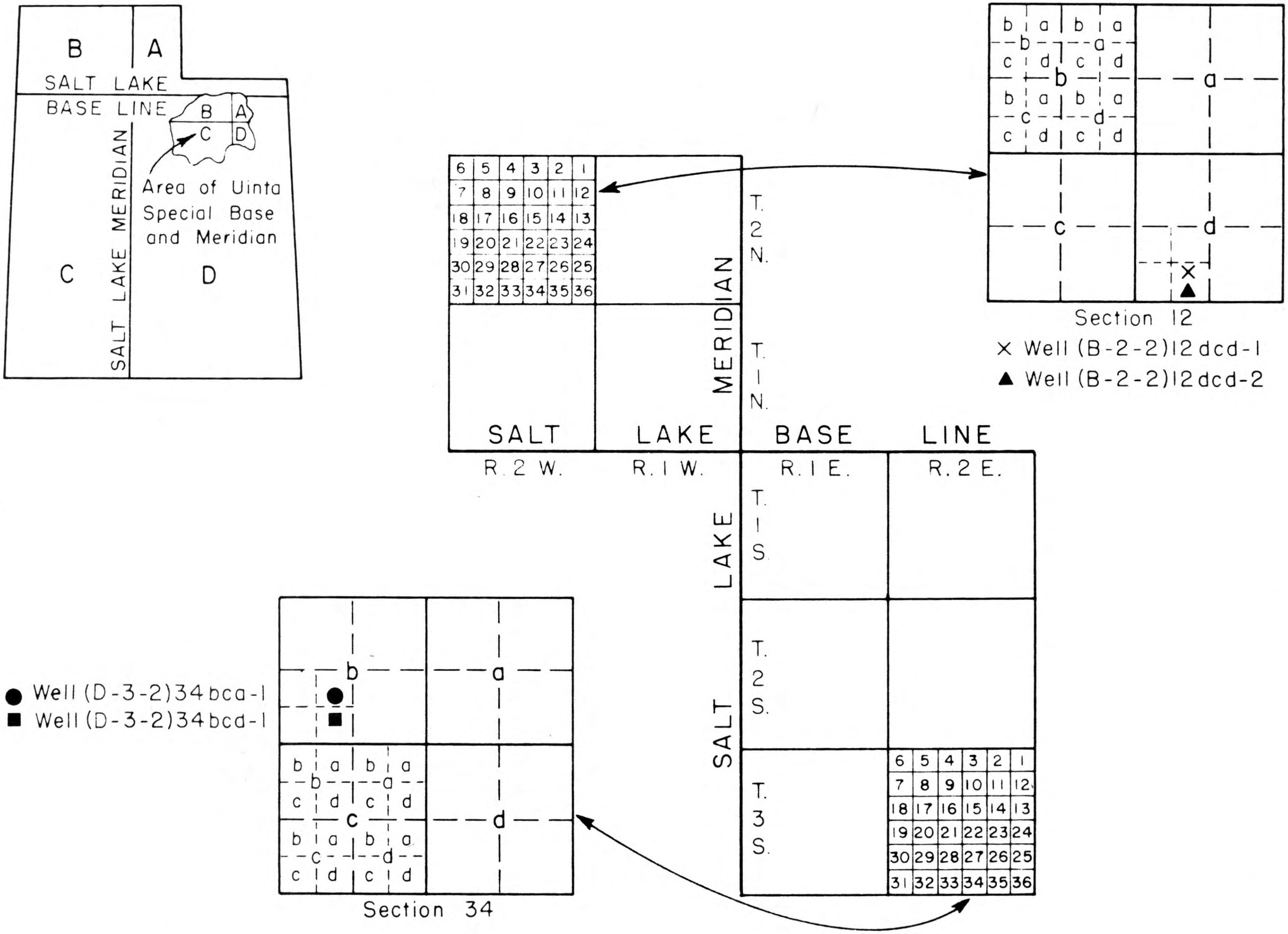


Figure 2. Well-numbering system used in Utah.

Acknowledgments

Many well owners in the Jordan Valley permitted their wells to be measured. Logs of wells were obtained from the office of the Utah State Engineer, and additional information was supplied by drillers. Samples of well cuttings were collected by the following well drillers upon request: Melvin Church, Comer Drilling Company, Harkness Drilling Company, Richard Larsen, J. S. Lee and Sons, Roscoe Moss Drilling Company, J. J. O'Brien, and Robinson Drilling Company.

Salt Lake City Corporation supplied water-level measurements which filled a gap in the records of the U.S. Geological Survey for the period 1935-55. Mr. Tom MacDonald of the Salt Lake City Water Department was very helpful in locating and providing information about suitable observation wells. Professor R. E. Marsell of the University of Utah, through many discussions, gave the writers the benefit of his experience in the area.

Ground-water consultants John Ward, Win Templeton, A. H. Sorensen, A. Z. Richards, Clarence Shupe, and Gordon Kirby contributed data from their personal files. Personnel of the Utah State Engineer's Office made helpful suggestions based on their experience in the area.

Well-numbering System

The well numbers used in this report indicate the well location by land subdivision according to a numbering system that was devised cooperatively by the Utah State Engineer and G. H. Taylor of the U. S. Geological Survey about 1935. The system is illustrated in figure 2. The complete well number comprises letters and numbers that designate consecutively the quadrant and township (shown together in parentheses by a capital letter designating the quadrant in relation to the base point of the Salt Lake Base and Meridian, and numbers designating the township and range); the number of the section; the quarter section (designated by a letter); the quarter of the quarter section; the quarter of the quarter-quarter section; and, finally, the particular well within the 10-acre tract (designated by a number). By this system the letters A, B, C, and D designate, respectively, the northeast, northwest, southwest, and southeast quadrants of the standard base and meridian system of the Bureau of Land Management, and the a, b, c, and d designate, respectively, the northeast, northwest, southwest, and southeast quarters of the section, of the quarter section, and of the quarter-quarter section. Thus, the number (D-1-1) 4adc-1 designates well 1 in the SW$\frac{1}{4}$ SE$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 4, T. 1 S., R. 1 E., the letter D showing that the township is south of the Salt Lake Base Line and the range is east of the Salt Lake Meridian.

GENERAL GEOGRAPHY

Topography

The Jordan Valley is a structural valley in the Basin and Range physiographic province (Fenneman and Johnson, 1946) which is partly filled with unconsolidated and semiconsolidated deposits. It is drained by the Jordan River which flows northward from Utah Lake (altitude about 4,490 feet) in Utah County and empties into Great Salt Lake (altitude about 4,200 feet).

The Wasatch Range, east of the Jordan Valley, has several peaks higher than 11,000 feet above sea level and a relief of about 6,000 feet. Most of the streams that drain the range head about 10 miles back from the mountain front and flow westward through deep canyons. After they emerge from the mountains, these streams cross the valley fill in the eastern part of the Jordan Valley (fig. 3) and flow toward the Jordan River. A low east-west salient from the Wasatch Range, called the Salt Lake salient by Eardley (1944, p. 821), bounds part of the Jordan Valley on the north. The relief of this salient is about 3,000 feet.

On the south, the Jordan Valley is separated from Utah Valley by the Traverse Mountains, whose relief is about 2,000 feet and whose peaks are between 6,000 and 7,000 feet above sea level. The Traverse Mountains are divided into east and west parts by the Jordan Narrows, a water gap through which the Jordan River flows (fig. 3).

West of the Jordan Valley the Oquirrh Mountains have peaks higher than 9,000 feet above sea level and a local relief of about 4,000 feet.

Climate

The climate of Jordan Valley is semiarid with moderately cold to cold winters and hot summers. Precipitation on the valley and on the adjacent mountains is greater during the winter than during the summer (fig. 4). Annual precipitation exceeds 60 inches on some of the high peaks in the Wasatch Range and exceeds 40 inches on some of the peaks of the Oquirrh Mountains. This is appreciably greater than the annual average total of about 14 inches at Midvale that is typical of precipitation on the valley floor. The precipitation at intermediate altitudes will range between the extremes recorded at the high peaks and the valley floor.

An important source of water for the Jordan Valley is snow in the adjacent mountains. The snowpack accumulates from about October through April, and during the period 1931-58 the October through April precipitation averaged about 78 percent of the total annual precipitation. The snow melts during May, June, and July, and the runoff during these 3 months is a principal source of ground-water recharge. Figure 5 shows the October through April precipitation at a valley station and at a mountain station from 1931 to 1958. The cumulative-departure graph of precipitation in figure 5 shows that in general the period 1931-40 was below average whereas the period 1940-52 was above average. The period 1952-58 was slightly below average.

The mean monthly temperatures for a valley station and a mountain station are shown in figure 4. The highest temperature recorded at the Salt Lake City Airport was 106°F. on July 21, 1931, and the lowest -30°F. on February 9, 1933.

Hydrography

The principal source of the surface water that enters the Jordan Valley is the Jordan River and six major creeks that drain the Wasatch Range. In addition, a significant amount of water enters the valley from adjacent areas through canals and aqueducts. No perennial streams enter the valley from the Traverse or Oquirrh Mountains. Most of the hydrographic features of the Jordan Valley are shown in figure 6.

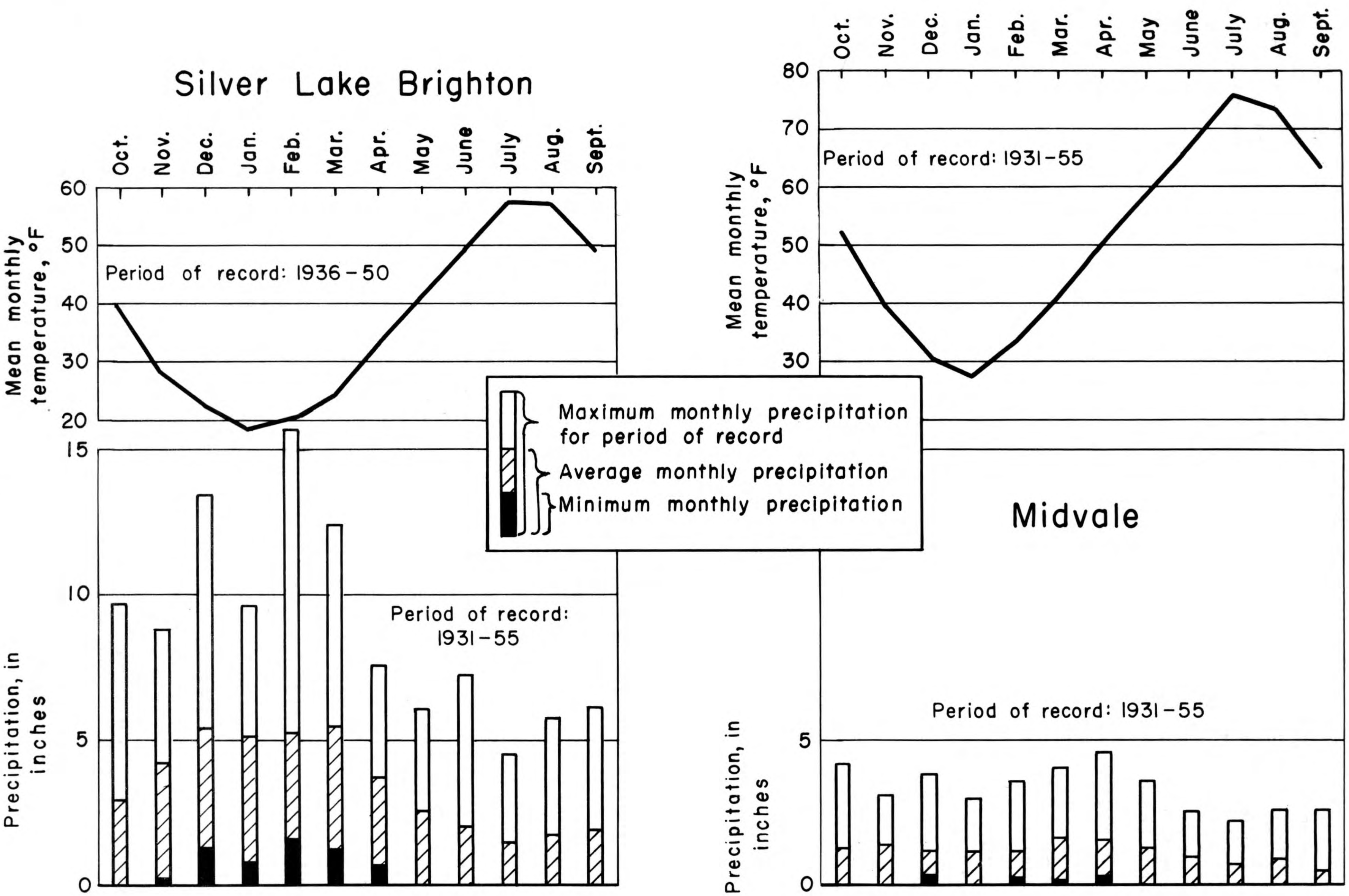


Figure 4. Maximum, average, and minimum monthly precipitation, and mean monthly temperature at a mountain station in the Wasatch Range (Silver Lake Brighton) and at a valley station (Midvale) in Salt Lake County. (Data from U.S. Weather Bureau.)

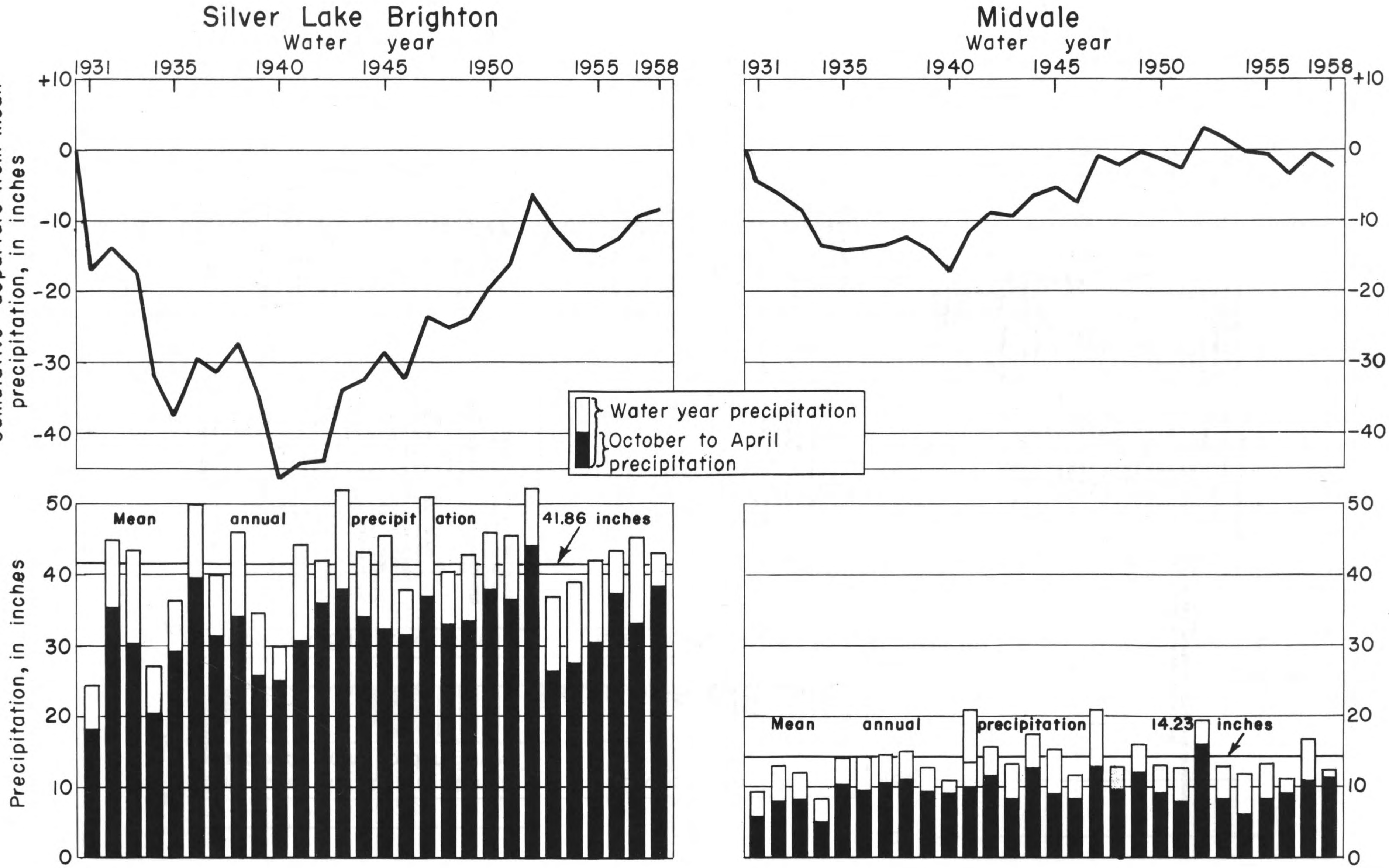
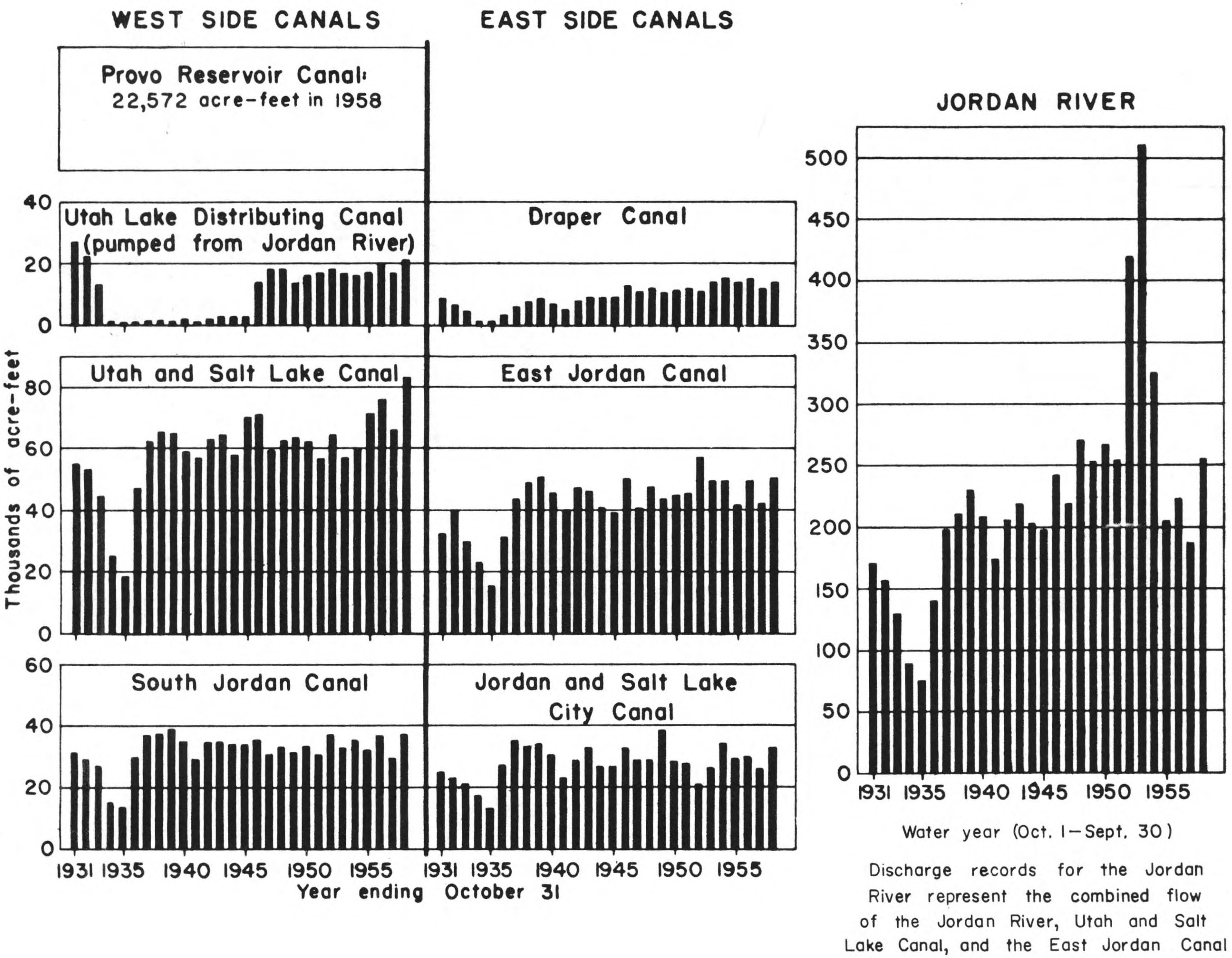


Figure 5. October to April precipitation, total annual precipitation by water year, and cumulative departure from mean annual precipitation at a mountain station (Silver Lake Brighton) and at a valley station (Midvale), 1931-58.
(Data from U.S. Weather Bureau.)



Discharge records for the Jordan River represent the combined flow of the Jordan River, Utah and Salt Lake Canal, and the East Jordan Canal

Figure 7. Diversions of selected canals in the Jordan Valley, and flow of the Jordan River at the Jordan Narrows, 1931-58. (Data for Provo Reservoir Canal from the Provo River Water Users Assn. Data for other canals from D. I. Gardner, written communication. Data for Jordan River from U.S. Geological Survey.)

The Jordan River drains Utah Lake in Utah Valley, enters the Jordan Valley at the Jordan Narrows, and flows northward into Great Salt Lake. The flow of the water from Utah Lake is regulated, and when minimum requirements for downstream use cannot be met by gravity flow, water is pumped from the lake. Regardless of the contribution from Utah Lake, however, ground-water seepage in Jordan Valley maintains a base flow in the river throughout the year. The average annual flow of the Jordan River at the Jordan Narrows for the period 1913-57 was about 267,000 acre-feet, and it has ranged from a minimum of 76,000 in 1935 to a maximum of 603,000 acre-feet in 1922.[1] Figure 7 shows the flow of the Jordan River during 1931-58.

The Jordan River supplies most of the water used for irrigation and some water used for industrial purposes in the Jordan Valley. The water from the river is not of suitable chemical quality for municipal, domestic, and some industrial uses. Water is diverted from the river through a number of canals (fig. 6), and the amounts of water diverted from selected canals are shown in figure 7.

The Surplus Canal was constructed to prevent the Jordan River from overflowing its banks in its lower course where the hydraulic gradient is relatively flat. This canal carries the flood flows of the Jordan River to ponds and a marsh area near the edge of Great Salt Lake. Water can also be diverted from the Surplus Canal to Goggin Drain and directly to Great Salt Lake (fig. 6).

The Wasatch Range east of the Jordan Valley is drained by six major and several minor creeks (fig. 6). The major creeks are City, Emigration, Parleys, Mill, Big Cottonwood, and Little Cottonwood, and much of their flow is used for municipal water supply in the Jordan Valley. The average combined discharge of the six creeks at the mouths of their canyons in the Wasatch Range is about 140,000 acre-feet per year. The flow characteristics of the creeks are shown in figure 8, and the discharge of each creek for the period 1931-58 is shown in figure 9.

Downstream from the mouths of their canyons, the creeks draining the Wasatch Range lose part of their flow by influent seepage to sand and gravel deposits. In the lower parts of their valleys, however, the flow increases as they gain water from the unconsolidated deposits in the Jordan Valley. The creeks are all tributary to the Jordan River. Mill, Big Cottonwood, and Little Cottonwood Creeks flow directly into the Jordan River, and the flows of City, Emigration, and Parleys Creeks reach the Jordan River by way of underground conduits through the lower area of Salt Lake City.

Water is imported into the Jordan Valley from nearby watersheds through one open canal and two closed aqueducts. The Provo Reservoir Canal is the highest canal on the west side of the Jordan Valley, ranging in elevation from about 4,720 to 4,650 feet above sea level (fig. 6). The water in this canal is diverted from the Provo River in Utah County, and it flows through a series of canals in northeastern Utah Valley and through a siphon under the Jordan Narrows. The water is used for irrigation, and in 1958 the flow in the canal into the Jordan Valley was about 23,000 acre-feet. The Salt Lake City Aqueduct brings water from the Provo River into the Jordan Valley for municipal and irrigation purposes. In 1958 this aqueduct, which is operated by the Metropolitan Water District of Salt Lake City, carried about 19,000 acre-feet of water. The Kennecott pipeline brings water into Salt Lake County from Tooele Valley for use by the mills at the north end of the Oquirrh Mountains. The annual flow through this aqueduct is approximately 10,000 acre-feet.

A small quantity of water enters the Jordan Valley in ephemeral streams that drain the front of the Wasatch Range, and ephemeral streams tributary to the Jordan River drain the Traverse and Oquirrh Mountains. The principal streams in the Oquirrh Mountains are Bingham, Butterfield, and Rose Creeks, and they supply water for municipal, industrial, and irrigation purposes.

Several reservoirs in north-central Jordan Valley receive water from the Jordan River through the North Jordan Canal. These reservoirs provide controlled storage for water going to the metal-refining mills at the north end of the Oquirrh Mountains.

Surface drainage out of the Jordan Valley is by flow of the Jordan River, Surplus Canal, Goggin Drain, Salt Lake City outflow sewer, and the Kennecott Copper Corp. drain. All the water moves northward toward Great Salt Lake.

Economic Development

Population

The population of Salt Lake County was more than 380,000 in 1960, and most of these people lived in the Jordan Valley. Figure 10 shows the growth in population of Salt Lake County from 1930 to 1960 and of Salt Lake City from 1860 to 1960. Much of the recent increase has been in suburban areas on the outskirts of Salt Lake City.

Agriculture

Salt Lake County is urbanizing at a rapid rate, and as urban areas encroach on the farmland, agriculture diminishes. Agriculture, however, is still important to the economy of the valley and continues to support many people. The principal crops are grain, hay, sugarbeets, corn, and garden vegetables. Most of the grain is dry farmed, and it is grown principally above the highest canals on the west side of the valley (fig. 6) where the land surface ranges in altitude from about 4,720 to about 4,650 feet above sea level. Below the highest canal on the west side, hay is the main crop. On the east side and in the lower parts of the valley, truck farming is the principal type of agriculture, and peaches, cherries, apricots, apples, berries, and other fruits are raised. Dairy herds and poultry farms are scattered throughout the valley, and during parts of the year several herds of beef cattle and flocks of sheep are kept on the flat lake plain near Great Salt Lake.

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[1] Discharge records for the Jordan River represent the combined flow of the Jordan River, Utah and Salt Lake Canal, and the East Jordan Canal.

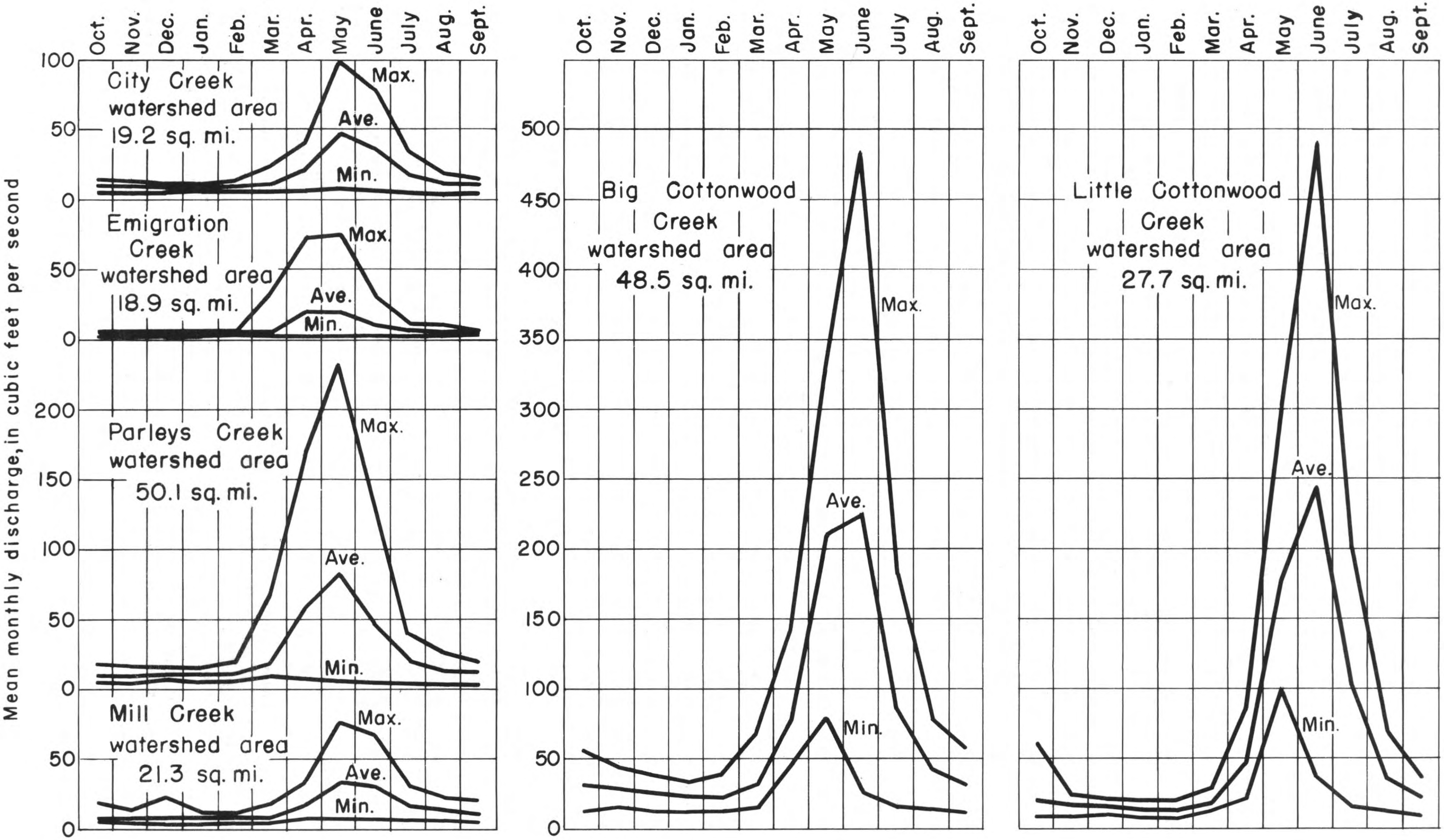

Figure 8. Maximum, average, and minimum mean monthly discharge of six creeks, 1915-58.
(Basic data, averages, and watershed areas supplied by Salt Lake City Corp.)

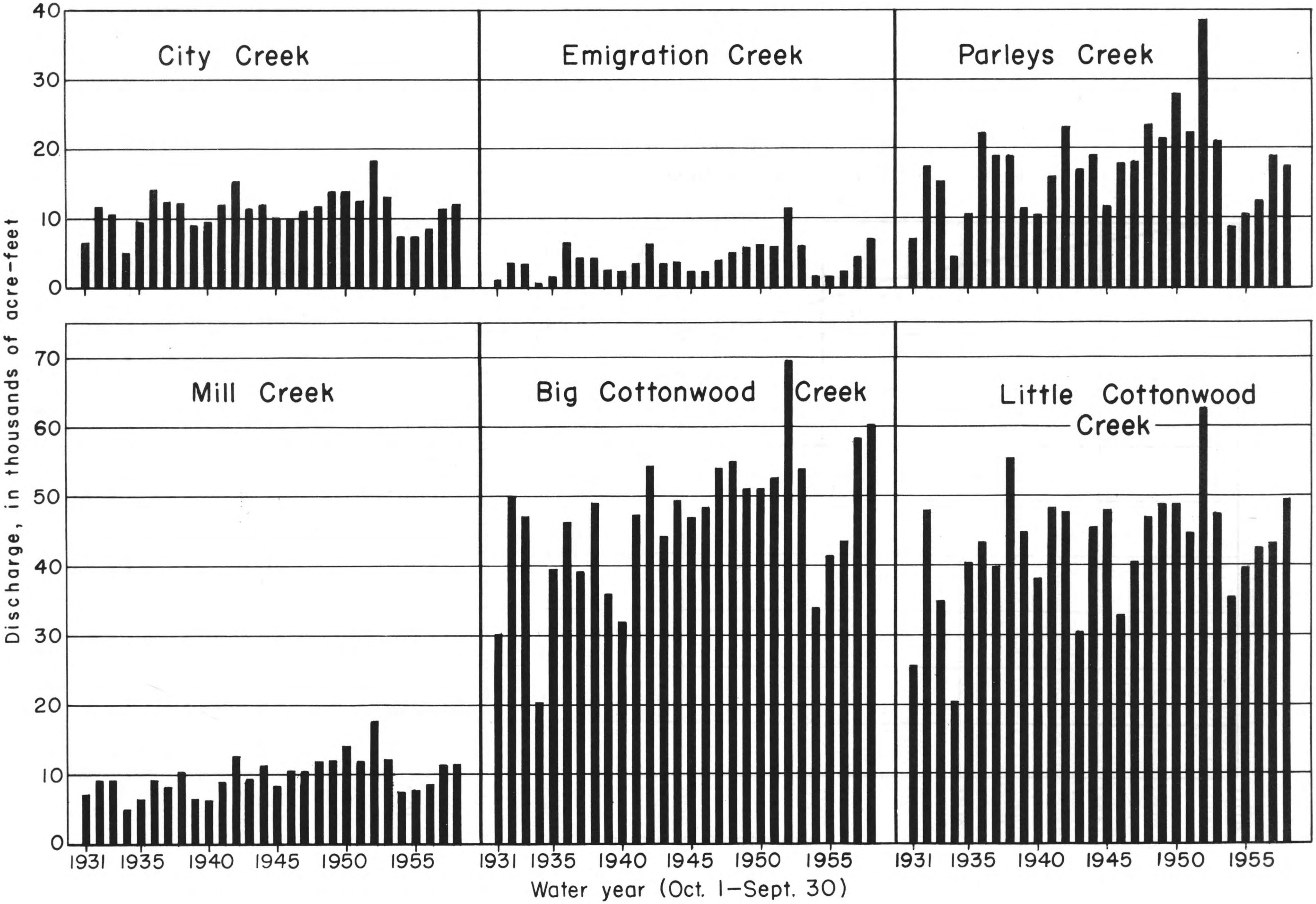

Figure 9. Annual discharge of six creeks, 1931-58. (Mean monthly discharge supplied by Salt Lake City Corp.; computation of annual runoff by U.S. Geological Survey.)

