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HYDROLOGIC RECONNAISSANCE OF HANSEL VALLEY AND NORTHERN ROZEL FLAT, BOX ELDER COUNTY, UTAH

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HYDROLOGIC RECONNAISSANCE OF HANSEL VALLEY AND NORTHERN ROZEL FLAT, BOX ELDER COUNTY, UTAH

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ABSTRACT

Hansel Valley and northern Rozel Flat are in northeastern Box Elder County and their drainage is directly tributary to Great Salt Lake. The study area extends from T. 9 N. to T. 15 N. and from R. 6 W. to R. 9 W. The hydrologic budget area, for the Hansel Valley drainage basin only, includes about 152,000 acres. The main ground-water reservoir is in unconsolidated and semiconsolidated rocks of Tertiary and Quaternary age. Water also is obtained from consolidated rocks of Paleozoic age.

The source of most water in the Hansel Valley drainage basin is precipitation, which is estimated to average 160,000 acre-feet annually. Of this amount, an estimated 2,500 acre-feet runs off in streams, all of which are intermittent. The total runoff is estimated to average 5,000 acre-feet annually and includes unconsumed spring discharge.

Average annual ground-water recharge and discharge are in balance and are estimated to be 11,000 acre-feet each; recharge derived from precipitation within the Hansel Valley drainage basin is estimated to average 8,000 acre-feet annually. Ground water is discharged from Hansel Valley by evapotranspiration (7,600 acre-ft), subsurface outflow (1,000 acre-ft), and unconsumed spring discharge (2,400 acre-ft) to streams. Well discharge in 1969 was insignificant.

The estimated perennial yield of ground water in Hansel Valley is negligible. Only about 13,000 acres in the northern part of the valley is underlain by ground water suitable for irrigation, and water for that purpose would have to be drawn from storage (mined). An estimated 65,000 acre-feet of water could be recovered by dewatering 100 feet of the reservoir in that part of the valley.

The chemical quality of water in Hansel Valley and northern Rozel Flat limits the potential development. The concentration of dissolved solids in water samples analyzed ranged from about 400 to 94,000 milligrams per liter. Fresh water is obtained from wells and springs in northern Hansel Valley and along the base of the North Promontory Mountains. In the rest of the study area, the ground water ranges from slightly saline to briny. All the water is very hard. Little of the water is suitable for public supply, all the water has a high-salinity hazard for irrigation, and about half the area yields ground water suitable for stock.

Agricultural use of water in Hansel Valley and northern Rozel Flat is mainly for stock. Most wells in the area have been drilled since 1910. The only irrigation is by supplemental use of one well and the application of saline spring water to saltgrass meadows. Future development probably will follow the pattern of the past. Some additional development can be made in the fresh-water area by the use of low-yield wells (about 1 cubic foot per second) with large pumping lifts. A detailed study of the area is not immediately needed.

INTRODUCTION

This report is the ninth in a series by the U.S. Geological Survey in cooperation with the Utah Department of Natural Resources, Division of Water Rights, which describes the water resources of the western basins of Utah (see fig. 1). Its purpose is to present available hydrologic data for Hansel Valley, to provide an evaluation of the potential water-resource development of the valley, and to identify needed studies that would improve understanding of the valley's water supply. Hydrologic data from the northern part of adjacent Rozel Flat were collected to aid in evaluation of southern Hansel Valley, and these data also are included in this report.

The investigation on which this report is based consisted largely of a study of available data for geology, streams, wells, springs, climate, and water use in Hansel Valley. These data were supplemented with field data on landforms, vegetation, geology, and water sources collected during a 7 man-day reconnaissance during October and November 1969. Basic data for the valley and adjacent northern Rozel Flat are presented in tables 3 and 6-9.

Hansel Valley is in northeastern Box Elder County, Utah. The valley as depicted on plate 1, extends from T. 10 S. to T. 15 N. and from R. 6 W. to R. 9 W. The area of the drainage basin above a land surface altitude of 4,200 feet is 152,000 acres (about 237 sq mi), the mouth of the valley opens onto Spring Bay of Great Salt Lake; the mean elevation of the bay in 1969 was about 4,195 feet. The part of Rozel Flat studied lies in parts of Tps. 9-11 N., Rs. 7-9 W. The area slopes west-southwestward to the east shore of Great Salt Lake.

The land in Hansel Valley is used for agricultural purposes. Most is used for grazing, but a substantial part is used for the dryland cultivation of small grains, mostly winter wheat. The dryland farms are mainly in the northern part of the valley and along the edges of the mountains where adequate tillable soils are to be found. One supplemental irrigation well and one test well have been drilled in the valley, but no land was under full-time irrigation in November 1969. The permanent population of the valley is small, consisting of perhaps two or three families. During the planting and harvest seasons, farm operators commute from nearby towns and communities.

The small amount of information that has been published concerning the water resources of the valley is in a report by Carpenter (1913, p. 55-58). The principal sources of basic data are the files of the Geological Survey and of the Utah State Engineer, who made a hydrographic survey of the valley in 1966-67. The hydrographic survey, together with files of claims of water use in the valley, provides a comprehensive listing of the water sources in the valley. Of these sources, a few springs and most of the wells were visited for this investigation. Related references to Lake Bonneville, Great Salt Lake, and the region are given in the selected references.

Descriptions of the geology of Hansel Valley and northern Rozel Flat, which provide data on the hydrogeologic framework of the water-resources system, include the geologic map of Utah (Stokes, 1964) which is the main source of the geology in figure 1. Heylmun (1965, p. 25-26) briefly described Tertiary rocks of the kind found in part of the area, and Slentz and Eardley (1956) described Tertiary sedimentary and igneous rocks that crop out a short distance south of the area.

See the appendix for a description of the system of numbering wells, springs, and other hydrologic-data sites and the use of metric units in this report.

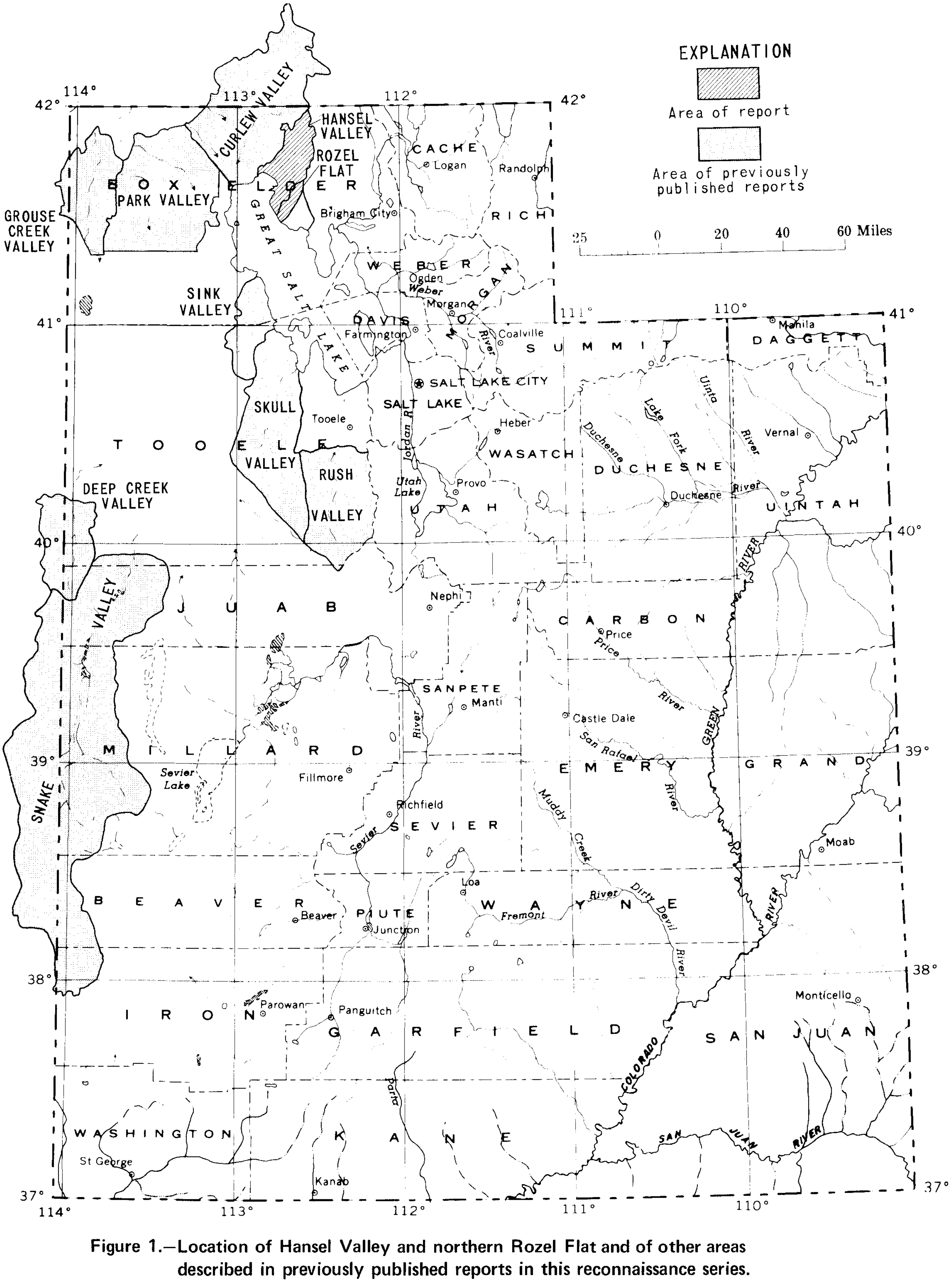

Figure 1.—Location of Hansel Valley and northern Rozel Flat and of other areas described in previously published reports in this reconnaissance series.

GENERAL HYDROLOGIC ENVIRONMENT

In the following discussion of the water-resources system in Hansel Valley, the interpretation of the system and the quantitative estimates are based not only on available specific hydrologic data, but also on consideration of the general effects of physiographic, geologic, vegetative, and climatic factors.

Physiography

Hansel Valley is near the edge of the northeastern part of the Great Basin section of the Basin and Range physiographic province (Fenneman, 1931, 1946). The valley is in the Great Salt Lake drainage basin and is directly tributary to the lake (pl. 1).

The total relief in the Hansel Valley drainage basin is about 2,900 feet. The mountains that bound the valley on the east and west have moderate to high relief. The highest point in the North Promontory Mountains is 7,114 feet above mean sea level; the highest point in the Hansel Mountains is 6,320 feet. The lowest altitudes in the valley are along the shore of Great Salt Lake, which in 1969 reached a maximum altitude of about 4,196 feet.

The North Promontory Mountains, from the vicinity of northern Rozel Flat to Highway I-80N (fig. 2), are a very steep, narrow cuesta-shaped ridge that overlooks a steep alluvial slope that is relatively broad in the south and very narrow in the north. The short spurs of the lower slopes in the mountains are nearly all faceted, and several areas of landslides are visible. One large and several smaller inliers of consolidated rocks rise above and interrupt the continuity of the alluvial slopes. The short, narrow canyons in the west side of the mountains have very small drainage areas and contain only ephemeral streams that have deeply incised the alluvial slope at the foot of the mountains.

The Hansel Mountains consist of a narrow line of inliers of consolidated rocks that rise from the shore of Great Salt Lake and are surrounded by alluvium-mantled slopes and terraces. The shape and drainage of the mountains is controlled by the structure of the consolidated rocks. Most of the streams that drain the Hansel Mountains are ephemeral and all are intermittent.

North of Highway I-80N, the two mountain areas merge into a series of parallel, north-trending ridges. Drainage from this area also appears to be ephemeral and is strongly controlled by geologic structure.

Salt Wells Flat is an extension of the bottom of Great Salt Lake that has been exposed by recession of the lake. It slopes uniformly from an altitude of about 4,250 feet down to the lake. The flat has been somewhat eroded by stream action, but its shape has been changed mainly by wind scour that has lowered its surface to the top of the ground-water capillary zone. The flat is bounded by low bluffs cut into both unconsolidated and consolidated rocks. From the vicinity of sec. 27, T. 12 N., R. 8 W., to about sec. 20, T. 12 N., R. 7 W., the flat is bounded by a bay-mouth bar which a county road traverses. A smaller flat north of this bar contains a small perennial pond and stores runoff from up the valley.

The framework of Hansel Valley and its present shape are due mainly to two causes: (1) basin- and range-type faulting that created nearly parallel mountain blocks with an intervening trough-shaped valley and (2) the erosion associated with Lake Bonneville. Blocks thrown up on either side of the valley form the adjacent mountains and the downthrown block now underlies the valley floor. Lake Bonneville inundated the valley and adjacent Rozel Flat and modified the land surface up to altitudes of 5,160 to 5,200 feet (Crittenden, 1963, fig. 3). In parts of the area that face Great Salt Lake, wave-cut terraces are strongly developed on consolidated rocks at several levels and numerous old shorelines mark some of the alluvial slopes. In sheltered parts of the area, bars and spits deposited in the lake link or extend from the inliers of consolidated rocks.