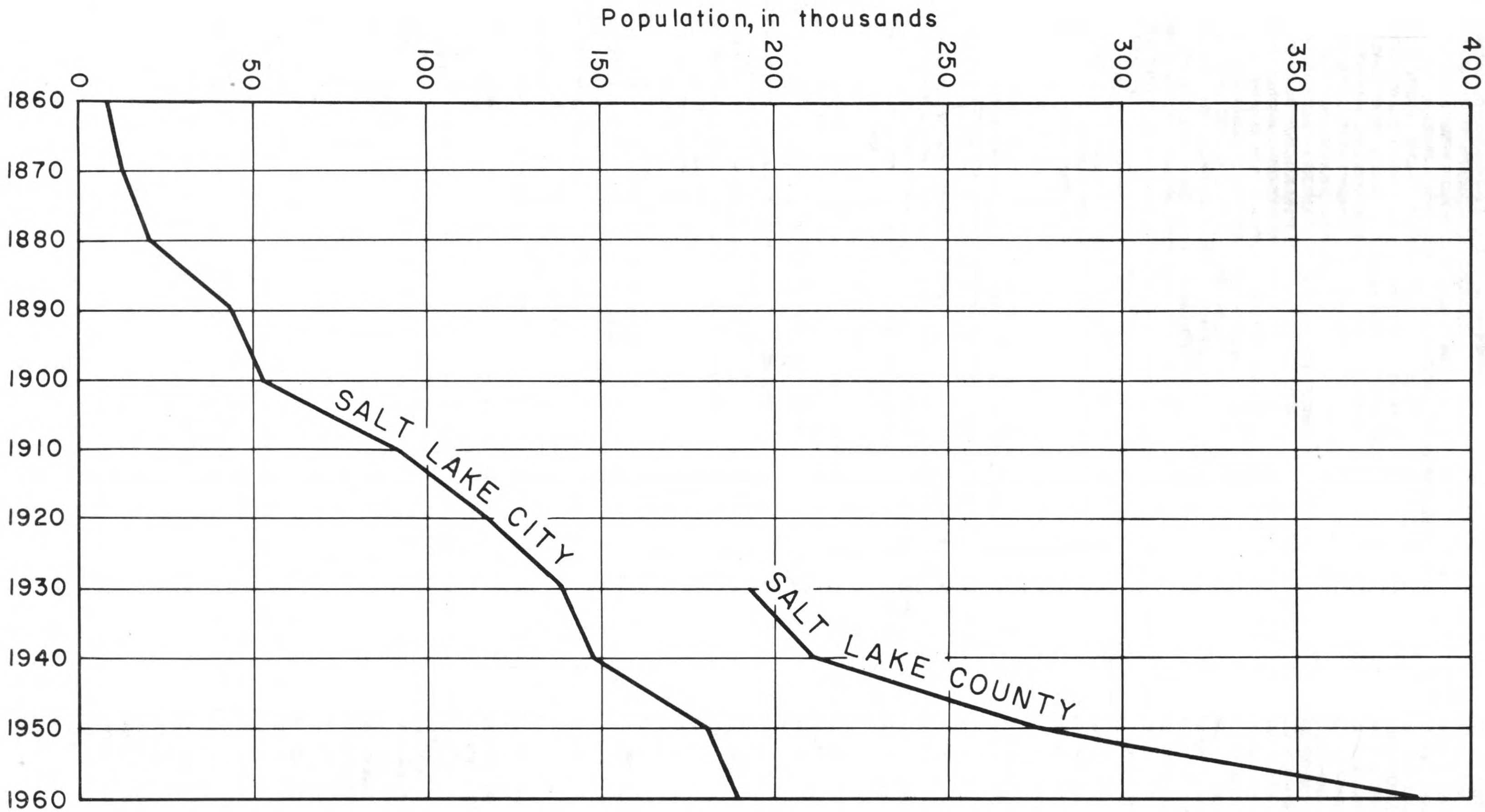

Figure 10. Population growth in Salt Lake County and Salt Lake City.
(Data from U. S. Census Bureau.)

Industry

The principal industries in Salt Lake County are mining and processing of metals, petroleum refining, and production of military and defense equipment. The most important industry by far is mining, and the principal mining activity is in the Oquirrh Mountains where the Bingham Canyon Copper Mine, operated by Kennecott Copper Corp., is the largest open pit copper mine in North America. It supplies ore to mills, smelters, and refineries at the north end of the Oquirrh Mountains. Other underground mines near Lark yield lead, zinc, copper, gold, and silver (U.S. Bureau of Mines, 1957). In the past, gold, silver, copper, lead, and zinc have been mined from the Wasatch Range near Salt Lake City (Calkins and Butler, 1943), but production now is small. A quarry in Parleys Canyon, east of Salt Lake City, supplies rock materials for the manufacture of portland cement. One of the most important mining activities in the valley is the excavation of sand and gravel from shore deposits of prehistoric Lake Bonneville, and gravel pits exist at many sites.

PHYSIOGRAPHY

The depositional and erosional history of the Jordan Valley has been exceedingly complex; therefore, the relationships of the sediments in the valley are best understood by considering existing landforms, which are the product of the rocks that form them and of the erosion to which the rocks have been subjected since deposition. Beaches, lake plains, wave-cut cliffs, wave-cut benches, spits, bars, and deltas were formed by or in lakes; pediments, alluvial fans, stream terraces, incised channels, flood plains, and mud-rock flow deposits were formed by streams or running water; dunes and blowouts were formed by wind; moraines were formed by ice; and fault scarps were formed by earth movements. Each process was responsible for certain details of the landscape, but many of the larger features, such as the slope of the surface from the Oquirrh Mountains eastward to the Jordan River or from the foot of the Wasatch to the Jordan River, are due to a number of combinations of these processes. (See fig. 3.)

Lake Deposits and Erosion Features

Lake deposits and the products of wave erosion are among the most impressive features of the landscape of the Jordan Valley. Lake deposits form the massive embankments at the mouths of many canyons and at the Jordan Narrows, and they underlie the broad flat plain of the northwestern part of the valley. The distinctive wave-cut cliffs along the face of the Wasatch Range are the products of wave erosion.

The number of lakes that occupied the Jordan Valley in Pleistocene time is not known, but the lakes that left the prominent features which we see today have been collectively designated as Lake Bonneville. Lake Bonneville had several periods of high water and several periods when the water stood as low or lower than the present Great Salt Lake, whose surface elevation is about 4,200 feet above sea level. Gilbert (1890) described four major levels of Lake Bonneville which, ranging from highest to lowest, he called the Bonneville shoreline, the Intermediate shorelines, the Provo shoreline, and the Stansbury shoreline. Eardley and others (1957, p. 1161) added a fifth lower level called the Gilbert shoreline.

The Bonneville shoreline generally is accepted as being at an altitude of 5,135 feet above sea level in the Jordan Valley, although at most places in the valley it has been uplifted by faulting to an altitude of about 5,180. This shoreline represents the highest lake level recognized; and in general it marks the transition from mountain topography, which is shaped by erosion, to valley topography, which is shaped largely by deposition. The Bonneville shoreline is usually a wave-cut cliff in consolidated rock, below which is either a wide wave-cut bench covered by a thin gravel deposit or a steep embankment deposit of boulders and gravel. The wave-cut cliff may be almost indiscernible in places where the shore of the lake sloped gently or where it was sheltered from violent wave action. Bars and spits are found along the Bonneville shoreline at places where the topography of the headland was favorable for their formation (fig. 3). Jones and Marsell (1955, p. 94-95) have suggested that the Alpine Member of the Little Cottonwood Formation (table 3) includes the deposits associated with the Bonneville shoreline.

The Intermediate shorelines of Gilbert (1890, p. 135) refer to evidence of deposition and erosion between the Bonneville and Provo shorelines. Hunt (in Hunt, Varnes, and Thomas, 1953, p. 17) applied the name Alpine Formation to the deposits associated with Gilbert's Intermediate shorelines. The highest Intermediate shoreline in the Jordan Valley is at an altitude of about 5,050 feet, but it is indistinct compared to the other major shorelines.

The Provo shoreline is at an altitude of about 4,800 feet, and it is marked by large embankment deposits that usually are in the form of spits and by distinct wave-cut cliffs associated with a wide wave-cut bench. Bissell (1952) and Jones and Marsell (1955, p. 103) have recognized two sets of Provo shore features. The higher set, at an altitude of about 4,800 feet, has been called Provo I, and the lower set, at about 4,760 feet, has been called Provo II.

The Stansbury shoreline has an average altitude of about 4,470 feet, but the altitude ranges considerably in the valley. The shoreline is marked mostly by embankment deposits and small spits that are below, but in the same general area as, the larger Provo shoreline spits.

The Gilbert shoreline, which is at an altitude of 4,240 feet, separates two distinct types of topography. Below the Gilbert shoreline the topography consists of a flat, nearly featureless lake plain with very poor drainage, and above the shoreline the topography is sloping and has many features of relief.

Between the Provo and Stansbury shorelines and below the Stansbury shoreline are gently sloping, elongate mounds of gravel and sand formed as parts of deltas in a receding lake. The deltas below the Stansbury level are not as large or well developed as those above the Stansbury level. A particularly distinct deposit of this type is evident along Bingham Creek where it has been exposed by the stream (fig. 3). The northern part of a deltaic deposit along Parleys Creek was eroded by the creek before it incised its channel, but the southern part is well exposed between the Provo and Stansbury levels. The landscape in front of the two Cottonwood Creeks is built up by massive delta deposits.

Most streams in the Jordan Valley flow in deeply incised channels and many of them have terraces in their upper courses which indicate several cycles of erosion. The incised channels in the Jordan Valley are shown in figure 3. Some of the larger streams have developed flood plains within the incised channels. On the flood plain of the Jordan River, which extends the entire length of the valley, are ox-bow lakes, meander scars, thick flood-plain deposits, and other features typical of flood plains.

Mud-rock flow deposits consist of poorly sorted mixtures of material that range in size from clay to large boulders. Like alluvial fans, mud-rock flow deposits are fan shaped and form at the mouths of canyons or where stream channels widen greatly; unlike alluvial fans, mud-rock flow deposits are unsorted. They may be slightly graded vertically, however, with the coarser material at the bottom. Mud-rock flows generally result from cloudburst-type rains, and they have probably occurred since the Jordan Valley was formed in middle Tertiary time. Numerous mud-rock flows have occurred along the front of the Wasatch Range in historic time.

Stream Deposits and Erosion Features

Among the oldest features in the valley landscape are the alluvial fans and mud-rock flows on which the pediment surfaces east of the Oquirrh Mountains were carved by later erosion. Slentz (1955, p. 34) has indicated that most of the pediment "was sculptured on a series of coalescing alluvial fans (Harkers Fanglomerate) but, no trace of the forms of the old fans can be seen today." His description of the Harkers as poorly sorted and with torrential bedding and cut-and-fill structure is convincing evidence that the unit was built up by streams and probably by mud flows. Slentz (1955, p. 35) recognized traces of three episodes of pedimentation above the Bonneville shoreline east of the Oquirrh Mountains. The pediments in this area are developed on rocks of the Salt Lake Formation of Tertiary age. In pre-Lake Bonneville time the pediments extended below the Bonneville shoreline for a considerable distance, perhaps to the Granger fault scarp (fig. 3). Although they account for the even, gentle slope of the west side of the Jordan Valley, the pediments have been modified by wave-cut cliffs, spits, and beach deposits of Lake Bonneville and have been deeply dissected by post-Lake Bonneville streams.

Other pediments in the Jordan Valley are: (1) Between the Bonneville Golf Course fault scarp and the Wasatch Range. This pediment surface is cut on rocks of Mesozoic age which are at most only a few feet, and at many places only a few inches, below the surface. (2) On the west side of City Creek near its mouth (Eardley and others, 1957, p. 1158). This pediment is developed on rocks of the Wasatch Formation of Tertiary age. (3) On the north flank of the East Traverse Mountains (Eardley and others, 1957, p. 1159). This pediment remnant is developed principally on rocks of the Oquirrh Formation of Permain and Pennsylvanian age. It is nicked by several wave-cut cliffs, and it is covered partly by beach deposits. Both the pediment and the beach deposits are being dissected by modern gullies.

Most of the alluvial fans that retain their distinctive fan shape at present were formed by stream action after Lake Bonneville time. A few fans along the north face of the West Traverse Mountains, however, are of pre-Lake Bonneville age because they are cut by Lake Bonneville wave-cut cliffs. The post-Lake Bonneville fans are broad with gentle slopes, indicating that they are thin deposits. Downtown Salt Lake City is located on such a gently sloping fan built by City Creek. Another post-Lake Bonneville fan in front of a small canyon on the Salt Lake salient was pictured by Gilbert (1890, p. 348) in his work on Lake Bonneville; but this fan has now been removed by gravel operations in the area.

Wind Deposits and Erosion Features

Recent thin windblown deposits that are a few inches to a few feet thick cover a large part of the Jordan Valley, but prominent dunes and recognizable blowouts are generally restricted to areas near the large Provo spits (fig. 3). Blowouts and small mounds of windblown sand which have no predominant lineation mark the surface of small spits between the Evaporating Ponds spit and the Jordan River. Below and west of the Draper spit are similar wind deposits. Prominent dunes north of Dry Creek channel and north of Little Cottonwood Creek are elongate in a north-south direction.

Glacial Deposits

Some of the material that fills the Jordan Valley was originally eroded from the Wasatch Range by glaciers. Little of the material that was plucked from the mountains by the ice, however, was deposited in the valley directly by the glaciers. Before deposition, the material was sorted and redistributed by melt-water streams or by lakeshore currents. Glaciers in Little Cottonwood Canyon and Bells Canyon flowed directly into the valley, however, leaving a terminal moraine and several lateral moraines at the mouths of the canyons.

Fault Scarps

Recent or late Pleistocene faulting has modified the landscape at several places in the Jordan Valley. Although movement on these faults has not been noted in historical time, the presence of scarps in unconsolidated alluvium indicates recent movement. A series of scarps on the east side of the valley face toward the west, and several on the west side of the valley face toward the east (fig. 3). These scarps and the faulting that produced them are discussed in greater detail in the section on "Structure."

GEOLOGY

Geology of the Mountains Bordering Jordan Valley

The Jordan Valley lies at the eastern edge of the Basin and Range physiographic province, bounded on the east by the Wasatch Range, a part of the Rocky Mountains, and on the south and west by the Traverse and Oquirrh Mountains, which are in the Basin and Range province. The rocks in the Wasatch Range include thick sequences of sedimentary rocks of Precambrian, Paleozoic, Mesozoic, and Cenozoic age intruded by granitic rocks of Late Cretaceous or early Tertiary age. The Traverse Mountains consist principally of rocks of the Oquirrh Formation of Pennsylvanian and Permian age and of sedimentary and volcanic rocks of Tertiary age. The part of the Oquirrh Mountains that borders the Jordan Valley is composed of Paleozoic rocks, principally of the Oquirrh Formation but including Mississippian rocks, and sedimentary, intrusive, and extrusive rocks of Tertiary age. The pre-Quaternary rocks of the Wasatch Range are described in table 1 and those of the Traverse and Oquirrh Mountains are described in table 2.

The major structure of the Wasatch Range east of the Jordan Valley is a large east-trending syncline, the axis of which is near Parleys Canyon. North and south of Parleys Canyon the rocks become progressively older until Precambrian rocks are reached north of the Salt Lake salient and near Big Cottonwood Canyon. A minor syncline and anticline between Parleys and Emigration Canyons and several thrust and normal faults complicate the structure. In the Little Cottonwood Canyon area granodiorite of Late Cretaceous or early Tertiary age intrudes the south flank of the major syncline, and parts of the north flank on the Salt Lake salient are covered by conglomerates of early Tertiary age.

The Oquirrh and Traverse Mountains that border the Jordan Valley consist principally of the Oquirrh Formation of Permian and Pennsylvanian age in the higher areas and volcanic and sedimentary rocks of the Salt Lake Formation in the foothills. In the Oquirrh Mountains, igneous rocks of Tertiary age have intruded the Oquirrh Formation. These intrusives and adjacent sedimentary rocks are the host rocks for the copper, molybdenum, gold, lead, and zinc ores of the Bingham mining district. In the Oquirrh and Traverse Mountains, the Oquirrh Formation is much thicker than formations of similar age in the Wasatch Range. This has lead to the postulation that the area was overridden from the west by a major thrust that carried eastward part of the thick Oquirrh Formation of the Oquirrh Mountains. Volcanics and semiconsolidated rocks of the Salt Lake Formation crop out in large areas above 5,200 feet and at a few places below 5,200 feet (fig. 11). These rocks are often penetrated by wells on the west side of the Jordan Valley.

Geology of the Valley

Surface geology

The rocks at the surface in the Jordan Valley consist principally of unconsolidated deposits of boulders, gravel, sand, silt, clay, and mixtures of these which were laid down by streams, lakes, or the wind in Quaternary time. In addition, there are extensive outcrops of semiconsolidated and consolidated rocks of Tertiary age and small isolated outcrops of consolidated rocks of Mesozoic and Paleozoic age. The pre-Quaternary rocks of the valley are described in tables 1 and 2, and their areas of outcrop are shown in figure 11.

Pre-Quaternary rocks crop out principally in areas where pediments extend from the mountains into the valley, and the rocks that form the pediments are similar to the rocks exposed in the nearby mountains. The most prominent outcrops of pre-Quaternary rocks in the valley include the Wasatch Formation in the City Creek Fan and North Bench subdistricts; Mesozoic rocks in the East Bench subdistrict, south of Emigration Creek; Paleozoic rocks in the Southeast district; volcanic rocks of Tertiary age in the South Fan subdistrict along the north slope of the western Traverse Mountains; and sedimentary and volcanic rocks of the Salt Lake Formation in the West Slope district along the eastern slope of the Oquirrh Mountains. (fig. 11).

The Quaternary rocks of the Jordan Valley are unconsolidated and semiconsolidated deposits of Lake Bonneville alluvial fans, mudflows, sparse sand dunes, and glacial deposits. The relief of this partly filled valley from its present floor to slightly above the highest shoreline of Lake Bonneville (approximately 5,200 feet above sea level) is about 1,000 feet. The type of material that was deposited in any locality was determined to some degree by the nearness of the locality to a canyon mouth, the mountain front, or a valley stream channel. Thus, no stratigraphic sequence is applicable to the valley as a whole. Some of the areas that were inundated by Lake Bonneville received deposits from the lake, other areas were eroded by lake currents; some areas that received Lake Bonneville deposits were later subjected to extensive stream erosion which removed the lake deposits, other areas were covered by post-lake stream deposits. The stratigraphy of the deposits in the Jordan Valley is similar to the stratigraphy described by Hunt in northern Utah Valley (Hunt, Varnes, and Thomas, 1953). Hunt's stratigraphic column was modified for the Jordan Valley by Jones and Marsell (1955, p. 91), and table 3 is modified from their work.

Subsurface geology

Extensive study of drillers' logs and well cuttings provided information about the geologic characteristics that define the ground-water districts, about the distribution of gravel, and about the source of sediments that comprise the valley fill. The stratigraphy developed for the surface deposits is difficult to distinguish in the subsurface, and no stratigraphic or water-bearing zones could be correlated throughout the entire valley such as was done in northern Utah Valley (Thomas, 1953, p. 83-87). The subsurface deposits in the Jordan Valley are divided into several geologic divisions which differ in tectonic or depositional histories. These divisions of the valley are the ground-water districts and subdistricts as outlined in this report. Within some of the districts it has been possible to correlate zones of water-bearing sediments over a significant area.

The distribution of gravel-bearing intervals[1] in the Jordan Valley is shown in figure 12, which was prepared from information obtained from drillers' logs of about 150 wells drilled by the cable-tool method. The percentages indicated in figure 12 represent the ratio of the intervals in which gravel was reported by the driller to the total depth of the well. No attempt was made to determine how much gravel was present in any gravel-bearing interval, however, and figure 12 gives only a qualitative indication of the differences in gravel content of the sediments in the various parts of the valley. The strata in the areas of

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[1] The term gravel, as applied in figure 12, includes all rock particles that exceed 2 millimeters in diameter.

TABLE 2

GENERALIZED SECTION OF THE PRE-QUATERNARY GEOLOGIC UNITS OF THE OQUIRRH AND TRAVERSE MOUNTAINS BORDERING THE JORDAN VALLEY

(Adapted from *Slentz, 1955, Gilluly, 1932, Tooker and Roberts, 1961, and James, Smith, and Welsh, 1961.)

Era	System		Series	Stratigraphic unit		Thickness (feet)	Description
Cenozoic	Tertiary		Pliocene	Salt Lake Formation	*Harkers Fanglomerate	300	Fanglomerate, tan to gray, poorly consolidated. Poorly sorted with occasional channels of reddish silt. The particles are angular to subrounded quartzite, sandstone, dark limestone, andesite, and latite which range in size from silt to boulders 8 feet across.
					*Travertine unit	20	Dense, massive, flinty travertine to coarse, crustiform limestone often resembling tufa. May be contemporaneous with Harkers Fanglomerate.
					unconformity		
					*Camp Williams unit	100	Red to tan mudstone, siltstone, and sandstone. A basal conglomerate consists primarily of igneous detritus.
					unconformity		
					*Jordan Narrows unit	More than 300 Perhaps 2,000	White marlstone; oolitic, argillaceous, and cherty limestone; sandstone clay and rhyolitic tuff.
					*Traverse volcanics	1,000 to 3,000	Red to purple andesite and andesite breccia; augite and biotite-hornblende latitie; and lesser amounts of rhyolite and basalt.
				unconformity			
Paleozoic	Permian		Lower	Oquirrh Formation		12,000 to 15,000+	Interbedded lenticular quartzite and limestone with thin beds of shale and dolomite.
	Carboniferous	Pennsylvanian	Upper				
			Middle				
			Lower	Manning Canyon(?) Shale		100+	Shale and shaly limestone; only incomplete section is exposed.
		Mississippian	Upper				

Intrusive rocks of the Oquirrh Mountains

Era	System	Series	Stratigraphic unit	Description
Cenozoic	Tertiary			Intrusive stocks, sills, and dikes of granite, monzonite, granite porphyry, and rhyolite-quartz latite.

TABLE 3

GENERALIZED SECTION OF THE GEOLOGIC UNITS OF THE VALLEY FILL IN THE JORDAN VALLEY

(Modified from Jones and Marsell, 1955)

System	Series	Stratigraphic unit			Thickness (feet)	Lithology and depositional environment
Quaternary	Recent	Sediments and sedimentary rocks			-	Alluvial fans. Fluviatile gravel, sand, silt, and clay. Peat. Dunes of oolites and of quartz sand. Lake sediments; calcareous clay usually gray or blue. Thin evaporites, oolites.
	Pleistocene	Lake Bonneville Group	Draper Formation		-	Shore gravel and sand, and lake-bottom silt and clay commonly buff or gray. Fluviatile gravel, sand, silt, and clay. Deltaic gravel, sand, and silt. Alluvial fans.
			Little Cottonwood Formation	Provo and Bonneville Members	0-80	Beach gravel and sand. Spit and delta gravel and sand. Lake-bottom silt and clay, buff or gray. Terrace gravels. Mud-rock flow deposits. Glacial deposits. Turbidity-flow deposits.
				unconformity		
				Alpine Member	0-400	Beach gravel and sand. Spit and delta gravel and sand. Lake-bottom silt and clay, commonly buff. Turbidity-flow deposits. Mud-rock flow deposits.
		unconformity				
		Green clay Basal fanglomerate			0-700 50-400	Siliceous siltstone and claystone resembling glacial flour; grayish-green. Alluvial-fan gravel. Mud-rock flow deposits.
		unconformity				
Tertiary	Pliocene	Salt Lake Formation				See table 2.

higher percentages of gravel-bearing intervals in general will yield water to wells more readily than the strata in areas with lower percentages of gravel-bearing intervals.

An appreciable number of wells have more than 50 percent of gravel-bearing intervals in the East Bench district, the City Creek Fan subdistrict, the Cottonwoods district, and the South Fan subdistrict. No wells in the main part of the Northwest Lake Plain district or in the main part of the East Lake Plain district have 50 percent of gravel-bearing intervals, and most wells in those districts have less than 25 percent of gravel-bearing intervals. Most wells in the Southeast district and in the South Margin and North Oquirrh subdistricts have between 25 and 50 percent of gravel-bearing intervals.

Studies were made to determine the source of the detritus that makes up the valley fill by relating well cuttings from many drilled wells to the geologic formations in the adjacent mountains. In general, the results of this study indicated that the sediments in the East Bench district came from the adjacent Wasatch Range to the east. Most sediments in the East Lake Plain subdistrict have probably been redeposited from erosion of material in the East Bench district, although much of the sediment in the southern part of the East Lake Plain subdistrict is derived from the the drainage basins of the Cottonwood Creeks. The subsurface sediment in the Cottonwoods district was derived exclusively from the drainage basins of the two Cottonwood Creeks. Although sediments from both drainage basins can be found throughout the district, the coarser materials usually consist of material from the Big Cottonwood Creek basin. Sediments in the Southeast district are derived principally from slopewash from the Wasatch front and from the Cottonwood Creeks drainage basins. Near the southern part of the district, however, the sediments are derived from the Traverse Mountains. All of the sediments in the West Slope district are derived from the Oquirrh Mountains. Most of the sediments in the Mid-Jordan subdistrict are derived from the drainage basins of the two Cottonwood Creeks, with material from the Little Cottonwood Creek basin predominant. The sediments in the Northwest Lake Plain subdistrict are of a granitic composition, and they have either been derived from the Little Cottonwood Creek basin or from the Wasatch Range north of the Jordan Valley. The detritus in the South Margin and North Oquirrh subdistricts is derived from the Oquirrh Mountains.

Structure

The Jordan Valley is a graben, and the surrounding mountains have been uplifted relative to the valley. According to Cook and Berg (1961, p. 79-81 and pl. 13), the boundary between the valley and the Wasatch Range to the east and Traverse Mountains to the south, in many places, is marked by a fault zone. The southern part of the boundary between the valley and the Oquirrh Mountains to the west is marked by a fault (Slentz, L. W., written communication, 1955), but there is no evidence of a major fault north of Bacchus. In addition to the boundary faults separating the Jordan Valley from the adjacent mountains, other faults, more or less in the middle of the valley, have been recognized from their topographic expression and from studies of hydrology and well records (fig. 11). These faults, together with some of the boundary faults, define an inner graben within the Jordan Valley which contains a considerable thickness of sediment derived from the adjacent mountains.

Boundary faults

The Wasatch fault zone separates the Wasatch Range from the Jordan Valley between Corner Creek and the Mount Olympus salient (fig. 11). Recent movement along this fault zone is shown by fresh scarps and fault trenches in the Lake Bonneville shore deposits along the mountain front (fig. 3). A total throw of about 3,000 feet along this fault zone has been estimated by Granger and others (1952, p. 28). Well (D-3-1)2ccc-1 (fig. 11), drilled in 1955 about a mile west of the fault zone, failed to penetrate bedrock at a depth of more than 1,000 feet. It may be, therefore, that the total throw along the Wasatch fault zone is even greater than the estimated 3,000 feet.

A boundary fault close to the mountain front has not been mapped immediately north of the Mount Olympus salient. The Bonneville Golf Course fault, a mile or so west of the mouth of Emigration Creek, could be the boundary fault in that area, however, and it may extend farther south than has been recognized. Farther north near the Salt Lake salient, the Wasatch Range is separated from the Jordan Valley by the Warm Springs fault. Recent movement along this fault has left low scarps along the base of the salient; older movement has left mature hanging valleys on the crest of the salient.

The southern part of the Jordan Valley may be separated from the Traverse Mountains by a fault (shown in fig. 11 as the Steep Mountain fault). The face of Steep Mountain is suggestive of a fault scarp (Cook and Berg, 1961, p. 81), and many of the outcrops of Paleozoic rock below the face of the mountain are extremely brecciated.

The southern part of the boundary between the Jordan Valley and the Oquirrh Mountains is marked by a fault that Slentz (1955, p. 35) mapped between the Paleozoic rocks of the mountains and the Tertiary rocks of the foothills. This fault does not show the sharp scarps of Recent movement, such as may be seen along the Wasatch fault zone; and "in part the fault is buried by the Harkers Fanglomerate" (Slentz, 1955, p. 36), which is probably the subaerial accumulation resulting from the faulting. The fanglomerate terminates south of Bacchus, and there is no evidence of a major fault continuing north from Bacchus. At the north end of the Oquirrh Mountains, however, the abrupt change between the mountain mass and the flat lake plain is due to an east-west fault zone (Roberts and Tooker, 1961, fig. 3). The Paleozoic rock is folded, and large adjacent blocks have discordant dips. Wells in this area penetrate a breccia of Paleozoic limestone and quartzite which probably is related to faulting.

Faults within the valley

The East Bench fault, which has the most conspicuous topographic expression within the Jordan Valley, is on the east side of the valley with west-facing fault scarps (fig. 3). It forms the eastern boundary of most of the inner graben in the Jordan Valley. The fault extends from the Mount Olympus salient to the mouth of Dry Creek (fig. 11).

Except at its northern and southern ends, the East Bench fault is between 2 and 3 miles west of the mountain front. The scarp of the northern part of the East Bench fault has a maximum height of 80 feet. Toward the south, however, where the fault consists of en echelon scarps, the individual scarps are smaller. In the vicinity of sec. 29, T. 1 S., R. 1 E., southeast of South Salt Lake, there are at least three semiparallel scarps.

The scarps of the East Bench fault are preserved in unconsolidated Lake Bonneville deposits, thus indicating Recent movement along the fault. Displacement of the lake beds has been observed by R. E. Marsell and D. J. Jones (oral communication). Mud-rock flow deposits of boulders, gravel, and clay, which lie beneath lake deposits in the upthrown block, are opposite lake deposits of sandy clay and thin lenses of gravel in the downthrown block.

The Granger and Taylorsville fault scarps are on the west side of the Jordan Valley facing east (fig. 3), and they are part of a north-trending fault zone herein called the Jordan Valley fault zone (fig. 11). This fault zone forms the western boundary of the inner graben in the Jordan Valley. The Granger and Taylorsville fault scarps trend north-northwest and are 10-20 feet high, with the west side up.

The scarps are evidence of Recent movement along the fault zone. The total vertical displacement along the fault zone is at least 750 feet. This is indicated by comparison of well (C-2-1)4bbc-2 (fig. 11), which is west of the Granger scarp, and which penetrated Tertiary sediments at 24 feet, and well (C-1-1)27dda-8, which is east of the Taylorsville scarp, and which did not reach Tertiary sediments at a depth of 775 feet. The records of small-diameter jetted wells in sec. 33, T. 1 S., R. 1 W., suggest that at least 200 feet of this displacement is in the vicinity of the Granger scarp. On the upthrown side of the Granger scarp most wells in section 33 are about 100 feet deep (fig. 13), whereas on the downthrown side most wells in the same section are more than 300 feet deep (fig. 14).

The geophysical evidence of Cook and Berg (1961, p. 81 and pl. 13) suggests that the Jordan Valley fault zone extends northward out of the Jordan Valley. Additional evidence to support this suggestion is provided by a narrow area of high ground-water temperatures (fig. 30) which extends northward from the northern end of the Jordan Valley fault zone. It is equally possible that the Jordan Valley fault zone extends southward from the Granger fault, approximately along the path of the Jordan River, as indicated by the linear trending area of high ground-water temperature in the southern part of the valley (fig. 30) and the deep trough of Pleistocene sediments east of the Jordan River.

Geologic History

The Jordan Valley includes several tectonic areas having different depositional and erosional histories, and an understanding of the geologic history of the valley helps in understanding ground-water conditions in the several areas. The chronology developed by Eardley (1955, p. 40-43) for Tertiary and Quaternary time is used as a framework for the following discussion.

1. An orogeny west of the Jordan Valley resulted in the deposition of the Wasatch Formation during early Tertiary time in the Wasatch Range and in at least the eastern part of the present site of the Jordan Valley. This group consists principally of conglomerate that was deposited rapidly by swiftly moving streams draining the front of the mountains rising to the west. Volcanic activity during this time contributed flow rock and breccia to the Wasatch Formation.

2. Broad folding and block faulting outlined the future Jordan Valley. Tuff and limestone of the Jordan Narrows unit of the Salt Lake Group of Slentz (1955, p. 25) were deposited in a fresh-water lake in the valley. Vulcanism was common, as evidenced by extrusive lavas, mainly in the Traverse Mountains, and the tuff beds in the lake deposits.

3. The lake disappeared, and a widespread, gently undulating surface was eroded on the lavas and the Jordan Narrows unit of Slentz. This surface forms part of the crest of the Traverse Mountains.

4. Minor block faulting followed, accompanied by the deposition of the Camp Williams unit of Slentz--an alluvial fan deposit in which silt and clay are major constituents.

5. Block faulting along the Wasatch and the Oquirrh fronts raised the mountains, and the erosion that followed resulted in the deposition of alluvial fans extending far out into the valley. On the west side of the valley, the fan deposits form the Harkers Fanglomerate of Slentz (1955). On the east side, the fan deposits are the sediments on the upthrown side of the East Bench fault.

6. A stable and arid period followed during which the Oquirrh, East Traverse, Emigration, and City Creek pediments were formed.

7. Block faulting along the Warm Springs fault, the East Bench fault, the Wasatch fault zone in the Cottonwoods area, and the Jordan Valley fault zone formed an inner graben within the valley which subsided and was concurrently filled with sediment. Lakes formed, dried up, and reappeared several times. Alluvial fans formed when a lake did not occupy the inner graben, the most extensive being at the mouths of the Cottonwood Creeks. Sedimentation in the graben generally kept pace with faulting, and subaerial sediments are interbedded with lake sediments. Lake Bonneville, which existed in late Pleistocene time, was the most extensive of the lakes, and it covered not only the inner graben but much of the adjacent pediments.

8. The last of the Bonneville lakes disappeared; but the inner graben continued to subside, creating the present Granger, Taylorsville, and East Bench fault scarps. The filling of the inner graben is continuing.

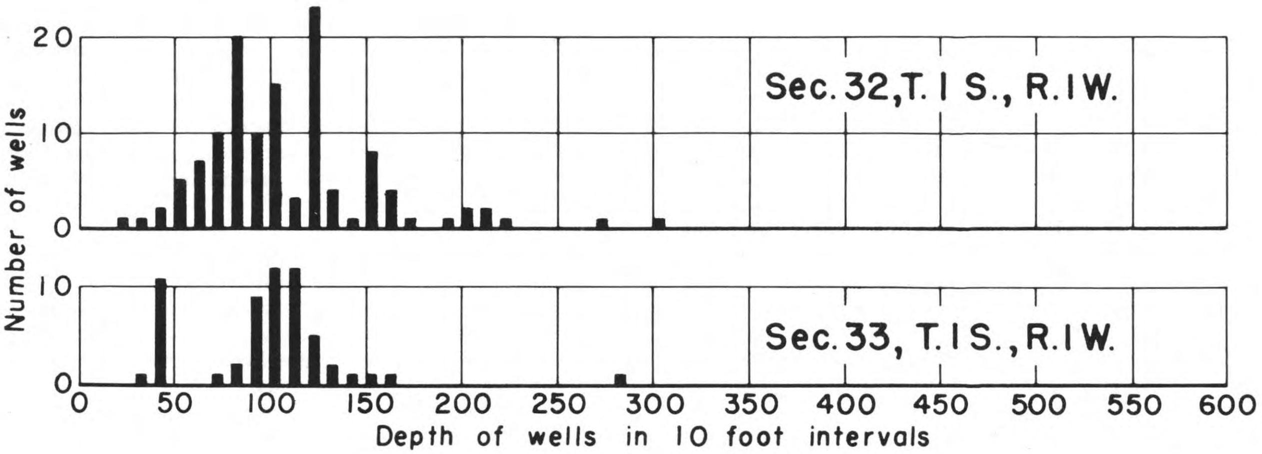


Figure 13. Depth of wells and number of small-diameter wells bottoming at those depths in two sections in the West Slope district. (Sections shown in figure 15.)

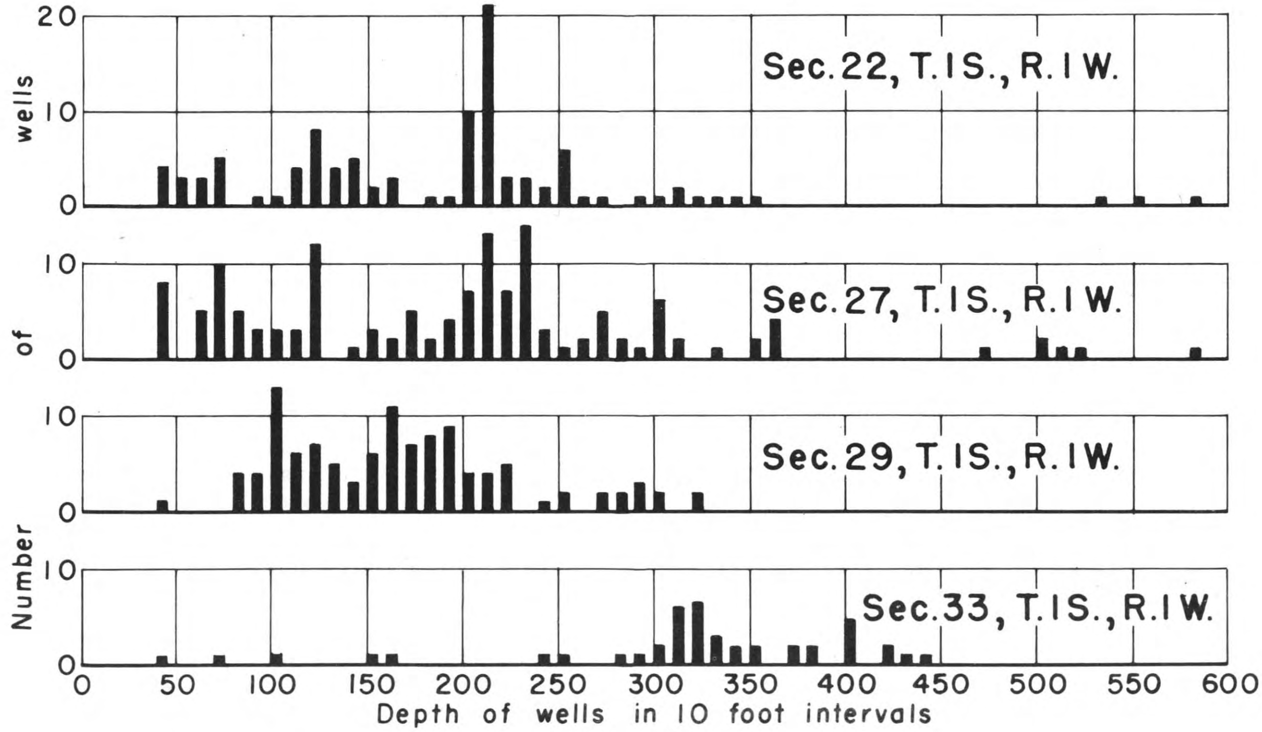


Figure 14. Depth of wells and number of small-diameter wells bottoming at those depths in four sections in the Northwest Lake Plain district. (Sections shown in figure 15.)

GROUND WATER

Principles of Occurrence

Ground water is water that fills the pore space and other openings in rocks in the zone of saturation of the earth. Rocks whose pore spaces or other voids form an appreciable part of their volume are said to be porous; rocks whose voids are interconnected by openings that will permit the passage of water are said to be permeable. Rocks that yield water readily to wells are called aquifers.

In unconsolidated sediments, such as the materials that fill much of the Jordan Valley, the porosity of the material is determined principally by the sorting of the grains. Poorly sorted material with a wide range of sizes contains less pore space than material of uniform size, because many of the spaces between large grains are occupied by smaller grains.

The permeability of unconsolidated sediments is determined primarily by the number and size of the interconnecting passages between the voids in the rock and the size of the voids themselves. Small interconnecting passages or voids fill with water that is prevented from moving freely mainly by molecular attraction between the water and the grains of rock. Such material as clay, therefore, even though having appreciable pore space between the tiny, uniform-sized grains, is only slightly permeable--the molecular attraction succeeds in holding essentially all contained water against the walls of the voids and will not release it except under a large hydraulic gradient. On the other hand, saturated deposits of well-sorted sand or gravel have voids that are connected by passages appreciably larger than those in clay and which permit water to pass readily.

Both the particle size and the sorting of a deposit are determined by the history of the erosion, transportation, and deposition of the deposit. Deposition by surface water usually favors sorting; streams commonly deposit well-sorted, coarse material in their channels. Floodplain deposits are well sorted, but they are fine in texture and usually have low permeability. Deposits of the shore zones of lakes also commonly consist of well-sorted, coarse material. Deposits on lake bottoms are usually well sorted but fine grained; thus, they have low permeability. Mud-rock flows commonly contain coarse material mixed with fine-grained material; thus, they have low permeability. Glacial deposits, where not reworked by running water, also are mixtures of coarse and fine materials; thus, they generally have low permeability. Eolian deposits are usually well sorted, and those that are coarse in texture generally have moderately high permeability. All of the depositional environments listed above are common in the Jordan Valley.

Water in an aquifer may occur under either confined (artesian) or unconfined (water table) conditions. Artesian conditions occur where a permeable bed, such as gravel, is overlain and underlain by less permeable (confining) beds, such as clay. Because it is confined, the water in the permeable bed is under pressure. If the hydrostatic pressure is sufficient to cause the water to flow at the ground surface from a well penetrating such a bed, the well is a flowing artesian well. If the hydrostatic pressure is not sufficient to cause the water to flow at the surface, the well is a nonflowing artesian well. The height to which the pressure can raise the water is called the pressure head, or simply, the head. The imaginary surface formed by pressure heads is called the piezometric surface.

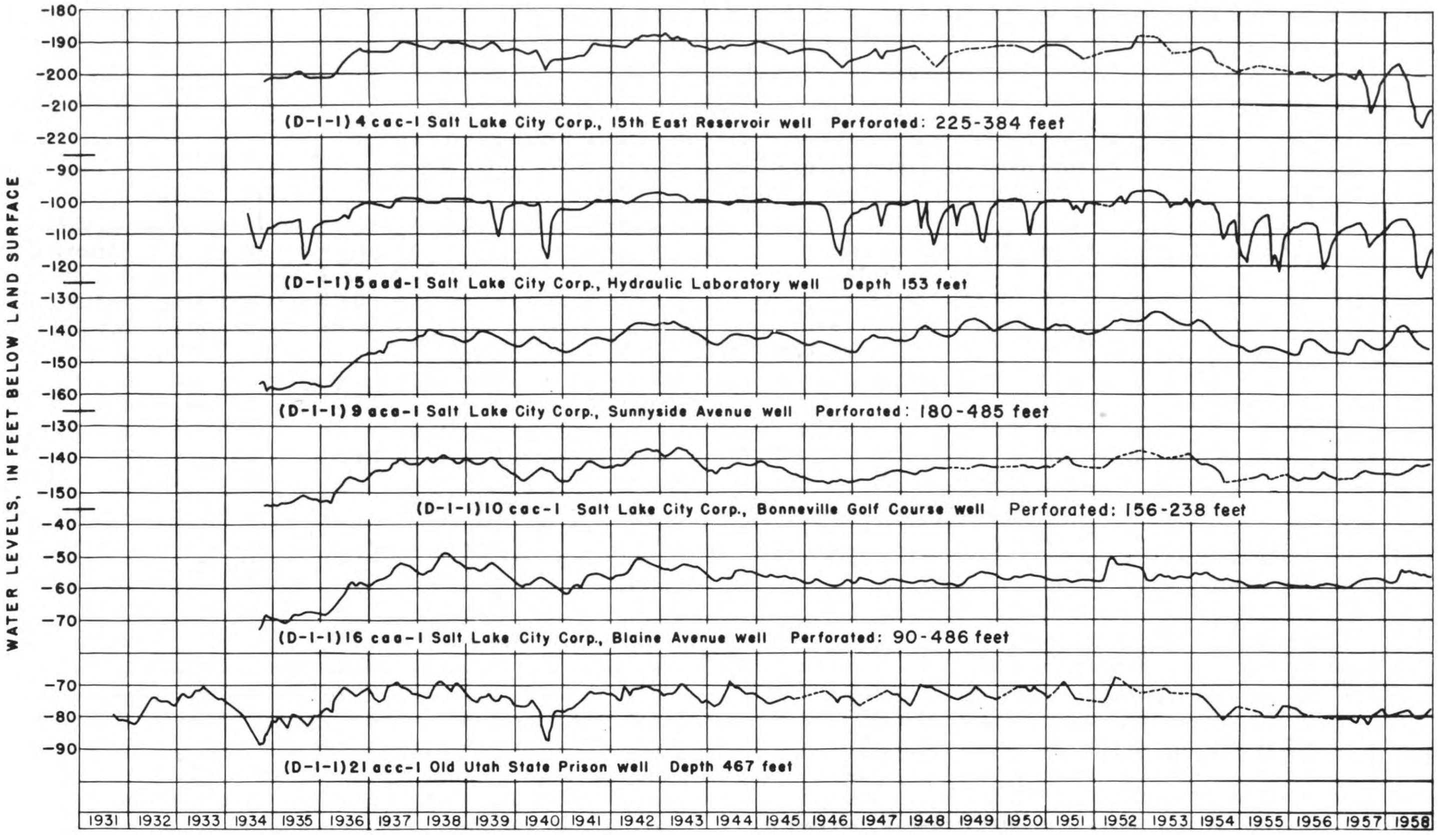
In unconfined conditions, the upper surface of the zone of saturation is defined as the water table. The water level in wells penetrating deposits that are under water-table conditions indicates the position of the water table below land surface. The water table is not a plane surface. It is usually an irregular sloping surface, and ground water moves in the aquifer in the direction of the slope of the water table. If the pressure head in an artesian aquifer declines to a point below the overlying confining bed, water-table conditions will result.

Occurrence in the Jordan Valley

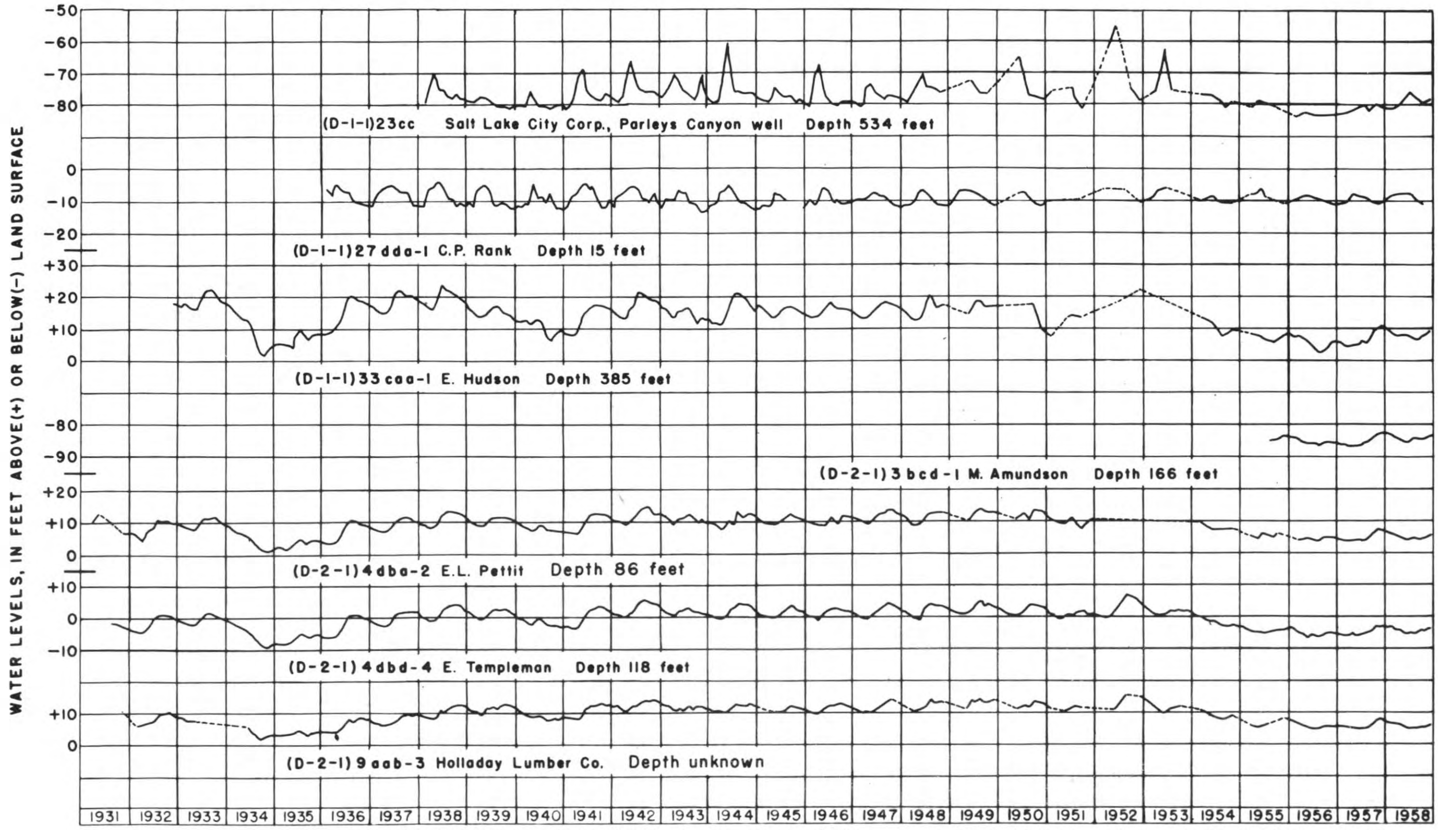
According to Taylor and Leggette (1949, p. 16), "The ground water in the Jordan Valley occurs in three general divisions: (1) A shallow ground-water body overlying the confining layer that creates the artesian basin, (2) local perched water bodies, and (3) an artesian basin or reservoir including the recharge area." Much of the recharge area for the artesian basin is along the benchlands on the sides of the valley, and here the ground water is unconfined. It forms a continuous body, however, with the confined water in the lower parts of the valley which constitute the bulk of the ground-water resource. This report is concerned mostly with the artesian basin because this basin contains most of the ground water that is or can be used by man.

Water-level trends

Water levels in the Jordan Valley rise in response to recharge to the ground-water reservoir and decline in response to discharge from the reservoir. Fluctuations may be temporary or repeated daily or seasonally, but a steady downward trend during a period of years indicates that discharge is exceeding recharge and the ground-water reservoir is being depleted. Downward trends occur during



(All water levels after 1935 measured by Salt Lake City Corp.)



(Water levels in wells (D-1-1) 23cc, (D-1-1) 27dda-1, (D-1-1) 33caa-1, (D-2-1) 4dba-2, and (D-2-1) 9aab-3 measured by Salt Lake City Corp. prior to 1955.)

Figure 17. Hydrographs of wells in the East Bench district. (Well locations shown in figure 15.)

periods of drought, partly because recharge is lessened and partly because withdrawal by wells is increased to make up for the decrease in surface supplies. A horizontal trend indicates that recharge and discharge are about equal, and the ground-water reservoir is in equilibrium. An upward long-term trend in water levels indicates that recharge exceeds discharge and the reservoir is filling. Upward trends occur when a wet period follows a drought, and water levels rise in the previously depleted ground-water reservoirs in response to the increase in recharge.

Hydrographs are shown in figures 17, 20, 22, 23, and 24 for representative wells in the Jordan Valley for the period 1931-58. The locations of the wells are shown in figure 15. The overall trend of the water level in most wells in the valley for the entire period of record is approximately horizontal. In the East Bench and Cottonwood districts, however, there has been a slight downward trend since 1953, and in the West Slope district there has been an upward trend during most of the period of record. The causes for the water-level fluctuations are discussed in detail in the following discussion of "Ground-water conditions by districts."

A water-level contour map (fig. 16) constructed from measurements made in the spring of 1958 shows that there has been little significant change in the size and shape of the ground-water reservoir in the Jordan Valley since 1931 (Taylor and Leggette, 1949, pl. 5).[1] The area in which wells commonly flowed at the land surface in 1956 also is shown in figure 16. This area is about the same as it was in 1931-33 (Taylor and Leggette, 1949, pl. 2) and in 1904 (Richardson, 1906, pl. 7).[1]

Ground-water conditions by districts

The sediments that fill the Jordan Valley were deposited by several forces in several environments, and the complex pattern of deposition resulted in a ground-water reservoir that ranges widely from place to place in permeability and the ability to yield water to wells. Specific aquifers generally are not traceable over large areas, and they are underlain, overlain, and grade into beds with lesser permeability. It has been possible, however, to divide the Jordan Valley into six ground-water districts on the basis of differences in geology and hydrology. The districts have been delimited on the surface principally by geomorphic features that reflect the subsurface geology. Three of the ground-water districts have been divided into subdistricts. The subdistrict boundaries are based on smaller differences in geology or hydrology, hence they are not as sharp as the district boundaries.

East Bench district

Boundaries, surface features, and geology.--The East Bench district is bounded on the east by the Wasatch Range and on the northwest, west, and south by the East Bench fault (fig. 11). The mountain-front boundary to the east is both a physiographic and hydrologic boundary for the district, and the sharp boundary of the East Bench fault effectively separates the East Bench from the East Lake Plain district to the west and northwest and from the Cottonwoods district to the south.

The East Bench district takes its name from the prominent bench formed on the upthrown side of the East Bench fault by the streams issuing from Red Butte, Emigration, Parleys, and Mill Creek Canyons. The district is underlain by both pediments and alluvial fans, and the pediment-bajada slope of the bench has been modified by wave-cut cliffs and embankment deposits of Lake Bonneville and by faulting. The major creeks that cross the district flow in incised channels.

The sediments in the East Bench district were derived from the Wasatch Formation, and they consist predominantly of boulders, gravel, silt, and clay. Large boulders are common, and the sediments recovered from most wells contain gravel in more than 50 percent of the intervals reported in drillers' logs (fig. 12). The sediments are principally the accumulation of mud-rock flows, although well-sorted channel deposits are also common. The clay and silt, other than those in the mud-rock flows, probably are colluvial and flood-plain deposits. The clay is mostly red, brown, and yellow; and blue or gray clay is rare and fossils are absent, indicating that deep lake sediments are not present. Lake sediments probably are limited to a thin surface cover of deposits of the Lake Bonneville Group.

The thickness of alluvium in the East Bench district ranges from 0 to about 700 feet. South of Emigration Creek a pediment extends about a mile from the mountain front into the valley. At most places on this pediment, Mesozoic rocks are only a few feet below the surface and are generally covered by thin channel sand and gravel. Bedrock has been exposed at places during excavation for basements or water and sewer lines. By contrast, the alluvium has a maximum known thickness of about 700 feet in the fans that have developed west of the mouths of Parleys and Mill Creek Canyons.

Wells and ground-water conditions.--The East Bench is one of the most favorable areas in the Jordan Valley for the construction of wells with large yields. Most wells in the district were drilled by percussion (cable tool) method, and they are 6 inches or greater in diameter. Many of these wells obtain large yields--ranging up to nearly 5,000 gpm (gallons per minute)--from well-sorted, coarse, channel deposits, and the specific capacities of

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[1] The 1958 map shows appreciably more detail than the 1931 and 1904 maps principally because new wells were available for measurement in 1958 in areas that had few or no wells in 1931 and 1904.

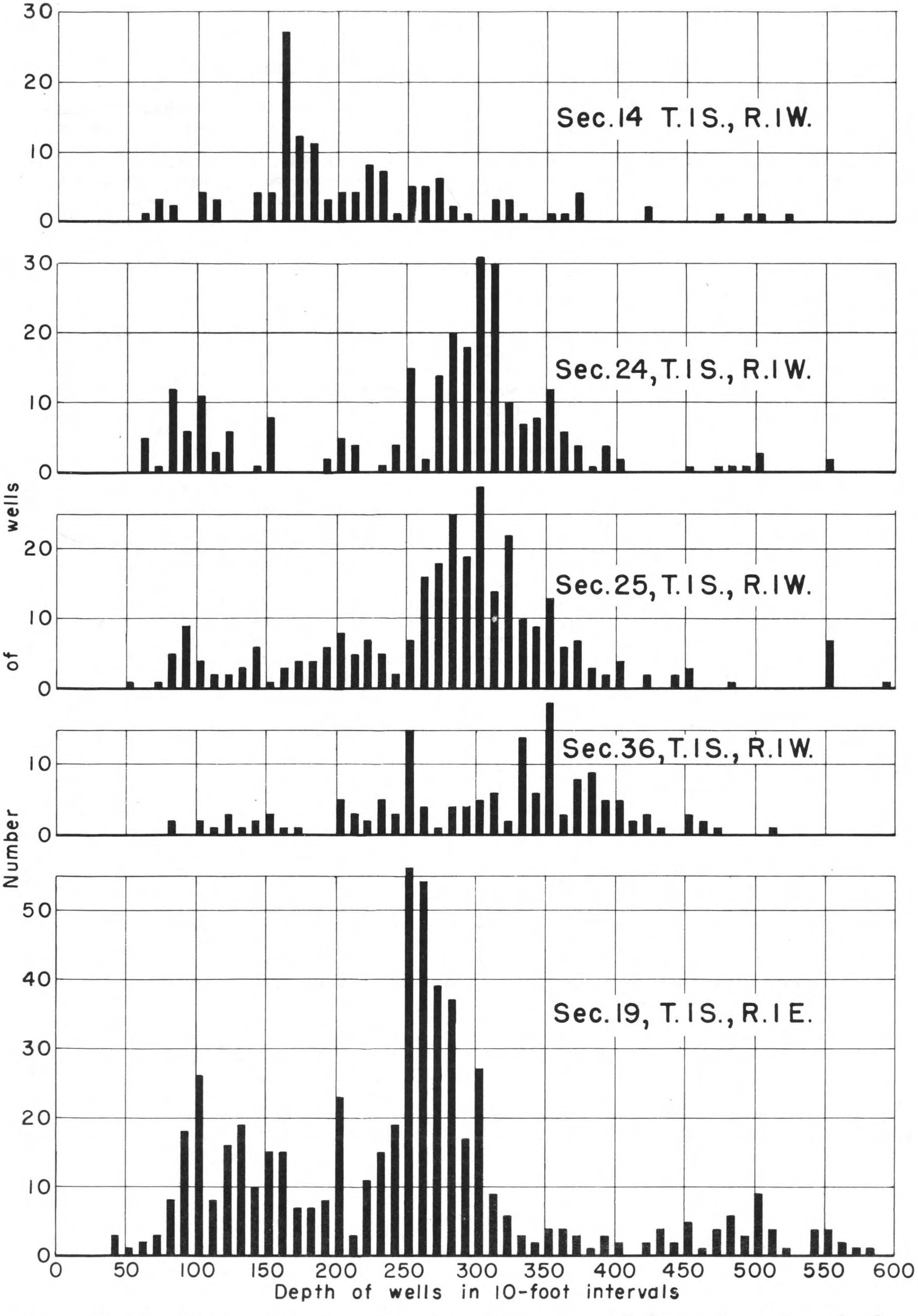


Figure 19. Depth of wells and number of small-diameter wells bottoming at those depths in nine sections in the East Lake Plain district. (Sections shown in figure 15.)

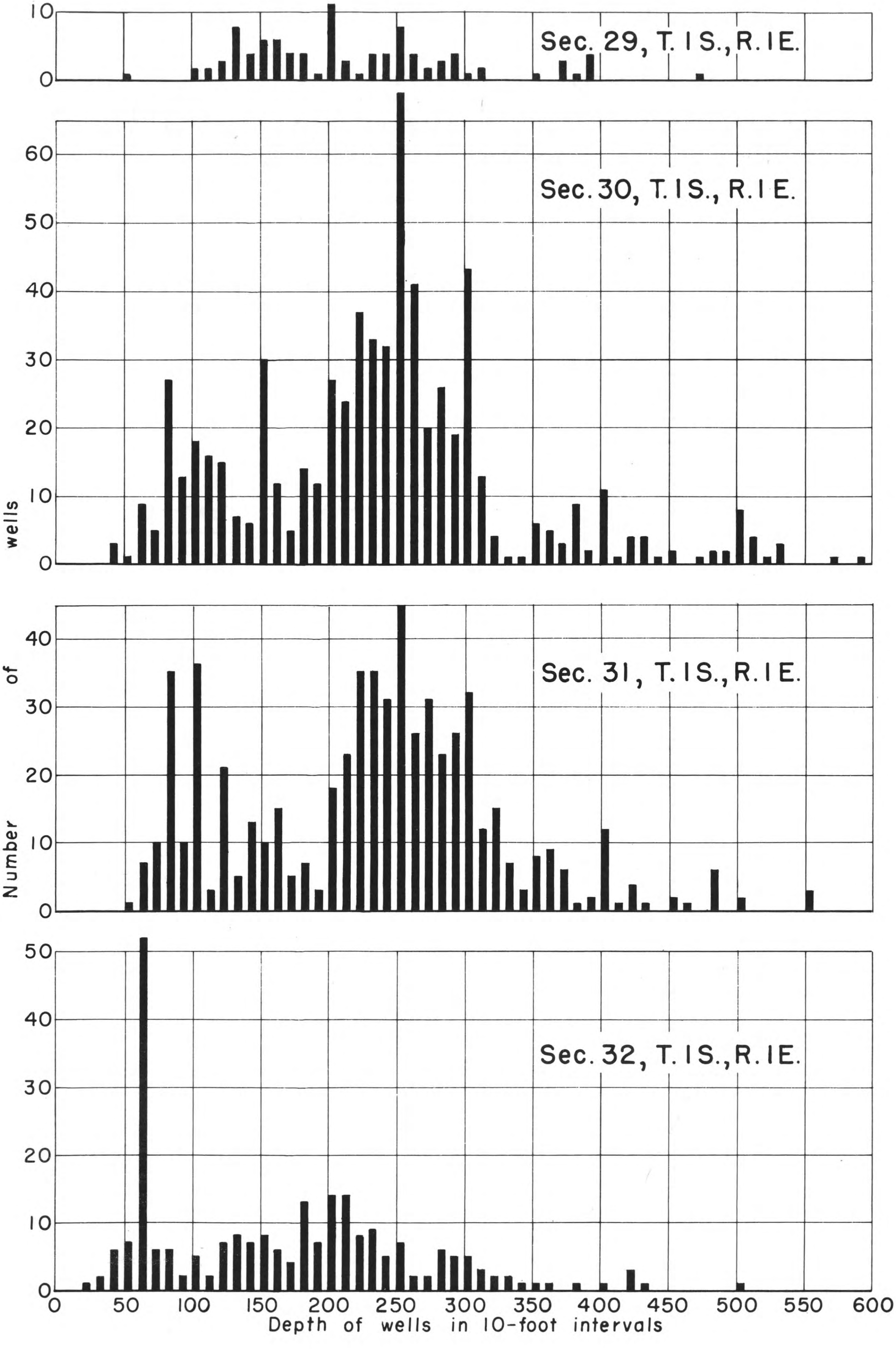
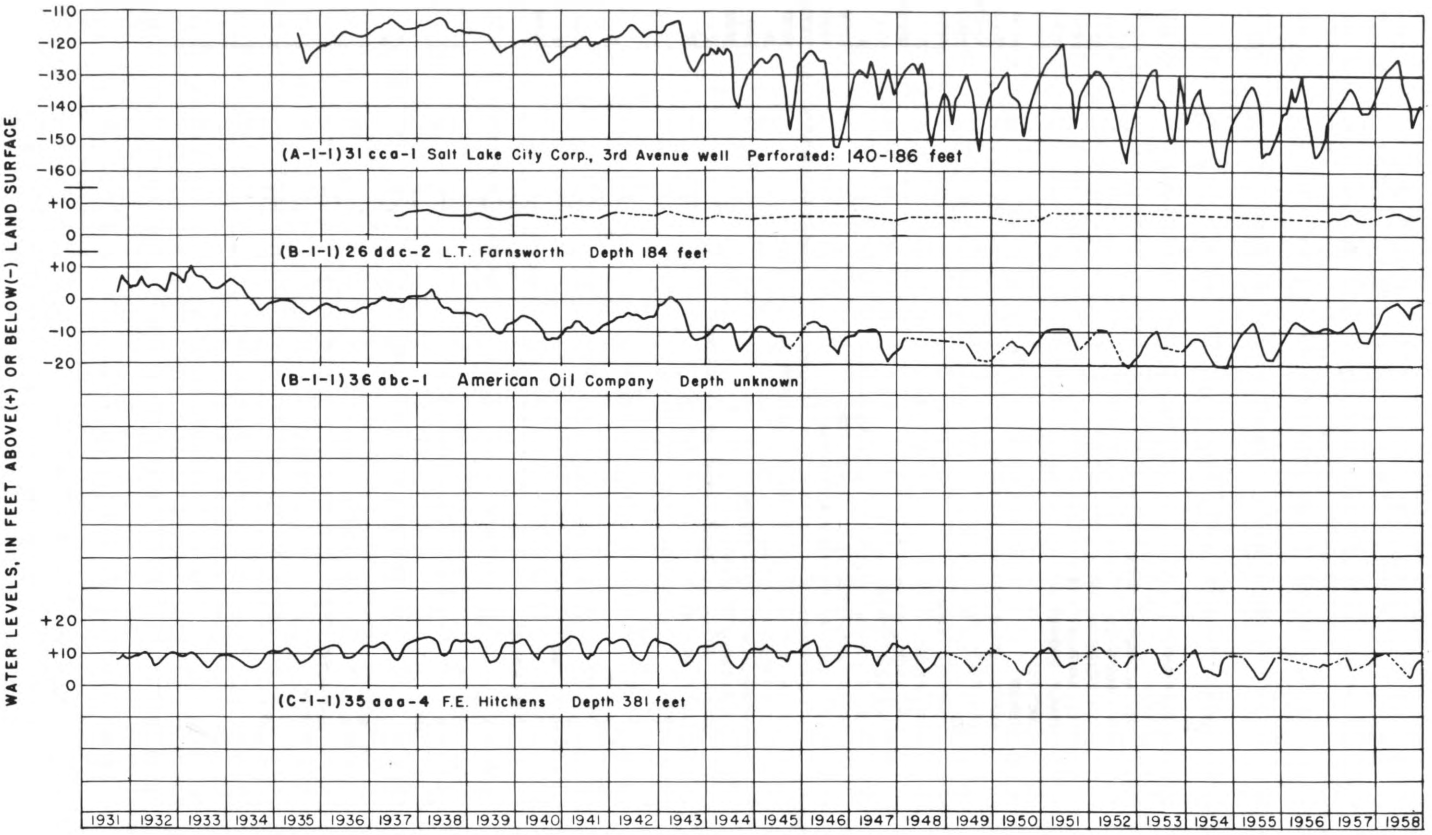


Figure 19. (Continued.)



(Water levels in wells (A-1-1) 31cca-1, (B-1-1) 26ddc-2, and (B-1-1)36abc-1 measured by Salt Lake City Corp.)

(Salt Lake City Corp. measured water levels in wells (D-1-1) 7dbd-3, (D-1-1)8bcc-2, (D-1-1) 30bbc-9, and (D-1-1) 20cca-2 prior to 1955; in well (D-2-1) 4cab-2 prior to 1956; and in wells (D-1-1) 31caa-2 and (D-2-1)5aaa-1 from 1932 to 1955.)

Figure 20. Hydrographs of wells in the East Lake Plain district. (Well locations shown in figure 15.)

19 wells range from 0.1 to 135 and average 42 gpm per foot of drawdown. The wells with the lowest specific capacities are closest to the mountain front (fig. 11). The sediments in much of the district contain boulders, which prevent the successful jetting of wells. The few jetted wells inventoried are concentrated in the southwestern corner of the district. A few dug wells obtain water from perched water bodies throughout the district.

Much of the ground water in the East Bench district is unconfined; but water is under artesian pressure in the lower parts of the district, and wells flow in the southwestern corner of the district. Ground water in the district moves westward toward the East Lake Plain district. The direction of movement is generally perpendicular to the contour lines shown in figure 16.

Water levels in the East Bench district (fig. 17) correlate with the flow of Emigration, Parleys, and Mill Creeks (fig. 9) and with precipitation (fig. 5). Water levels declined sharply in 1934 owing to a severe drought. From 1935 to 1937 water levels rose to about their pre-1934 height, and from 1937 to 1952 the trend was virtually horizontal. Water levels rose in 1952, but beginning in 1953 and continuing through 1956, water levels declined. Water levels again rose in 1957, but they generally declined or remained at virtually the same level in 1958. At the end of 1958 water levels were generally lower than they were in 1952. There was no overall downward trend of water levels from 1931 to 1958 in the East Bench district.

East Lake Plain district

Boundaries, surface features, and geology.--The East Lake Plain district is bounded on the east by the East Bench fault, on the south by the northernmost ancient channel scarp of Big Cottonwood Creek, on the west by the Jordan River, and on the north by the Salt Lake salient and the Salt Lake-Davis County line (fig. 11). The boundaries formed by the Salt Lake salient and the East Bench fault are sharp on the surface and in the subsurface. The channel that marks the southern surface boundary is appreciably sharper than the corresponding boundary in the subsurface where the deposits between the East Lake Plain and Cottonwoods districts are gradational for a mile or more. The boundary formed by the Jordan River is a convenient surface boundary, and it also marks a line of discharge from the ground-water body, not only in this district but in other districts of the valley as well.

The East Lake Plain district has been divided into three parts: The East Lake Plain, the City Creek Fan, and the North Bench subdistricts. The East Lake Plain district and subdistrict are named for the nearly flat lake plain that is the principal feature of the main part of the district. Modifying the lake plain are the Recent flood plain of the Jordan River and Recent broad alluvial fans of City, Emigration, Parleys, and Mill Creeks. The City Creek Fan subdistrict consists principally of the pre-Lake Bonneville alluvial fan deposited by City Creek. The North Bench subdistrict covers primarily a steep slope formed principally of mud-rock flows and alluvial deposits derived from the Wasatch Formation which covers much of the Salt Lake salient. The features of both the City Creek Fan and North Bench subdistricts are modified in part by wave-cut benches and near-shore deposits of Lake Bonneville.

The subsurface deposits in the three parts of the East Lake Plain district are as distinctive as the physiographic features for which the areas are named. The deposits in the East Lake Plain subdistrict are principally blue-gray or yellow lake-bottom clays, with intercalated discontinuous[1] thin lenses of gravel. These deposits terminate abruptly at the East Bench fault and are gradational with the slightly coarser, alternating lake and alluvial deposits of the Cottonwoods district. Sediments of the Lake Bonneville Group underlie the subdistrict, and they are underlain by deposits of many pre-Lake Bonneville lakes. In the northern and eastern parts of the subdistrict, the lake deposits of Lake Bonneville and pre-Lake Bonneville age may be underlain by alluvial-fan deposits similar to those in the East Bench district, and the alluvial-fan deposits in turn may be underlain by limestone or shale of Tertiary age. The only well that is reported to have passed completely through the lake deposits in the subdistrict is well (C-1-1) 12bdb-1 (fig. 11) which bottomed at 1,170 feet in 2 feet of shale.

The pre-Lake Bonneville fan in the City Creek fan subdistrict consists of well-sorted, very permeable deposits which are largely boulders and gravel. Gravel was reported in more than 50 percent of the intervals listed in drillers' logs of wells in the subdistrict (fig. 12). The amount of gravel decreases abruptly at the southern boundary of the subdistrict. As indicated in figure 18, well (D-1-1) 6bbb-1, in the City Creek Fan subdistrict, penetrated mostly gravel to a total depth of 440 feet, whereas well (D-1-1) 6cbb-1, in the East Lake Plain subdistrict, penetrated mostly clay to an equivalent depth. The Wasatch Formation underlies the City Creek Fan subdistrict at a depth of about 500 feet below land surface.

Most sediments in the North Bench subdistrict are derived from pre-Lake Bonneville mud-rock flows from the Wasatch Formation on the Salt Lake salient. Large boulders and clay are common in these flows. Lake Bonneville deposits containing much gravel and clay overlie the flow deposits in places, and Recent mud-rock flows overlie the Lake Bonneville deposits. The mudflow deposits may grade into the lake-bottom deposits of the East Lake Plain subdistrict in the subsurface south of the toe of the slope that forms the southern boundary of the North Bench subdistrict.