The principal effects of lake action on the shape of the area were to plane off substantial areas of older rocks and to cover the cut surfaces with a few tens of feet of alluvium. An example is the broad, high terrace area in central T. 12 N., R. 8 W. Elsewhere, as in T. 12 N., R. 7 W., numerous small outcrops of consolidated rocks are found near the crests of hillocks and on the faces of low terraces in what otherwise appears to be a broad alluvium-filled valley. A prominent example at Monument Point is shown in figure 2. The significance of these lake features on the water supply are discussed in the section on ground water.

Geology

Rocks ranging from Paleozoic to Holocene in age are exposed or have been penetrated by wells in Hansel Valley and northern Rozel Flat. The pre-Tertiary rocks are consolidated sedimentary and metasedimentary rocks of marine origin. The consolidated and semiconsolidated rocks of Tertiary age are igneous and sedimentary rocks that include some pyroclastic deposits. The rocks of Quaternary age are largely unconsolidated sedimentary deposits derived from erosion of the older rocks and deposited by streams and by Lake Bonneville. Plate 1 shows the distribution of the rock units and table 1 gives a generalized description of their character and water-bearing properties.

Hansel Valley is a structural depression that was created by the deformation of consolidated rocks of Tertiary and earlier age. The valley is a composite graben in which the older rocks beneath the valley dropped down along major faults that bound the east and west sides of the valley proper. The shapes of contours on the bottom of Spring Bay, the several small outcrops of consolidated rocks seen in the lowlands of the valley, the apparent direction of movement and quality of ground water, and the several faults at the north end of the valley together suggest that the downthrown block consists of several nearly parallel blocks separated by faults of unknown, but probably small throw. It is probable that some cross faulting is present beneath the valley in the same manner as in the adjacent North Promontory Mountains.

Vegetation

The distribution of vegetation in the area of this reconnaissance was studied both because phreatophytic vegetation is direct evidence of ground-water discharge and because the general distribution is useful in confirming the general availability of water as indicated by available climatic, streamflow, and other data.

In Hansel Valley, data on vegetation was obtained both from a map (Foster, 1968) showing the distribution of major plant communities and from field observation. The significant native plants in the drainage basin include juniper (probably *Juniperus Utahensis*), sagebrush *(Artemisia tridentata),* shadscale (*Atriplex confertifolia*), range grasses, desert saltgrass (*Distichlis stricta*), greasewood (*Sarcobatus vermiculatus*), and pickleweed (*Allenrolfea occidentalis*). The latter three plants, together with an observed non-native invader, saltcedar (*Tamarix gallica*) are phreatophytes. Clearing of large parts of the native cover has changed the botanical regimen in parts of Hansel Valley and its adjacent uplands.

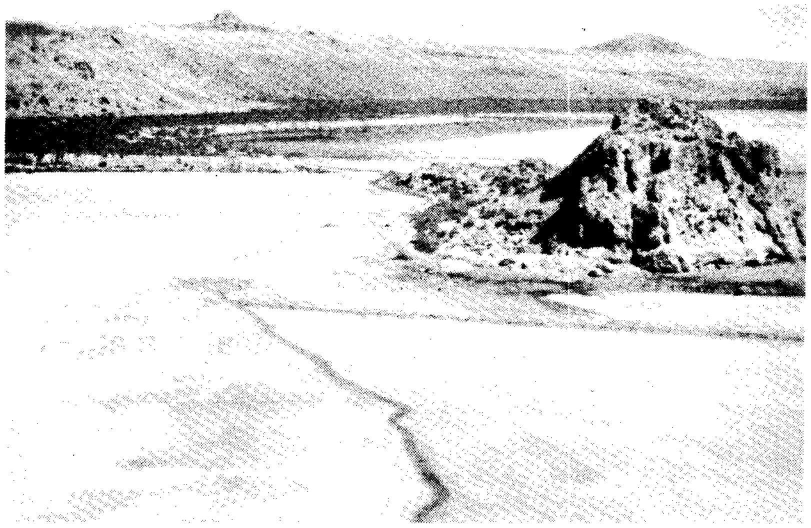

Figure 2.—Saline spring area at Monument Point, in northeast ¼ sec. 10, T. 11 N., R. 9 W., at the west side of Hansel Valley. Pothole springs and seep areas rise in lake-bottom silt around the outcrop of consolidated rock. The consolidated rock of the outcrop in the bluff in the middle ground and in the hills in the background (to north-northeast) is part of the Oquirrh Formation of Pennsylvanian and Permian age. The rock is badly shattered, and near lake level it has been eroded by solution and wave action. Note the dark band of phreatophytic vegetation between the saltflat and the bluff. (Photograph by D.C. Hahl.)

Juniper mainly crowns the hills and mountains where consolidated rocks crop out and soils are thin and well drained. The lack of coniferous vegetation confirms that precipitation even in the mountains is only moderate. In the North Promontory Mountains, vegetation is densest on the north-facing, shaded slopes of canyons and gullies, which shows the precarious balance between available moisture and vegetative cover.

Below the juniper zone, sagebrush is the dominant species. It intermingles with juniper in places; but it is densest where soils are fairly thick, receive the most precipitation, and are low in salinity, as along the flanks of the northern Hansel Mountains. In this area also, xerophytic

Table 1.—Age, character, and water-bearing properties of major lithologic units in Hansel Valley and northern Rozel Flat

Age			Geologic unit	Character of material	Water-bearing properties
CENOZOIC	Quaternary	Pleistocene and Holocene	Alluvium, colluvium, and alluvial surfaces	Surficial deposits of clay, silt, sand, and gravel on steep slopes below outcrops of consolidated rock. Near mountains these deposits generally have appearance of being coarse grained and in east-central T. 13 N., R. 7 W. appear to be very fine grained, but in most areas the deposits are a mixture of both fine and coarse material. Includes alluvial apron along bases of Hansel and North Promontory Mountains, landslide deposits at base of North Promontory Mountains, and alluvium in mountain valleys. In parts of Hansel Valley, the deposits include a soil zone and probably are less than 10 feet thick. Maximum thickness probably is about 100 feet; but in most of the valley, the thickness is probably less than 50 feet. The deposits lie upon both older unconsolidated rocks and consolidated rocks.	Low to high permeability. As a whole, these deposits are not water bearing; but in mountain valleys and on steep slopes at edges of mountains, they act as intake area for ground-water recharge from runoff. In northern Hansel Mountains and adjacent to North Promontory Mountains at southeastern side of Hansel Valley, the deposits locally contain ground water that is partly discharged through springs and evapotranspiration.
		Pleistocene	Near-shore lake deposits	Chiefly deposits of gravel and sand in terraces, spits, and bars and probably are less than 50 feet thick. Most of these deposits lie adjacent to outcrops of consolidated rocks and extend from or link such outcrops in both the mountains and the valley. May overlie both consolidated and unconsolidated rocks.	Moderate to high permeability. These deposits are not known to include aquifers, but locally they act as intake area for recharge from precipitation and runoff.
			Lake-bottom deposits	Chiefly clay, but include silt and fine sand, and near boundaries of outcrops include reworked gravel; maximum thickness probably is less than 100 feet in most of Hansel Valley and northern Rozel Flat. Underlies most of area below 4,600 feet in Hansel Valley and 4,800 feet in northern Rozel Flat. Underlies small areas behind bars as high as about 5,200 feet.	Low permeability; not water bearing in much of the area; inhibits recharge. Part of the precipitation that falls on these deposits is retained as soil moisture and part is locally ponded and evaporates; the rest runs off to Salt Wells Flat and to Great Salt Lake. These deposits are water bearing in Salt Wells Flat and along Great Salt Lake shore, where they are saturated with saline to briny water. In these areas, the fine-grained deposits cause a capillary rise to near land surface and water is discharged from them by evapotranspiration. The area designated as Qm on plate 1 is saturated at the land surface during part of the year.
	Tertiary and Quaternary	Late(?) Pliocene(?) and Pleistocene	Older alluvial deposits	Conglomeratic deposits of sand and gravel and intercalated beds of clay (not shown on pl. 1) of varying thickness, which underlie surficial alluvium and lake deposits. These conglomeratic deposits are unconsolidated to well consolidated with calcium carbonate and may include some pyroclastic rocks. In northern Hansel Valley the deposits contain intercalated basalt flows; the owner reports that well (B-14-6)31baa-1 taps "the usual sand, etc." beneath lava rock. Probably is somewhat deformed by tectonic movement; small outcrop seen in streambank in southern sec. 34, T. 13 N., R. 7 W., shows some tilting of beds. Thickness may locally exceed 450 feet in Hansel Valley and 300 feet in northern Rozel Flat.	Low to moderate permeability; probably functions together with the Salt Lake Formation as the principal ground-water reservoir in northern Hansel Valley, and part of the ground-water reservoir in southern Hansel Valley and northern Rozel Flat. Three irrigation test wells in the study area yielded 400-900 gallons per minute, but specific capacities for two of the wells ranged between 1 and 6 gpm per foot of drawdown. Ground water from wells that probably are finished in these deposits ranges in chemical quality from fresh in northern Hansel Valley to moderately saline in northern Rozel Flat.
	Tertiary	Pliocene(?)	Basalt and basaltic andesite flows	Appear to be more than one kind of extrusive igneous rock in study area as a whole, and the rocks may be of more than one age within Tertiary (and Holocene?). In northern Hansel Valley structurally deformed rocks weather to a dark brown; a few outcrops appear fresher and darker in color. Black, vesicular basalt that is badly eroded by wave action near the Great Salt Lake shore was seen in the northeastern part of T. 9 N., R. 9 W. Basalt of same age designation intercalated with Salt Lake Formation (Slentz and Eardley, 1956). Rocks in both areas contain numerous joints and fractures. Logs from several wells in the vicinity of Rozel Flat and well (B-13-7)2ccc-1 indicate the basalts have a greater areal extent in the subsurface. At well (B-14-6)31baa-1 the inferred residual thickness of the basalt is less than 360 feet.	Low primary permeability; high secondary permeability because of joints and fractures. Where saturated, similar rocks in adjacent Curlew Valley have high permeability. The chemical quality of water in these flows is unknown, but it is inferred to be fresh in northern Hansel Valley and slightly to moderately saline in the southern Hansel Valley-Rozel Flat area.
			Salt Lake Formation	In the west side of adjacent Blue Spring Creek Valley (and small areas of southern Hansel Valley) consists of white limestone, tuff, and claystone (Heylmun, 1965, p. 26). South of the study area the formation is as much as 3,700 feet thick and includes limestone, marl, tuff, clay, ashy silt, sandstone, shale, and sand. Colors range from white to black with various intermediate shades of gray, green, yellow, tan, and brown. Some sands and shales are unconsolidated and some limestone is massive and porous. Most of section is consolidated, and it contains intercalated basalt flows in the upper part of the section (Slentz and Eardley, 1956, p. 33-36). Where not removed by erosion, the formation is believed to underlie much of the valley lowlands. Remnants crop out around older consolidated rocks in the vicinity of Sunset Pass and southward.	Formation as a whole has low permeability; some beds of clastic rocks such as sand and sandstone probably have moderate permeability and can yield small amounts of water to wells. Probably functions together with older alluvial deposit as part of main ground-water reservoir.
PALEOZOIC	Mississippian to Permian		Sedimentary and metasedimentary rocks	Quartzite, limestone, dolomite, sandstone, and shale. In Hansel Mountains, include the Oquirrh Formation of Permian and Pennsylvanian age and the Manning Canyon Shale of Pennsylvanian and Mississippian age, and in the North Promontory Mountains, beds of the Oquirrh Formation only. Most of the rocks are deformed, mainly by faulting. Underlie all the study area at various depths from the surface to several thousand feet depending on the geologic structure. Numerous small outcrops are in some areas where the principal surface rock is unconsolidated rock.	Low primary permeability; low to high secondary permeability due to joints, fractures, and cavernous zones caused by solution. Badly shattered rocks of this unit are the source of brines from the spring group (1.2 cfs or more) in northeastern T. 11 N., R. 9 W., and the rocks are the probable source of water from the Salt Wells spring group (4 cfs) in sec. 21, T. 12 N., R. 7 W. Most of the springs (seeps to 15 gpm) in northern T. 13 N. and T. 14 N. are related directly or indirectly to this unit. Several wells (table 6) penetrate this unit, and wells (B-12-8)3dbb-2 and (B-12-8)19ddc-1 may draw part or all their water from the unit. Water from this unit in Tps. 13-14 N. and probably in all the main block of the North Promontory Mountains is fresh. In the study area, south of T. 13 N., water from the unit probably is slightly saline to briny.

rabbitbrush (*Chrysothamnus nauseosus*), which grows along some streambeds, appears to confirm that available soil water is low to moderate in salinity (Mower and Nace, 1957, p. 18). Sage, however, was found growing nearly at the level of Salt Wells Flat near the southwest corner of T. 12 N., R. 8 W. The sparse growth in such low areas probably indicates fairly high soil permeabilities and a moderate annual rate of precipitation, which in turn indicate a low to moderate soil salinity.

At the lower edge of the sagebrush zone, as in parts of T. 12 N., R. 7 W., shadscale apparently grows where precipitation is moderate, the water table deep, and the soil fine grained and possibly saline.

Below the shadscale zone where conditions are much the same but the water table is about 60 feet or less below the land surface, almost pure stands of greasewood of varying density grow down to the edge of Salt Wells Flat. The relative density and healthiness of the greasewood appear to be functions of the depth to water and the chemical quality of the ground water.