Wells and ground-water conditions.--The size and productivity of the wells of the East Lake Plain district are directly related to the hydrologic characteristics of the sediments which underlie the district. Small-diameter jetted wells flow in the East Lake Plain subdistrict and in the western part of the City Creek Fan subdistrict; large-diameter, highly productive wells penetrate well-sorted gravel in the central part of the City Creek Fan

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[1] The discontinuity of the gravel lenses was demonstrated by the construction of a peg model for sections 19 and 30 of T. 1 S., R. 1 E. Logs were used for 160 jetted wells, each more than 250 feet deep. Attempts at correlating gravel beds were fruitless, and it was found that wells within 150 feet of each other had penetrated completely different sets of gravel lenses.

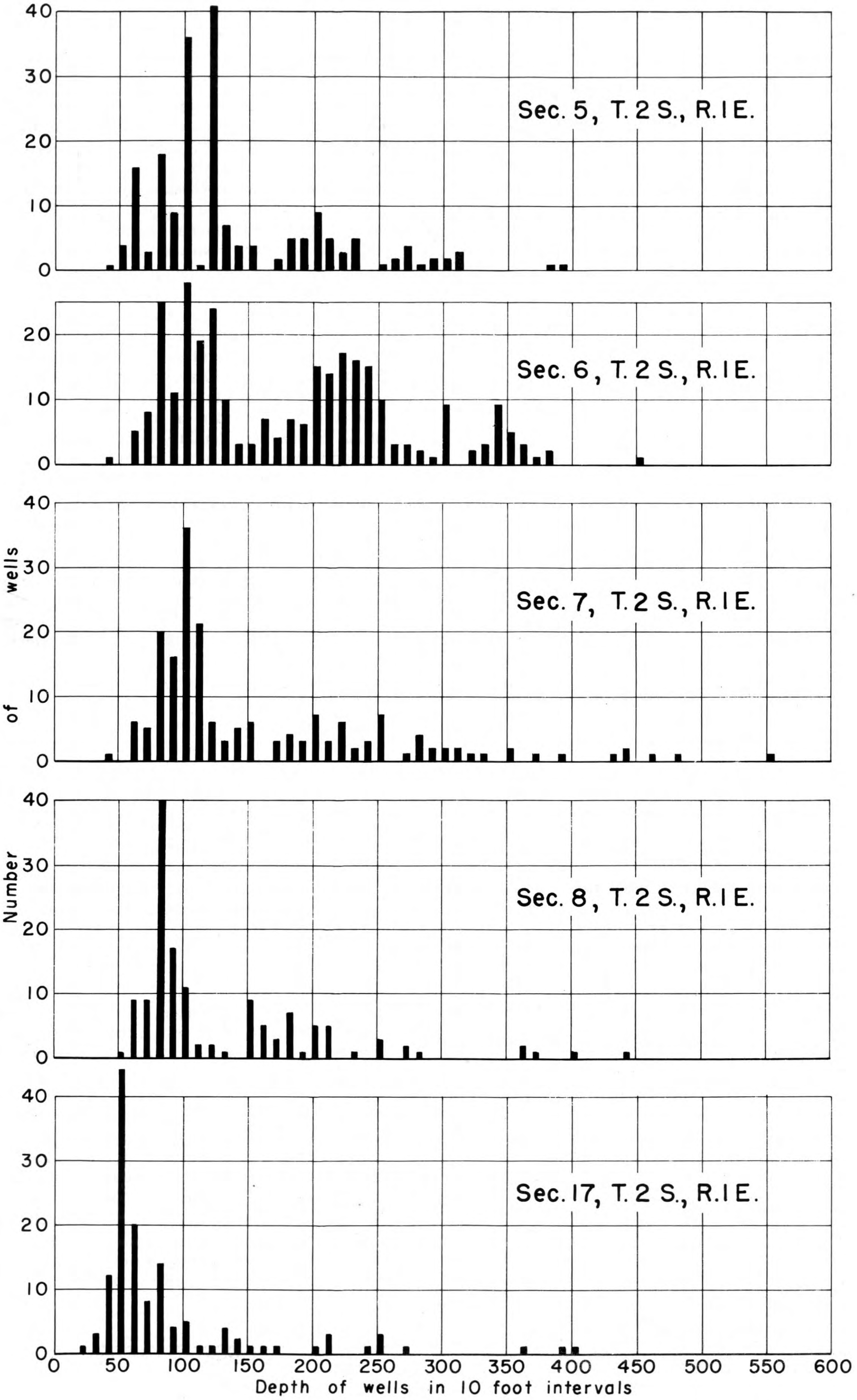


Figure 21. Depth of wells and number of small-diameter wells bottoming at those depth in five sections in the Cottonwoods district. (Sections shown in figure 15.)

subdistrict; and few wells have been drilled in the North Bench subdistrict, probably because of the low permeability of the mud-rock flows that underlie most of the subdistrict.

Many small-diameter wells in the East Lake Plain subdistrict obtain small but dependable supplies of water from jetted wells which flow at the surface. The water comes from small discontinuous lenses of gravel which are mostly at depths of 250 to 300 feet but range in depth from about 30 to about 600 feet (fig. 19). The yields of wells tapping the gravel lenses generally cannot be enlarged appreciably by increasing the diameter of the wells because the lenses derive water from slow movement through the surrounding clayey sand and sandy clay. The rate of movement is sufficient to maintain only small yields. The specific capacities of eight large-diameter (6 inches or greater) wells in the subdistrict range from 0.9 to 15 and average 4 gpm per foot of drawdown.

The yields of wells range considerably in the City Creek Fan subdistrict. The pre-Lake Bonneville alluvial-fan deposits in the subdistrict yield large quantities of water to wells on the west side of City Creek. The specific capacities of seven large-diameter wells range from 28 to 410 and average 150 gpm per foot of drawdown (fig. 11). East of City Creek, however, the deposits are less permeable, and the specific capacities of three large-diameter wells were only 1.6, 6.1, and 17 gpm per foot of drawdown. The water in the higher parts of the subdistrict is unconfined, but at lower elevations in the western part of the subdistrict clay deposits overlap the toe of the fan and the water is confined. Many small-diameter flowing wells have been jetted in this area. The same clay deposits also support a small perched water body. Although no wells tap this perched body, enough water seeps from it to necessitate the maintenance of sump pumps in the basements of several buildings in downtown Salt Lake City.

The movement of the ground water in the East Lake Plain district is indicated by the water-level contours in figure 16. The overall direction of movement is to the west and northwest toward the Northwest Lake Plain district.

Water levels in the East Lake Plain subdistrict respond very slowly to climatic cycles. Most water levels in the subdistrict had a slight upward trend during the period 1931-42 and a slight downward trend from 1943-58 (fig. 20). Although this suggests a period of lag of almost 10 years behind regional climatic fluctuations, the post-1943 decline may be due in part to the increased withdrawal of water from wells in the subdistrict.

In the City Creek Fan subdistrict, fluctuations of water levels (wells (A-1-1)31cca-1 and (B-1-1)36abc-1 on fig. 20) correlated with fluctuations of the flow of City Creek until about 1943 when Salt Lake City Corporation constructed well (A-1-1)31cac-1. Water levels declined about 10 feet at that time and since then have fluctuated in response both to the flow of City Creek and to variations of seasonal pumpage. Water levels in the subdistrict have risen slightly since 1955 probably because of decreased withdrawals from wells.

Cottonwoods district

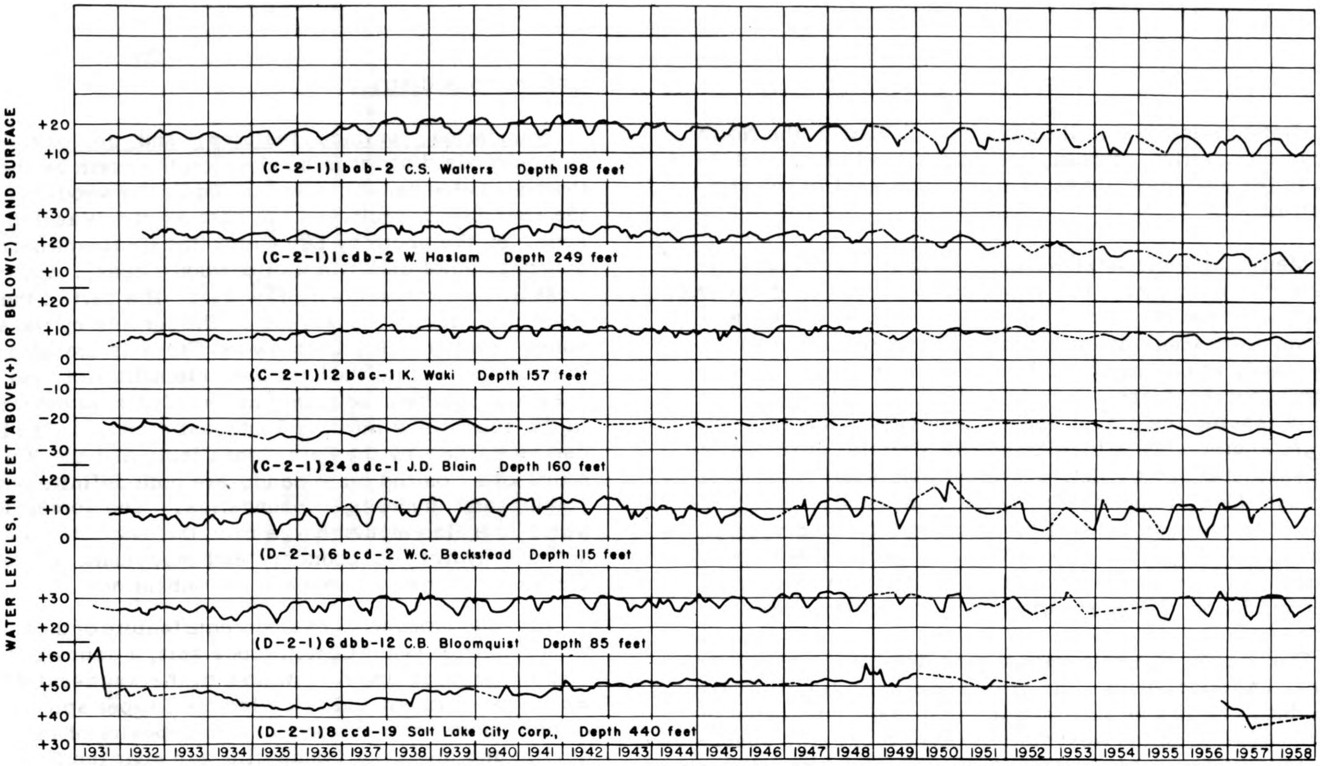
Boundaries, surface features, and geology. -- The Cottonwoods district is bounded on the north by the northernmost abandoned channel of Big Cottonwood Creek and the East Bench fault, on the east by the Wasatch fault zone, on the south by Dry Creek (the southernmost abandoned channel of Little Cottonwood Creek), and on the west by the Jordan River (fig. 11). The part of the northern boundary that is marked on the surface by the abandoned channel of Big Cottonwood Creek is gradational in the subsurface into the East Lake Plain district, and likewise the southern boundary at Dry Creek is gradational in the subsurface into the Southeast district. The boundaries marked by the East Bench fault and the Wasatch fault zone, on the other hand, are both definite physiographic and hydrologic boundaries. The Jordan River, which is a line of discharge from the district, is also a definite hydrologic boundary and may mark an equally definite geologic boundary in the subsurface.

The most prominent physiographic feature of the Cottonwoods district is the Cottonwoods spit, a deposit of Lake Bonneville extending southward into the Southeast district where its southern end is called the Draper spit (fig. 3). Glacial moraines intertongue with deposits of Lake Bonneville and pre-Lake Bonneville age near the Bonneville shoreline. West of the spit the surface is covered with Lake Bonneville deposits except where they have been channeled by the Cottonwood Creeks. In the Cottonwood channeled lands, post-Lake Bonneville fluvial deposits fill the channels and veneer the surface of some of the areas between channels.

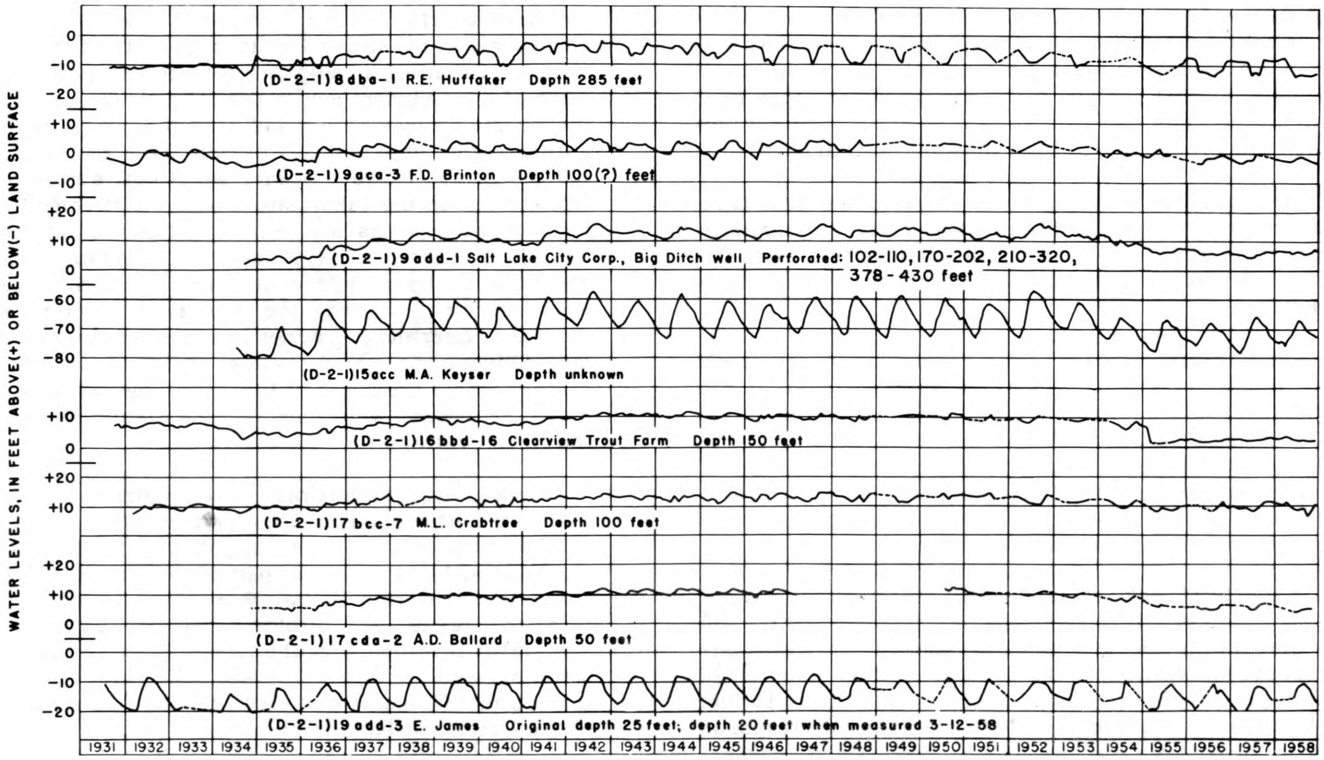
Except for material swept into the Cottonwoods district by southward-flowing lake currents of Lake Bonneville and earlier lakes, the stream and lake deposits of the district were derived from the adjacent Wasatch Range. Probably much of the sediment now in the district was eroded from the mountains by glaciers and carried down to the Jordan Valley by the large volumes of melt water that came from the glaciers. These deposits were well sorted by the streams and in the lakes into which the streams flowed. Most of the deposits are well-sorted gravel interbedded with the lake-bottom clay. The gravel generally is coarse and in thick beds and the clay layers are thin near the mountain front, whereas the clay layers are thicker and the gravel finer and in thinner lenses westward toward the Jordan River and northwestward toward the East Lake Plain district. Near the mouth of Little Cottonwood Canyon unsorted sediments were dumped by a glacier that entered the Jordan Valley.

Sedimentation in the Cottonwoods district differed from that in the adjacent East Lake Plain district. Whenever a lake occupied the East Lake Plain district, it also occupied at least the lower part of the Cottonwoods district. Deltas were built into these lakes by the two Cottonwood Creeks, and turbidity currents carried coarse material still farther from the shore. Little of this coarse material went as far as the East Lake Plain district; the lake currents generally carried only the fine material out of the Cottonwoods district.

During interlake periods, alluvial fans were built all along the mountain front, but those deposited in the Cottonwoods district differed from those in the East Bench district to the north and those in the Southeast district to

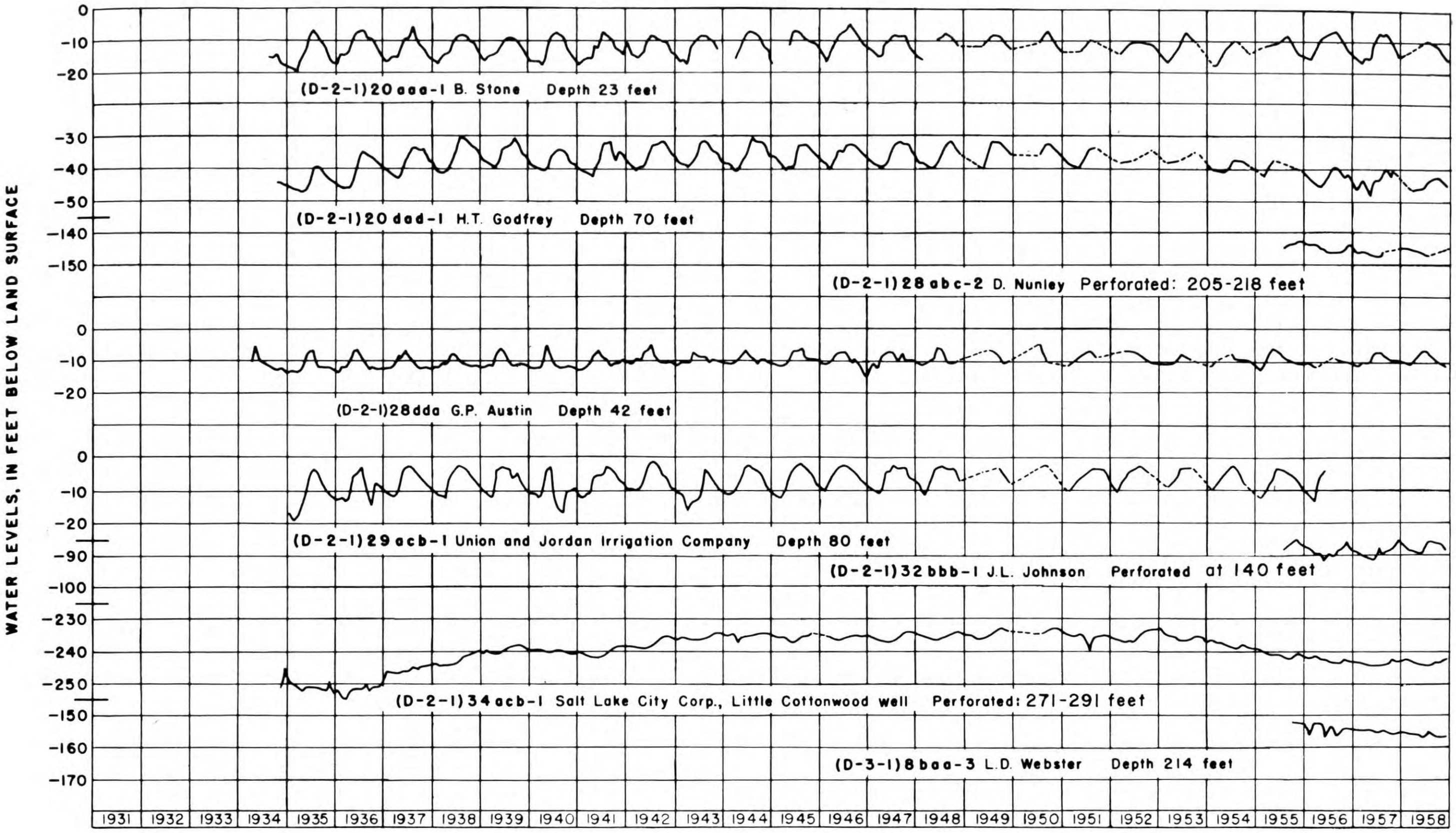


(Salt Lake City Corp. measured water levels in well (D-2-1)6bcd-2 from 1932-55; in wells (C-2-1)1cdb-2, (D-2-1)6dbb-12, and (D-2-1)8ccd-19 prior to 1956; and in well (C-2-1)12bac-1 from 1932 to 1955.)



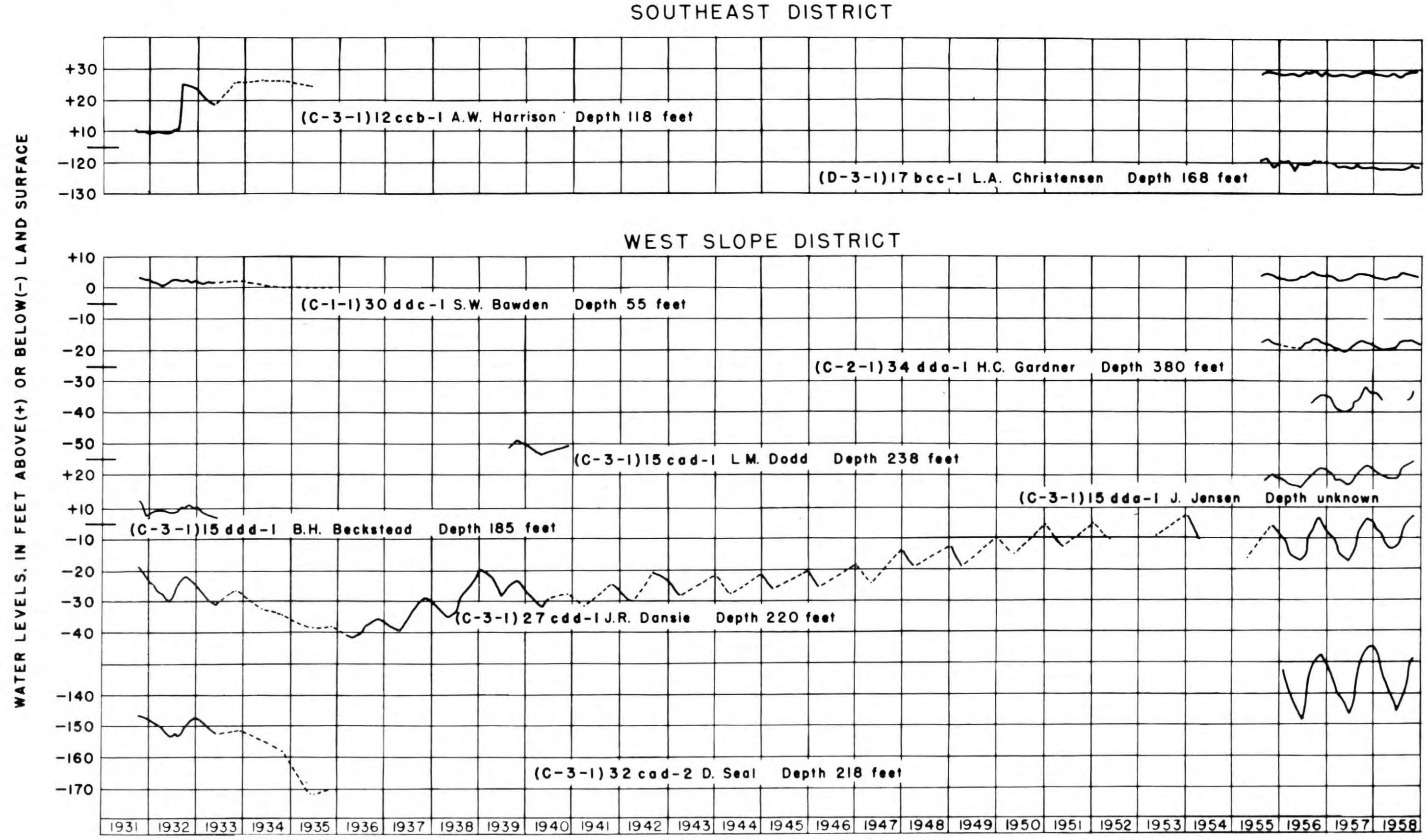
(Salt Lake City Corp. measured water levels in wells (D-2-1)9add-1, (D-2-1)16bbd-16, and (D-2-1)8dba-1 from 1933 to 1955; in well (D-2-1)9aca-3 prior to 1955; in well (D-2-1)17bcc-7 prior to 1956; in well (D-2-1)17cda-2 from 1932 to 1955; and in well (D-2-1)19add-3 from 1932 to 1956.)

Figure 22. Hydrographs of wells in the Cottonwoods district. (Well locations shown in figure 15.)



(Salt Lake City Corp. measured water levels in wells (D-2-1)20aaa-1, (D-2-1)34acb-1, and (D-2-1)20dad-1 prior to 1956; in well (D-2-1)28dda prior to 1957; and in well (D-2-1)29acb-1 prior to 1955.)

Figure 22. (Continued.)


SOUTHEAST DISTRICT

WEST SLOPE DISTRICT

Figure 23. Hydrographs of wells in the Southeast and West Slope districts. (Well locations shown in figure 15.)

the south. The alluvial fans in the Cottonwoods district are dominantly channel sediments of perennial creeks. The alluvial fans in the East Bench district, however, are a combination of mud-rock flows and intermittent channel deposits, and the fans in the Southeast district are poorly sorted slopewash or alluvial deposits of small ephemeral streams. Most of the fan deposits underlying the East Bench district are older than the fan deposits in the Cottonwoods and Southeast districts and may correlate in time with the Harkers Fanglomerate of Slentz (1955) which was deposited on the western side of the Jordan Valley.

The sediments in much of the Cottonwoods district contain large quantities of gravel (fig. 12), and gravel-bearing intervals in drillers' logs exceed 50 percent of the total logged depth in the eastern and western parts of the district. The sediments contain less than 25 percent of gravel-bearing intervals in areas which extend into the center of the district from both the East Lake Plain and the Southeast districts. Although some wells have penetrated loosely consolidated Pleistocene conglomerates, no wells in this district have penetrated deposits that could be Tertiary in age, and no wells have reached bedrock.

Wells and ground-water conditions.--Large-diameter (6 inches or greater) drilled wells are common throughout the Cottonwoods district. The specific capacities of 22 wells range from 6 to 200 and average about 45 gpm per foot of drawdown. The larger specific capacities generally are from the higher, eastern half of the district where the sediments are coarsest (fig. 11).

Small-diameter jetted wells are common in the lower parts of the Cottonwoods district, especially in the Cottonwood channeled lands area (fig. 3). Most of the wells flow and, according to a detailed study in five sections, most range from 50 to about 130 feet in depth (fig. 21).

Dug wells are common in the Cottonwoods district, and many tap perched water bodies. Some of the dug wells go dry during the winter when there is no seepage from irrigated fields.

Wells in the Cottonwood channeled lands area obtain water from four zones in the subsurface. (The log of well (D-2-1)16bba-2 typifies the sediments in this area. See table 9.) The shallowest zone includes all water-bearing material from the surface down to about 130 feet, and it is tapped by most of the small-diameter wells in the area (fig. 21). The second water-bearing zone includes all water-bearing material from about 200 to 300 feet below the surface, and it is also commonly tapped by small-diameter wells. (See secs. 5 and 6, T. 2 S., R. 1 E., in fig. 21.) The third zone is about 40 feet thick and is encountered at depths ranging from about 360 to about 400 feet below land surface. It is tapped by large-diameter wells and a few deep small-diameter wells. During a pumping test at well (D-2-1)16bba-2 (fig. 11), which is perforated in this zone, water levels were lowered in wells tapping the third zone in secs. 7, 8, 9, 16, 17, and 18, T. 2 S., R. 1 E. Thus the water-bearing beds in this zone are hydraulically interconnected in an area of at least 6 square miles. The fourth zone consists of interbedded gravel and clay from about 500 to 600 feet below land surface. Only a few wells tap the fourth zone, and the available data are not sufficient for estimating its areal extent.

Wells in the eastern, higher part of the Cottonwoods district obtain large yields from an extensive perched aquifer about 300 feet below the land surface. This aquifer yields water to large-diameter wells in secs. 23, 27, 33, and 34, T. 2 S., R. 1 E. When water from this aquifer enters the casing of wells perforated at several depths, the water in some wells falls to a lower level, and in other wells flows to lower zones. This was demonstrated by a current-meter survey in well (D-2-1) 23bcb-1 (fig. 11), which is perforated from 300 to 480 feet. The survey indicated that about 50 gpm entered the well between 305 and 315 feet, flowed downward to about 400 feet, and moved out into an aquifer from 400 to 425 feet below land surface.

Ground water moves northwestward through the Cottonwoods district (fig. 16). In the higher elevations of the eastern part of the district where the ground water is unconfined, the movement has a downward component; conversely in the Cottonwood channeled lands area, where the ground water is confined under artesian pressure, the movement has an upward component.

Water levels in the Cottonwoods district respond irregularly to climatic cycles. The water levels in many wells rose slightly during the period 1931-37, remained essentially level during the period 1938-52, and then declined slightly from 1953 to 1958 (fig. 22). At other wells, water levels had a slight upward trend from 1931 to 1942 and a slight downward trend from 1943 to 1958.

Southeast district

Boundaries, surface features, and geology. -- The Southeast district is bounded on the north by Dry Creek, on the east by the Wasatch fault zone, on the south by the Traverse Mountain front, and on the west by the Jordan River (fig. 11). The Wasatch fault zone and the Traverse Mountains are sharp boundaries. The boundary along Dry Creek is gradational in the subsurface into the Cottonwoods district. The Jordan River marks a line of discharge from the district, perhaps principally for shallow ground water. The boundary along the river, however, may be less distinct in the subsurface than on the surface.

The Southeast district is so named because of its location in the Jordan Valley. One of the principal physiographic features in the district is a pediment which is formed principally on the Oquirrh Formation at the foot of the Traverse Mountains. The pediment, which is buried under lake-shore gravel, extends into the valley an unknown distance, and in places it is dissected by recent gullies. Lake-bottom deposits cover much of the district, and in the northern part, the Draper and Crescent spits form prominent topographic features (fig. 3).

Wells are relatively scarce in the Southeast district; therefore, less is known about the sediments there than about the sediments in other districts. Most deposits, except those in or near the Lake Bonneville spits, are poorly sorted. Well (D-3-1)22bcb-1 (fig. 11) penetrated sediments that are typical of the Draper spit (table 9).

In the western part of the district, well (C-4-1)2ddb-1 penetrated sediments that are typical of the West Slope district (table 9). The Lake Bonneville deposits of the upper 82 feet of this well are separated by hardpan from underlying Tertiary sediments. The gravel and conglomerate between 135 and 463 feet below the surface probably belong to the Harkers Fanglomerate and the Camp Williams unit of Slentz (table 2). The interval from 463 to 722 feet which contains much sticky clay is probably the Jordan Narrows unit of Slentz, and below this is lava of the Traverse volcanics of Slentz.

In the Jordan Narrows, well (C-4-1)23dbb-1 penetrated Pleistocene spit gravel and lake clay down to 154 feet below the surface. The well then went into the Harkers Fanglomerate or the Camp Williams unit (table 9).

Near the northern boundary of the Southeast district, well (D-3-1)18cba-1 penetrated an exceptionally thick section of pre-Lake Bonneville Pleistocene fan deposits, which apparently were derived from the mountains on both sides of the valley (table 9). The Lake Bonneville deposits bottomed at about 84 feet below the surface, and below this the well penetrated a thick sequence of sediments that show little change down to 1,150 feet. The sediments from 0 to about 300 feet are mostly from the Wasatch Range; the sediments from about 300 to about 750 feet are principally from the west side of the Jordan Valley; and the sediments from about 750 to about 1,150 feet are principally from the east side of the valley. Sediments from both sides, however, are represented throughout the section penetrated by the well.

The gravel content and thickness of the sediments differ considerably in the Southeast district. In part of the district the gravel-bearing intervals in drillers' logs are less than 25 percent of the total logged depth, but in two wells in the southwestern part of the district near the Jordan River, the gravel-bearing intervals exceed 50 percent (fig. 12).

The Oquirrh Formation crops out in the southern part of the district, but in the northern part well (D-3-1)18bcd-1 penetrated 1,150 feet of unconsolidated sediments without reaching bedrock.

Wells and ground-water conditions.--Few wells have been constructed in the Southeast district. The most common types are dug wells which tap perched water bodies and jetted wells which are mostly in the lower parts of the area. Records were obtained for seven large-diameter drilled wells, and the specific capacities of four of them range from 0.4 to 1,800 gpm per foot of drawdown. The latter specific capacity is the largest known in the Jordan Valley (fig. 11). Aquifers that can be correlated from one well to another have not been found in the Southeast district.

Ground water moves in a generally northwesterly direction through the Southeast district (fig. 16). The only lengthy record of water-level fluctuations available for the district indicates that water levels rose slightly during the period 1931-58 (fig. 23).

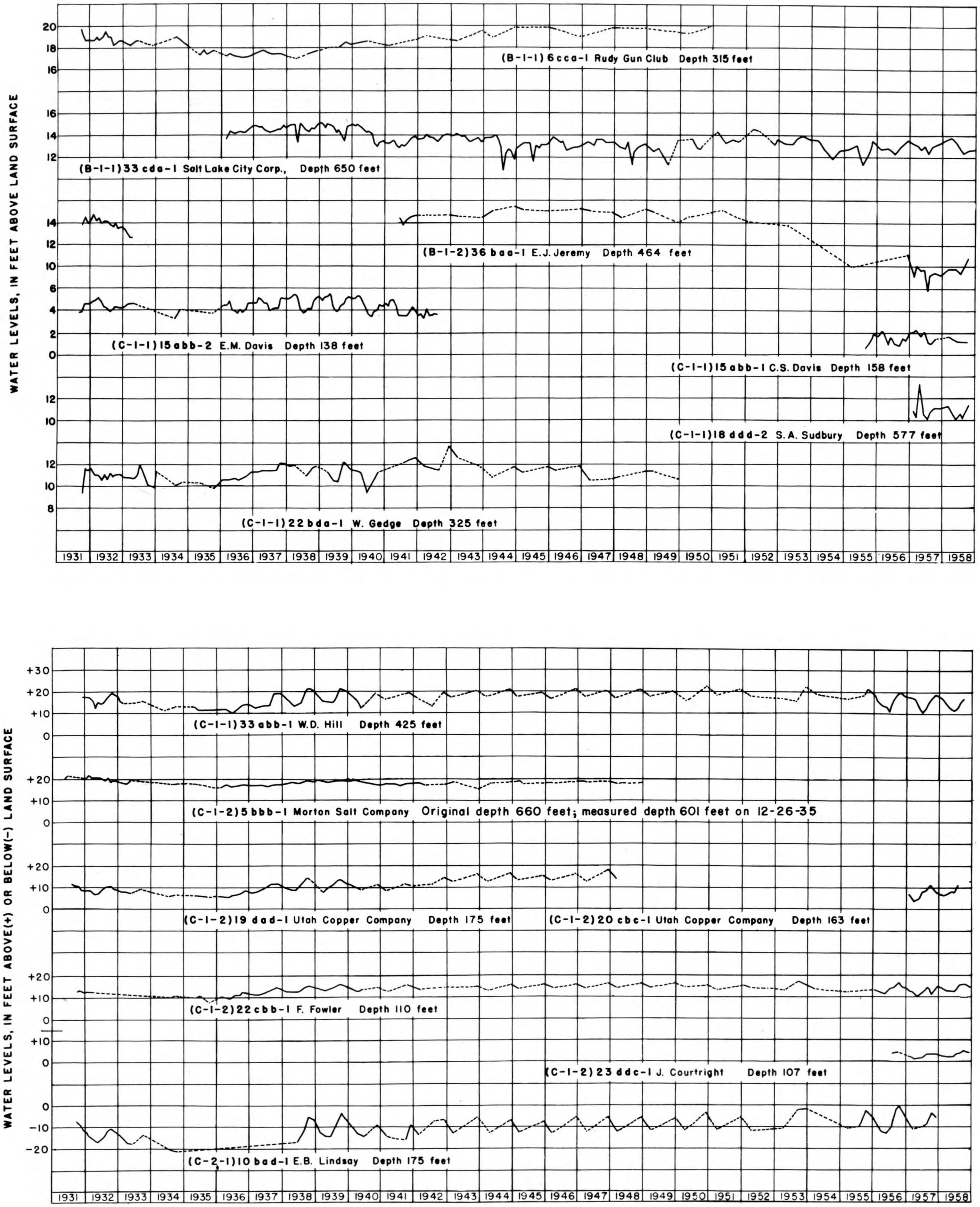
West Slope district

Boundaries, surface features, and geology.--The West Slope district is bounded on the south by the Traverse Mountains, on the west by the Oquirrh Mountains, on the north by a physiographic break from a slope to a flat lake plain, on the northeast by the Granger fault scarp, and on the east by the Jordan River (fig. 11). The boundaries along the Traverse and Oquirrh Mountains and the Granger scarp are sharp, both on the surface and in the subsurface. The northern boundary is marked principally by a change in slope at the surface, but it is more definite in the subsurface where it separates the Salt Lake Formation of the West Slope district from the Pleistocene lake deposits of of the Northwest Lake Plain district. The Jordan River, which is a line of discharge from the district, marks a definite boundary in the subsurface in the northern part of the district, but the boundary is less distinct in the subsurface in the southern part.