In Salt Wells Flat, saltgrass is sustained by the discharge of springs, and the area of grass is actively maintained for forage and hay production by the ranch owners. Down the flat toward the lake pickleweed grows on the mudflats. Saltcedar apparently is a relatively recent arrival in Hansel Valley, but a fringe of well-established growth rims the small pond in about sec. 20, T. 12 N., R. 7 W. Saltcedar, if not eradicated or well controlled, will supplant other plants such as saltgrass, will increase the annual discharge of ground water several fold, and can lead to the degradation of the already poor quality of water in the lower part of the valley. Phreatophytic vegetation is discussed further in the section on ground-water discharge.

Agricultural practices in Hansel Valley have modified the botanical regimen; therefore, it is believed they may have somewhat altered the natural hydrologic regimen. In some areas, native vegetation on the alluvial slopes has been replaced with range grasses to improve the forage supply. This replacement may have had little effect other than to reduce the velocity of surface-water runoff.

Field examination and study of aerial photographs indicate that about 20,000 acres of nonirrigated wheatland is planted annually along the edges of the mountains, in some small upland valleys, and in much of the valley bottom between Highway I-80N and the south end of T. 13 N. Most of these lands were once covered with sagebrush, and elimination of the brush lowers the demand on soil moisture. It is probable that the difference between the needs of the deep-rooted perennial sagebrush and the shallow-rooted seasonal grain adds a small but significant increase in recharge of water to the ground-water system. Cultivation of the lands, moveover, breaks up the near-surface structure of the generally permeable soils and both improves the intake of available moisture and reduces the return of moisture to the surface where it evaporates.

Climate

The climate of Hansel Valley is characterized by moderately cold winters, hot summers, small to moderate amounts of annual precipitation, and moderate evaporation rates. Average annual precipitation on the drainage basin ranges from about 9 inches on the southernmost valley floor (pl. 1) to a maximum of nearly 20 inches on the highest peaks of the North Promontory Mountains (U.S. Weather Bureau, 1963a, 1963b).

Most of the valley receives 12-14 inches of precipitation annually, of which about two-thirds falls in winter and spring and about one-third in summer and fall (see fig. 3). Most of the summer precipitation is consumed; the winter precipitation is more important as a source of water supply to the valley.

The average monthly and annual air temperature in Hansel Valley is indicated by the record at Snowville in adjacent Curlew Valley (fig. 3). Average monthly temperature for the 63 years of record during 1899-1966 ranged from 22°F (-6°C) in January to 69°F (20°C) in July and August. Air temperature in the flats of Hansel Valley near Great Salt Lake probably is slightly higher. During the period 1949-69, the average growing season (for the number of days between the last spring and first fall temperature of 28°F (-2°C) was about 122 days based on the record at Snowville.

Potential evapotranspiration in Hansel Valley is estimated to be the same as for Curlew Valley, which according to Bolke and Price (1969, p. 9) is an estimated 41 inches annually. Lake evaporation alone, according to a regional analysis of data from evaporation at class A weather stations by Kohler and others (1959), is estimated to be 42 inches.

HYDROLOGY

Volume of precipitation

The principal source of water in Hansel Valley is precipitation, estimated to average 160,000 acre-feet annually, on its drainage area. Of this amount, all but about 7 percent is consumed at or near the point of fall. The average annual volume of precipitation was estimated from the precipitation data shown on plate 1, and the computation is shown in table 2. The precipitation data are used in the following sections to estimate runoff and ground-water recharge.

Surface water

The estimated average annual runoff from Hansel Valley is 5,000 acre-feet. This water is derived from spring discharge and overland runoff. An estimated 2,400 acre-feet of unconsumed spring discharge flows from Salt Wells Flat to Great Salt Lake. (See section on ground water discharge for this estimate.)

Overland runoff in Hansel Valley cannot be calculated accurately because adequate streamflow data do not exist. A figure for runoff, therefore, was estimated using the runoff worksheets described by Bagley, and others (1964, p. 56). The worksheet provided by them for the Brigham City 1:250,000 series map shows that about 9,000 acres yields from 1 to slightly more than 2 inches, and the remainder of the Hansel Valley drainage basin yields less than 1 inch. If it is assumed that the average annual runoff in the latter area is 0.5 inch from areas underlain by consolidated rocks and 0.1 inch from areas underlain by unconsolidated rocks, the total estimated is 2,800 acre-feet annually. According to figures determined by Hood and Price (1970, p. 12) for the Grouse Creek drainage basin, however, estimates for the arid western part of Utah based on the worksheets of Bagley and others (1964) tend to be slightly high. Using the figures of 0.5 inch and 0.1 inch for all the areas shown in table 2 an estimate of 2,200 acre-feet is obtained; therefore, an average annual overland runoff of 2,500 acre-feet seems reasonable.

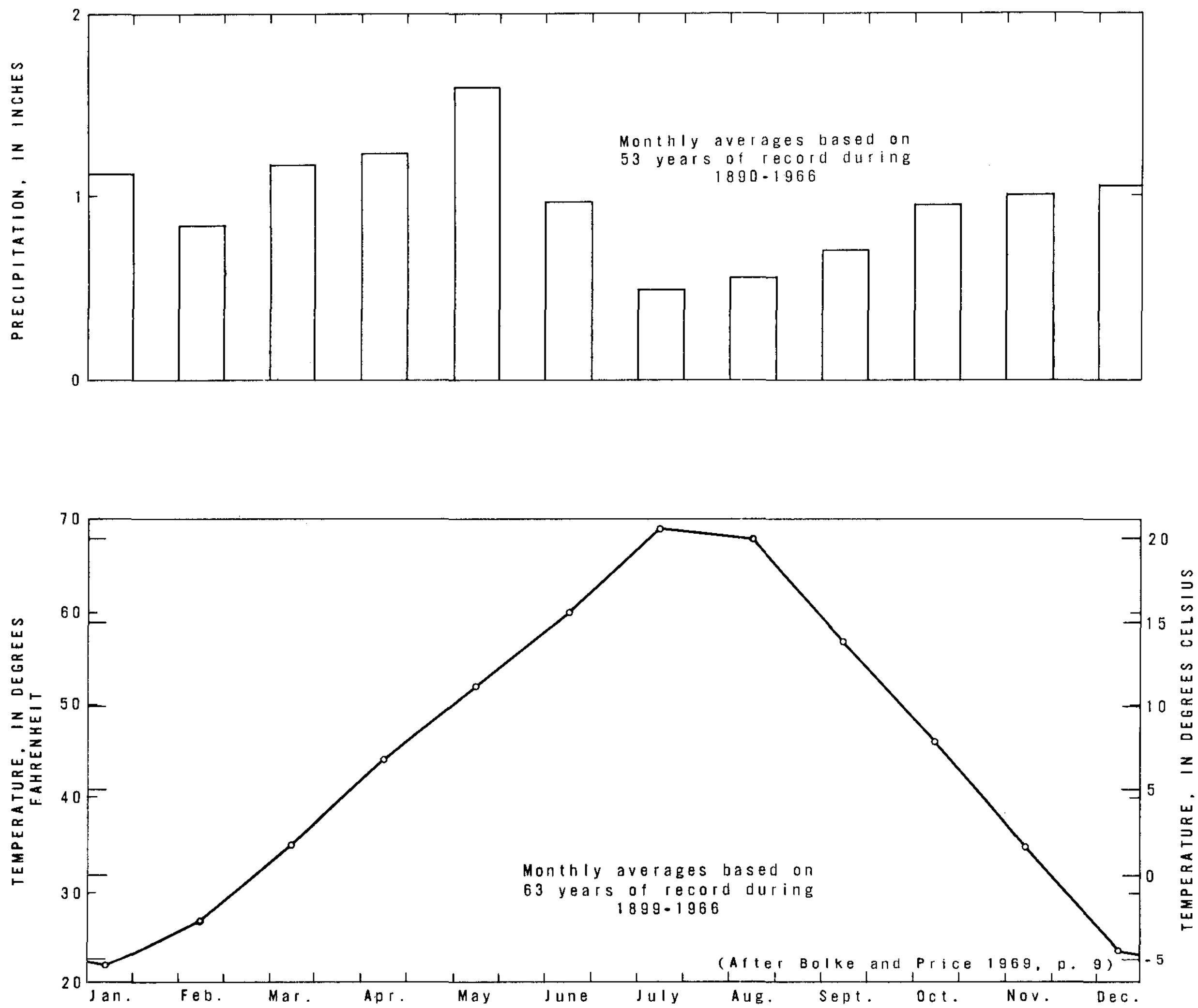

Figure 3.—Average monthly precipitation and air temperature at Snowville.

The total runoff in Hansel Valley, therefore, is

Unconsumed springflow	2,400
Overland runoff	2,500
Total	5,000 acre-feet (rounded)

Ground water

The principal source of ground water in Hansel Valley is the reservoir in the sedimentary rocks of Cenozoic age. (See table 1.) This reservoir consists of unconsolidated and semiconsolidated sedimentary rocks, but it may include intercalated basalt flows of Tertiary age.

A ground-water reservoir also exists in the consolidated rocks of Paleozoic age. Several large springs and a few wells derive ground water from those rocks. The relation between this reservoir and the one in Cenozoic rocks was not determined.

Recharge

The ground-water system in Hansel Valley and northern Rozel Flat is recharged by precipitation that infiltrates the adjacent mountains and their slopes. Most of the recharge in Hansel Valley is derived from precipitation on the drainage basin; but on the basis of the estimated recharge and discharge, it seems probable that a part of the recharge is derived from outside the drainage basin.

The estimated average annual recharge derived from precipitation on the Hansel Valley drainage basin is 8,000 acre-feet, or about 5 percent of the total volume. The estimate was made using the method described by Hood and Waddell (1968, p. 22-23); the factors and computation are shown in table 2.

Occurrence and movement

Ground water in Hansel Valley and northern Rozel Flat exists under artesian (confined) and water-table (unconfined) conditions, and it may be perched in part of the area. In general, ground water moves from the Hansel and North Promontory Mountains toward the lower parts of the valley and the flat (pl. 1) and ultimately some water reaches Great Salt Lake.

The rocks of Cenozoic age in northern Hansel Valley contain water under both artesian and water-table conditions. In wells such as (B-13-7)2ccc-1 and (B-13-7)10ddc-1, the water level rises considerably above the top of the permeable beds that yield water to the wells. Water-table conditions are indicated at such wells as (B-13-7)27abb-1 and (B-14-7)22dcd-1 where the water level is in the permeable beds. Depths to water in northern Hansel Valley range from 39 to 340 feet below land surface.

Along the east side of Hansel Valley, water-table conditions appear to exist in the sedimentary rocks of Cenozoic age except at well (B-11-7)2ccc-1 where nonflowing artesian conditions were found. Depths to water for the most part range from 200 to 600 feet beneath the upper alluvial slopes.

Table 2.—Estimated average annual volumes of precipitation and ground-water recharge in the Hansel Valley drainage basin

[Areas of precipitation zones measured from geologic and isohyetal maps (pl. 1). Estimates of average annual precipitation are weighted for steeply sloping areas.]

Precipitation zone (in.)	Acres	Estimated annual precipitation		Estimated annual recharge	
		Feet	Acre-feet	Percent of precipitation	Acre-feet
Areas underlain by Quaternary and Tertiary sedimentary rocks					
8-12	43,280	0.82	35,490	0	0
12-16					
Lake-bottom deposits and marsh	22,000	1.17	25,740	0	0
All other	57,740	1.17	67,560	6	4,050
More than 16	310	1.50	460	10	50
Subtotal (rounded)	123,300		129,200		4,100
Areas underlain by Tertiary igneous and Paleozoic rocks					
8-12	3,400	0.75	2,550	1	30
12-16	20,700	1.15	23,800	10	2,380
More than 16	4,240	1.50	6,360	15	1,000
Subtotal (rounded)	28,300		32,700		3,400
Totals (rounded)	152,000		160,000		8,000

In central and lower Hansel Valley, the sedimentary rocks of Cenozoic age are water bearing, but only three stock wells draw water from these deposits. Depths to water in the wells range from 63 to 140 feet below land surface. Near the shore of Great Salt Lake and in Salt Wells Flat, ground-water levels are at or near land surface. In this area, lake-bottom silts of low permeability impede ground-water flow and the water moves upward toward the surface. Local overflow occurs through springs, as in Tps. 11 and 12 N., R. 8 W.

Perched ground-water conditions are inferred for one area in Hansel Valley and are possible in two others. In most of T. 12 N., R. 8 W., most of the rocks of Cenozoic age probably do not contain aquifers; the regional water table there is inferred to be in the underlying consolidated rocks of Paleozoic age. The record for well (B-12-8)3ddb-2 (table 6) shows that the water table is near an altitude of 4,240 feet. In test well (B-12-8)10bcc-1, drilling reportedly was stopped at 320 feet because the drilling mud was lost into a very porous formation. If the water table at this location also is near the altitude of 4,240 feet, it would be about 80 feet below the bottom of the test hole, and most water in the overlying rocks could drain down to the water table. In the same area, however, one old well, (B-12-8)10bdc-1, was reportedly drilled to only 100 feet, and such water as it yielded came from a body of perched water in the Cenozoic rocks.