The West Slope district is named for the broad, alluvial-pediment slope of the western side of the Jordan Valley. This slope is formed principally on rocks of the Salt Lake Formation of Tertiary age which were largely of mud-rock flow origin. It is dissected by stream channels, it is scarred by wave-cut cliffs at the Bonneville and Provo shorelines, and its surface is modified by the Bennion and Evaporating Ponds spits of Lake Bonneville (fig. 3). Alluvial fans and shore features of Lake Bonneville mark the south margin of the district along the Traverse Mountains. The Oquirrh Formation, the Salt Lake Formation, and volcanic rocks crop out in various places along the western and southern boundaries of the West Slope district (fig. 11).

The West Slope district has been divided into two parts: the North Pediment subdistrict and the South Fan subdistrict. The division is based on subsurface data, and on the surface the subdistrict boundary is at about the middle of the district along Bingham Creek (fig. 11). The area of the North Pediment subdistrict evidently was higher than the area of the South Fan subdistrict during late Tertiary time; both the Harkers Fanglomerate of Slentz and the Camp Williams unit of Slentz are thin or absent on the North Pediment, whereas the Harkers is about 300 feet thick and the Camp Williams unit is about 100 feet thick in the South Fan subdistrict. The difference in the two subdistricts is evident also from the geophysical studies of Cook and Berg (1961, pl. 13) which show that a portion of the deepest part of the Jordan Valley graben underlies the South Fan subdistrict.

The sediments of the South Fan subdistrict contain large quantities of gravel, and in much of the area drillers' logs report gravel in more than 50 percent of the total logged depth (fig. 12). Much of the gravel is in the 200 to 400 feet of gravel, boulders, and clay that probably belong mostly to the Harkers Fanglomerate of Slentz and partly to the Camp Williams unit of Slentz (1955, p. 26-30). These two units were deposited as alluvial fans when the Oquirrh Mountains were uplifted in late Tertiary time, and they consist principally of tan, gray, or white quartzite from the Oquirrh Formation and minor amounts of andesite.



(Water levels in well (B-1-1) 33cda-1 measured by Salt Lake City Corp.)

Figure 24. Hydrographs of wells in the Northwest Lake Plain district. (Well locations shown in figure 15.)

Underlying the fan deposits is the Jordan Narrows unit of Slentz which consists of fine-grained sediments with a few thin gravel lenses, principally of andesite. The fine-grained sediments are mostly volcanic tuff, fresh-water limestone, and clay, all of which are usually reported as clay in drillers' logs. The contact of the Jordan Narrows unit with the overlying coarse fan deposits was identified from the study of well cuttings at 438 feet below land surface in well (C-3-1)9ccc-1 (fig. 11), at 196 or 218 feet in well (C-3-1)30aba-1, at 472 feet in well (C-3-1)32cdc-1, and at 498 feet in well (C-3-2)34daa-1 (table 9).

No wells in the South Fan subdistrict are known to have penetrated the Oquirrh Formation, but well (C-4-1)6acb-1 penetrated volcanic rock at 561 feet (table 9). Well (C-3-1)30aba-1 bottomed at 700 feet, still in unconsolidated sediments.

In the North Pediment subdistrict, the Harkers Fanglomerate of Slentz and the Camp Williams unit of Slentz are thin or absent; so the Jordan Narrows unit of Slentz commonly underlies the thin surface deposits of alluvium or lacustrine material of Lake Bonneville. Even where the Harkers or the Camp Williams are present, however, they generally are not saturated and hence do not yield water to wells. Wells in this subdistrict have not penetrated bedrock, but the Oquirrh Formation crops out southeast of Magna, about a mile from the mountain front, and volcanic rock crops out more than 2 miles farther east in sec. 35, T. 1 S., R. 2 W. (fig. 11). Well (C-2-1)34bcd-1 bottomed at 1,397 feet, still in unconsolidated sediments.

Wells and ground-water conditions.--Most wells in the higher parts of the South Fan subdistrict are drilled or dug, but in the lower parts many are jetted. Ground water is commonly unconfined in the higher parts of the subdistrict; but it is confined in the lower parts, and many wells near the Jordan River flow at land surface (fig. 16). Perched water bodies, some containing confined water, are common throughout the subdistrict; some wells that penetrate the perched aquifers flow during the irrigation season. Much of the recharge to this subdistrict comes from irrigation water from surface sources which is applied to the land below the highest canal on the west side of the valley (fig. 6).

The yields of wells in the South Fan subdistrict differ widely. The specific capacities of 11 wells range from 0.2 to 113 and average 18 gpm per foot of drawdown (fig. 11).

No aquifers that are traceable laterally have been found in the alluvial-fan deposits of the South Fan subdistrict. The fan deposits are the most likely to yield large quantities of water to wells, whereas the underlying thick Jordan Narrows unit of Slentz produces very little water.

Ground water in the South Fan subdistrict in general moves toward the east (fig. 16).

In the North Pediment subdistrict, jetted wells in the lower parts of the valley and dug wells in the higher parts obtain water that is perched on the relatively impermeable beds of the Jordan Narrows unit of Slentz. Many of the jetted wells flow, and the yield is sufficient for domestic needs. Many of the dug wells are deeper than 150 feet, and the water level is generally within 10 feet of the well bottom. Large-diameter deeper wells have not been able to produce yields sufficient for irrigation from the Jordan Narrows unit. The specific capacities of nine large-diameter wells in the subdistrict range from 0.3 to 3.0 and average 1.5 gpm per foot of drawdown. No wells have penetrated the full thickness of the Jordan Narrows unit, although well (C-3-2)5aac-1 (fig. 11) is 1,200 feet deep and well (C-2-1)34bcd-1 is 1,397 feet deep.

Most of the ground water in the subdistrict is confined in the Jordan Narrows unit of Slentz or in the overlying Pleistocene or late Tertiary gravel. Shallow wells that tap the gravel, especially those in the lower part of the subdistrict, flow at the land surface. Deep wells that tap the Jordan Narrows unit, however, generally do not flow. Much of the recharge to the gravel beds comes from irrigation water obtained from surface sources. Although excessive irrigation results in recharge to the aquifers, it also creates drainage problems in the lower parts of the subdistrict.

Ground water in the North Pediment subdistrict generally moves toward the northeast (fig. 16).

Water levels rose in the West Slope district during the period 1931-58 as shown in figure 23. Water levels in the district probably have been rising since about 1900--the water level in well (C-3-1)15ddd-1 was reported to be 16 feet below land surface when the well was constructed in 1900, the well began to flow about 1916 (Taylor and Leggette, 1949, p. 226), and in 1958 the water level in the well was measured at 15 feet above the land surface. Seasonal water levels in the district are highest near the end of the irrigation season irrespective of well depth, indicating that seepage from irrigated lands is an important factor in recharging the ground-water reservoir. The rising trend of water levels reflects a continuous increase in the amount of ground water in storage as the annual recharge exceeds discharge.

Northwest Lake Plain district

Boundaries, surface features, and geology.--The Northwest Lake Plain district includes the northwestern part of the Jordan Valley. The northern and northwestern boundaries of the district are the arbitrary limits of the area of this investigation--the shore of Great Salt Lake and the county lines between Salt Lake and Tooele and between Salt Lake and Davis Counties. The eastern boundary is the Jordan River, and the southern boundary is the north face of the Oquirrh Mountains and a change in slope that separates the pediment in the West Slope district to the south from the flat lake plain in the Northwest Lake Plain district. The Jordan River, which is a line of discharge for some of the ground water of the district, is a hydrologic boundary. Tooker and Roberts (1961, pl. 6) have mapped thrust faults along the north face of the Oquirrhs and these constitute a sharp geologic and hydrologic boundary. The sharp change in the sediments from the Pleistocene lake deposits of the Northwest Lake Plain to the Tertiary deposits of the West Slope district suggest that the faults at the north end of the Oquirrh Mountains may extend eastward.

The Northwest Lake Plain district is named for the flat, essentially featureless plain whose surface is covered with the lake-bottom deposits of Lake Bonneville. These deposits cover older deposits which differ enough in the subsurface to warrant dividing the district into four parts: the Northwest Lake Plain, North Oquirrh, South Margin, and Mid-Jordan subdistricts (fig. 11).

The Northwest Lake Plain subdistrict is underlain by several thousand feet of unconsolidated sediments which consist of lake-bottom clays interbedded with thin sand lenses. Well (C-1-2)6aaa-4 (fig. 11) was drilled to a depth of 1,150 feet without encountering any gravel (table 9 and fig. 12). Formation samples examined from a deeper well (L. E. Whitlock, Morton Salt No. 1, an oil test in sec. 24, T. 1 N., R. 3 W.) indicate that the clay and sand are present to a depth of about 2,300 feet. From 2,300 feet to about 2,800 feet the test penetrated andesitic rock interbedded with sand. The Tertiary-Quaternary contact was not marked, but presumably it is at 2,300 feet or above. Sand was logged again from 2,800 feet to the bottom of the test at 4,230 feet, but an electric log of the hole shows that there is a sharp lithologic break at 3,655 feet below land surface. The rocks below 3,655 feet may be one of the conglomerates in the Wasatch Formation.

The North Oquirrh subdistrict includes about 5 square miles at the north end of the Oquirrh Mountains. The subdistrict is underlain by blue or gray lake-bottom clay or silt. This material thins to a feather edge near the Oquirrh Mountains, thickens to about 450 feet in the northern part of the subdistrict, and becomes even thicker north of the subdistrict. Underlying the clay is a coarse, permeable, angular gravel that was derived from the Oquirrh Formation of the Oquirrh Mountains as alluvium, slopewash, or fault breccia. The gravel is 150 to more than 450 feet thick, and it is underlain by the Oquirrh Formation. Most wells in the subdistrict penetrate gravel-bearing intervals that account for between 25 and 50 percent of the total depth logged (fig. 12).

The South Margin subdistrict includes an area about 1 1/2 miles wide extending from the North Oquirrh subdistrict eastward to the Granger fault scarp (fig. 11). The subdistrict is underlain by about 100 feet of lake-bottom sediments of Lake Bonneville, below which is gravel that alternates with clay beds of varying thickness to depths of 300-400 feet. Wells in the subdistrict commonly penetrate gravel-bearing intervals for 25 to 50 percent of their total depths (fig. 12). The origin of this gravel is not known. The unconsolidated sediments underlying the subdistrict have a maximum known thickness of 524 feet, as indicated by the log of well (C-1-2)21adb-1 (table 9). This well went through either the Camp Williams unit or the Harkers Fanglomerate of Slentz before reaching what is thought to be the Oquirrh Formation.

The Mid-Jordan subdistrict lies in the wedge-shaped area between the Granger fault scarp, the Jordan River, and the Northwest Lake Plain subdistrict. It is underlain principally by flood-plain deposits of the Jordan River which underlie the lake-bottom deposits that are at the surface in the other parts of the district.

The gravel-bearing intervals of the total depth logged in wells increases from less than 25 percent in the northern part of the subdistrict to more than 50 percent in the southern part (fig. 12). Most of the gravel is granite or quartzite fragments, similar to that in the Cottonwoods district; but some is andesite fragments, similar to that in the West Slope district. All of the gravel was probably moved into the Mid-Jordan subdistrict by northward flowing streams, and some was probably reworked by lakes. The maximum thickness of Pleistocene or Recent deposits penetrated is 775 feet by well (C-1-1)27dda-8 (table 9). No wells are known to have penetrated Tertiary deposits or bedrock.

Wells and ground-water conditions.--Most wells in the Northwest Lake Plain subdistrict were jetted, but several were drilled by the rotary method. Ground water occurs under artesian conditions, and most wells flow at the land surface. The permeability of the sediments is low, and the specific capacity of most wells probably is less than 5 gpm per foot of drawdown. Although some of the sand lenses may be widespread, aquifers have not been delimited over any appreciable distance.

All wells in the North Oquirrh subdistrict were drilled, and they tap confined water in gravel deposits. Most of the wells flow, and they all have large yields. The specific capacities of seven wells range from 22 to 750 and average 170 gpm per foot of drawdown (fig. 11). Springs mark breaks in the confining clay, which overlies the gravel.

Most wells in the South Margin subdistrict were constructed by jetting. Ground water throughout the subdistrict occurs under artesian conditions, and nearly all the wells flow at the land surface. The permeability of the sediments underlying the subdistrict generally is high, and tests of two large-diameter wells indicated specific capacities of 12 and 20 gpm per foot of drawdown (fig. 11).

Most wells in the Mid-Jordan subdistrict were constructed by jetting, and they have a considerable range in depth. (See sections 22, 27, and 33 in fig. 14.) Tests of two large-diameter wells indicated specific capacities of 4.2 and 17 gpm per foot of drawdown (fig. 11).

The direction of ground-water movement in the Northwest Lake Plain district is generally toward the north. Piezometric heads, however, are greater in a linear north-trending zone in the north-central part of the district than they are in areas to the east and west (fig. 16). This suggests that the ground water may be moving toward two areas of natural discharge--the Jordan River to the east and the Great Salt Lake to the west.

Water levels in the Northwest Lake Plain district have had no significant upward or downward trend during the period 1931-58 (fig. 24). Effects of climatic cycles are almost indiscernable on hydrographs of wells in this district.

Recharge

Recharge to the ground-water reservoir in the Jordan Valley comes from at least seven sources: (1) seepage from irrigated lands, (2) seepage directly from precipitation, (3) seepage from creek channels, (4) subsurface bedrock springs, (5) underflow from mountain canyons,

(6) underflow from Utah Valley through the Jordan Narrows, and (7) seepage from irrigation canals. Quantitative information about the amount of water contributed by these sources is lacking for all except source (3), but qualitative evaluations of these sources of recharge are worthy of mention.

Seepage from irrigated lands.--This probably is the largest source of recharge to the underground reservoir. Almost all the average annual flow of about 267,000 acre-feet of the Jordan River at the Jordan Narrows is diverted for irrigation in the valley. The amount that recharges the ground-water reservoir is not known; but the effect of the recharge from irrigation water is especially noticeable in the West Slope district where water levels rise during the irrigation season, and where water levels have probably been rising since about 1900. Even where the effect cannot be recognized from water-level records, recharge undoubtedly occurs to some degree everywhere that irrigation is practiced. A quantitative estimate of the amount of recharge from irrigated lands could be made by determining the amount of land (by crop type) under irrigation and relating the amount of water applied for irrigation to the duty of water of the crop.

Seepage directly from precipitation.--The direct penetration of precipitation is probably an important source of recharge to the aquifers in the Jordan Valley. The benchlands on the east side of the valley are underlain by coarse alluvial and lacustrine sand and gravel deposits and in places by sand dunes, all of which readily accept water. A quantitative estimate of the amount of recharge from precipitation on the benchlands could be made by mapping the area of potential recharge, determining the permeability of the materials underlying the recharge area, and evaluating the climatic data to determine the percentage of the annual rainfall that is available for recharge.

Seepage from creek channels.--Seepage from streams on both sides of the Jordan Valley contribute a sizeable but unknown quantity of water to the ground-water reservoir. Studies of losses in streamflow from Mill, Big Cottonwood, and Little Cottonwood Creeks were reported by Taylor and Leggette (1949, p. 24-29), and estimates of losses from these streams are summarized in table 4. The table also includes a "Total loss" column which indicates that the total loss in the influent reach of 3 1/2 miles of Little Cottonwood Creek ranges from 2.1 to 25 cfs (cubic feet per second) and the total loss in the influent reach of 1 1/2 miles of Big Cottonwood Creek ranges from 4.8 to 11.1 cfs. The greatest losses occur during highest flow, but the ratio of loss to total flow is generally highest during periods of low flow. All measurements of loss included evaporation and transpiration, as well as recharge to the ground-water reservoir.

The total losses from the two Cottonwood Creeks in their influent reaches were plotted against the upstream discharge measured at the time of loss (fig. 25). The resulting curves indicate that in Little Cottonwood Creek the mean discharge (for the period 1915-58) of 60.5 cfs should result in a channel loss of 20 cfs and in Big Cottonwood Creek the mean discharge (for the period 1915-58) of 69.9 cfs should result in a channel loss of 12 cfs. These losses total more than 23,000 acre-feet annually. During medium or high stages of the creek almost all of this loss would be recharge to the ground-water reservoir.

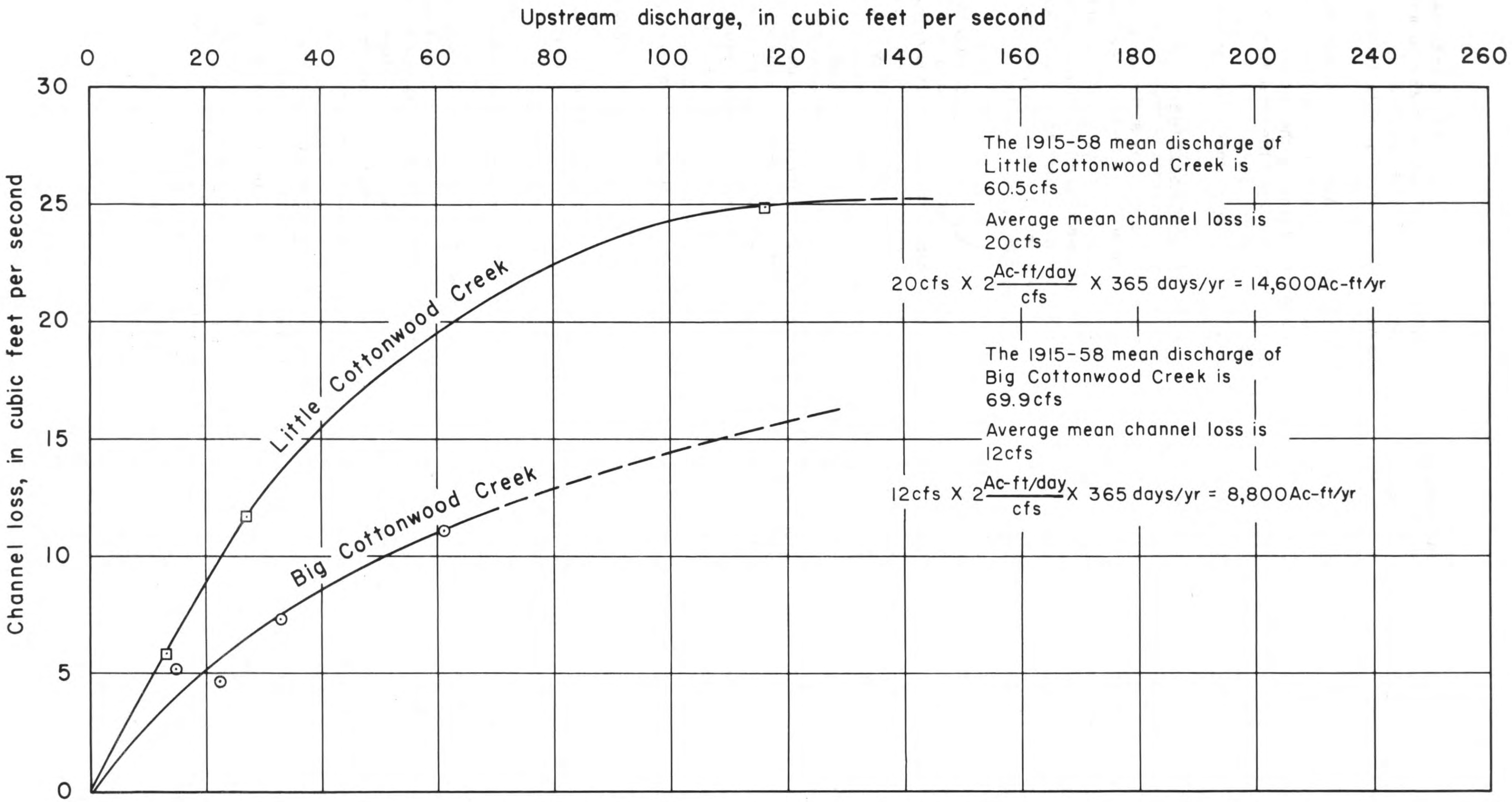
Other creeks draining the Wasatch Range and Oquirrh Mountains also contribute sizeable but undetermined amounts of recharge to the ground-water reservoir. A quantitative estimate of the total amount of recharge from stream channels could be made by bracketing the effluent reaches of all major streams with gaging stations.

Subsurface bedrock springs.--Water probably is moving directly from the bedrock of the mountains into the valley fill without coming to the surface. Springs occur in the mountains bordering the Jordan Valley, and similar springs undoubtedly have been buried in the course of filling the valley. It is not possible to measure directly the amount of recharge from bedrock springs. An estimate could be made, however, by the preparation and balancing of a water budget for the entire valley.

Underflow from mountain canyons.--Coarse deposits of alluvium that cover the bottoms of all canyons in the mountains probably transmit into the valley fill appreciable quantities of water that do not appear at the surface. Near the mouth of Little Cottonwood Canyon, for example, well (D-3-1)12acd-1 (fig. 11) penetrates 150 feet of boulders and gravel. Water moving through these deposits is the subsurface flow of Little Cottonwood Creek, but it cannot be measured at the surface. A quantitative estimate of the underflow of the major streams entering the Jordan Valley could be made by applying the transmissibility of the water-bearing material (determined by means of pumping tests at wells), at the observed hydraulic gradient, to the cross-sectional area of subsurface flow (determined by means of test drilling, if necessary).

Underflow from Utah Valley through the Jordan Narrows.--Ground water may be moving into the Jordan Valley from Utah Valley through a buried pre-Lake Bonneville river channel east of the present Jordan River. Tertiary deposits are more than 100 feet deeper at well (C-4-1)23dbb-1 than they are at the present Jordan River, and the overlying deposits are mostly permeable gravel. Several springs just north of the Jordan Narrows have a perennial flow of about 1 cfs, and these springs are probably supplied by overflow from a much larger quantity of water moving through subsurface gravels in the Narrows. A quantitative estimate of the underflow through the Jordan Narrows could be made in a manner similar to that described in the previous paragraph.

Seepage from irrigation canals.--Seepage from canals may be a source of recharge to the ground-water reservoir in the Jordan Valley. In recent years, urbanization has reduced the number of canals, and many canals and ditches have been lined to prevent seepage losses. In the southern part of the valley, however, some water is lost from several of the west side canals. A quantitative estimate of canal losses could be made by establishing a series of measuring stations along the major canals.



The 1915-58 mean discharge of Little Cottonwood Creek is 60.5cfs

Average mean channel loss is 20cfs

$$20\text{cfs} \times 2\frac{\text{Ac-ft/day}}{\text{cfs}} \times 365 \text{ days/yr} = 14{,}600 \text{Ac-ft/yr}$$

The 1915-58 mean discharge of Big Cottonwood Creek is 69.9cfs

Average mean channel loss is 12cfs

$$12\text{cfs} \times 2\frac{\text{Ac-ft/day}}{\text{cfs}} \times 365 \text{ days/yr} = 8{,}800 \text{Ac-ft/yr}$$

Figure 25. Graph showing relation of channel loss to discharge in the two Cottonwood creeks.

Discharge

Ground water is discharged in the Jordan Valley by evapotranspiration, nonthermal springs and seeps, thermal springs, wells, and drains. Springs and seeps that flow into the Jordan River and its tributaries account for about 180,000 of the more than 270,000 acre-feet, which is the total annual visible discharge of ground water. Wells discharge about 90,000 acre-feet, and other springs and seeps discharge about 3,000 acre-feet. The amount of ground water discharged by evaporation and by transpiration was not determined.

Evapotranspiration

Evapotranspiration is the water that is returned to the air by transpiration of vegetation or through direct evaporation. Where ground water is near the land surface, it may be conducted to the surface by capillary action and evaporated, or it may be transpired by plants. The water table is within reach of roots of plants in many areas in the Jordan Valley because ground-water levels are maintained near the land surface by upward leakage from artesian aquifers. The amount of water discharged in the Jordan Valley by evapotranspiration was not determined.

Nonthermal springs and seeps

Ground water issues from springs and seeps in the Jordan Valley where the water table of the main ground-water reservoir or perched water bodies intersect the land surface or where water under artesian pressure leaks through confining beds to the surface. In general, the water-table springs are in areas where wells do not flow, and the artesian springs are in the area of flowing wells shown in figure 16. The locations of many existing and covered springs in the Jordan Valley are shown in figure 6.

Springs that are close to the Wasatch Range probably derive their flow from sources in the mountains. Dye tests have shown that the flow of the Holladay Spring (fig. 6) is related to the flow of Neffs Creek (Marsell, R. E., oral communication). St. Mary's Spring issues from the bedrock of the pediment south of Emigration Creek.

Springs are aligned along the entire length of the East Bench fault scarp (fig. 6). Most of them are fed by perched water bodies which intersect the scarp; others result because the relatively impermeable sediments of the East Lake Plain district are unable to transmit all of the water delivered through the coarse deposits of the East Bench district.

Springs and seeps are common in the Cottonwood channeled lands because the land surface in places is below the piezometric surface, and the confining beds are not completely effective. Ground water in this area contributes to the flow of the Cottonwood Creeks by seepage along their channels. Other creeks that drain the Wasatch Range are also effluent in their lower courses.

The flow of the Jordan River is increased by numerous springs and seeps along its channel between the Jordan Narrows and 33rd South Street near Granger (fig. 6). The Jordan River is a line source of discharge, and generally ground water moves toward it from both sides. Part of the ground-water contribution to the flow of the river is upward artesian leakage, and part is seepage from irrigation, but the respective amounts are not known.

Taylor and Leggette (1949, p. 42) estimated that the total gain in the Jordan River from the Jordan Narrows to 33rd South Street, exclusive of tributaries, was 165 cfs in November 1932. The gain represents ground-water discharge from both the shallow ground-water body and the artesian reservoir. Ward and others (1957, p. 4) estimated that ground water contributed 177 cfs to the river along the same reach in November 1957. The ground-water contribution to the tributaries of the Jordan River along the same reach in 1932 was 82 cfs (Taylor and Leggette, 1949, p. 45-46), and it was about the same in 1957 (Ward and others, 1957, p. 4). The similarity of the piezometric surfaces of the ground-water reservoir in 1931 (Taylor and Leggette, 1949, pl. 5) and 1958 (fig. 16), and the similarity of the estimates of the gain of the Jordan River and its tributaries in 1932 and in 1957, suggest that the ground-water contribution to the Jordan River and its tributaries has remained relatively constant at about 250 cfs, or 180,000 acre-feet a year.

Springs result from upward artesian leakage in several places in the Northwest Lake Plain. Taylor and Leggette (1949, p. 34-35) described a "fresh" water spring in a then recently abandoned part of the bed of Great Salt Lake, and they suggested that other such springs might occur within the bed of the lake.

Taylor and Leggette (1949, p. 45) estimated that about 3,600 acre-feet was discharged from nonthermal springs and seeps other than those tributary to the Jordan River. These springs and seeps probably continued to yield about the same amount of water.

Thermal springs and seeps

The Jordan Valley contains two areas of thermal springs: one is about 3 miles north of the Jordan Narrows and is called Crystal Hot Springs; the other which is at the western base of the Salt Lake salient, includes Beck's Hot Springs and Wasatch Springs Plunge (fig. 6). The maximum water temperatures recorded at the springs are 139^{o}F. at Crystal Hot Springs and 129^{o}F. at Beck's Hot Springs. The combined discharge of the hot springs, as recorded by Taylor and Leggette (1949, p. 35-41), is in the magnitude of 3 cfs, or about 2,000 acre-feet a year.

TABLE 4

SUMMARY OF MEASUREMENTS OF LOSS IN STREAMFLOW

(from Taylor and Leggette, 1949, p. 24-29)

Stream	Date	Length of section (miles)	Length of influent part of section (miles)	Upstream flow (cfs)	Loss (cfs)	Flow loss (percent)	Loss per mile of influent section (cfs)	Total loss if measured loss were constant over total length of influent section in stream (cfs)	Remarks
Mill Creek	Sept. 1902	2			2.56	22.7	1.28		Upper section
		.75			.14	3.6	.19		Lower section
		2.75			2.70	24	.98		Both sections
	July 10 1932	1.75		18.05	2.02	11.2	1.15		Upper section
		1		11.34	.41	3.6	.41		Lower section
		2.75		18.05	2.43	13.5	.89		Both sections
Big Cottonwood Creek	Sept. 1902	2.5	1.5	32.8	7.4	22.6	4.9	7.4	Total length of influent section in stream: 1.5 miles.
	Aug. and Sept. 1925	2	1.5	22.5	4.8	21.3	3.2	4.8	Average of five measurements.
	Aug. and Sept. 1928	2	1.5	15.8	5.1	32.2	3.4	5.1	Average of four measurements.
	July 14 1932	1.5	.8	61.6	5.9	9.6	7.4	11.1	
Little Cottonwood Creek	Earlier than 1902		3.5			16			Total length of influent section in stream: 3.5 miles.
	July to Nov. 1931	3.5	2.5		1.47		.59	2.1	Average of eight measurements. Loss ranged from 0.63 to 2.40 cfs.
	July 2 1932	1.4	1.4	116	10	8.6	7.1	25	
	July 25 1932	1.4	1.4	27.1	4.8	17.7	3.4	11.9	
	Aug. 1 1932	1.4	1.4	13.8	2.4	17.4	1.7	6	

Wells[1]

The discharge of water from flowing and pumped wells in the Jordan Valley in 1957 was about 90,000 acre-feet. About 55,000 acre-feet was discharged from about 100 large-diameter (6 to 24 inch) drilled wells used for industrial, municipal, public-supply, irrigation, and air-conditioning purposes, whereas about 35,000 acre-feet was discharged from several thousand small-diameter (less than 6 inch) wells and dug wells used for domestic and stock use and fish and fur culture. The amounts of water discharged from wells for various uses during 1957 are shown in table 5, and the discharge from wells and well fields in the Jordan Valley is shown in figure 26.

Most of the water discharged from large-diameter wells in the Jordan Valley is used by industries for metal and petroleum refining, packing, canning, brewing, manufacturing, washing gravel, dairying, and other operations. The discharge from 41 wells used for industrial purposes in 1957 was about 36,000 acre-feet. The greatest use of water was by ore processing plants and petroleum refineries, and most of the industrial wells are in the East Lake Plain District and the North Oquirrh subdistrict of the Northwest Lake Plain district.

Most municipalities in the Jordan Valley obtain at least part of their water supply from ground-water sources. Magna, South Salt Lake, and Copperton rely entirely on wells for their municipal supply. Murray relies almost entirely on wells, and Salt Lake City, Midvale, Sandy, Riverton, and Herriman supplement their surface-water supplies with water from wells. Ground-water supplies also supplement the surface-water supplies of companies serving suburban areas in Salt Lake County, including the Metropolitan Water District of Salt Lake City, the Salt Lake County Water Conservancy District, the County Water System, the West Side Water Company, the Granger-Hunter Improvement District, and the Union-Jordan Irrigation Company. The discharge from 34 large-diameter municipal wells in use in the Jordan Valley in 1957 was about 15,000 acre-feet. Most of these wells are in the East Bench, East Lake Plain, Cottonwoods, and Northwest Lake Plain districts.

Water from nine large-diameter wells in the Jordan Valley was used for public supply in 1957 at hospitals, schools, hotels, churches, department stores, and public fountains. The discharge from these wells was about 1,900 acre-feet.

The use of large quantities of ground water for irrigation is a comparatively new development in the Jordan Valley. The first large-diameter well used for irrigation in the valley was drilled in 1954, and by 1957 there were 18 large-diameter irrigation wells in use. Most of the wells are in the Riverton-Herriman area, and they are used primarily in late summer and early fall to supplement surface-water supplies. The annual discharge from nine of the wells was estimated on the basis of annual electrical power consumption and the rate of power use while pumping a measured discharge, and the annual discharge from the other nine wells was estimated from information supplied by well owners. About 1,900 acre-feet of water was discharged from wells for irrigation use in 1957.

Six wells supplied water used for air conditioning in Salt Lake City during 1957. It has been estimated from data obtained from owners of the wells that about 760 acre-feet was pumped in 1957, but it is not known how much of this was returned to the ground-water reservoir in recharge wells.

More than 7,700 wells supply water for domestic and stock use and fish and fur culture in the Jordan Valley. Most of the wells are small-diameter (less than 6 inch) jetted wells in the area of artesian flow in the East Lake Plain, Cottonwoods, and Northwest Lake Plain districts (fig. 16).

The amount of water discharged from small-diameter wells was estimated by determining the percentage of increase of such wells since 1939 and assuming a proportionate increase in discharge. In 1939, the Utah State Engineer in cooperation with the Works Progress Administration (Utah State Engineer, 1940, p. 33-41), determined that there were 6,647 wells in Salt Lake County and that they discharged 29,500 acre-feet of water during the year. These figures were adjusted to exclude 10 large-diameter (6 to 24 inch) wells which discharged 1,500 acre-feet and about 470 dug and jetted wells which were not used in 1939. Thus there remained about 6,200 small-diameter wells in the Jordan Valley which in 1939 discharged about 28,000 acre-feet of water.

Field checks were made in representative areas in the Jordan Valley in 1957 to determine the change in the number of small-diameter wells in use then as compared to 1939 (fig. 26). These checks indicated that there were about 25 percent more small-diameter and dug wells in 1957 than in 1939, and the total number in use in 1957 was about 7,700. The increase of 25 percent was applied to the known discharge of 1939 to give a discharge in 1957 of about 35,000 acre-feet.

Drains generally are in the lower parts of the Jordan Valley or in creek beds where ground water is near the land surface, and they usually are developed to rid areas of excessive water rather than to develop the water for beneficial use. Many of the drains contribute water to the Jordan River or its tributaries, and their discharge is included in the estimates of ground-water discharge for those streams.

The total visible discharge of ground water in the Jordan Valley in 1957 was about 270,000 acre-feet. This figure does not include evapotranspiration of ground water

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1/ Most wells in the valley are jetted, drilled by the percussion (cable-tool) method, or dug by hand. The vast majority of the wells are small diameter(less than 6 inches) jetted wells. Approximately 7,700 jetted wells were in use in 1958, supplying water mainly for domestic use. Most of these wells are in the valley lowlands, where boulders are uncommon, and many of them flow at the land surface. Most of the large-diameter wells (6 to 24 inches) are drilled by the percussion method for municipal, industrial, irrigation, and air-conditioning purposes. Records were obtained for 186 large-diameter wells in the valley in 1958. The dug wells are mainly on the sides of the valley where they obtain water from shallow perched aquifers. On the west side of the valley, however, some wells have been dug as deep as 150 feet.