The ground water in rocks of Cenozoic age in part of northern Hansel Valley also may be perched. The water-level contours for the area north of T. 12 N. (pl. 1) indicate movement southward and eastward; the eastward component is toward a trough probably related to structural features that involve all the rocks beneath the valley, and the trough may indicate drainage into deeper formations.

On either side of the drainage divide between Hansel Valley and northern Rozel Flat, adjacent to the North Promontory Mountains, wells tap aquifers in the Salt Lake Formation and the older rocks of Quaternary age. Water levels range from the land surface, as at Cedar Spring, (B-11-7)34dbbS-1 (table 8), to a little more than 100 feet below land surface near the base of the mountains. The relation of water in the Salt Lake Formation to that in the underlying consolidated rocks is not evident; but water in the Salt Lake Formation may be perched.

In northern Rozel Flat, artesian conditions occur in the western part of the flat but water-table conditions probably exist near the North Promontory Mountains. Near the lakeshore, artesian conditions may be due in part to the presence of lake-bottom silt that acts as a confining layer overlying the aquifer. The water-level contours for this area (pl. 1) show that the potentiometric surface has a regular slope and, therefore, the variations in depth to water are mainly due to variations in the height of the land surface. Depths to water range from the land surface at the lakeshore to about 235 feet below land surface in well (B-10-8)13cbd-1.

The role of the consolidated rocks of Paleozoic age in the occurrence of ground water in Hansel Valley and northern Rozel Flat is difficult to assess because most evidence for their water-bearing characteristics is indirect. These consolidated rocks act as intake areas for recharge from precipitation and as media for the direct discharge of ground water; and it is inferred that the consolidated rocks act both as drains for water from overlying Cenozoic deposits in the mountains and as recharge sources for the Cenozoic aquifers in Hansel Valley.

Most recharge to the consolidated rocks probably percolates down to a deep water table. Wells (B-12-8)3ddb-2 and (B-12-8)19ddc-1 are the only wells in Hansel Valley that are inferred to draw part or all their water from the consolidated rocks; in these wells the depths to water are 188 and 434 feet, respectively, below land surface.

The consolidated rocks of Paleozoic age yield water to small upland springs in western T. 13 N, R. 7 W. (pl. 1, tables 8 and 9); this water probably is derived from recharge near the springs. Large spring discharge is associated with outcrops of the consolidated rocks in the lower part of Hansel Valley. Springs around Monument Point (pl. 1 and fig. 2) in sec. 10, T. 11 N., R. 9 W., and the Salt Wells springs group in sec. 21, T. 12 N., R. 7 W., discharge a total of at least 5.2 cfs (cubic feet per second) of saline water, or nearly half the estimated ground-water discharge in Hansel Valley. Figure 2 depicts conditions around the Monument Point spring group. At Salt Wells, the springs discharge from a series of similar pothole springs where the silts of Salt Wells Flat abut a low terrace; consolidated rocks of Paleozoic age crop out in a part of the terrace.

The consolidated rocks of Paleozoic age may serve as a source of recharge to the Cenozoic deposits in middle and lower Hansel Valley, south of T. 13 N. In this area, many small outcrops of the consolidated rocks (a few of which are shown on pl. 1) indicate that the base of the Cenozoic deposits is uneven and that the consolidated rocks are near enough to the land surface that they can contribute water to the Cenozoic deposits where the water table intersects the contact between two units. Such subsurface discharge from the consolidated rocks may occur in west-central Hansel Valley where wells (B-12-8)3ddb-2 and (B-12-8)14 reportedly produced saline water—the former from consolidated rocks and the latter presumably from unconsolidated rocks (table 5). As the ground water in the Cenozoic deposits in T. 12 N., R. 8 W., should not be appreciably different in chemical quality from the water in T. 13 N., R. 7 W., where it is fresh, this suggests possible movement of water from the consolidated rocks to the unconsolidated rocks in T. 12 N., R. 8 W.

Undisturbed sections of the unconsolidated rocks in Hansel Valley and northern Rozel Flat probably would yield little water to wells, but where the rocks are permeable because of shattering or solutional activity, large yields are possible. Relative permeabilities can be indicated by the hydraulic gradients shown on plate 1. In northern Hansel Valley, where the maximum well yields from the Cenozoic deposits are about 1 cfs, the hydraulic gradient is 50-100 feet per mile, and locally steeper. Gradients measured from wells (B-12-8)3ddb-2 and (B-12-8)19ddc-1 to the 4,200-foot contour (approximate altitude of the Monument Point spring area) are 4 to 5 feet per mile. The low gradients are suggestive of a zone of high permeability which may be within highly fractured consolidated rocks. Such highly fractured zones were observed in surface exposures, both near the spring area at Monument Point and in parts of the North Promontory Mountains.

Storage

Under natural conditions, a ground-water system is in dynamic equilibrium; long-term average annual recharge and discharge are equal, and the amount of ground water in storage remains nearly constant. Year-to-year changes in storage are indicated by corresponding changes in the water levels in wells. When recharge exceeds discharge, water levels rise; conversely, when discharge is greater, the water levels decline.

Ground-water storage conditions in Hansel Valley and northern Rozel Flat in 1969 were still under natural conditions. The one well used for supplemental irrigation had not been pumped to any appreciable extent, and the remaining withdrawal of ground water was small. The short-term water-level records (table 3) show that fluctuations in nonpumping water levels amounted to less than 1 foot during the period May 1967-November 1969. The one exception, in well (B-9-7)16bcb-1, may have been the result of pumping shortly before the well was measured. The changes in storage were due to seasonal effects such as evapotranspiration, recharge, or change in the level of Great Salt Lake; and the levels are not significantly affected by pumpage.

An estimate of the total amount of ground water in storage in Hansel Valley was not made for this report because much of the water is saline, and therefore not desirable for use; and because the available data are not sufficient to outline the areal subsurface extent and thickness of the sedimentary rocks of Cenozoic age.

A rough estimate of the amount of ground-water available from storage was made for the area of water of good chemical quality in parts of Tps. 13-14 N., Rs. 6-7 W., where the sedimentary rocks of Cenozoic age are several hundred feet thick. This is an area of about 20 square miles, or about 13,000 acres. The logs in table 7 show that the material below the water

Table 3.—Water levels in observation wells

Water levels, in feet below land-surface and measured with a steel tape, except as noted

(B-9-7)6dac-1		**(B-10-7)19ccc-1**	
May 8, 1967	101.6	May 8, 1967	140.2
May 15, 1969	101.7	May 15, 1969	140.3
Oct. 8	101.5	Oct. 8	139.8
		Nov. 28	139.9
(B-9-7)9acb-1			
May 15, 1969	77.6	**(B-10-8)1cba-1**	
Oct. 8	77.8	May 8, 1967	63.4
		May 15, 1969	62.6
(B-9-7)16bcb-1		Oct. 8	62.7
May 8, 1967	72.0	Nov. 28	62.5
May 15, 1969	52.1		
Oct. 8	52.8	**(B-10-8)33bba-1**	
		May 8, 1967	40.0
(B-9-8)2bbd-1		May 15, 1969	40.1
May 8, 1967	46.8	Oct. 8	40.4
May 15, 1969	46.9	Nov. 28	40.2
Oct. 8	47.1		
Nov. 11	47.0	**(B-13-7)27abb-1**	
		Apr. 1969	133.5[1]
		Oct. 15	133.5
		Nov. 26	133.4

[1] Level reported by owner, adjusted from top of casing to land surface.

level in wells is diverse, ranging from gravel to clay. The specific yield, therefore, is estimated conservatively to be about 5 percent. Based on these figures, if 100 feet of the aquifer were dewatered, the quantity of ground water recovered would be about 65,000 acre-feet. The dewatering, however, would require a network of wells, spaced uniformly throughout the area.

Discharge

An estimated 11,000 acre-feet of ground water is discharged annually from Hansel Valley by (1) evapotranspiration, (2) subsurface outflow, and (3) unconsumed spring discharge during the cold part of the year when evapotranspiration is at a minimum. During the growing season, the discharge of all the small springs and part of the discharge from the large springs is dissipated by evapotranspiration, and that discharge is included in the figure for evapotranspiration.

Evapotranspiration.—The only area of significant size in which phreatophytic vegetation and evaporation from soils and open water account for ground-water discharge is Salt Wells Flat and a strip of the slope adjacent to the flat (pl. 1). Within the flat, the water table is at or very near the land surface; and the water available for evapotranspiration is saline to very saline.

The source of the ground water consumed by evapotranspiration in the flat is the discharge from the Salt Wells (springs), the discharge from other smaller springs around the edge of the flat, and the water that moves to the surface of the flat by diffuse seepage. During the hot, dry summer period, the surface of most of the flat is dry, and the shallow water table declines. As colder weather sets in and evapotranspiration slackens, the water table rises; and later in the year part of the unconsumed ground water flows out of the flat in surface channels.

Evapotranspiration in the flat is by several modes: (1) evaporation from small bodies of open water, from streams, and from bare mudflats; (2) transpiration by native vegetation; and (3) transpiration from wet meadows of saltgrass that are both naturally and artificially supplied with springflow. The mudflats, as observed and as evaluated from aerial photographs, constitute at least 50 percent of Salt Wells Flat. Among the areas of mudflat are raised areas 1-5 feet high that constitute perhaps 30 percent of the flatland and are fringed with pickleweed and crowned with greasewood. In most areas observed, as along the county road from Cedar Spring to Monument Point, this phreatophytic growth is variable in density and healthiness. It ranges from very sparse, low sickly plants to moderately dense, large healthy plants. The saltgrass meadowland occupies not more than 20 percent of the flat. Most of the grass is in the upper northeast part of the flats where it is irrigated, but it also extends along the several distributary stream channels and grows in smaller patches below the springs along the northwest side of the flats.

On the slopes adjacent to Salt Wells Flat, ground water is transpired by phreatophytes consisting almost entirely of greasewood. The upper boundary of the greasewood belt is sharply delineated in the several areas where it was directly observed, and the upper extent of the greasewood appears to be a function of the depth to water. The upper boundary was found, for example, to be directly at well (B-10-8)1cba-1 (table 6) in which the depth to water was 63 feet in November 1969. The greasewood on the slopes ranges from sparse low plants near the upper boundary to moderately dense plants of 3-4 feet in height in some areas near the edge of the flat. The healthiness of the larger plants probably is a function of ground-water quality and is variable along the edge of the flats. For example, the healthy, fairly dense growth of greasewood along the flat in the southwestern corner of T. 12 N., R. 8 W., indicate that the ground water available there may be of a better chemical quality than that from springs a few miles to the northeast.

The estimated average annual quantities of water that are discharged from the several areas of evapotranspiration designated on plate 1 are given in table 4. The acreage of the areas above the 4,200-foot contour was determined from plate 1. The estimated average rate of evapotranspiration, in acre-feet per year, takes into account the probable spread of values for given points, as affected by depth to water and chemical quality of the ground water; and the rates are believed to be conservative.

Subsurface outflow.—A part of the ground water that leaves Hansel Valley moves through the water-bearing formations and discharges into Great Salt Lake directly, below the 4,200-foot contour. Most of the aquifer material near the lake is believed to be fine grained and of low permeability.

Subsurface outflow was estimated by use of a variation of Darcy's Law in the following equation:

$$Q = 0.00838\ T\ I\ L$$

in which Q is the discharge, in acre-feet per year, 0.00838 is a units-conversion factor, T is the transmissivity of the aquifer material in cubic feet per day per foot ($ft^2\ day^{-1}$), I is the slope of the water table, in feet per mile, and L is the length, in miles, of the 4,200-foot contour between water-table divides on either side of the valley. In Hansel Valley, T is estimated to be 3,000 $ft^2\ day^{-1}$. The slope of the water table is estimated to be the same as the land surface along the axis of the Salt Wells Flat, or about 5 feet per mile. The length of the contour is about 8 miles. Thus the subsurface outflow is approximated as

$$Q = 0.00838 \times 3{,}000 \times 5 \times 8$$
$$= 1{,}000 \text{ acre-feet per year (rounded)}$$

Table 4.—Estimated average annual evapotranspiration of ground water in Hansel Valley

Locality and vegetation	Area (acres)	Depth to water (ft)	Evapotranspiration Acre-feet per year	Evapotranspiration Acre-feet (rounded)
Slopes adjacent to Salt Wells Flat; mainly greasewood	8,400	0-60	0.3	2,500
Salt Wells Flat[1], including:				
(1) Mud and salt flats	8,500	0-2	.1	900
(2) Sparse greasewood and pickleweed	5,100	0-10	.15	800
(3) Saltgrass and small areas of open water	3,400	0-5	1.0	3,400
Total	25,400			7,600

[1] Breakdown of area based on estimated percentages obtained from field reconnaissance and from aerial photographs.

Unconsumed spring discharge.—Springs discharge onto Salt Wells Flat around its periphery. Many of these are seeps, but a few are large enough to create flow in surface channels across the flats. During the growing season, water from the Salt Wells (springs) is spread for irrigation of pasture and hay meadow grasses; and much, if not all, the water is consumed. Water from most of the other springs is dissipated in the flats. During the fall and winter, as air temperatures fall, evapotranspiration slackens, soil moisture in the flats is replenished, and most of the spring water flows to Great Salt Lake. The estimated quantity of flow is tabulated as follows:

Salt Wells spring group	4 cfs
Monument Point spring group	1.2
Other small springs and seeps	.3
Total	5.5 cfs, or about 4,000 acre-feet per year.

For the purpose of estimate, it is assumed that no water flows from the valley during the evapotranspiration season. This season is about the length of the growing season of 122 days, or about 0.33 year. It is further assumed that only a short time is needed to satisfy soil-moisture requirements; therefore, the total period of consumption of the spring water is about 0.4 year. Spring water discharges to the lake during the remaining 0.6 year. The quantity discharged is 0.6 x 4,000, or about 2,400 acre-feet per year.

Ground-water budget for Hansel Valley

Those parts of the ground-water recharge and discharge that can be estimated by the methods used in this reconnaissance report are as follows:

Item		Average annual quantity, in acre-feet
Recharge from precipitation in drainage basin (table 2)		8,000
Discharge:		
Evapotranspiration	7,600	
Subsurface outflow	1,000	
Unconsumed spring flow	2,400	11,000
Difference between estimated recharge and discharge		3,000

Although the estimates of recharge and discharge are subject to refinement during a subsequent, more detailed investigation of the valley, the writer believes that the large difference between the two figures indicates that the recharge figure is incomplete and probably should contain an amount due to inflow from areas outside the valley. The validity of the conclusion could not be assesed during this study.

Perennial yield

The perennial yield of a ground-water system is the maximum amount of water that can be withdrawn from the system for an indefinite period of time without causing a permanent and continuing depletion of ground water in storage and without causing a deterioration of the chemical quality of the ground water. The perennial yield is limited ulitmately by the amount of natural discharge of water of good quality that can be salvaged for beneficial use.

In Hansel Valley, the perennial yield, as defined, is negligible. Only near intake areas is the water of a chemical quality suitable for most uses, and salvage activites such as pumping would have to be carried out near the discharge areas where only saline ground water has been found. If the ground-water reservoir is pumped heavily in the area of good quality water, the water in storage will be continuously depleted.

Chemical quality of the water

The dissolved-solids concentration in water samples from Hansel Valley and northern Rozel Flat ranges from about 400 to 94,000 mg/l (milligrams per liter). The known and inferred areas in which fresh water (containing 1,000 mg/l or less of dissolved solids) may be obtained are in the northern Hansel Valley drainage basin and a narrow strip of land along the base of the

North Promontory Mountains (pl. 1). In the rest of the area, probably including most of northern Rozel Flat, the ground water ranges in chemical quality from slightly saline (containing from 1,000 to 3,000 mg/l of dissolved solids) to brine (containing more than 35,000 mg/1 of dissolved solids). All the water is very hard. These figures are based on field observations and reports (table 5) and 24 chemical analyses of well, spring, and stream water (table 9).

Table 5.—Generalized chemical quality of ground water inferred from reports and observations

Well or spring location	Report or observation
(B-9-7)9acb-1	Salty water (driller)
(B-9-8)9ddbS-1	Spring and seepage area observed on lakeshore adjacent to basalt outcrop. Water is low enough in dissolved-solids concentration to freeze readily and support a dense growth of saltgrass.
(B-10-8)26adb-1	Water warm and brackish (driller)
33bba-1	Very salty (driller). Intended for stock but unused.
(B-11-7)22aba-1	Poor quality and hard (owner)
(B-11-8)27cbbS-1	Salt spring (topographic map)
33adaS-1	do
33adcS-1	do
(B-11-9)2dbdS-1	do
11bbaS-1	do
(B-12-8)3ddb-2	Chloride concentration about 3,000 mg/l (private laboratory); water hot or warm (owner's brother).
10[1]	Water reported to be in sandstone, low in mineral content, but too warm to be palatable.
14[1]	Water too salty even for stock was encountered at 50 feet, and no better water was found to total depth of 150 feet.
26badS-1	Salt spring (Utah State Engineer's file of claims)
26bbdS-1	Salt spring (topographic map)
27cccS-1	do
27dbbS-1	Salt spring (Utah State Engineer's file of claims)

[1] Carpenter (1913, p. 57) reports wells (B-12-8)10 and (B-12-8)14 to be in R. 7 W., but examination of the claim files of the Utah State Engineer and interpretation of data accumulated in 1969 indicate that the well locations are as listed. These two wells are not listed in table 6 or shown in figure 2.

Most of the water in the basin is not suitable for domestic and public consumption according to the standards of the U.S. Public Health Service (1962, p. 7) because the dissolved solids exceed 500 mg/l.

Much of the water in the valley can be used by livestock, because the more highly mineralized water is a chloride type and supplies a part of the salt needed by the animals. Concentrations of more than about 5,000 mg/l of dissolved solids, however, probably would render the water unpalatable to most livestock. Water with 5,000 mg/l or less of dissolved solids probably can be obtained in about half of the study area.

Because of the prevalence of saline water in most of the study area, water suitable for irrigation of cultivated crops is relatively scarce, and ground water is used mainly to irrigate salt-tolerant vegetation near the Salt Wells springs. Figure 4, which shows the classification of water samples with reference to irrigation (after U.S. Salinity Laboratory Staff, 1954, p. 79-81), indicates that even the best ground water in the valley has a high-salinity hazard. Some of this water, however, is suitable for irrigation because it has a low sodium hazard. Lands irrigated with such water must have good permeability and subsurface drainage, and adequate water should be applied to assure flushing of the soil.

The minerals that are dissolved in ground water in the study area have several possible sources. The principal source is the mineral content of the rocks through and over which the water passes. In northern Hansel Valley, the dominant cations in the water are calcium and magnesium, which probably are derived from limestones and other calcareous rocks in the area. As the water moves downgradient, it continues to dissolve mineral matter from the sediments through which it passes. The gain is mainly in sodium and chloride, which are the dominant ions in the water near the lowlands. In the area of Cedar Spring, (B-11-7)34dbbS-1, and in northern Hansel Valley, near well (B-13-7)24aad-1, the ground water contains silica concentrations ranging from 37 to 66 mg/l (table 9), which is considerably more than the silica concentration in the ground water in other parts of the study area. The high silica concentration results from the movement of the ground water through rocks of volcanic origin, probably pyroclastics.

A second source of the dissolved solids in the ground water is the spray and dust from Great Salt Lake and its adjacent flats which are blown onto the recharge areas. The relatively high chloride content of the water from well (B-14-7)30dbb-1 may be derived from this source.

A third source of dissolved solids in the ground water, particularly in the lowlands, probably is unflushed water from sediments covered by Great Salt Lake when the lake was slightly higher in stage in the past. Flushing of this water from the aquifers in the lowlands has been slow because the rate of ground-water recharge is small, gradients are low, and ground-water movement is slow.

SUMMARY OF WATER USE

Past and present use

Early settlers in Hansel Valley found little water of usable chemical quality. The springs were few in number and water supplies from streamflow were undependable. The first application to the Utah State Engineer for the use of water in Hansel Valley was made by W.W. Hickman on November 21, 1904, for the total flow (4 cfs) of the Salt Wells spring group in sec.

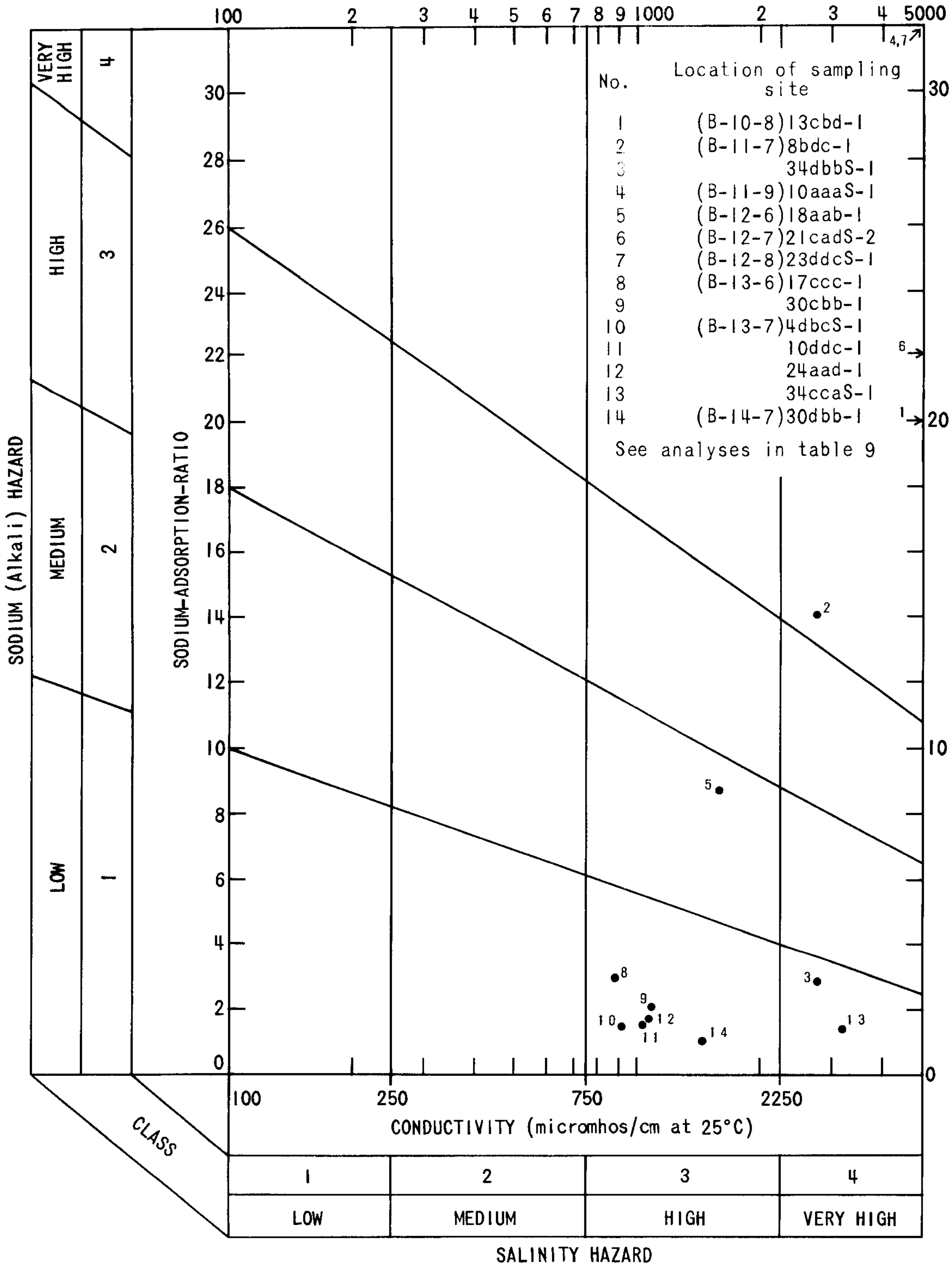

Figure 4.—Classification of representative well and spring water for irrigation in Hansel Valley and northern Rozel Flat.

21, T. 12 N., R. 7 W. The earliest reported use of a well was before 1907 at the "State Well," (B-13-7)14aaa-1. Most of the wells for which records are available date from the period subsequent to 1910 and were drilled for stock and domestic use. In 1969, Hansel Valley contained one irrigation well that was used intermittently to supplement precipitation. The well originally was drilled to provide water for highway construction. One other well has been drilled for irrigation, but it was unused pending deepening to test for a greater supply.

In northern Rozel Flat, a slow but steady drilling program was started about 1945; as of 1969, only saline water had been obtained; irrigation test wells reportedly have been drilled, but sustained yields reportedly are low.

Future development

Future development in much of Hansel Valley and northern Rozel Flat probably will be similar to past development—drilling of wells that supply saline water suitable for stock. Along the edge of the North Promontory Mountains and in the northern part of Hansel Valley, however, small supplies of water of suitable quality for irrigation probably could be obtained from wells. Because of deep water levels and low well yields in these areas, however, pumping lifts would be great. In the northern part of Hansel Valley, the fresh-water aquifer may be perched above consolidated rocks containing saline water. If wells penetrate such a deeper aquifer, any saline water encountered would have to be plugged off.

It appears that Carpenter (1913, p. 57) was correct in his assessment that development of the area was and will be hindered by a deep water table in the uplands and salty water in the lowlands.

DATA NEEDED FOR ADDITIONAL STUDIES

The results of this reconnaissance indicate that a detailed investigation is not needed immediately to further the development of Hansel Valley and northern Rozel Flat. However, full development of the county and the State ultimately will require further consideration of the area. The main problem in development of usable water supplies is a careful delineation of the character and the horizontal and vertical extent of the aquifers that carry fresh and slightly saline water and their hydrologic relation to underlying older rocks. Secondly, to arrive at a satisfactory water budget for the area, it is believed that a synthesis must be made of data for the valley together with data for the surrounding valleys. This would require that those valleys be studied before Hansel Valley is studied in detail. In support of further investigations in the Hansel Valley drainage basin and to provide the greater detail needed for determining the optimum development, the following are needed:

1. Detailed geologic studies, including mapping of surficial deposits in both the mountains and the areas covered with unconsolidated deposits, and analysis of geologic structure as it affects the distribution and thickness of the aquifers. In support of this work, areal geophysical mapping is needed to extend the work of Cook and others (1964). All available existing wells and other borings should be logged with geophysical logging equipment, and test holes should be drilled at selected sites. If volcanic rocks are encountered at shallow depths, they should be penetrated several hundred feet; if rocks of Paleozoic age are encountered, they should be penetrated enough to identify the formation. Data obtained from the test holes should include detailed lithologic sampling, geophysical logging, determination of water level in the aquifer(s), and selective water sampling of individual water-bearing beds.