TABLE 5

SUMMARY OF ESTIMATED WELL DISCHARGE IN THE JORDAN VALLEY IN 1957

(acre-feet)

Use of water	East Bench district	East Lake Plain district	Cotton-woods district	South-east district	West Slope district	North-west Lake Plain district	Total
Industrial	380	3,100	1,200		25	31,000	36,000
Municipal	2,700	2,800	6,200		380	3,300	15,400
Public supply	900	1,000					1,900
Irrigation	77		290	95	1,400		1,900
Air conditioning	160	580		16			760
Total water use from large-diameter drilled wells (rounded)	4,200	7,500	7,700	110	1,800	34,000	55,000
Domestic and stock and fish and fur culture1/	neg.	10,000	10,000	neg.	5,000	10,000	35,000
Total water use from all wells (rounded)	4,200	17,000	18,000	110	7,000	44,000	90,000

1/ Estimates for these uses are based on scanty data.

TABLE 6

GROUND-WATER STORAGE IN WATER-TABLE AREAS IN THE JORDAN VALLEY

East Bench District

Water-table area 8,000 acres[1]

Depth zone		Gravel	Sand	Clay, sand, and gravel	Clay and gravel	Clay	Total	Volume of material (acre-ft)	Zone storage (acre-ft)
Water level to	Feet logged	205	49	14	318	64	650		
50 feet below	Percent logged	31.5	7.5	2.2	49.0	9.8	100		
the water level	Specific yield (percent)	7.9	1.5	.2	2.5	.3	12.4	400,000	50,000
50-100 feet be-	Feet logged	170	65	34	250	131	650		
low water level	Percent logged	26.2	10.0	5.2	38.4	20.2	100		
	Specific yield (percent)	6.5	2.0	.5	1.9	.6	11.5	400,000	45,000

East Lake Plain District, City Creek Fan Subdistrict, Water-table area 1,300 acres

Depth zone		Gravel	Sand	Clay, sand, and gravel	Clay and gravel	Clay	Total	Volume of material (acre-ft)	Zone storage (acre-ft)
Water level to	Feet logged	22	47	0	12	69	150		
50 feet below	Percent logged	14.7	31.3	-	8.0	46.0	100		
the water level	Specific yield (percent)	3.7	6.3	-	.4	1.4	11.8	65,000	7,700
50-100 feet be-	Feet logged	18	91	16	0	25	150		
low the water	Percent logged	12.0	60.6	10.7	-	16.7	100		
level	Specific yield (percent)	3.0	12.1	1.1	-	.5	16.7	65,000	10,800

1/ Approximately all area in the district above 4,600 feet.

TABLE 6. Ground-water Storage in Water-table Areas in the Jordan Valley. (continued)

East Lake Plain District,
East Lake Plain Subdistrict,
Water-table area 2,000 acres

Depth zone		Gravel	Sand	Clay, sand, and gravel	Clay and gravel	Clay	Total	Volume of material (acre-ft)	Zone storage (acre-ft)
Water level to	Feet logged	8	6	92	63	281	450		
50 feet below	Percent logged	1.8	1.3	20.4	14.0	62.5	100		
the water level	Specific yield (percent)	.4	.3	2.0	.7	1.9	5.3	100,000	5,300
50-100 feet be-	Feet logged	30	3	171	16	230	450		
low water level	Percent logged	6.7	.7	38.0	3.6	51.0	100		
	Specific yield (percent)	1.7	.1	3.8	.2	1.5	7.3	100,000	7,300

Cottonwoods District
Water-table area 12,400 acres[1]

Depth zone		Gravel	Sand	Clay sand, and gravel	Clay and gravel	Clay	Total	Volume of material (acre-ft)	Zone storage (acre-ft)
Water level to	Feet logged	126	277	30	84	133	650		
50 feet below	Percent logged	19.4	42.6	4.6	12.9	20.5	100		
the water level	Specific yield (percent)	4.8	8.5	.5	.6	.6	15.0	620,000	93,000
50-100 feet be-	Feet logged	101	131	72	155	191	650		
low water level	Percent logged	15.5	20.2	11.1	23.8	29.4	100		
	Specific yield (percent)	3.9	4.0	1.1	1.2	.9	11.1	620,000	69,000

1/ Approximately all area in the district above 4,600 feet.

TABLE 6. Ground-water Storage in Water-table Areas in the Jordan Valley. (continued)

West Slope District, South Fan Subdistrict, Water-table area 12,600 acres[1]

Depth zone		Gravel	Sand	Clay, sand, and gravel	Clay and gravel	Clay	Total	Volume of material (acre-ft)	Zone storage (acre-ft)
Water level to	Feet logged	38	40	20	165	37	300		
50 feet below	Percent logged	12.7	13.3	6.7	55.0	12.3	100		
the water level	Specific yield (percent)	3.2	2.7	.7	2.8	.4	9.8	630,000	62,000
50-100 feet be-	Feet logged	115	33	15	96	41	300		
low water level	Percent logged	38.3	11.0	5.0	32.0	13.7	100		
	Specific yield (percent)	9.6	2.2	.5	1.6	.4	14.3	630,000	90,000

West Slope District, North Pediment Subdistrict, Water-table area 25,000 acres[2]

Depth zone		Gravel	Sand	Clay, sand, and gravel	Clay and gravel	Clay	Total	Volume of material (acre-ft)	Zone storage (acre-ft)
Water level to	Feet logged	36	33	2	146	133	350		
50 feet below	Percent logged	10.3	9.5	.5	41.7	38.0	100		
the water level	Specific yield (percent)	2.5	1.9	0	2.0	1.1	7.5	1,250,000	94,000
50-100 feet be-	Feet logged	28	21	14	56	231	350		
low water level	Percent logged	8.0	6.0	4.0	16.0	66.0	100		
	Specific yield (percent)	1.4	1.2	.4	.8	2.0	5.8	1,250,000	72,000

1/ Approximately all area in the subdistrict above 5,000 feet.
2/ Approximately all area in the subdistrict above 4,800 feet.

and ground water discharged in the subsurface directly to Great Salt Lake. The figure of 270,000 acre-feet may be compared to the total visible discharge of 217,000 acre-feet per year which was estimated for the period 1931-35 (Taylor and Leggette, 1949, p. 46). Ground-water discharge to the Jordan River and its tributaries and the flow of springs probably have remained relatively constant over the years; thus, the increase in visible discharge may be attributed essentially to withdrawals by wells--90,000 acre-feet in 1957 as compared to 36,000 acre-feet in 1932.

Storage

The quantity of water that can be removed from (or placed in) storage in an aquifer by lowering (or raising) water levels depends on the coefficient of storage of the aquifer.1/ The coefficient of storage varies considerably depending on whether the water is under water-table or artesian conditions. Under water-table conditions, lowering of the water table results in a dewatering of the aquifer by gravity drainage. The volume of water drained divided by the total volume of the zone is the specific yield, and for practical purposes for a water-table aquifer the specific yield is equivalent to the coefficient of storage. The storage coefficients of water-table aquifers range from about 0.05 to 0.30. Under artesian conditions, however, lowering the water level results only in a decrease of pressure in the aquifer. Inasmuch as no dewatering of the aquifer is involved, the water released from storage can be attributed only to the compressibility of the aquifer material and of the water. This quantity is very small; therefore, the coefficient of storage of an artesian aquifer is very small. The storage coefficients of artesian aquifers may range from about 0.00001 to 0.001. When the water level in an artesian aquifer declines sufficiently so that the aquifer is actually being dewatered, the storage coefficient changes to one of water-table proportions.

The amount of water that could be obtained from storage if water levels were lowered 100 feet below the level of the water table in 1958 was calculated only for the areas where water-table conditions prevail in the Jordan Valley. The amount of water in storage in the artesian areas was not calculated because the exact size of the area in which artesian conditions prevail is not known, the coefficients of storage of the artesian aquifers in these areas are not known, and the coefficients of storage of artesian aquifers are extremely small. Considering all these factors, it was felt that the possible error involved in computing the amount of water in artesian storage would be very large in relation to the amount of water that would actually be released from storage by a lowering of artesian pressures of 100 feet. Furthermore, the amount of water in storage in the water-table aquifers is so large in relation to the amount in storage in artesian aquifers which is represented by pressure heads above the top of the aquifer, that the latter can be neglected.

The calculations of storage in the water-table aquifers were based on estimates of specific yield which were obtained from the study of drilling samples from 42 wells in the Jordan Valley (fig. 11), using a method described by Cardwell (1958, p. 103-106). The following table of values for specific yield, although determined for sediments in California, is believed to be fairly representative of similar sediments in the Jordan Valley:

Category[1]	Assigned specific yield (percent)
Gravel (boulders, cobbles, gravel, and shells)	25
Sand (clamshells, sand and gravel, gravelly sand)	20
Clay, sand and gravel (dirty sand, quicksand, coarse sandstone, silt)	10
Clay and gravel (cemented gravel, hard sandstone)	5
Clay (decomposed rock, hardpan, shale--where probably clay)	3
Rock (hard shale, shale--if not clay, serpentine, basalt, or lava)	0

[1] First term or terms denote category in which drillers' terms, enclosed by parentheses, have been grouped. (Cardwell, 1958, table 10).

The estimates of specific yield for the Jordan Valley were used in table 6 to compute the water in storage to depths of 50 and 100 feet below the water table. Table 6 does not include data for the southeast district because of a lack of sufficient well-log information on which to determine specific yields. The total quantity of ground water in storage in the upper 100 feet of saturated permeable sediments underlying the areas listed in table 6 is about 600,000 acre-feet, or about 6,000 acre-feet for each foot of sediment.

QUALITY OF WATER

General Statement

The Jordan Valley was divided into ground-water districts on the basis of differences in subsurface geology and in ground-water conditions, but the ground water in the districts also differs in chemical quality. The differences in quality have been determined from 376 chemical analyses of water from wells and springs. All these analyses are reported in a basic-data report by Marine and Price (1963), but most of the data are summarized in figures 27 and 28 and table 7 of this report. Analyses for 11 wells and springs specifically referred to in this report are presented in table 8.

1/ The coefficient of storage is defined as the volume of water the aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in the component of head normal to that surface.

The dissolved solids contained in water from selected wells and springs in the Jordan Valley are shown in figure 27. Although the dissolved solids range from 75 to 31,800 ppm (parts per million) most wells yield water containing less than 600 ppm of dissolved solids. The ground water of best quality is in the Cottonwoods district, where most wells yield water that contains less than 250 ppm of dissolved solids. The water of worst quality is in part of the Northwest Lake Plain district where most wells yield water that contains more than 1,000 ppm of dissolved solids. The water of the various districts is discussed in more detail in the following section.

Chemical Quality of Ground Water by Districts

East Bench District

Most of the ground water in the East Bench district is of satisfactory chemical quality for domestic use and would meet most requirements for other uses. (See table 7 and fig. 28). All of the water is very hard, however, and it must be softened for many uses. Some of the water contains more than the maximum sulfate content of 250 ppm that is recommended for municipal supply by the U.S. Public Health Service (1962). Much of the water in the district is suitable for irrigation of most crops. According to the method of classification of irrigation waters of the U.S. Salinity Laboratory Staff (1954, p. 80), however, some of the water has a high salinity hazard (fig. 29), and special management practices may be necessary for irrigation.

Well (D-1-1)36bac-1 yields water that contains about 12 times the average sulfate content of water in the district (table 8). The well is within several hundred yards of the mountain front, opposite outcrops of the Park City Formation which is the source of the sulfate.

East Lake Plain District

Most of the ground water in the East Lake Plain district is very similar in chemical quality to the water in the East Bench district (table 7 and fig. 29.) This is to be expected, because much of the recharge for the East Lake Plain district comes from the East Bench district (fig. 16), and much of the sediment in the East Lake Plain district was derived from the East Bench district or from a common source.

Springs and wells near the Warm Springs fault along the west end of the Salt Lake salient yield water that contains more dissolved minerals than do other wells in the district. Water from Beck's Hot Springs, (B-1-1)14dcb (table 8), contains 27 times more dissolved solids than does the average water in the district (table 7). Well (B-1-1)36bac-29, which was perforated at several zones from 120 to 320 feet below land surface also yields water that contains an unusually high content of dissolved minerals (table 8). The spring and the well probably both yield water that is rising along the Warm Springs fault.

Cottonwoods District

Ground water in the Cottonwoods district contains less dissolved solids than does the ground water in any of the other districts in the Jordan Valley (table 7 and fig. 28). The water is suitable for most domestic, municipal, and irrigational (fig. 29) uses, but most of the water is hard and some water contains more than the maximum sulfate content of 250 ppm that is recommended for municipal supply by the U.S. Public Health Service (1962).

Well (D-3-1)7ccd-1 yields water (table 8) that contains considerably more dissolved minerals than do other wells in the district (table 7). The well probably draws water from an aquifer that is being recharged by seepage from fields that are being irrigated with water diverted from the Jordan River.

Southeast District

The chemical quality of water in the Southeast district differs from place to place in the district (fig. 27), apparently because some water is derived directly from precipitation, some from seepage from irrigation, and some may be rising along faults. Precipitation infiltrates directly into the ground on and near the Draper spit, and nearby wells obtain water of good chemical quality that is characterized by a low content of dissolved solids. A typical analysis of such water is from well (D-3-1)29abc-1 (table 8). Seepage from fields irrigated with water diverted from the Jordan River is the main source of recharge below the Draper and East Jordan Canals (fig. 6), and water derived from this source has a high nitrate and sulfate content and is very hard. A typical analysis of such water is from well (D-3-1)30dcb (table 8). Water that may be rising along faults issues from Crystal Hot Springs and has been tapped by wells. A typical water of this type is distinguished from other waters in the district by its high temperature and high silica content. (See analysis for spring (C-4-1)11ad in table 8.)

West Slope District

Ground water in the West Slope district generally contains more dissolved solids and is harder than most ground water in the eastern part of the Jordan Valley (figs. 27 and 28 and table 6). The main sources of the dissolved minerals have been surface water poured on the land for irrigation and industrial waste water.

Water from springs and from wells less than 300 feet deep that are below the highest canal that carries Jordan River water is similar in chemical quality to the canal water. These waters generally contain more than 1,000 ppm of dissolved solids, and they have a relatively high nitrate content.

Waste water from industrial activities has contaminated the ground water in two known areas in the West Slope district. The evaporating ponds shown in figure 6 are used for the disposal of waste mine water. Water sampled from a seep, (C-3-1)18abc, at the base of a slope east of the ponds contains 17,400 ppm sulfates (table 8). A comparatively high sulfate content of 1,150 ppm in the water from well (C-3-1)9ccc-1 (table 8), about 1 1/2 miles east of the evaporating ponds, indicates that some of the water from the evaporating ponds is mixing with the ground water in this area.

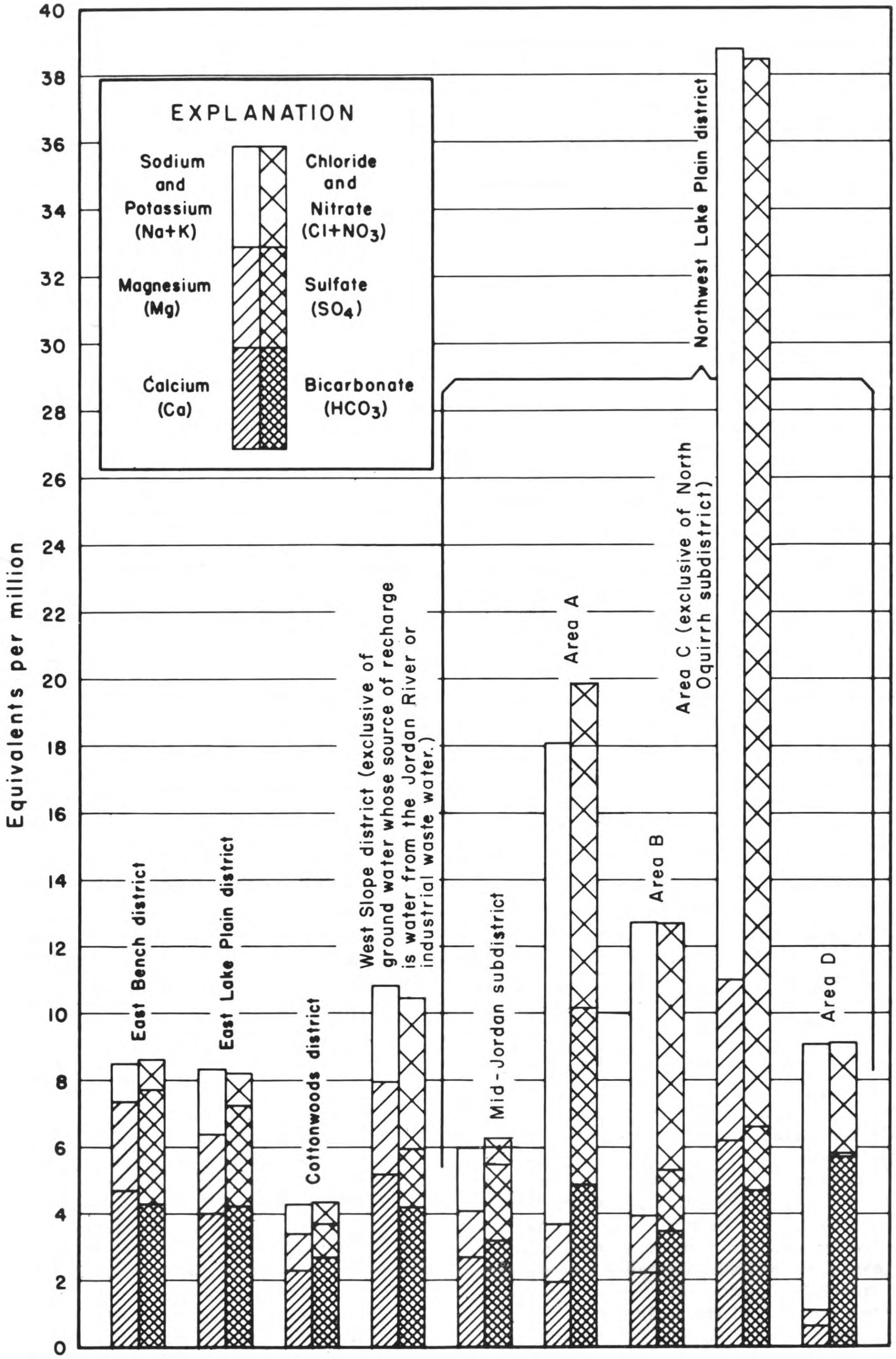

Figure 28. Chemical character of ground water in the Jordan Valley. (Compiled from the average analyses in table 7.)

TABLE 7

AVERAGE OF ANALYSES AND MAXIMUM AND MINIMUM NORMAL VALUES FOR CHEMICAL CONSTITUENTS, HARDNESS, AND CONDUCTIVITY IN THE JORDAN VALLEY[1]

District or area	Number of analyses		Parts per million											Specific conductance (micromhos/cm at 25°C)
			Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na + K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Dissolved solids 2/	Hardness as $CaCO_3$	
East Bench		Max.	19	0.12	144	52	67	341	386	45	12.0	774	552	1,080
district	25	Ave.	13	.02	94	32	26	264	164	30	3.6	602	336	790
		Min.	6	.00	64	22	1	104	70	7	.0	320	206	556
East Lake Plain		Max.	25	1.80	135	49	160	554	338	187	9.9	764	526	1,200
district	63	Ave.	17	.10	80	29	46	258	147	33	1.5	487	321	783
		Min.	8	.00	27	14	6	144	2	6	.0	251	108	431
Cottonwoods		Max.	54	.26	107	45	85	323	282	125	9.7	718	415	731
district	64	Ave.	13	.03	45	14	19	163	50	23	2.7	253	190	376
		Min.	5	.00	9	4	2	54	3	4	.0	75	38	156
Southeast		Max.	60	.28	162	146	352	478	549	598	31.0	1,390	1,004	2,470
district	12	Ave.	Not meaningful											
		Min.	17	.01	56	8	19	203	38	8	.5	255	184	409
West Slope		Max.	65	.60	229	61	148	360	317	329	19.0	1,240	790	1,700
district 3/	31	Ave.	35	.13	104	34	66	250	90	156	4.6	643	387	1,033
		Min.	9	.00	59	19	32	173	20	57	.8	365	245	725
Northwest Lake Plain district:														
Mid-Jordan		Max.	58	1.0	85	28	92	302	214	74	5.8	508	324	758
subdistrict	20	Ave.	29	.38	54	17	44	194	105	26	1.1	356	205	564
		Min.	15	.01	27	9	21	133	6	10	.0	244	127	394
area A		Max.	82	.18	64	36	384	405	338	325	23.0	1,430	326	2,280
	9	Ave.	67	.06	39	21	332	296	228	301	13.1	1,158	186	1,926
		Min.	57	.01	24	13	277	241	163	270	7.0	976	135	1,640
area B		Max.	64	.20	62	36	279	276	145	295	6.5	950	296	1,600
	9	Ave.	48	.05	42	22	203	212	90	259	2.5	816	195	1,395
		Min.	8	.00	25	12	135	144	44	190	.0	678	118	1,220
area C		Max.	63	.40	269	141	1,060	700	278	2,125	13.0	3,600	1,250	6,300
(exclusive	13	Ave.	41	.14	124	59	640	286	93	1,130	5.3	2,220	550	4,121
of North Oquirrh subdistrict)		Min.	21	.00	24	11	291	66	1	510	.0	1,080	136	1,980
North Oquirrh		Max.	19	-	321	214	3,670	336	231	6,280	-	10,800	-	-
subdistrict	5	Ave.	15	-	223	108	2,220	307	139	3,946	-	6,861	-	-
		Min.	12	-	110	48	760	283	60	1,330	-	2,485	-	-
area D		Max.	28	.15	14	8	208	452	3	140	.9	567	64	926
	3	Ave.	27	.10	12	5	185	343	2	122	.6	523	55	884
		Min.	26	.02	11	3	171	270	1	91	.3	492	50	853

1/ The averages and ranges in this table indicate the type of water that is obtained from most wells in each district or area. Analyses for isolated occurrences of water that contain unusually high concentrations of one or several constituents were not used in compiling the table.

2/ Calculated from determined constituents.

3/ Exclusive of ground water whose source of recharge is water from the Jordan River or industrial waste water.

TABLE 8

CHEMICAL ANALYSES OF WATER FROM SELECTED WELLS AND SPRINGS IN THE JORDAN VALLEY

Well or spring number	Date of Collection	Temperature (°F)	Parts per million											Percent sodium	Sodium adsorption ratio (SAR)	Specific conductance (micromhos /cm at 25°C)	pH	Analysis by[2]
			Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na+K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Dissolved solids[1]	Hardness as $CaCO_3$	Noncarbonate hardness as $CaCO_3$					
(B-1-1) 14dcb	8-29-47	-	35	688	136	4,100	235	800	7,210	-	13,100	2,280	2,080	80	37	19,400	-	GS
36bac-29	7-11-50	-	-	-	-	-	233	896	3,252	-	-	1,978	708	-	-	-	-	UO
(C-1-1) 34cdc-2	8-18-58	57	55	85	55	97	198	179	228	2.4	798	437	275	33	2.0	1,310	7.9	GS
(C-2-2) 5aac	8- 4-58	68	57	363	105	195	409	284	310	856	2,370	1,340	1,000	24	2.3	3,320	7.5	GS
(C-3-1) 9ccc-1	8-13-58	57	33	425	156	122	544	1,150	225	7.5	2,390	1,700	1,250	14	1.3	2,960	7.1	GS
18abc[3]	9-11-58	-	139	648	2,390	3,290	-	17,400	388	.7	24,300	11,400	11,400	38	13	9,970	3.0	GS
(C-4-1) 11ad	5-22-34	137	60	106	25	304	285	97	598	-	[4]1,665	368	134	-	-	-	7.6	SL
(D-1-1) 36bac-1	3- 3-54	-	-	590	162	72	136	2,060	28	-	-	2,140	2,030	7	.7	3,100	7.4	GS
(D-3-1) 7ccd-1	9-15-58	59	22	234	92	337	314	726	480	7.7	2,050	964	707	43	4.7	2,970	7.4	GS
29abc-1	9-15-58	55	18	56	11	19	214	38	7.5	.5	255	184	9	19	.6	409	7.8	GS
30dcb	3- 6-33	-	-	162	146	352	478	549	555	31	[4]2,030	1,000	612	43	4.8	-	-	GS

[1] Dissolved solids are calculated from determined constituents except as noted.

[2] Analysis by: GS, U.S. Geological Survey; SL, City Chemist, Salt Lake City, Utah; UO, Utah Oil Refining Co.

[3] Analysis includes acidity of 54 ppm as H_2SO_4 and density of 1.019.

[4] Residue on evaporation.

The unusually high nitrate concentration of 856 ppm (table 8) in the water from spring (C-2-2) 5aac which issues from a surface outcrop of the Salt Lake Formation indicates that this water may be contaminated with waste from a powder plant which is about a mile up the hydraulic gradient from the spring.

The South Fan subdistrict of the West Slope district contains most of the large-diameter irrigation wells in the Jordan Valley, and, therefore, the quality of the ground water in relation to irrigation is particularly important. Native water in the subdistrict, which is not contaminated by surface water or industrial waste water, has a low sodium hazard and a high salinity hazard (fig. 29), according to the method of classification of irrigation waters of the U.S. Salinity Laboratory Staff (1954, p. 80).

Northwest Lake Plain District

Differences in chemical quality of the ground water in the Northwest Lake Plain district have warranted a division of the district, for the discussion of water quality, into five areas that differ somewhat from the ground-water subdistricts. These areas are the Mid-Jordan subdistrict and four areas designated as A, B, C, and D (fig. 27).

The ground water in the Mid-Jordan subdistrict contains less dissolved solids than does the water in any other area except the Cottonwoods district (fig. 27 and table 7). It is likely that water moves from the Cottonwoods district directly to the Mid-Jordan subdistrict. The water from well (C-1-1)34cdc-2 in the Mid-Jordan subdistrict contains 798 ppm of dissolved solids (table 8). This is anomalously high, and fluctuations of the water level in this well indicate that some of the recharge for this well comes from irrigation water that is obtained from the Jordan River.

The ground water in area A is derived mostly from seepage of irrigation water from the adjacent West Slope district, and like the Jordan River water, it contains a large amount of dissolved solids (fig. 27 and table 7). Water in this area does not meet U.S. Public Health Service standards (1962) for municipal use, although it is used for municipal and domestic supply. The water has a high sodium-salinity hazard (fig. 29); therefore, its use for irrigation may require special soil management practices.

The ground water in area B contains less dissolved solids than does the water in area A and more dissolved solids than does the water in the Mid-Jordan subdistrict (fig. 27 and table 7). Apparently the water in area B is a mixture of the water of poor quality from area A and the better quality water from the Mid-Jordan subdistrict.

The ground water in area C everywhere contains more than 1,000 ppm of dissolved solids and in places contains considerably more (fig. 27). The water in the extreme western part of the area (that part occupied by the North Oquirrh subdistrict) in general contains more dissolved solids than does water in other parts of the area, but the proportions of constituents are similar (table 7). The water in area C is not suitable for most purposes (fig. 28 and table 7), but large quantities are used in the milling, smelting, and refining of ores.

The ground water in area D contains considerably less dissolved solids than does the water in area C (fig. 27). This is surprising, considering the closeness of area D to Great Salt Lake. The water in area D is of the sodium bicarbonate type, and it contains practically no calcium, magnesium, and sulfate (fig. 28 and table 7). The presence of this soft water that contains less than 600 ppm of dissolved solids so close to Great Salt Lake suggests that some of the water in area D may be coming from the East Shore area, north of the Jordan Valley.

Temperature of Ground Water

The temperature of ground water as measured and reported in the Jordan Valley ranges from 46° to 139° F. (fig. 30). The temperature of the water in most wells and springs, however, ranges from 52° to 60° F. Temperatures below 52° F. were measured by Taylor and Leggette (1949, p. 192-193 and 245-247) from a few wells less than 250 feet deep in the eastern part of T. 1 S., R. 1 W., and the western part of T. 1 S., R. 1 E. A temperature of 46°F. was reported from well (C-3-2)5acb-1 which is 1,274 feet deep.

The temperature of the ground water exceeds 60° F. principally in two areas in the Jordan Valley. The smaller of the two areas is in the southeastern part of the valley, west of Draper (fig. 30). The highest temperature recorded in this area is 139° F., at Crystal Hot Springs (spring number (C-4-1)11ad), and the temperature of the ground water apparently decreases away from the springs. The high temperatures are probably caused by hot water moving upward along a fault zone at or near Crystal Hot Springs.

The geothermal gradient in the area, as indicated by temperatures measured at different depths in well (D-3-1) 18cbb-1 in January 1959 may be about 2 1/2° F. per hundred feet. The measurements were made with a maximum thermometer, and they indicate maximum temperatures between the surface and the depths shown, as follows: 100 - 70°; 400 - 87°; 500 - 87°; 600 - 90°; 800 - 90°; 1,025 - 95°; 1,093 - 95°.

The larger of the two areas of high-temperature ground water occupies much of the northern part of the Jordan Valley (fig. 30). The eastern margin of this area is marked by several hot springs which rise along the Warm Springs fault (Taylor and Leggette, 1949, p. 35), and the warmest water reported is 129° F., at Beck's Hot Springs (spring number (B-1-1)14dcb). Most of the wells west of Beck's Hot Springs yield water warmer than 60° F. It is unlikely that underflow from the spring area has any effect on the temperature of the ground water more than 1 mile west of the springs, however, because water-level data for the area indicate that the direction of movement of the ground water on the west side of the Jordan River is toward the east or northeast (fig. 16).

The source of the heat for the large area of warm water west of the Jordan River is not known. Warm water may be rising along a fault zone such as suggested by Cook and Berg (1961, p. 81), or the heat may result from exothermic reactions in the organic clays of the area. At the western margin of the area, warm water may be rising along the faults which bound the north end of the Oquirrh Mountains.

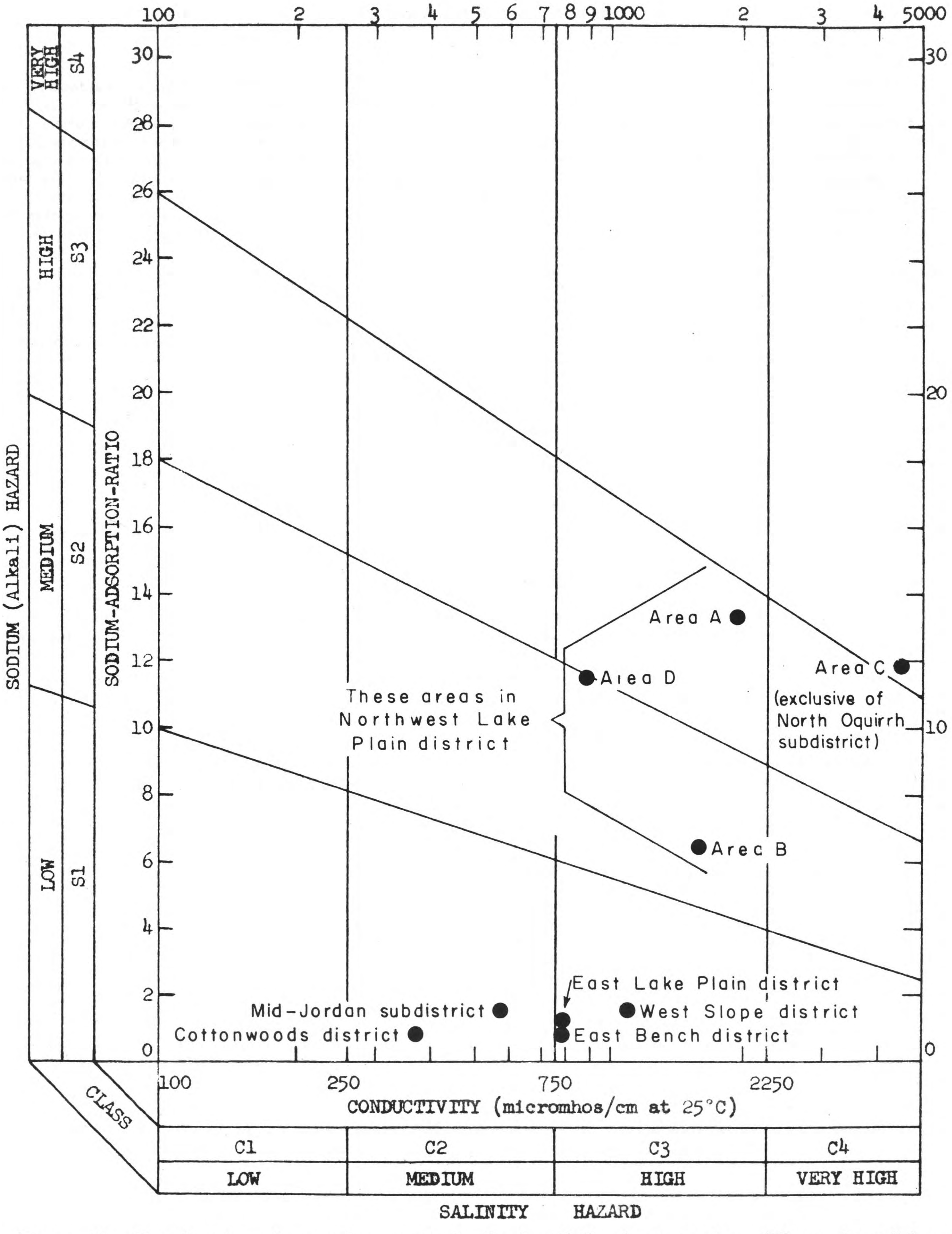

Figure 29. Classification of ground water in the Jordan Valley for irrigation. (Chart adapted from U.S. Salinity Laboratory Staff, 1954, p. 80; points plotted are the average analyses in table 7.)

SUMMARY AND CONCLUSIONS

The Jordan Valley is divided into six ground-water districts: East Bench, East Lake Plain, Cottonwoods, Southeast, West Slope, and Northwest Lake Plain. Three of the districts are further subidivded into subdistricts: East Lake Plain, City Creek Fan, and North Bench in the East Lake Plain district; North Pediment and South Fan in the West Slope district; and Northwest Lake Plain, Mid-Jordan, South Margin, and North Oquirrh in the Northwest Lake Plain district. The subsurface geology and ground-water conditions are different in each of the districts.

The sediments of the East Bench district are predominantly boulder and clay deposits of alluvial fan origin. Yields of wells generally are large, and the specific capacity of 19 wells averages 42 gpm per foot of drawdown. Ground water in this district is of good chemical quality and the average dissolved solids in water from 25 wells is about 600 ppm. The average temperature of the groundwater is about 55° F. About 4,200 acre-feet of water per year is pumped from the district without any appreciable effect on water-level trends. This district could yield additional supplies of ground water, and it would be an excellent area for artificial recharge of the ground-water reservoir. The amount of ground water in storage in water-table areas in the district within the first 100 feet below the level of the water table in 1958 is estimated to be 95,000 acre-feet.

The sediments in the East Lake Plain subdistrict of the East Lake Plain district are mostly lake-bottom clay and silt with thin, discontinuous, gravel lenses. Yields of wells are comparatively small, and the specific capacity of eight large-diameter wells averages 4 gpm per foot of drawdown. Many small-diameter wells supply water for domestic use, and most of these wells flow. The water is of suitable chemical quality for most uses, and it contains an average of about 500 ppm of dissolved solids. The average temperature of the ground water is about 55°F. Water levels in the subdistrict fluctuate very slowly in response to climatic cycles.