2. A detailed inventory and measurement of discharge of ground water sources is needed, including chemical analyses of water from each source. Wells should be tested to determine aquifer coefficients.

3. Daily stream discharge in most major stream channels should be determined in order to assess the relation between surface water and ground water during the period of study. For a water budget and for planning and design, streamflow data should be obtained by multiple regression of streamflow characteristics with physical and climatological characteristics of the valley, or by other indirect methods such as the use of channel parameters for estimating mean annual runoff.

4. Refined botanical mapping in connection with depth-to-water studies and water-level fluctuations in a network of observation wells is needed to refine estimates of evapotranspiration.

5. Supplemental data needed include recording precipitation gages and thermographs. Precipitation should be sampled at different times of the year for chemical analysis. In addition to geologic mapping, a soils study is needed to assess the intake capacity of surficial materials.

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[1] Climatological data were published prior to 1967 by the U.S. Weather Bureau and from 1967 forward by the Environmental Data Service of Environmental Science Services Administration.

APPENDIX

Well- and spring-numbering system

Wells, springs, and other hydrologic-data sites are numbered in this report using the system of numbering wells and springs in Utah. The numbering system is based on the cadastral land-survey system of the Federal Government. The number, in addition to designating the well, spring or other data site, locates the site to the nearest 10-acre tract in the land net. By this system the State is divided into four quadrants by the Salt Lake base line and meridian. These quadrants are designated by the uppercase letters A, B, C, and D, thus: A, for the northeast quadrant; B, for the northwest; C, for the southwest; and D, for the southeast quadrant. Numbers designating the township and range, respectively, follow the quadrant letter, and the three are enclosed in parentheses. The number after the parentheses designates the section, and the following three letters give the location of the site within the section. The first letter indicates the quarter section, which is generally a tract of 160 acres, the second letter indicates the 40-acre tract, and the third letter indicates the 10-acre tract. The number that follows the letters indicates the serial number of a well within the 10-acre tract. Thus, well (B-13-7)24aad-1 in Box Elder County, is in the SE¼NE¼NE¼ sec. 24, T. 13 N., R. 7 W., and is the first well constructed or visited in that tract (see fig. 5).

Springs are designated by the letter S preceding the serial (final) number at the end of the location number, for example, (B-11-9)10aaaS-1. Other hydrologic-data sites are numbered similarly except that the serial number is not used, for example, (B-11-8)2cab. This numbering system, when used for surface-water gaging sites, supplements and does not supplant the established system of numbering such sites in downstream order.

Metric units and units conversion

In this report, the units that indicate concentrations of dissolved solids and individual ions determined by chemical analysis and the temperatures of air and water are metric units. This change from reporting in "English units" has been made as a part of the gradual change to the metric system that is underway within the scientific community. The change is intended to promote greater uniformity in reporting of data. Chemical data for concentrations are reported in milligrams per liter (mg/l) rather than in parts per million (ppm), the unit used in earlier reports in this series. For concentrations less than 7,000 mg/l, the number reported is about the same as for concentrations in parts per million. For more highly mineralized water, the concentrations reported in milligrams per liter must be adjusted for the density of the sample to get the equivalent parts per million, and the concentrations in parts per million is a smaller number than the equivalent number in milligrams per liter. For example, a concentration of dissolved solids of 94,400 mg/l (the most highly mineralized water reported in this study) is equivalent to 89,200 ppm.

Water temperature is reported in degrees Celsius (centigrade or °C), but the customary English unit of degrees Fahrenheit (°F) follows in parentheses in the text. Air temperature is reported in °F, but the equivalent temperature in °C follows in parentheses in the text for easier comparison with water temperature in tables. The reporting of temperatures in both metric and English units is done to assist those readers who are not familiar with the Celsius temperature scale. The following conversion table will also help to clarify the relations between degrees Fahrenheit and degrees Celsius:

TEMPERATURE-CONVERSION TABLE

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

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

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

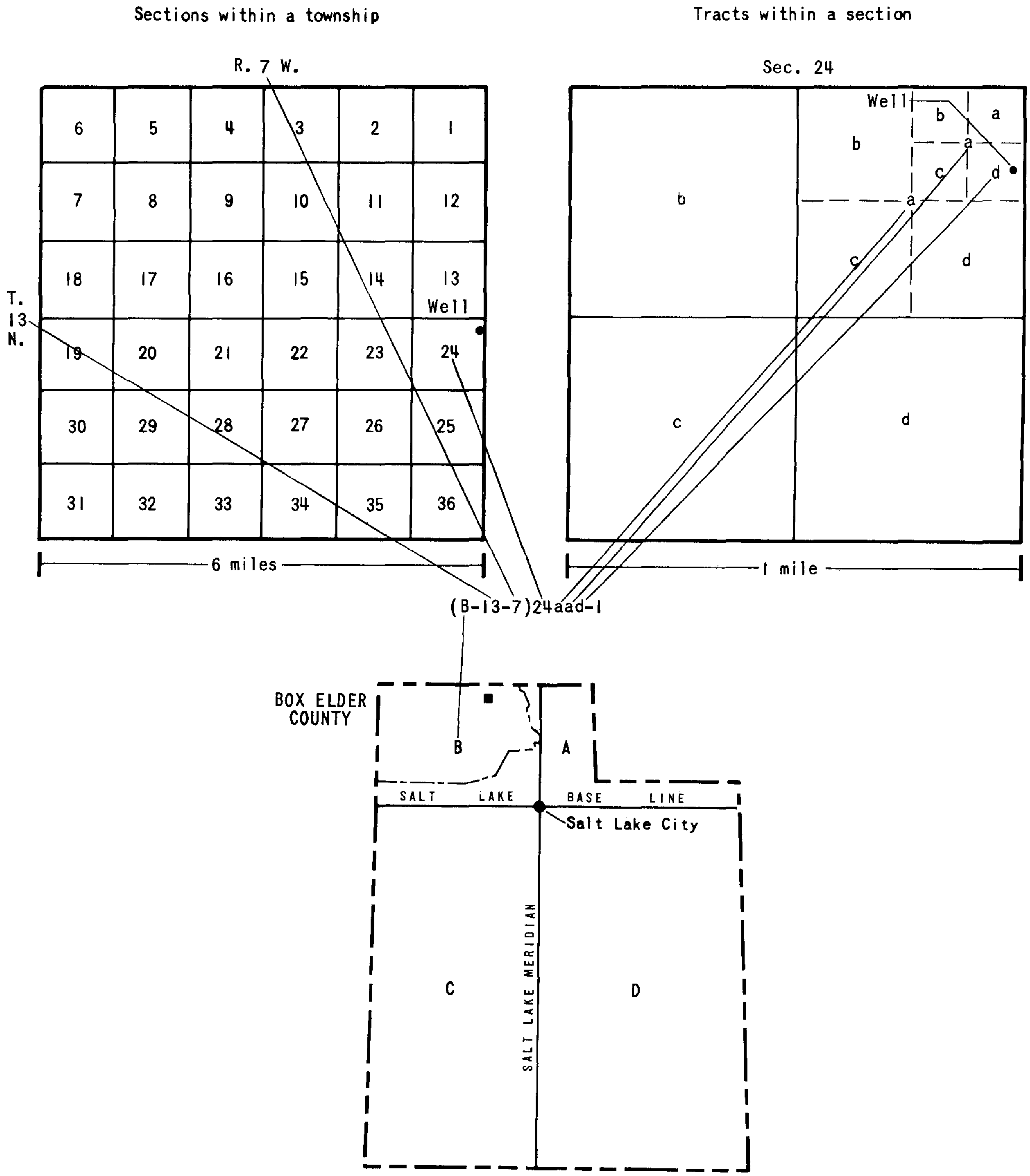

Figure 5.—Well- and spring-numbering system used in Utah.

New hydrologic terms

A new hydrologic term (transmissivity) is used in this report to describe a property of water-bearing formations. This term is one of several, as provided by a U.S. Geological Survey committee on redefinition of hydrologic terms, that express hydrologic parameters in consistent units. Some of the terms have been assigned different symbols to avoid confusion with the older, previously used terms.

Transmissivity replaces the term "coefficient of transmissibility"; both are designated T.

The coefficient of transmissibility:

$T = Pfm$, in gallons per day (gpd) per foot,

in which Pf is the field coefficient of permeability in gpd per ft^2; and m is the thickness of the aquifer, in feet.

Transmissivity:

$T = Kb$, in cubic feet per day per foot, or $ft^2 day^{-1}$,

in which b, in feet, replaces m; and K, the hydraulic conductivity, equals

$$\frac{Pf}{7.48}.$$

BASIC DATA

Table 6.—Records of selected wells

Location: See appendix for description of well- and spring-numbering system used in Utah.
Type of well: C, drilled with percussion (cable-tool) rig; D, dug; H, drilled with hydraulic rotary rig; T, trench (covered).
Casing: Diameter - The smallest casing that extends to the land surface. Finish - H, horizontal collector; O, open-end unperforated casing; P, perforated casing (generally done with a Mills knife); S, screen; X, open hole (uncased) in aquifer.
Aquifer: Lithology - G, gravel; 2G, fine gravel; 4G, coarse gravel; 5G, very coarse gravel; I, basalt of Pliocene(?) age (probably weathered); JI, jointed or fractured basalt of Pliocene(?) age; L, limestone; R, sand and gravel; 6R, clayey sand and gravel; S, sand; V, sandstone; Y, clayey gravel. Formation - PPo, Oquirrh Formation; Tsl, Salt Lake Formation.
Altitude: In feet above mean sea level. South of lat. 41°45' interpolated from 7½-minute topographic maps. North of lat. 41°45' interpolated from large-scale topographic map but most locations checked with surveying altimeter.
Water level: In feet below land surface. M, measured; R, reported.
Type of lift: N, none; P, piston (cylinder); S, submergible; T, turbine.
Yield: Rate and drawdown data shown by E, estimated; D, from driller's report; T, reported by other than driller.
Use of water: H, domestic; I, irrigation; S, stock; U, unused. Use of water either observed or reported in State Engineer's records of claims. In multipurpose wells, the use listed is the principal use according to claim.
Other data available: C, chemical analysis in table 9; D, driller's log of well in table 7; W, periodic water-level measurements in table 3.

Location	Owner	Year drilled	Type of well	Depth of well (feet)	Casing		Aquifer		Altitude (feet)	Water level (feet)	Date of measurement	Type of lift	Yield		Use of water	Other data available
					Diameter (inches)	Finish	Lithology	Formation					Rate (gpm)	Draw-down (feet)		
(B-9-7)																
6dac-1	Swan Co.	1963	C	135	8	P	G	-	4,338	102M	Oct. 1969	P	22D	0	S	
9acb-1	do	1959	-	-	18	-	-	-	4,316	78M	Oct. 1969	T	470D	189	S	W
16aaa-1	G. and J. Deflon	1964	C	510	20	P	6R	-	4,289	75R	Aug. 1964	-	900D	165	I	D
16bcb-1	Swan Co.	1945	-	85	6	S	G	-	4,288	53M	Oct. 1969	-	20D	2	S	D,W
(B-9-8)																
2bbd-1	do	-	-	117	8	-	-	-	4,263	47M	Nov. 1969	P	-	-	S	W
(B-10-7)																
8ddd-1	O. C. Garn	1965	-	320	6	-	-	-	4,609	-	-	-	-	-	S	
17acc-1	do (1/)	1952	H	7,918	14	-	-	(2/)	4,601	-	-	-	-	-	-	
19ccc-1	Swan Co. (3/)	1951	-	255	10	X	JI	-	4,369	140M	Nov. 1969	S	125D	14	S	D,W
(B-10-8)																
1cba-1	do	1945	C	170	6	S	4G	-	4,273	63M	Nov. 1969	P	30D	5	S	D,W
13cbd-1	do	1963	C	286	12	P	2G	Tsl	4,456	235R	Oct. 1963	S	20D	0	H	C,D
26adb-1	do	1937	-	154	4	O	-	-	4,338	25R	1945	P	65D	-	S	D
33bba-1	H. W. Hunter	1966	C	68	4	P	5G	-	4,239	40M	Nov. 1969	N	10D	0	U	D,W
(B-11-7)																
2ccc-1	R. Adams	1967	C	367	6	P	5G	Tsl	4,563	322M	Nov. 1969	S	8D	0	S	D
8bdc-1	Holmgren Land and Livestock Co.	1960	C	235	8	P	R	Tsl	4,375	140R	1960	P	2	-	S	C,D
12dcc-1	D. B. Green	1957	-	212	-	-	-	-	5,230	Dry R	1957	-	0R	-	U	
22aba-1	L. Y. Mills	(4/)	-	175	6	O	-	-	4,775	124M	Nov. 1969	N	10R	-	S	
23cac-1	do	-	C	85	6	P	-	-	5,164	56R	May 1963	P	6D	-	S	
26caa-1	M. V. W. Johnson	1912	D	26	4	-	G	-	5,300	20M	Nov. 1969	N	5R	-	U	
34acc-1	R. J. Toombs	1942	T	10	3	H	V	Tsl	4,880	5R	June 1942	N	2R	-	H	
35bcd-1	W. B. Hendrix	1967	C	132	12	P	G	Tsl	5,079	49M	Nov. 1969	S	40D	2	H	D
35cbc-1	do	(5/)	-	-	12	-	-	-	4,968	76M	Nov. 1969	-	-	-	-	
35cbd-1	do	1968	C	290	12	P	-	-	5,030	-	-	-	-	-	-	D
(B-11-8)																
26dcc-1	U.S. Bureau of Land Management	-	-	-	6	-	-	-	4,362	125M	Nov. 1969	P	7R	-	S	
(B-12-6)																
18aab-1	Isaki Brothers	1937	C	718	4	-	-	-	5,030	600R	-	P	3D	0	H	C
(B-12-8)																
3ccc-1	E. Peterson	-	-	256	6	-	-	-	4,530	-	-	N	20R	-	U	
3ddb-2	D. Peterson	1965	H	270	6	P	-	PPo	4,430	188M	Nov. 1969	S	10D	0	S	
10bcc-1	do	1965	H	320	6	X	-	-	4,640	Dry R	1965	N	0R	-	U	
10bdc-1	E. Peterson	1909	-	100	6	-	-	-	4,600	-	-	N	-	-	U	
19ddc-1	Holmgren Land and Livestock Co.	1968	C	469	6	P	L	PPo	4,648	434R	May 1968	S	4D	5	S	D
31dcb-1	do (6/)	1948	-	514	-	-	-	PPo 7/	4,280	-	-	N	-	-	U	
(B-13-6)																
5bad-1	R. H. Stewart	1922	-	370	4	-	-	-	5,120	290R	1922	N	24R	10	U	D
17ccc-1	S. O. Bernard	-	C	470	4	-	S	-	4,850	430R	June 1958	S	5D	-	H	C
18ccc-1	E. Rinderknecht	-	-	300	6	P	-	-	4,840	300R	-	N	.5R	-	U	D
18d	-	-	-	265	-	-	-	-	4,860	-	-	N	-	-	-	
19ccc-1	E. J. Zollinger	-	-	350	-	-	-	-	4,850	325R	Feb. 1936	P	2R	-	H	
30bbc-1	A. H. Abrams	-	-	286	6	O	-	-	4,870	274M	Oct. 1969	N	6R	-	U	
30cbb-1	E. B. Mitchell	-	C	365	6	P	-	-	4,930	330R	Oct. 1969	S	20R	0	H	C
(B-13-7)																
2ccc-1	W. D. Holmgren	1938	-	321	4	-	I	-	4,920	90R	Jan. 1938	P	-	-	H	D
10dcd-1	M. B. Hansen	-	C	279	4	P	-	Tsl	4,880	261R	-	N	2R	-	U	
10ddc-1	do	1954	C	268	6	P	R	Tsl	4,840	220R	Oct. 1961	S	10D	4	S	C,D
14aaa-1	G. E. Ballard	(8/)	-	405	4	-	-	-	4,850	248R	1936	P	6R	-	H	C
23bcd-1	E. A. Zollinger	1914	-	250	8	-	-	-	4,780	155M	Oct. 1969	N	-	-	U	
24aad-1	A. R. Hupp	(9/)	-	303	6	O	-	-	4,840	256R	Mar. 1940	P	2	-	H	C
25cbb-1	E. Rinderknecht	-	-	-	5	-	-	-	4,850	235M	Oct. 1969	P	-	-	S	
27abb-1	Hansel Heights Farm Co.	1969	C	450	20	P	Y	-	4,760	133M	Oct. 1969	N	450R	-	I	D,W
34bad-1	W. Peterson	1934	C	120	8	F	-	-	4,650	39M	Oct. 1969	T	60D	40	S	
(B-13-8)																
35bbb-1	R. J. Brough	-	-	348	6	-	-	-	4,730	Dry M	Nov. 1969	N	-	-	U	
(B-14-6)																
6dbc-1	R. W. Tolman	-	-	220	-	-	-	-	5,800	Dry R	1957	N	0R	-	U	
21cba-1	L. Reese	1912	-	306	6	P	-	-	5,340	270R	1946	P	3D	-	H	
28aca-1	Doris Allen	-	-	250	-	-	B	Tsl	5,285	230R	Mar. 1936	P	15R	5	H	D
28dbc-1	Lynn Allen	-	-	250	6	-	-	-	5,270	-	-	P	7R	-	H	
31baa-1	M. V. Francom	1928	-	380	4	-	S	-	5,190	340R	-	P	-	-	S	
33abb-1	Lynn Allen	1922	-	190	6	X	-	-	5,270	155R	1922	N	1R	-	S	
(B-14-7)																
22dcd-1	J. W. Ward, Jr.	1959	C	485	12	P	R	-	5,030	120R	July 1959	T	400D	300	I	D
30dbb-1	D. Holmgren	-	-	180	2	-	-	-	5,800	-	-	P	.3	-	S	C

1/ Oil test drilled for Utah Southern Oil Co.
2/ Consolidated rocks of Pennsylvanian age from surface to 3,580 feet (Peace, 1956, p. 23).
3/ Originally drilled as water supply for Utah Southern Oil Co.
4/ Drilled before 1915.
5/ Well being drilled in November 1969.
6/ Oil Test drilled for Mohawk Petroleum Co.
7/ Drilling stopped in rocks of Pennsylvanian-Permian age. Top of consolidated rocks not recorded.
8/ Drilled before 1907. "State well" of Carpenter (1913, p. 57).
9/ Drilled before 1925.

Table 7.—Selected drillers' logs of wells

Altitudes are in feet above sea level for land surface at well; south of lat. 41°45', interpolated from U.S. Geological Survey 7½-minute topographic maps; north of lat. 41°45' interpolated from U.S. Geological Survey 1:250,000 series topographic map. Most locations checked with surveying altimeter.
Thickness in feet.
Depth in feet below land surface.

Material	Thickness	Depth
(B-9-7)6dac-1. Log by M. L. Davis. Alt. 4,338 ft.		
Soil	5	5
Clay, yellow	15	20
Clay and gravel	20	40
Lime hard	25	65
Gravel, small; no water	10	75
Gravel, white	35	110
Hardpan	10	120
Gravel, white; water	13	133
Clay	2	135
Perforated 120-133 ft.		
(B-9-7)16aaa-1. Log by C. D. Bishop. Alt. 4,289 ft.		
Clay, dark brown	18	18
Gravel, gray	4	22
Clay, gravel, and hardpan; water at 55 ft	41	63
Clay, brown	7	70
Clay, gravel, and hardpan, brown	12	82
Clay, brown	2	84
Clay, gravel, and hardpan, light brown	31	115
Clay, brown	5	120
Clay, gravel, and hardpan, light brown	15	135
Clay, light brown	3	138
Clay, gravel, and hardpan, tan	7	145
Clay, tan	7	152
Clay, gravel, cobbles, and hardpan, light brown	34	186
Clay, tan	12	198
Sand and gravel, light brown	4	202
Clay, tan	6	208
Sand and gravel, light brown	7	215
Clay and thin strata of gravel	40	255
Gravel, light brown	3	258
Clay and sand	2	260
Clay and gravel in layers	37	297
Sand, light brown	2	299
Clay and sand, hard	2	301
Silt and sand, dark brown	2	303
Clay and gravel in layers	7	310
Sandstone, light gray	20	330
Clay, sand, and sandstone, white, in layers	8	338
Clay and sandstone, white	9	347
Clay and sandstone, gray	32	379
Limestone, white	8	387
Clay, sticky, white	6	393
Sandstone, brown	4	397
Clay, sticky, brown	10	407
Sandstone, brown	2	409
Clay, sticky, white	6	415
Limestone, light brown	7	422
Bedrock, gray	8	430
Clay, sticky, dark brown	9	439
Clay, sticky, light gray	10	449
Limestone, white	3	452
Boulders and conglomerate, loose	5	457
Clay and hardpan, white	29	486
Clay, hardpan, and conglomerate, hard, black	6	492
Bedrock, very hard, gray	18	510
Perforated 115-330 ft.		
(B-9-7)16bcb-1. Log by L. H. Stoddard. Alt. 4,288 ft.		
Clay	46	46
Hardpan	2	48
Clay	26	74
Gravel	11	85
Screen installed at 74-85 ft.		
(B-10-7)19ccc-1. Log by J. H. Peterson. Alt. 4,369 ft.		
Clay, sandy	46	46
Boulders	19	65
Clay, volcanic	51	116
Basalt, black	20	136
Clay, volcanic	31	167
Wash, porous volcanic; water	8	175
Basalt, broken, black and brown; possibly water	37	212
Clay, red and blue	43	255
Cased to 129 ft.		
(B-10-8)1cba-1. Log by L. H. Stoddard. Alt. 4,273 ft.		
Soil	5	5
Boulders	17	22
Clay and gravel	38	60
Gravel	11	71
Clay	27	98
Gravel	12	110
Clay and gravel	20	130
Clay	26	156
Gravel, large	14	170
Screen installed at 160-170 ft.		
(B-10-8)13cbd-1. Log by Davis Drilling Co. Alt. 4,456 ft.		
Soil	10	10
Clay, white	10	20
Gravel, mixed with clay	60	80
Clay, sandy	30	110
Clay, white	50	160
Clay and gravel	20	180
Limestone, hard	20	200
Gravel with clay	40	240
Clay, white, with small rocks	20	260
Hardpan	9	269
Gravel, small; water	13	282
Clay	4	286
Water stood at 235 ft.		
Perforated 270-284 ft.		
(B-10-8)26adb-1. Log by David Musselman. Alt. 4,338 ft.		
Clay, white	137	137
Hardpan	5	142
Gravel, fine; warm and salty water	12	154
(B-10-8)33bba-1. Log by Cache Valley Drilling Co. Alt. 4,239 ft.		
Clay, gray	59	59
Gravel, cobbles, and boulders of lava.	8	67
Boulders of lava	1	68
Water reported to be very salty.		
(B-11-7)2ccc-1. Log by R. J. Howell Alt. 4,563 ft.		
Clay, gravel, and rock	10	10
Clay, hard	30	40
Boulders	5	45
Clay, white	20	65
Gravel, dry, water-laid, pea	7	72
Clay, brown	10	82
Clay, white, with rock	7	89
Hardpan, white, lime	11	100
Clay and gravel	20	120
Clay, yellow	10	130
Clay, hard, brown	17	147
Gravel, fine	3	150
Clay, brown	10	160
Clay, yellow	15	175
Clay, brown, sandy	25	200
Hardpan	5	205
Clay and gravel	15	220
Bentonite	100	320
Clay, brown	20	340
Shale	5	345
Clay, hard, brown	10	355
Cobbles, small; water	6	361
Clay, hard, red	6	367
Perforated 337-367 ft.		
(B-11-7)8bdc-1. Log by Valley Drilling Co. Alt. 4,375 ft.		
Clay, gray	47	47
Clay and pea gravel	20	67
Clay, gray	34	101
Sand, greenish	63	164
Silt	7	171
Sand and fine gravel; a little water	4	175
Sand; plenty of water	57	232
Clay, white, chalky	3	235
Perforated 171-230 ft.		
(B-11-7)35bcd-1. Log by R. J. Howell. Alt. 5,079 ft.		
Clay	25	25
Gravel, cemented	3	28
Clay and gravel	14	42
Cobbles	3	45
Lime	10	55
Gravel and boulders; water	4	59
Gravel, hard, cemented	11	70
Gravel, fine; water	4	74
Sand and fine gravel	23	97
Lime, white	3	100
Clay, white, and lime	10	110
Clay, brown	5	115
Gravel, coarse; water	7	122
Gravel, fine; water	4	126
Clay, white, warm	6	132
Perforated 55-59, 70-97, and 116-127 ft.		
(B-11-7)35cbd-1. Log by M. Church Drilling Co. Alt. 5,030 ft.		
Conglomerate	16	16
Clay and silt; seepage at 16 ft	8	24
Sand and hardpan	26	50
No record	4	54
Clay	19	73
Volcanic glass; water at 73-74 ft	17	90
Lime rock	13	103
(B-11-7)35cbd-1 - Continued		
Volcanic glass	24	127
Conglomerate	29	156
Bedrock	134	290
Cased to 156 ft.		
(B-12-8)3ddb-2. Log by Siaperas Drilling Co. Alt. 4,430 ft.		
Sand	32	32
Sand and gravel	12	44
Gravel	12	56
Conglomerate, hard, packed, cemented	89	145
Bedrock(?)	65	210
Hardpan	14	224
Silt, gray; water	9	233
Rock, broken	37	270
Well reportedly produced warm saline water. Perforated 250-270 ft.		
(B-12-8)19ddc-1. Log by Keith McKenzie. Alt. 4,648 ft.		
Soil	6	6
Clay, gray, and gravel	26	32
Clay, tan, and gravel	18	50
Clay, gray, and gravel	7	57
Sand and gravel, gray, packed	12	69
Conglomerate, hard	4	73
Sand and gravel, packed; 90 percent sand	24	97
Sand and gravel, gray, packed	24	121
Gravel and tan clay; 10 percent clay	52	173
Gravel and brown clay; 10 percent clay	11	184
Conglomerate, hard, brown	6	190
Gravel and brown clay; 10 percent clay	37	227
Gravel and tan clay; 20 percent clay	13	240
Conglomerate, gravel, and clay in alternating strata	51	291
Conglomerate, hard	24	315
Conglomerate and gravel in alternating strata	45	360
Gravel and brown clay, packed; 10 percent clay	50	410
Gravel and tan clay, packed; 10 percent clay	26	436
Rock, black, broken (not smooth)	33	469
Well cased to 464 ft.		
Perforated 441-460 ft.		
(B-13-7)2ccc-1. Log by J. P. Bosone Alt. 4,920 ft.		
Soil	18	18
Clay, yellow	275	293
Lava and boulders; water	28	321
Perforated 290-321 ft.		
(B-13-7)10ddc-1. Log by M. L. Davis Alt. 4,840 ft.		
Clay	100	100
Rock	10	110
Sandstone	40	150
Clay, white	40	190
Gravel, cemented	10	200
Clay, sandy	25	225
Clay, red	25	250
Rock	5	255
Sand and gravel; water	7	262
Clay	6	268
Perforated 249-268 ft.		
(B-13-7)27abb-1. Log by Waymon Yarbrough. Alt. 4,760 ft.		
Soil, sandy, and some gravel	20	20
Sand and gravel	30	50
Clay	7	57
Sand and gravel, some clay	13	70
Gravel, hard, cemented	15	85
Gravel and clay	5	90
Gravel	15	105
Boulders	2	107
Clay and gravel	8	115
Gravel, heavy	5	120
Boulders	5	125
Clay	5	130
Boulders	5	135
Clay and gravel; first water	10	145
Gravel	20	165
Clay	5	170
Clay and gravel	20	190
Clay	10	200
Gravel and clay	10	210
Gravel	5	215
Clay and gravel	10	225
Clay	10	235
Gravel	10	245
Clay	5	250
Gravel	5	255
Clay	15	270
Gravel	5	275