The City Creek Fan subdistrict of the East Lake Plain district is underlain by boulders and gravel of an alluvial fan laid down by City Creek. Yields to wells generally are large, and the specific capacity of seven wells averages 150 gpm per foot of drawdown. The water in this subdistrict is of good chemical quality, containing an average of 530 ppm of dissolved solids. The average temperature of the ground water is about 55° F. Water levels fluctuate in response to the flow of City Creek and to variations of seasonal pumpage.

The total discharge from wells in the East Lake Plain district in 1957 was about 17,000 acre-feet. Additional development of ground water in the district will be limited by the low permeability of the sediments in the East Lake Plain subdistrict and the small area of the City Creek Fan subdistrict. The amount of ground water in storage in the City Creek Fan subdistrict within the first 100 feet below the level of the water table in 1958 is estimated to be about 18,000 acre-feet.

The predominant sediments in the Cottonwoods district are gravel and sand of fluviatile and glacial-fluviatile origin interbedded with lake-bottom clay and silt. The gravel is more common near the mountains, and the clay and silt more common near the East Lake Plain district. Large-diameter wells yield large amounts of water throughout the district. The specific capacity of 22 wells averages about 45 gpm per foot of drawdown, but the largest yields are in the higher, eastern part of the district. Small-diameter artesian wells are common in the lower, western part of the district, and most of the wells flow. The quality of the ground water is suitable for most purposes, and the average content of dissolved solids in water from 64 wells is about 250 ppm. The average temperature of the ground water is about 55° F. Most water levels in the district declined slightly from 1953 to 1958. The discharge from all wells in the district in 1957 was about 18,000 acre-feet. The district could yield additional supplies of ground water, and it would be an excellent area for artificial recharge. The amount of ground water in storage in water-table areas in the district within the first 100 feet below the level of the water table in 1958 is estimated to be about 160,000 acre-feet.

The sediments underlying the South Fan subdistrict of the West Slope district consist largely of gravel, boulders, and clay which were deposited in alluvial fans. Yields of wells have a wide range, but the average specific capacity of 11 wells is 18 gpm per foot of drawdown. The average temperature of the ground water is about 55° F.

The North Pediment subdistrict of the West Slope district is underlain by fine-grained sediments, and most have small yields. The specific capacity of nine wells averages about 1.5 gpm per foot of drawdown. The average temperature of the ground water is about 60° F.

The ground water in the West Slope district is generally of satisfactory chemical quality for most uses, but in places it has been contaminated by industrial waste water. The ground-water reservoir in much of the lower part of the district is recharged from water that is diverted from the Jordan River and applied to the land for irrigation, and water levels generally rose in the district from 1931 to 1958.

The discharge of ground water from wells in the West Slope district in 1957 was about 7,000 acre-feet. The amount of ground water in storage in water-table areas in the district within the first 100 feet below the level of the water table in 1958 is estimated to be about 320,000 acre-feet. Additional supplies of ground water could be more readily obtained in the South Fan subdistrict rather than the North Pediment subdistrict because of the relatively low permeability of the sediments in the latter subdistrict.

The sediments underlying most of the Northwest Lake Plain district are lake-bottom clays with thin sand lenses. Gravel of fluviatile origin interbedded with clay and silt is common in the Mid-Jordan subdistrict, and gravel is common also in the South Margin subdistrict and in the North Oquirrh subdistrict. Most wells in the district are of small diameter and were jetted, but all wells in the North Oquirrh subdistrict are large-diameter drilled wells. The specific capacity of seven wells in the North Oquirrh subdistrict averages 170 gpm per foot of drawdown.

The water in the Northwest Lake Plain district has a considerable range in chemical quality. Dissolved solids average about 350 ppm in the Mid-Jordan subdistrict, but they average about 7,000 ppm in the North Oquirrh subdistrict. Much of the ground water in the remainder of the district contains more than 1,000 ppm of dissolved solids, much of which is sodium chloride. The temperature of the ground water in most of the district exceeds 60°F., and in part of the district the temperature exceeds 70°F. Water levels had no significant upward or downward trend in the district during the period 1931-58.

The total discharge from all wells in the Northwest Lake Plain district in 1957 was about 44,000 acre-feet, mostly in the North Oquirrh subdistrict for industrial use. Additional development of ground water throughout most of the district should be based on the willingness of the developer to utilize water of relatively poor chemical quality.

The ground water reservoir in the Jordan Valley each year discharges about 90,000 acre-feet through wells and about 180,000 acre-feet through natural discharge to the Jordan River. In addition, the reservoir discharges an unknown but large amount of water by evapotranspiration and by underflow to Great Salt Lake.

The Jordan Valley has a large potential for production of additional ground water. Large quantities of water have been discharged from the ground with no widespread decline in water levels. The basin is overflowing through springs, seeps and flowing wells, and artificial recharge probably is not feasible until more space for storage is created by lowering water levels. The total yield of the basin under the type of development that would use the basin as an active reservoir--drawing down water levels in times of low precipitation and thereby making room to store more water when it becomes available during times of high precipitation--certainly would be much greater than the present yield.

SELECTED REFERENCES

Bennison, E. W., 1947, Ground water, its development, uses, and conservation: St. Paul, Minn., Edward E. Johnson, Inc., 509 p.

Bissell, H. J., 1952, Stratigraphy of Lake Bonneville and associated Quaternary deposits in Utah Valley, Utah (abs.): Geol. Soc. America Bull., v. 63, no. 12, p. 1358.

Calkins, F. E., and Butler, B. S., 1943, Geology and ore deposits of the Cottonwood-American Fork area, Utah, with sections on history and production by V. C. Heikes: U.S. Geol. Survey Prof. Paper 201, 152 p., 51 pls.

Cardwell, G. T., 1958, Geology and ground water in the Santa Rosa and Petaluma Valley areas, Sonoma County, California: U.S. Geol. Survey Water-Supply Paper 1427, 273 p., 8 pls.

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, 276 p.

Cook, D. R. (ed.), 1961, Geology of the Bingham Mining District and northern Oquirrh Mountains: Utah Geol. Soc. Guidebook to the geology of Utah, No. 16, 145 p.

Cook, K. L., and Berg. J. W., Jr., 1961, Regional gravity survey along the central and southern Wasatch front, Utah: U.S. Geol. Survey Prof. Paper 316-E, p. 75-89.

Eardley, A. J., 1938, Sediments of Great Salt Lake, Utah: Am. Assoc. Petroleum Geologists Bull., v. 22, no. 10, p. 1305-1411.

____________1939, Structure of the Wasatch-Great Basin region: Geol. Soc. Am. Bull., v. 50, no. 8, p. 1277-1310.

____________1944, Geology of the north-central Wasatch Mountains, Utah: Geol. Soc. America Bull., v. 55, p. 819-864, 14 pls.

____________1952, Wasatch hinterland, in Geology of the central Wasatch Mountains, Utah: Utah Geol. Soc. Guidebook to the geology of Utah, No. 8, p. 52-60.

____________1955, Tertiary history of north-central Utah, in Tertiary and Quaternary geology of the eastern Bonneville basin: Utah Geol. Soc. Guidebook to the geology of Utah, No. 10, p. 37-44.

Eardley, A. J., and Gvosdetsky, Vasyl, 1960, Analysis of Pleistocene core from Great Salt Lake, Utah: Geol. Soc. America Bull., v. 71, p. 1323-44, 1 pl.

Eardley, A. J., and Gvosdetsky, Vasyl, and Marsell, R. E., 1957, Hydrology of Lake Bonneville and sediments and soils of its basin: Geol. Soc. America Bull., v. 68, no. 9, p. 1141-1201, 4 pls.

Fenneman, N. M., and Johnson, D. W., 1946, Physical divisions of the United States: U.S. Geol. Survey map.

Fiedler, A. G., 1927, The Au deep-well current meter and its use in the Roswell artesian basin, New Mexico: U.S. Geol. Survey Water-Supply Paper 596-A, p. 24-52.

Gilbert, G. K., 1890, Lake Bonneville: U.S. Geol. Survey Mon. 1, 438 p.

____________1928, Studies of basin-range structure: U.S. Geol. Survey Prof. Paper 153, 92 p., 40 pls.

Gilluly, James, 1932, Geology and ore deposits of the Stockton and Fairfield quadrangles, Utah: U.S. Geol. Survey Prof. Paper 173, 171 p., 32 pls.

Granger, A. E., Sharp, B. J., Crittenden, M. D., and Calkins, F. C., 1952, Geology of the Wasatch Mountains east of Salt Lake City, in Geology of the central Wasatch Mountains, Utah: Utah Geol. Soc. Guidebook to the geology of Utah, No. 8, p. 1-37.

Hem, J. E., 1959, Study and interpretation of the chemical characteristics of natural water: U.S. Geol. Survey Water-Supply Paper 1473, 269 p., 2 pls.

Hunt, C. B., Varnes, H. D., and Thomas, H. E., 1953, Lake Bonneville:Geology of northern Utah valley, Utah: U.S. Geol. Survey Prof. Paper 275-A, 99 p., 4 pls.

James, A. H., Smith, W. H., and Welsh, J. E., 1961, General geology and structure of the Bingham district, Utah, in Geology of the Bingham Mining District and northern Oquirrh Mountains: Utah Geol. Soc. Guidebook to the geology of Utah, No. 16, p. 49-70.

Jones, D. J., and Marsell, R. E., 1955, Pleistocene sediments of lower Jordan Valley, Utah, in Tertiary and Quaternary geology of the eastern Bonneville basin: Utah Geol. Soc. Guidebook to the geology of Utah, No. 10, p. 85-112.

Lofgren, B. E., 1952, Jordan Valley, Salt Lake County, in Status of development of selected ground-water basins in Utah: Utah State Engineer Tech. Pub. 7, p. 76-83.

Marine, I. W., and Price, Don, 1963, Selected hydrologic data, Jordan Valley, Salt Lake County, Utah: U.S. Geol. Survey open-file rept. (duplicated as Utah Basic-Data Report No. 4).

Peck, E. L., 1954, Hydrometeorological study of Great Salt Lake: Bull. Univ. Utah, v. 45, no. 8., 57 p.

Pitcher, G. G., 1957, Geology of the Jordan Narrows quadrangle, Utah: Brigham Young Univ. Research Studies, Geol. Ser., v. 4, no. 4, 46 p.

Richardson, G. B., 1906, Underground water in the valleys of Utah Lake and Jordan River, Utah: U.S. Geol. Survey Water-Supply Paper 157, 81 p., 9 pls.

Roberts, R. J., and Tooker, E. W., 1961, Structural geology of the north end of the Oquirrh Mountains, Utah, in Geology of the Bingham Mining District and northern Oquirrh Mountains: Utah Geol. Soc. Guidebook to the geology of Utah, No. 16, p. 36-48.

Slentz, L. W., 1955, Salt Lake Group in Lower Jordan Valley, Utah, in Tertiary and Quaternary geology of the eastern Bonneville basin: Utah Geol. Soc. Guidebook to the geology of Utah, No. 10, p. 23-26.

Taylor, G. H., and Leggette, R. M., 1949, Ground water in the Jordan Valley, Utah: U.S. Geol. Survey Water-Supply Paper 1029, 357 p., 14 pls.

Thomas, H. E., 1953, Water resources, in Lake Bonneville: Geology of northern Utah Valley, Utah: U.S. Geol. Survey Prof. Paper 275-A, p. 60-96, pls. 3-4, figs. 16-22, tables 16-28.

Tooker, E. W., and Roberts, R. J., 1961, Stratigraphy of the north end of the Oquirrh Mountains, Utah, in Geology of the Bingham Mining District and northern Oquirrh Mountains: Utah Geol. Soc. Guidebook to the geology of Utah, no. 16, p. 17-35.

U.S. Bureau of Mines, 1957, Minerals yearbook, v. 3, area rept., Salt Lake County: p. 1121-1123.

U.S. Departments of the Army and the Air Force, 1957, Wells: Tech. Manuals 5-297 (Army) and 85-23 (Air Force), 264 p.

U.S. Public Health Service, 1962, Drinking water standards: Public Health Service Pub. 956, 61 p.

U.S. Salinity Laboratory Staff, 1954, Diagnosis and improvement of saline and alkali soils: U.S. Dept. of Agriculture Handbook, no. 60, 160 p.

Utah State Engineer, 1940: Utah State Engineer Twenty-second Biennial Report, 226 p.

Ward, J. A., Skoubye, C. M., and Ward, G. A., 1957, Flow characteristics and chemical quality of the Jordan River, Salt Lake County, Utah for the year 1957: Utah State Water Pollution Control Board.

Woolley, R. R., and Marsell, R. E., 1946, Great Salt Lake: A selected bibliography: Am. Geophys. Union Trans., v. 27, no. 1, p. 103-107.

TABLE 9

DRILLERS' LOGS OF SELECTED WELLS IN THE JORDAN VALLEY

Altitudes are in feet above sea level for land surface at well.
Thickness and depth below land surface are in feet.

(C-1-2)6aaa-4. Log by Richard Larsen.

Altitude 4,212 ft.

	Thickness	Depth
Clay	32	32
Sand	8	40
Clay	60	100
Sand	4	104
Clay	35	139
Sand	6	145
Clay	37	182
Sand	6	188
Clay	32	220
Sand	7	227
Clay	35	262
Sand	8	270
Clay	40	310
Sand	3	313
Clay	60	373
Sand	3	376
Clay	30	406
Sand	9	415
Clay	33	448
Sand	8	456
Clay	42	498
Sand	7	505
Clay	20	525
Sand	4	529
Clay	30	559
Sand	3	562
Clay	8	570
Sand	4	574
Clay	50	624
Sand	8	632
Clay	15	647
Sand	8	655
Clay	20	675
Sand	6	681
Clay	52	733
Sand	4	737
Clay	14	751
Sand	12	763
Clay	35	798
Sand	14	812
Clay	11	823
Sand	9	832
Clay	7	839
Sand	10	849
Clay	60	909
Sand	4	913
Clay	35	948
Sand	6	954
Clay	45	999
Sand	8	1,007
Clay	31	1,038
Sand	6	1,044
Clay	10	1,054
Sand	70	1,124
Clay	10	1,134
Sand	4	1,138
Clay	3	1,141
Sand	2	1,143
Clay	7	1,150

(C-1-2)21adb-1. Log by Kennecott Copper Corp.

Altitude 4,225 ft.

Clay, blue	32	32
Clay, blue, and gravel; water	6	38
Clay, grey	12	50
Clay, grey and brown	30	80
Clay, brown, and coarse gravel; water	4	84
Clay, brown	40	124
Clay, brown, and coarse gravel; water	6	130
Clay, brown	18	148
Sand and gravel; water	4	152
Clay and gravel	18	170
Gravel and cobbles to 6 inches in diameter; water	10	180
Clay and gravel; water	50	230
Gravel and cobbles to 6 inches in diameter	10	240
Gravel and cobbles to 3 inches in diameter; water	36	276
Gravel, cemented, and hardpan	36	312
Clay, brown, and gravel	8	320
Gravel; water	6	326
Hard formation	4	330
Clay, brown, and gravel	6	336
Gravel; water	4	340
Tight formation	8	348
Clay, brown, soft, and gravel	20	368
Clay, brown, soft	12	380
Gravel, 1/4 to 2 inches in diameter; water	28	408
Clay, brown, and gravel	8	416
Hardpan	4	420
Clay, brown, and gravel	4	424
Clay, brown, and some gravel	2	426

TABLE 9. Drillers' Logs of Selected Wells (continued)

(C-1-2)21adb-1, continued

	Thickness	Depth
Clay, brown, and gravel	2	428
Clay and gravel	32	460
Gravel, loose	4	464
Gravel, loose, and some clay	11	475
Gravel and boulders in clay	5	480
Sand and gravel	36	516
Clay, brown, hard, with some fine gravel	2	518
Clay, brown, and coarse gravel	2	520
Solid lime	4	524

(C-3-1)9ccc-1. Log by J. S. Lee and Sons
Altitude 4,593 ft.

Topsoil	3	3
Sand	7	10
Gravel	45	55
Clay	45	100
Gravel	90	190
Sand and gravel; water	28	218
Clay	4	222
Gravel	12	234
Sand, fine	6	240
Gravel	13	253
Gravel, fine	15	268
Clay, sandy	8	276
Sand and gravel	19	295
Clay	5	300
Gravel	20	320
Conglomerate	118	438
Clay, sticky	34	472

(C-3-1)30aba-1. Log by Roscoe Moss Drilling Co.
Altitude 4,683 ft.

Topsoil	12	12
Gravel	2	14
Clay, yellow	23	37
Gravel and cobbles to 8 inches in diameter	23	60
Clay, yellow, and gravel conglomerate	49	109
Sand, gravel, and cobbles to 8 inches in diameter, tight	17	126
Clay and very coarse gravel	40	166
Clay, yellow	9	175
Clay and very coarse gravel	21	196
Clay, yellow	16	212
Sand and gravel	6	218
Clay, yellow	45	263
Conglomerate	3	266
Clay, yellow, tough	59	325
Clay and gravel	3	328
Clay, yellow	62	390
Sand and medium gravel, tight	6	396
Clay and gravel	6	402
Clay, yellow	298	700

(C-3-1)32cdc-1. Log by Robinson Drilling Co.
Altitude 4,612 ft.

	Thickness	Depth
Clay	11	11
Sand and clay	29	40
Clay, sandy	25	65
Clay	5	70
Gravel	5	75
Clay	45	120
Gravel and clay; water at 168 feet	48	168
Sand	12	180
Gravel	20	200
Gravel and clay	15	215
Sand and gravel	5	220
Sand	22	242
Clay and sand	13	255
Gravel	30	285
Clay	10	295
Gravel	15	310
Gravel and clay	40	350
Gravel	5	355
Gravel and clay	50	405
Clay and sand	67	472
Sand, white, hard, and clay	8	480
Sand, fine; water	8	488
Clay and sand	37	525
Gravel and clay	25	550
Sand and clay	35	585
Sand	5	590
Clay	10	600
Clay, sandy	30	630
Clay	12	642
Gravel	3	645
Clay and sand	25	670

(C-3-2)34daa-1. Log by Robinson Drilling Co.
Altitude 5,020 ft.

Soil	2	2
Gravel, very coarse, and boulders	8	10
Conglomerate	180	190
Gravel; water at 190 feet	110	300
Clay	2	302
Gravel	28	330
Gravel with hard shell	22	352
Gravel with streaks of clay	23	375
Gravel	10	385
Clay and gravel	30	415
Gravel	5	420
Gravel and clay	15	435
Gravel	10	445
Gravel and clay	5	450
Gravel	25	475
Gravel with hard zones	8	483
Conglomerate	15	498
Clay, brown	27	525
Clay, sandy	10	535
Clay, brown	5	540
Conglomerate	5	545
Bentonite	11	556
Clay, brown, sandy	9	565

TABLE 9. Drillers' Logs of Selected Wells (continued)

(C-3-2)34daa-1, continued

	Thickness	Depth
Clay, green, sandy	10	575
Clay, green	11	586
Clay, sandy	8	594
Clay, greenish brown	6	600
Clay, grey	10	610
Clay, brown, sandy	5	615

(C-4-1)2ddb-1. Log by J. S. Lee and Sons.

Altitude 4,430 ft.

Soil	3	3
Clay, blue	79	82
Sand and hardpan	37	119
Hardpan, grey	16	135
Conglomerate	65	200
Clay, grey	5	205
Conglomerate and gravel	43	248
Conglomerate	61	309
Gravel	31	340
Sand and gravel	87	427
Gravel and clay	36	463
Clay, gumbo	40	503
Clay, sticky	49	552
Sand and clay	30	582
Clay, sticky	21	603
Gravel and clay	62	665
Clay, sticky	42	707
Clay and gravel	15	722
Bedrock	103	825

(C-4-1)6acb-1. Log by J. S. Lee and Sons.

Altitude 4,715 ft.

Clay and boulders	130	130
Clay	17	147
Gravel and clay	13	160
Clay	40	200
Gravel	35	235
Clay	7	242
Clay and rocks	34	276
Clay, sandy	10	286
Lava and clay	40	326
Clay	75	401
Lava and gravel	15	416
Clay	5	421
Lava	16	437
Lava and sand	14	451
Gravel	10	461
Clay, sandy	17	478
Lava	3	481
Clay, sandy	60	541
Gravel, very coarse	10	551
Lava, sandy	10	561
Lava with gravel cap	16	577

(C-4-1)23dbb1-. Log by Robinson Drilling Co.

Altitude 4,495 ft.

	Thickness	Depth
Gravel	91	91
Clay, blue and gravel	3	94
Gravel	16	110
Clay, blue	7	117
Gravel	7	124
Clay, blue and gravel	8	132
Clay, blue, sandy	22	154
Clay, brown and gravel	22	176
Gravel	3	179
Clay, brown	22	201
Gravel and clay	2	203
Clay, brown	42	245
Clay, brown and some gravel	17	262

(D-2-1)16bba-2. Log by Roscoe Moss Drilling Co.

Altitude 4,350 ft.

Topsoil	4	4
Sand, gravel, and cobbles to 3 inches in diameter	24	28
Clay, sand, and coarse gravel	15	43
Clay, blue with some gravel and boulders	17	60
Gravel	28	88
Gravel and some cobbles to 5 inches in diameter	17	105
Clay, yellow	33	138
Clay, blue	50	188
Sand, gravel and small boulders	58	246
Clay and boulders	12	258
Sand and very coarse gravel	52	310
Clay, grey	24	334
Clay and gravel	26	360
Sand, gravel and cobbles to 5 inches in diameter	40	400
Clay, blue	86	486
Sand and very coarse gravel	18	504
Clay, yellow	6	510
Sand and very coarse gravel	24	534
Sand, gravel, and cobbles to 3 inches in diameter	12	546
Clay, yellow	4	550
Sand, gravel, and cobbles to 6 inches in diameter	10	560
Clay, yellow	4	564
Sand, gravel and tight clay	26	590
Clay, yellow and some gravel	20	610

TABLE 9. Drillers' Logs of Selected Wells (continued)

(D-3-1)18cba-1. Log by Robinson Drilling Co.
Altitude 4,413 ft.

	Thickness	Depth
Soil	2	2
Clay, blue, sandy, soft	16	18
Clay, firm	4	22
Clay, sandy	2	24
Clay, sandy, soft	19	43
Clay	5	48
Clay, sandy	12	60
Clay, blue	24	84
Sand	22	106
Sand, and granite boulders	19	125
Sand, clay, and gravel	15	140
Sand	32	172
Clay, yellow	16	188
Sand, coarse and gravel	12	200
Sand, coarse and fine gravel	18	218
Clay, yellow	4	222
Sand and gravel	26	248
Clay, yellow	2	250
Sand and gravel with clay streaks	35	285
Gravel	20	305
Sand and gravel	17	322
Clay, yellow	8	330
Gravel	6	336
Clay	6	342
Gravel	10	352
Clay	2	354
Gravel	16	370
Gravel, coarse, cemented	103	473
Clay, yellow	2	475
Clay, yellow and gravel	70	545
Gravel, cemented	35	580
Clay, yellow	5	585
Gravel, cemented	18	603
Clay, grey	7	610
Clay, yellow with some gravel	20	630
Gravel, cemented	10	640
Clay, yellow with some gravel	70	710
Clay, yellow and gravel	42	752
Gravel, cemented	15	767
Clay	8	775
Clay and gravel	5	780
Clay, yellow and gravel	24	804
Gravel, cemented	6	810
Clay, yellow and gravel	40	850
Clay, yellow and small boulders	10	860
Gravel, cemented	8	868
Clay and gravel	2	870
Clay, yellow and gravel	30	900
Clay, yellow and grey, and gravel	41	941
Gravel, cemented	17	958
Clay, yellow	2	960
Clay, yellow and gravel	18	978
Gravel, cemented	5	983
Clay and gravel	7	990
Clay with some gravel	22	1,012
Gravel, cemented	8	1,020
Clay, yellow	5	1,025
Gravel, cemented	5	1,030
Clay, yellow	15	1,045
Clay, yellow and gravel	13	1,058
Gravel, cemented	10	1,068
Clay, yellow	2	1,070
Clay, yellow and gravel, mixed	65	1,135
Gravel, cemented	15	1,150

(D-3-1)22bcb-1. Log by Robinson Drilling Co.
Altitude 4,760 ft.

	Thickness	Depth
Topsoil	5	5
Sand and coarse gravel	50	55
Clay, grey, sandy	15	70
Sand, fine	24	94
Gravel, coarse; water	29	123
Clay, blue	11	134
Sand, fine	64	198
Clay, grey, sandy	6	204
Sand and fine gravel	11	215
Sand; dry	23	238
Sand, coarse; dry	3	241
Sand and granite boulders	9	250
Clay, grey with rock	10	260
Sand and granite boulders	15	275
Sand, fine; dry	30	305
Gravel, fine, and clay	30	335
Sand, fine gravel, and boulders	15	350
Clay	14	364
Sand, fine	1	365
Sand, fine and some clay	17	382
Sand and granite boulders	41	423
Conglomerate and ground rock	8	431
Conglomerate, brown, hard	51	482
Granite sand and boulders	5	487
Conglomerate with hard and soft zones	20	507
Sand, fine, and clay	5	512
Conglomerate, brown	8	520
Sand, fine	7	527
Sand, coarse	3	530
Conglomerate	10	540
Sand, fine	38	578
Clay, grey	22	600
Clay with fine sand	10	610
Sand, fine	38	648
Clay, sandy	7	655
Conglomerate	8	663
Clay with fine sand	4	667

SELECTED PUBLICATIONS

WATER-RESOURCES BULLETINS

1 -	WATER PRODUCTION FROM OIL WELLS OF THE UINTA BASIN, UINTAH AND DUCHESNE COUNTIES, UTAH, by Harry D. Goode and Richard D. Feltis	$1.00
2 -	GROUND-WATER CONDITIONS IN THE SOUTHERN AND CENTRAL PARTS OF THE EAST SHORE AREA, UTAH, 1953-1961, by Ralph E. Smith and Joseph S. Gates	$1.75
3 -	DISSOLVED MINERAL INFLOW TO GREAT SALT LAKE AND CHEMICAL CHARACTERISTICS OF THE SALT LAKE BRINE. Part I: Selected Hydrologic Data, by D. C. Hahl and C. G. Mitchell	$1.75
	Part II: Technical Report, by D. C. Hahl and R. H. Langford	$1.25
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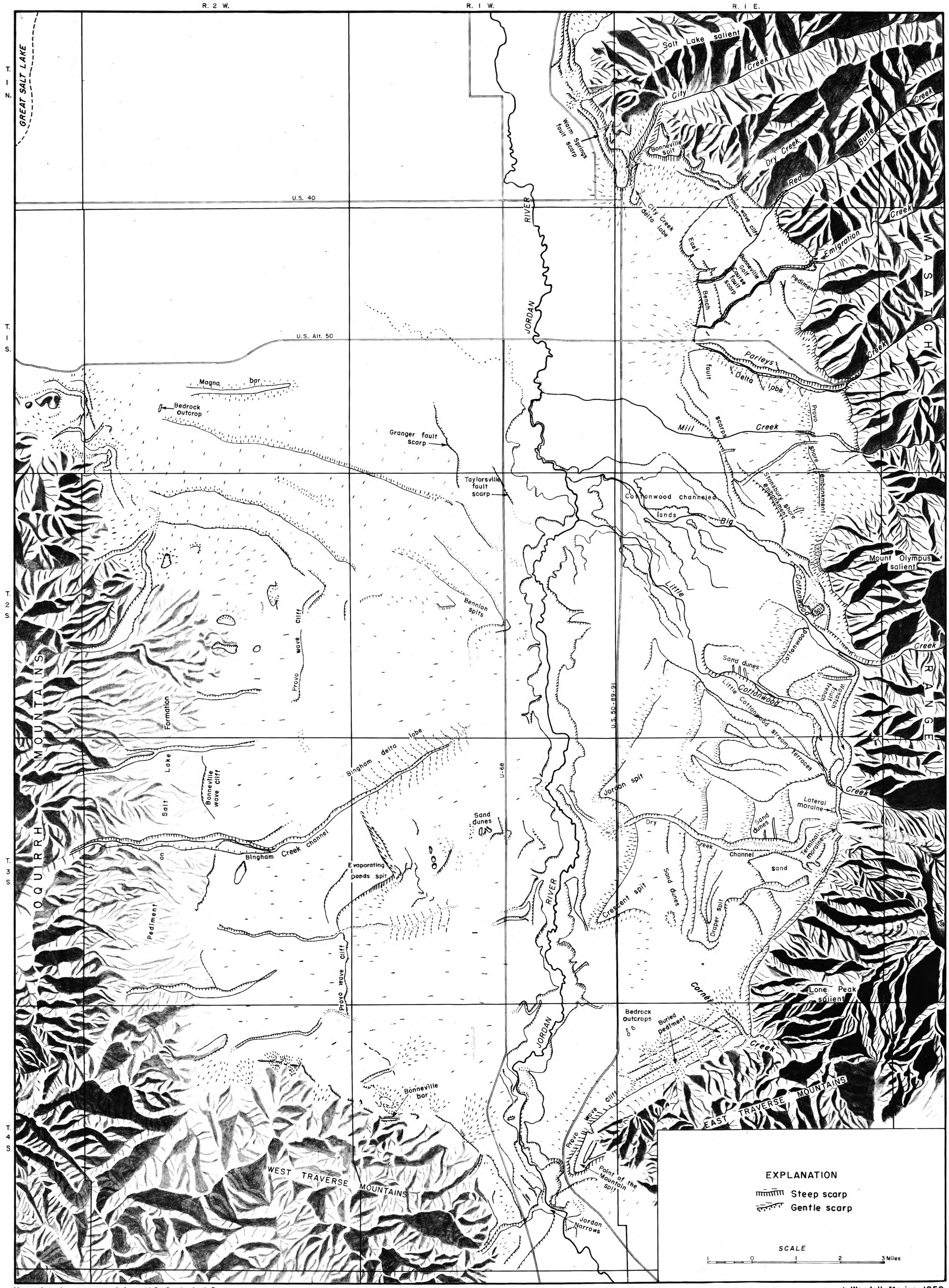
9 -	ALTERATION AREA SOUTH OF THE HORN SILVER MINE BEAVER COUNTY, UTAH , by Bronson Stringham	(In publication)

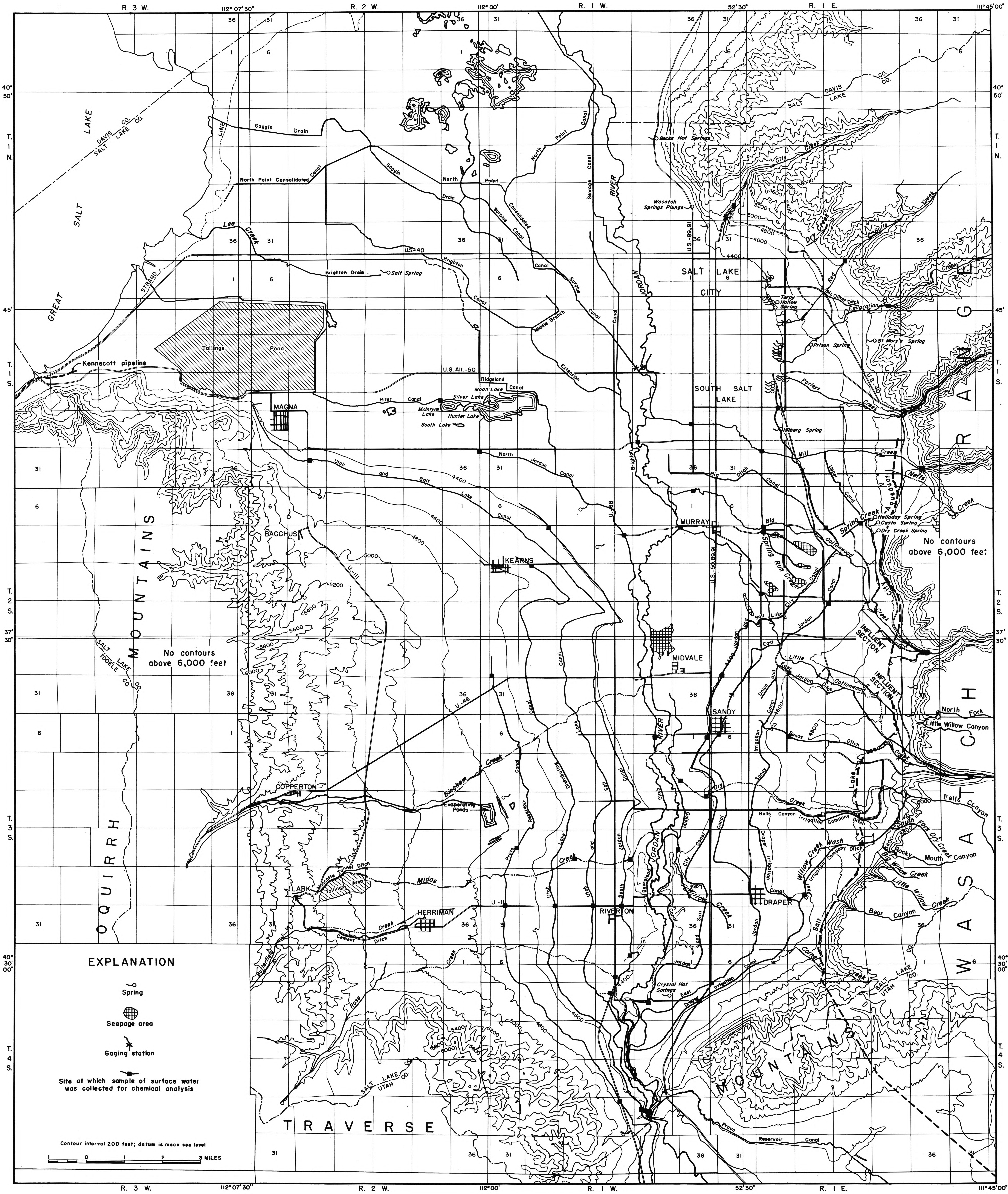
A Complete List of Publications is Available on Request



Mapped on base prepared from U.S. Geological Survey topographic maps

I. Wendell Marine, 1959

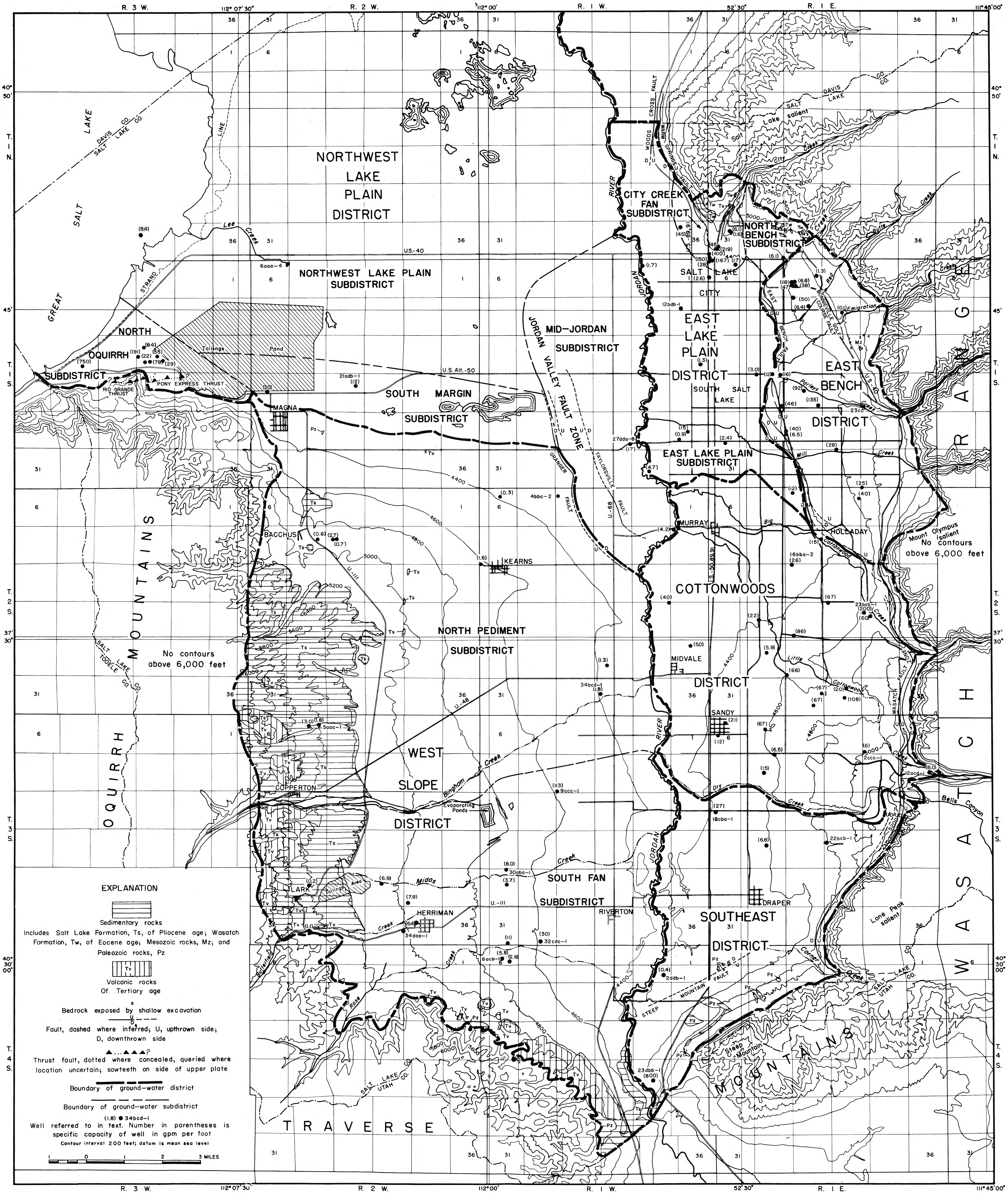
Figure 3. — Physiographic map of the Jordan Valley, Utah



Base map prepared from U.S. Geological Survey topographic maps.

Compiled by I. W. Marine, 1959

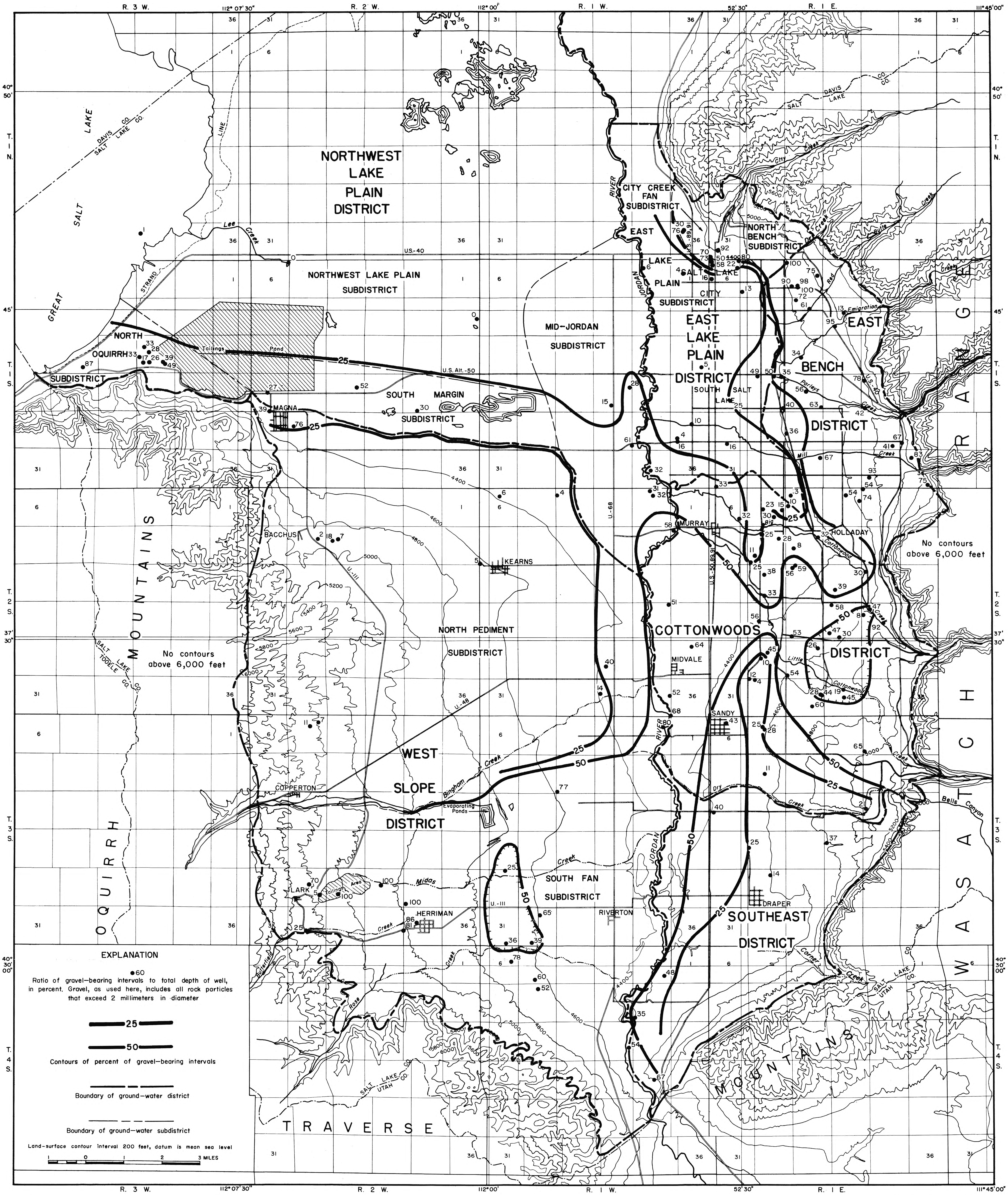
Figure 6.— Map showing hydrography of the Jordan Valley, Utah



Base map prepared from U. S. Geological Survey topographic maps.

Compiled by I. W. Marine, 1959

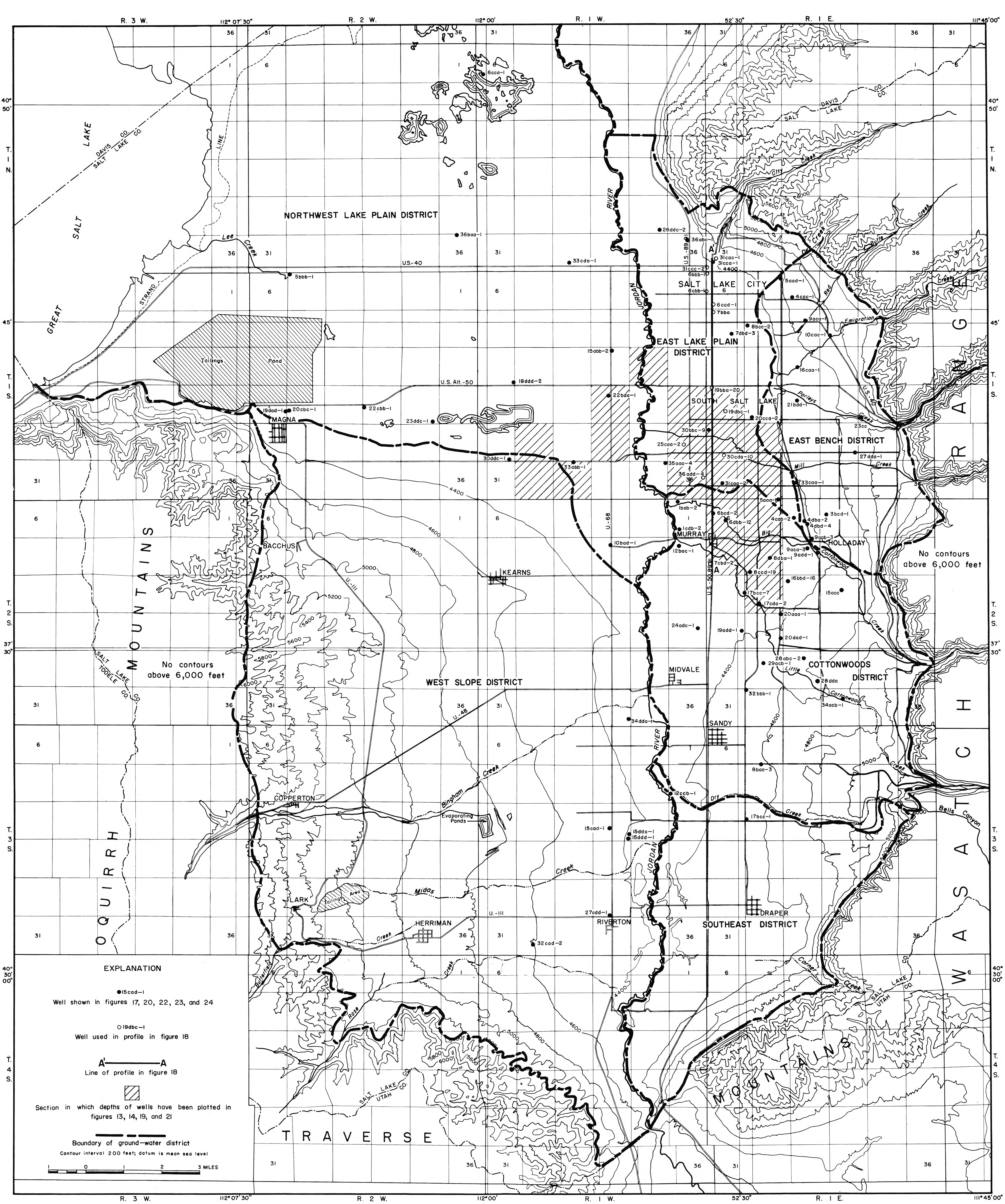
Figure 11.—Map of the Jordan Valley, Utah, showing selected sedimentary and volcanic rocks, districts and subdistricts, selected well locations, and specific capacities of selected wells. (Geology above 5,200 feet in West Slope district after L. W. Slentz, written communication.)



Base map prepared from U. S. Geological Survey topographic maps.

Compiled by I. W. Marine, 1959

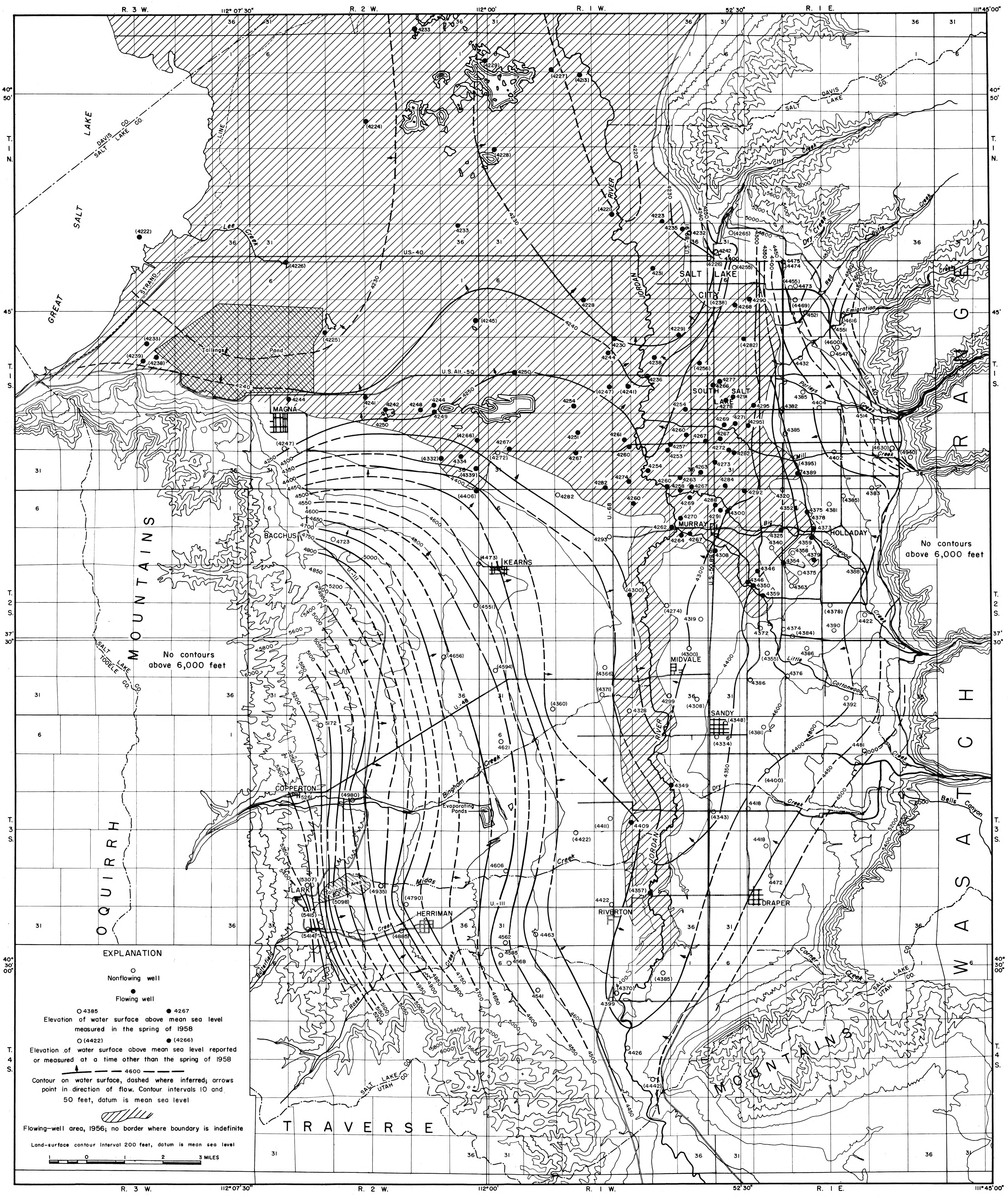
Figure 12.—Map of the Jordan Valley, Utah, showing ratio of gravel-bearing intervals to total depth of wells, in percent.



Base map prepared from U. S. Geological Survey topographic maps.

Compiled by I. W. Marine, 1959

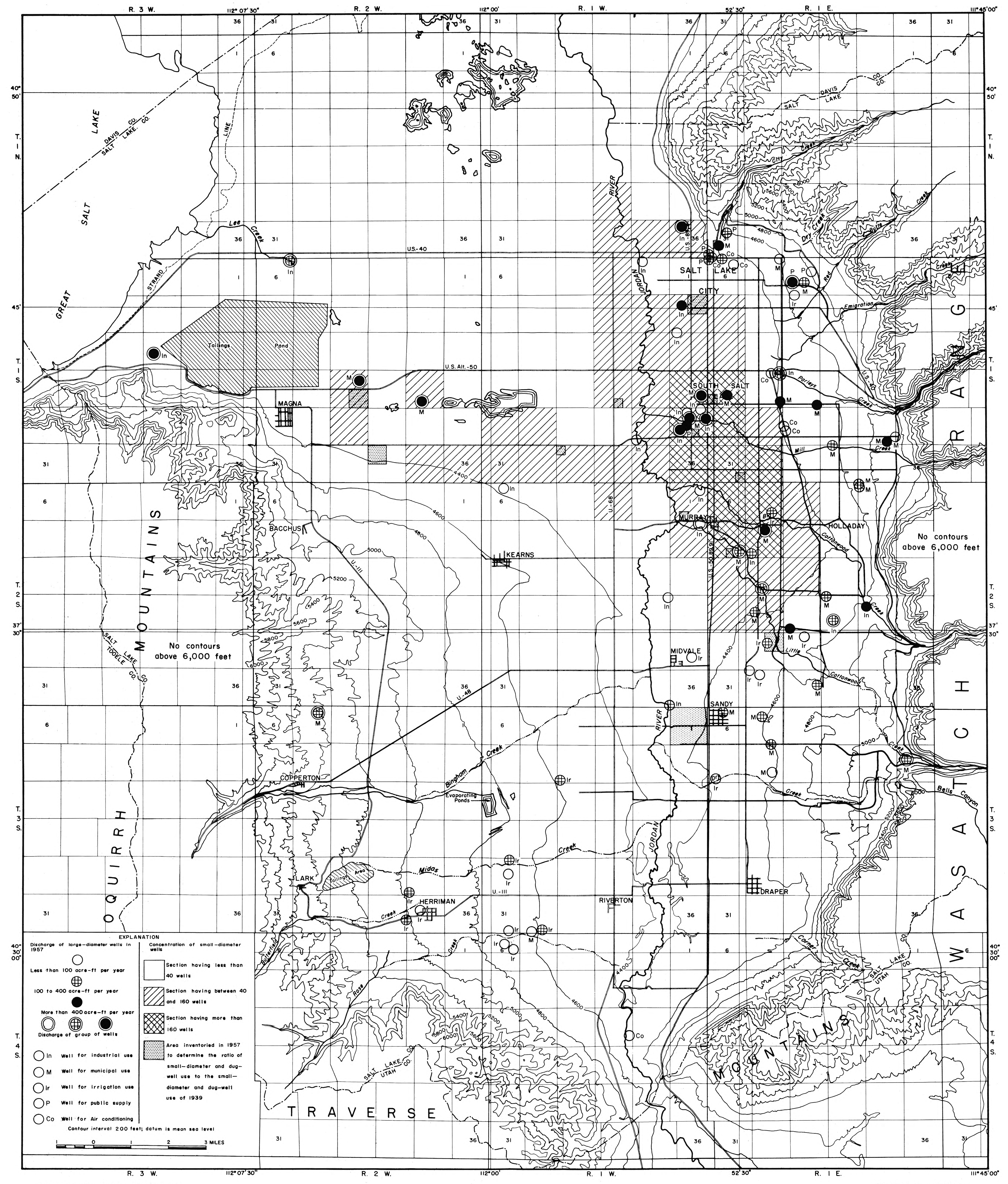
Figure 15.—Map of the Jordan Valley, Utah, showing the line of profile in figure 18; location of wells whose hydrographs are shown in figures 17, 20, 22, 23, and 24; and sections in which depths of wells have been plotted in figures 13, 14, 19, and 21.



Base map prepared from U. S. Geological Survey topographic maps.

Compiled by I. W. Marine

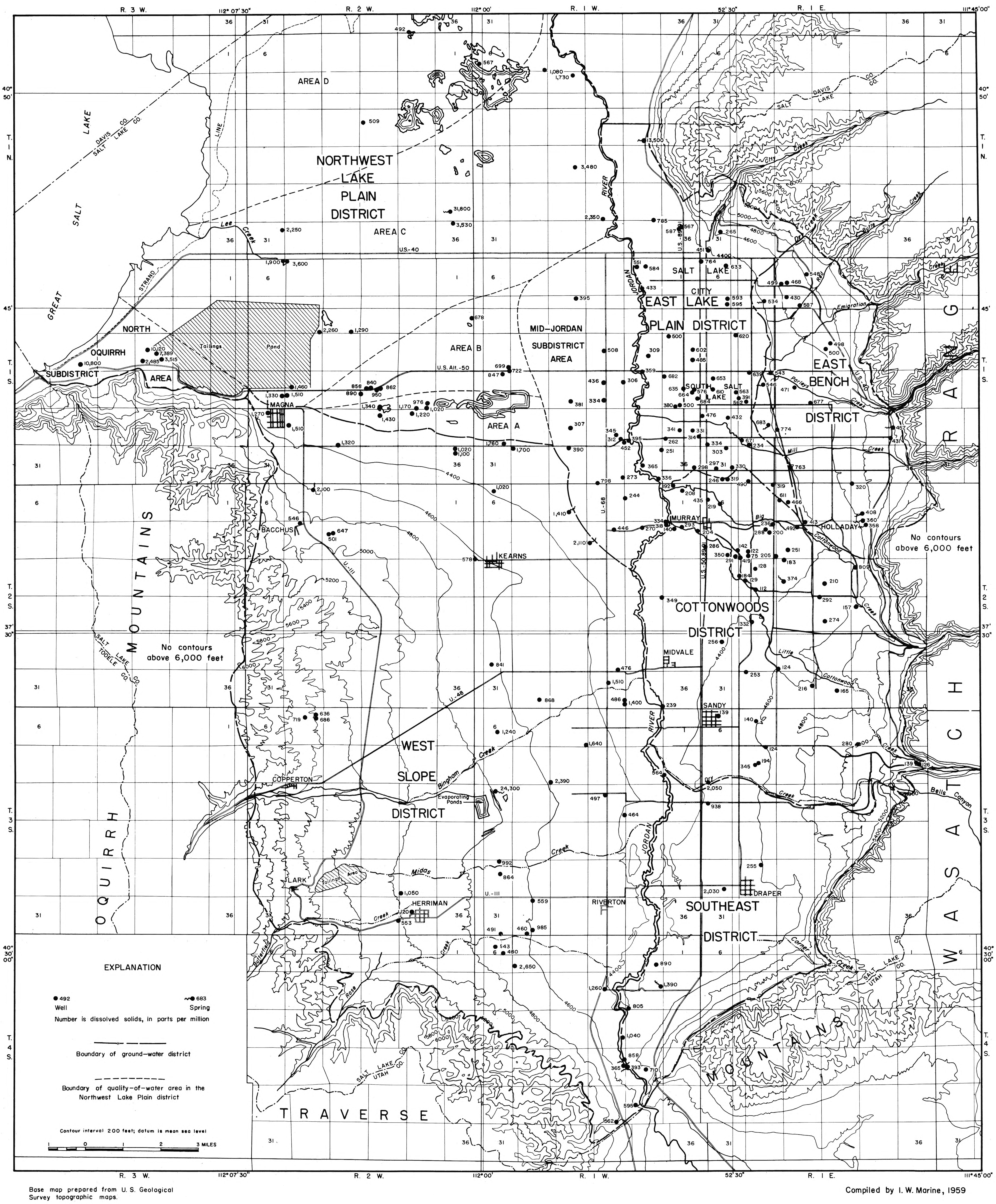
Figure 16.—Map of the Jordan Valley, Utah, showing the generalized piezometric surface in the spring of 1958 and the area of flowing wells in 1956.



Base map prepared from U. S. Geological Survey topographic maps.

Compiled by I. W. Marine

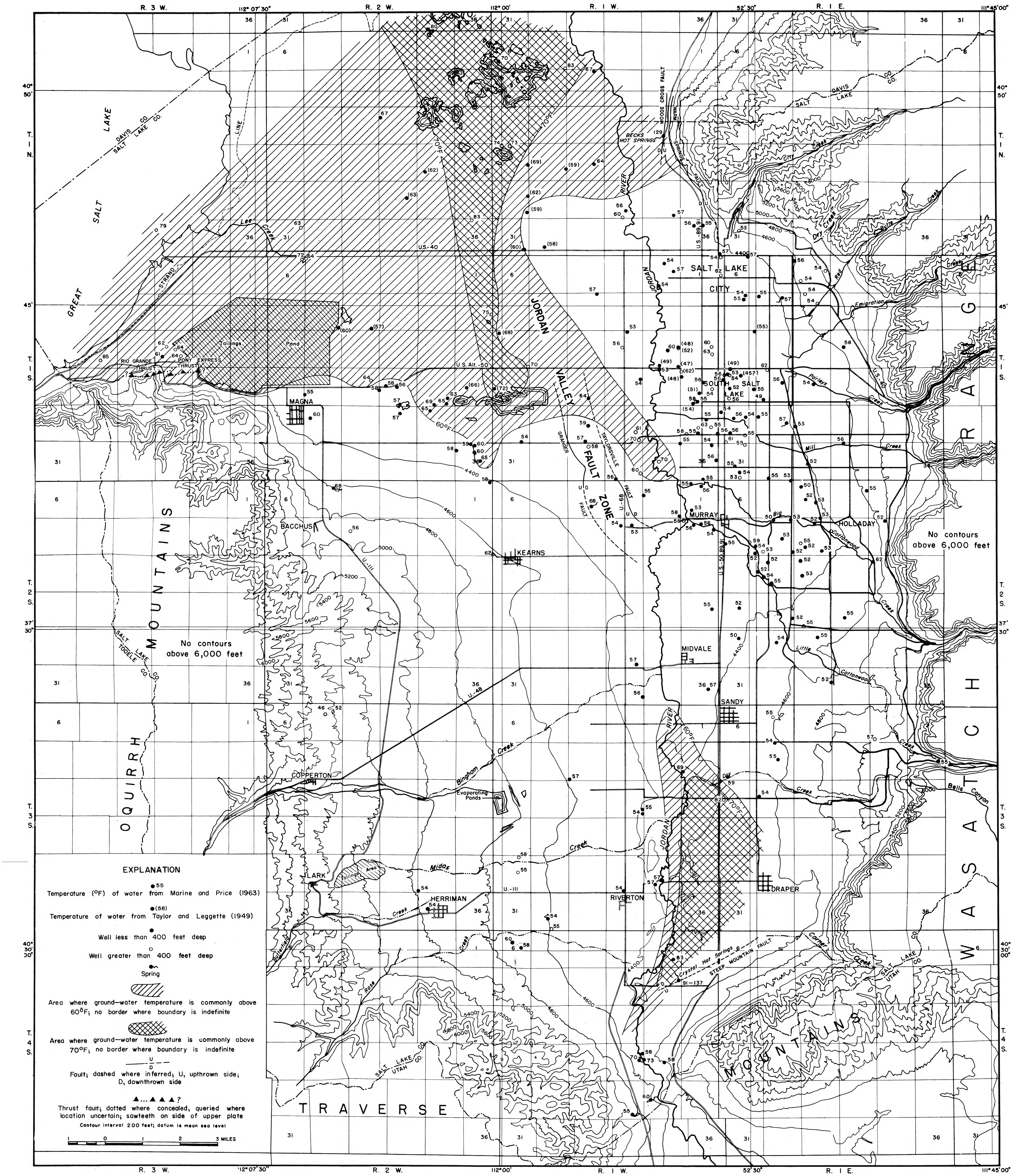
Figure 26.—Map of the Jordan Valley, Utah, showing discharge of large-diameter wells in 1957, concentration of small-diameter wells by sections, and areas in which small-diameter wells were inventoried in 1957.



Base map prepared from U. S. Geological Survey topographic maps.

Compiled by I. W. Marine, 1959

Figure 27.—Map of the Jordan Valley, Utah, showing dissolved solids in ground water, in parts per million.



Base map prepared from U. S. Geological Survey topographic maps

Compiled by I. W. Marine, 1959

Figure 30.—Map showing selected faults and temperatures of ground water in the Jordan Valley, Utah.

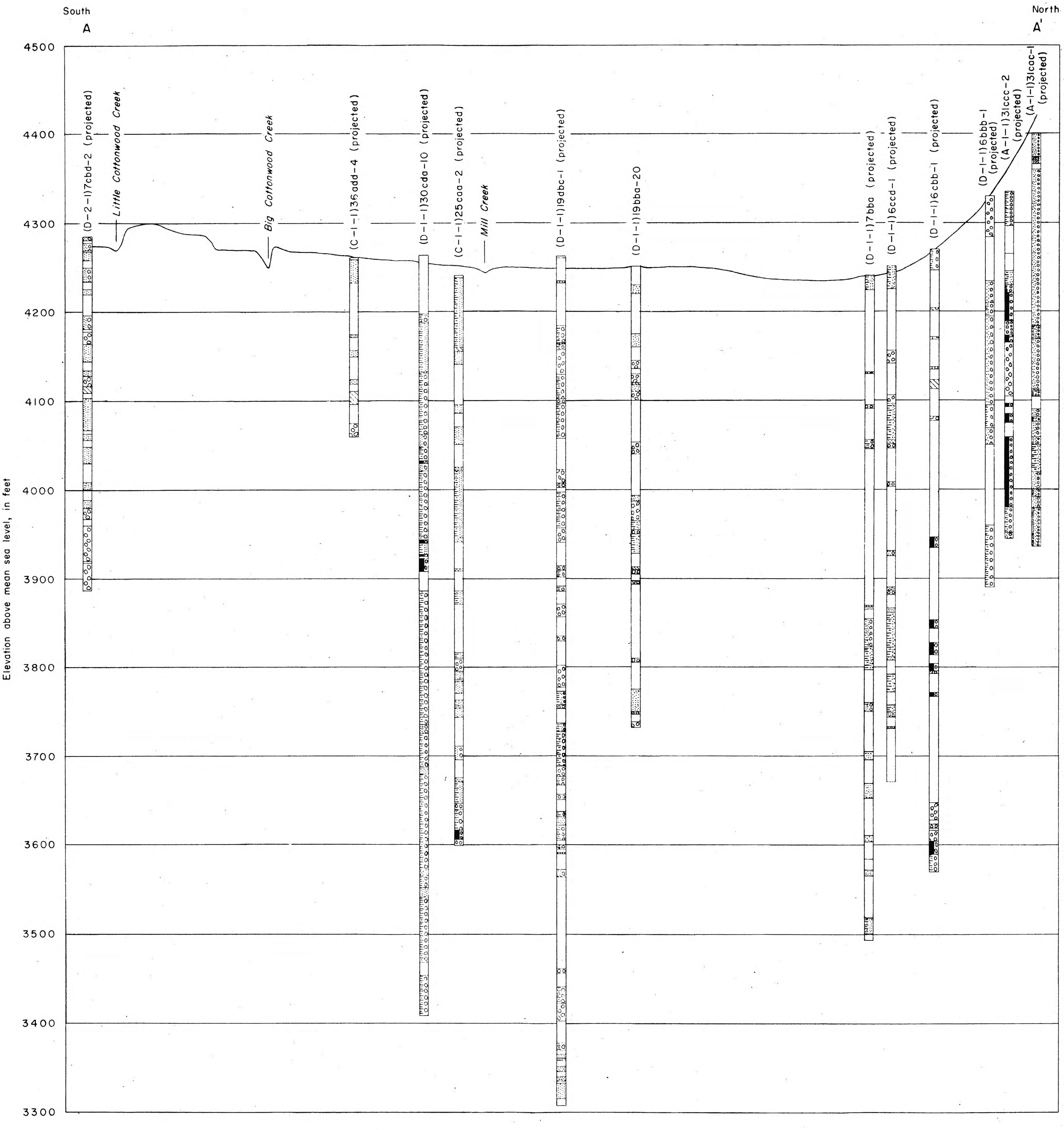


Figure 18.—Graphic logs of wells near State Street, Jordan Valley, projected to a profile along State Street. (Line of profile and well locations shown in figure 15.)

TABLE 1

GENERALIZED SECTION OF THE PRE-QUATERNARY GEOLOGIC UNITS OF THE WASATCH RANGE EAST OF THE JORDAN VALLEY

(Adapted from Granger and others, 1952, and M.D. Crittenden, Jr., oral communication)

Sedimentary and extrusive rocks

Era	System	Series	Stratigraphic unit	Thickness (feet)	Description
Cenozoic	Tertiary	Eocene	Wasatch Formation Knight equivalent	several thousand	Conglomerate, probably derived from reworking of older Tertiary conglomerates.
			unconformity		
			Andesite	-	Red-weathering andesitic flows and breccias.
			unconformity		
			Fowkes(?) equivalent	800	Poorly consolidated red sandstone, sandy limestone and water-laid tuff with some interbedded pale gray limestone.
			Almy(?) equivalent	1,000	Conglomerate with abundant boulders of Precambrian quartzite, Tintic Quartzite, and limestone.
			unconformity		
Mesozoic	Cretaceous	Upper	Wanship(?) Formation of Williams (Eardley, 1952, p. 53)		Conglomerate with boulders of Frontier Formation, Weber Quartzite, and Carboniferous limestone.
			unconformity		
			Frontier Formation	8,000	Pale yellowish-brown sandstone interbedded with yellow or pale-red tuffaceous clay and a few conglomerate beds.
		Lower	Kelvin Formation	1,500	Pale reddish-brown to purple siltstone, with smaller amounts of sandstone and conglomerate.
	Jurassic	Upper	Morrison(?) Formation	100	White algal limestone, some red sandstone and pebble conglomerate.
			Preuss Sandstone	1,000	Pale red shale and sandstone.
		Middle	Twin Creek Limestone	2,800	Pale gray limestone interbedded with greenish limy shale.
		Lower	Nugget Sandstone	800	Pale terra-cotta, strongly cross-bedded sandstone.
	Triassic	Upper Lower	Ankareh Shale	1,600	Brilliant red shale and sandstone with very little red to pale-gray limestone. A bed of white to purplish-red quartzite grit, 50-100 feet thick, divides the formation near the middle.
			Thaynes Limestone	1,000	Shale and massive fine-grained lime-sand rock; drab or greenish on fresh surface, but weathers to a tobacco brown. Also light gray limestone.
			Woodside Shale	1,000	Dark red shale and siltstone.
			unconformity		
Paleozoic	Permian		Park City Formation	600- 915	Limestone, limy shale, and sandstone.
			unconformity		
	Carboniferous Pennsylvanian		Weber Quartzite	1,200- 1,500	Pale gray, tawny-weathering, fine-grained quartzitic sandstone; interbedded limy and dolomitic quartzite and sandstone; and buff to blue-gray cherty limestone and dolomite.
		Lower	Round Valley Limestone	200- 350	Pale gray limestone with pink chert and minor amounts of greenish shale and quartzite.
	Mississippian	Upper	Doughnut Formation	400	Dark gray weathering, black limestone and limy shale.
			Humbug Formation	400- 725	Gray limestone interbedded with tawny sandstone.
			Deseret Limestone	500- 900	Dark gray cherty dolomite and dark gray limy shale.
		Lower	Gardison Limestone	450	Dark gray limestone.
			Fitchville Formation	150	Dark gray vuggy dolomite.
			unconformity		
			Pinyon Peak Limestone	460	Gray to blue limestone; tan to pink quartzite (on Salt Lake salient only).
	Devonian	Upper			
			unconformity		
	Cambrian	Middle	Maxfield Limestone	1,000	Gray oolitic limestone.
		Lower	Ophir Formation	400	Limy shale which weathers yellowish brown; blue-gray to whitish limestone; olive-green micaceous shale.
			Tintic Quartzite	800	White or pinkish, rust weathering quartzite.
			unconformity		
Precambrian			Mutual Formation	1,200	Medium-to coarse-grained red-purple quartzite and red and green shale.
			unconformity		
			Mineral Fork Tillite	3,000	Black tillite with boulders, cobbles, and pebbles of quartzite, limestone, and granite in a black sand matrix; black varved slate or shale; and dark gray quartzite.
			unconformity		
			Big Cottonwood Formation	16,000	Rusty-weathering white, pink, or green quartzite interbedded with brown green or blue-purple shale.
			unconformity		
			Little Willow Series	base not exposed	Gneissic quartzite, quartz-mica schist with basic igneous intrusions which are now altered amphibolite and chlorite schist. Perhaps equivalent to Farmington Canyon Complex of Eardley (1939) which crops out north of the Jordan Valley and consists of green shist, amphibolite, migmatite, granulite, and quartz schist.

Intrusive rocks

Probably Late Cretaceous or early Tertiary age	Little Cottonwood stock		Porphyritic quartz-monzonite.
	Clayton Peak stock		Diorite
	Alta stock		Granodiorite