Table 7.—Selected drillers' logs of wells—continued

Material	Thickness	Depth
(B-13-7)27abb-1 - Continued		
Clay	5	280
Gravel	5	285
Clay	15	300
Gravel	5	305
Clay	5	310
Clay and gravel	10	320
Gravel and sand	15	335
Clay	5	340
Gravel	5	345
Clay	12	357
Gravel	3	360
Clay	5	365
Clay, sticky	10	375
Gravel	5	380

Material	Thickness	Depth
(B-13-7)27abb-1 - Continued		
Clay	10	390
Gravel	5	395
Clay	3	398
Boulders	2	400
Clay	15	415
Clay and gravel	10	425
Clay	5	430
Gravel	12	442
Clay, soft	5	447
Clay, hard	3	450
Drill cuttings exposed in bailer dump consist mainly of brown clay or silt with a little gravel or gray limestone. Perforated 145-450 ft.		

Material	Thickness	Depth
(B-14-7)22dcd-1. Log by T. J. Burkhart. Alt. 5,030 ft.		
Soil and gravel	3	3
Clay (hardpan)	3	6
Clay with some sand and gravel	66	72
Gravel and some brown clay	170	242
Sandstone, light brown	2	244
Gravel and some brown clay	81	325
Gravel and sandy brown clay	48	373
Gravel and sand, dark brown	3	376
Gravel and some light brown clay	109	485
Gravel below 72 ft. was lava. Most water seemed to be in small seeps below 137 ft. Perforated 137-485 ft.		

Table 8.—Records of springs

Location: See appendix for description of well- and spring-numbering system used in Utah.
Altitude: In feet above mean sea level. South of lat. 41°45' interpolated to nearest foot from U.S. Geological Survey 7½-minute topographic maps. North of lat. 41°45' interpolated to nearest 10 feet from U. S. Geological Survey 1:250,000 series topographic map.
Aquifer: Lithology - A, alluvium; B, unclassified consolidated sedimentary rock; JB, fractured unclassified consolidated sedimentary rock; JI, jointed and fractured basalt; Q, lake-bottom silt and clay; V, sandstone; VC, semiconsolidated conglomerate and sandstone; ZL, strongly weathered limestone. Age - G, Pennsylvanian-Permian; Q, Quaternary; QR, Holocene; T, Tertiary; TP, Pliocene; Y, Paleozoic.
Discharge: E, estimated; R, reported.
Temperature: See appendix for equivalent temperature in °F.
Use of water: H, domestic; I, irrigation; S, stock; U, unused; (a), spring improved for indicated use.
Other data available: C, chemical analysis in table 9.

Location	Name or owner	Altitude (feet)	Aquifer: Lithology	Aquifer: Age	Discharge (gpm)	Date of measurement	Temperature (°C)	Use of water	Other data available
(B-9-8)9ddbs-1	-	4,199	JI	T	(1/)	Nov. 1969	-	U	-
(B-11-7)26caaS-1	M. V. W. Johnson	5,330	ZL	QR	-	-	-	H,S(a)	-
27addS-1	-	5,075	A	Q	1.0E	Nov. 1969	12.5	S(a)	C
34dbbS-1	Cedar Spring	4,885	V	TP	.5E	Nov. 1969	12.0	S(a)	C
35ccbS-1	W. B. Hendrix	4,985	-	-	2.0R	-	-	I,S(a)	-
(B-11-8)27cbbS-1	-	4,204	-	Q	-	-	-	U	-
33adaS-1	-	4,201	-	Q	-	-	-	U	-
33adcS-1	-	4,209	-	Q	-	-	-	U	-
(B-11-9)2dbdS-1	-	4,206	-	(2/)	-		-	U	-
10aaaS-1	-	4,203	JB	G	45E	Aug. 1963	17.5	U	C
10aacS-1	-	4,203	-	(2/)	-	-	-	U	-
10adaS-1	-	4,199	-	(2/)	400E	Aug. 1963	-	U	C
10adbS-1	-	4,199	-	(2/)	190E	Aug. 1963	-	U	C
11bbaS-1	-	4,201	-	(2/)	-	-	-	U	-
11bbaS-2	-	4,201	-	(2/)	-	-	-	U	-
11bbaS-3	-	4,201	-	(2/)	-	-	-	U	-
(B-12-7)21bcaS-1	Holmgren Land and Livestock Co.	4,250	-	(2/)				I,S	-
21cadS-1	Salt Wells Sp 1	4,250	-	(2/)	(3/)	-	-	I,S	-
21cadS-2	Salt Wells Sp 2	4,250	-	(2/)	-	-	-	I,S	C
21cadS-3	Salt Wells Sp 3	4,250	-	(2/)	-	-	-	I,S	-
21cdaS-1	Salt Wells Sp 4	4,250	-	(2/)	-	-	-	I,S	-
28abbS-1	Holmgren Land and Livestock Co.	4,245	Q	QR	-	-	-	U	-
(B-12-8)23ddcS-1	-	4,226	Q	QR	25E	Oct. 1969	11.5	U	C
26ddcS-1	Bureau of Land Management	4,228	Q	QR	-	-	-	S	-
26bbdS-1	-	4,228	Q	QR	-	-	-	U	-
27cccS-1	-	4,228	Q	QR	-	-	-	U	-
27dbbS-1	Bureau of Land Management	4,228	Q	QR	-	-	-	S	-
(B-13-7)3ccaS-1	Old Iron Spring	5,100						S	-
4dbcS-1	Holmgren Land and Livestock Co.	5,300	B	Y	-	Oct. 1967	12.0	S	C
9acdS-1	do	5,300	B	Y	-	-	-	S	-
34ccaS-1	Bureau of Land Management	4,560	VC	T	-	Nov. 1969	10.0	S(a)	C
(B-14-7)27bacS-1	Dillies Spring	5,180	B	Y	15R	July 1958	-	I,H,S(a)	C
34dccS-1	Holmgren Land and Livestock Co.	5,170	B	Y	-	-	-	S	-

1/ Discharges in seepage area on lakeshore near basalt outcrop.
2/ Rocks at point of discharge are depressions in lake-bottom silt and fine sand, but proximity of outcrops of consolidated rocks of Paleozoic age suggest that probable source of spring water is fractured or cavernous zones in the consolidated rock.
3/ Total discharge from Salt Wells Spring group reported to be about 4 cfs (1,800 gpm).

Table 9.—Chemical analyses of water from wells, springs, and streams

Location: See appendix for description of well- and spring-numbering system used in Utah. System also is used for locating other hydrologic sites in the land net. Station number is the standard U.S. Geological Survey number for surface-water sites.
Temperature: See appendix for equivalent temperature in °F.
Sodium and potassium: Where no value is given for potassium, sodium (Na) plus potassium (K) values are reported as sodium.
Dissolved solids: Residue on evaporation at 180°C, except c, calculated (sum of determined constituents); e, estimated from specific conductance.
Specific conductance: f, field determination.

Location No. or name	Date of collection	Temperature (°C)	Milligrams per liter													Sodium-adsorption ratio	Specific conductance (micromhos/cm at 25°C)	pH	Density
			Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$	Noncarbonate hardness as $CaCO_3$				
WELLS AND SPRINGS																			
(B-10-8)13cbd-1	11-28-69	18.0	56	184	265	1,850		187	0	620	3,340	76	7,060	1,550	1,400	21	10,500	8.0	1.000
(B-11-7)8bdc-1	11-28-69	16.0	52	9.6	53	511		280	0	102	710	18	1,630	240	10	14	2,770	8.2	-
27addS-1	11-28-69	12.5	-	-	-	-		-	-	-	-	-	800e	-	-	-	1,170f	-	-
34dbbS-1	11-28-69	12.0	56	232	92	202		214	0	131	762	16	1,910	960	785	2.8	2,740	7.8	-
(B-11-9)10aaaS-1	8-27-63	17.5	-	-	-	-		-	-	-	28,940	-	52,400	4,250	-	-	66,200	-	1.030
	10-10-67	-	14	421	796	16,200	564	118	0	1,910	28,200	27	1/51,500	4,320	4,230	107	61,100	7.4	1.031
10adaS-1	8-27-63	-	-	-	-	-		-	-	-	-	-	94,400	-	-	-	103,000	-	1.058
10adbS-1	8-27-63	-	-	-	-	-		-	-	-	45,900	-	83,500	6,020	-	-	94,100	-	1.050
(B-12-6)18aab-1	11-26-69	-	28	38	23	272		291	0	51	342	8.8	914	190	0	8.6	1,580	7.9	-
(B-12-7)21cadS-2	11-27-69	-	24	96	88	1,270		258	0	105	2,150	1.0	4,020	600	388	22	6,670	8.1	-
(B-12-8)23ddcS-1	10-15-69	11.5	25	216	131	3,310		322	0	240	5,500	0	10,300	1,080	816	44.0	14,900	7.9	1.003
(B-13-6)17ccc-1	10-15-69	-	66	44	34	106		306	0	117	70	15	604	252	1	2.9	884	7.9	-
30cbb-1	10-15-69	-	62	64	44	90		176	0	68	220	12	708	340	196	2.1	1,080	7.8	-
(B-13-7)4dbcS-1	10-10-67	12	43	91	21	61	6.9	250	0	34	160	2.4	2/610	316	111	1.5	920	7.5	-
10ddc-1	10-15-69	-	37	71	51	69		270	0	66	165	14	618	384	163	1.5	1,010	8.0	-
14aaa-1	10-23-11	-	46	74	22	58		180	8	27	146	8.0	3/543	275	114	1.5	-	-	-
24aad-1	11-26-69	15.0	63	96	31	77		220	0	104	166	14	731	368	188	1.7	1,070	7.6	-
34ccaS-1	11-29-69	10.0	46	321	182	123		296	0	502	740	9.2	2,560	1,550	1,310	1.4	3,330	7.9	-
(B-14-7)27bacS-1	1911	-	-	-	-	70		225	0	30	110	-	450c	225	41	2.0	-	-	-
	10-15-69	-	-	-	-	-		-	-	-	-	-	400e	-	-	-	605f	-	-
30dbb-1	10-11-67	13.0	17	122	65	57	4.1	248	0	50	315	4.5	4/960	570	367	1.0	1,410	7.5	-
SURFACE WATER																			
Hansel Valley Creek near Snowville: 10-1729.77 West distributary (B-12-8)34ccc	5/4-24-64	9.5	-	-	-	-	-	-	-	447	14,500	-	26,400	2,040	-	-	35,800	-	1.012
10-1729.78 Middle distributary (B-11-8)2cab	6/4-24-64	8.5	-	-	-	-	-	-	-	182	4,230	-	7,860	680	-	-	12,700	-	1.000
10-1729.79 East distributary (B-11-8)2cad	6/4-24-64	8.5	-	-	-	-	-	-	-	222	4,690	-	8,430	660	-	-	13,700	-	1.001

1/ Analysis includes 2.0 mg/l fluoride (F), 5.7 mg/l boron (B), 48 mg/l bromide (Br), 0.32 mg/l iodide (I), and 4.9 mg/l lithium (Li). Spectrographic analysis of trace elements available in files of U.S. Geological Survey, Salt Lake City.
2/ Analysis includes 0.4 mg/l fluoride (F), and 0.06 mg/l boron (B).
3/ Analysis includes 0.20 mg/l iron (Fe).
4/ Analysis includes 0.5 mg/l fluoride (F) and 0.09 mg/l boron (B).
5/ Discharge 1.0 cfs.
6/ Discharge 1.5 cfs.

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