Water-Supply and Irrigation Paper No. 157

Series { B, Descriptive Geology, 86
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DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

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IN THE

VALLEYS OF UTAH LAKE AND JORDAN RIVER, UTAH

BY

G. B. RICHARDSON

WASHINGTON
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WASATCH MOUNTAINS FROM LIBERTY PARK, SALT LAKE CITY.

Lake in foreground is supplied by artesian wells.

UNDERGROUND WATER IN THE VALLEYS OF UTAH LAKE AND JORDAN RIVER, UTAH.

By G. B. Richardson.

INTRODUCTION.

The valleys of Utah Lake and Jordan River are situated in north-central Utah, in the extreme eastern part of the Great Basin. The lofty Wasatch Range (Pl. I), the westernmost of the Rocky Mountain system, limits the valleys on the east, and relatively low basin ranges—the Oquirrh, Lake, and East Tintic mountains—determine them on the west. The valleys trend north and south, and are almost separated by the low east-west Traverse Range, the slopes of which constitute a dam for Utah Lake, which drains through Jordan River to Great Salt Lake.

The area under consideration is the most populous and flourishing part of the State. Salt Lake City and Provo, the first and third cities in the State, and many other thriving settlements are there located. At Bingham Junction and Murray a number of smelters treat the ores from near-by mines, but agriculture is the main industry. Water for irrigation is supplied by mountain streams, and intensive farming is successfully pursued. The practice of irrigation was begun by the Mormon pioneers in 1847, and has been discussed in several publications; little attention, however, has been given to the underground water resources, and, so far as the writer is aware, they have not before been described. The present paper outlines conditions of occurrence of the subterranean waters and describes their development in the valleys of Utah Lake and Jordan River.

TOPOGRAPHY AND DRAINAGE.

The drainage area of Utah Lake and Jordan River is approximately 3,300 square miles, of which 2,600 are tributary to Utah Lake and 700 to the Jordan north of the Traverse Mountains (Pl. II). About 2,000 square miles of the watershed are in the Wasatch Mountains, while the valleys themselves cover a little less than 1,000 square miles. Utah Lake Valley is about 38 miles long, averages 15 miles in width, and occupies about 560 square miles, including Utah Lake. Jordan Valley is approximately 28 miles long, 15 miles wide, and comprises 420 square miles. These valleys in late geologic time were occupied by Lake Bonneville, the Pleistocene predecessor of Great Salt Lake, and to that fact is due their characteristic topography. Almost flat unconsolidated lake sediments underlie the broad valleys, the borders of which are marked by a unique series of terraces that characterize the shore lines of the old lake. Descriptive details of these features will be given in the sections devoted to geology and to the occurrence of underground water.

The range in elevation is considerable. The present level of Great Salt Lake is approximately 4,210 feet above the sea, and that of Utah Lake is about 4,480 feet. From these lowest elevations the two valleys rise to their outer borders, which may conveniently be taken as the highest level occupied by Lake Bonneville, at approximately the 5,200-foot contour, above which the Wasatch Range towers up to 12,000 feet. The mountains on the west are narrow north-south ranges that rise abruptly from broad valleys. The

Oquirrh Mountains, west of Jordan River, are 30 miles long, 5 to 10 miles wide, and their summits rise to elevations of about 10,000 feet. The Lake Mountains, west of Utah Lake, are about 15 miles long, 5 miles wide, and 3,000 feet above the lake. They are connected by low hills with the Oquirrh Mountains on the north and with the East Tintic Mountains on the south. The East Tintic Mountains border Utah Lake Valley on the southwest, rising above it about 3,000 feet. A spur from these mountains extends northeastward, constituting the southern border of Utah Lake Valley, and almost unites with the Wasatch Range. The steep western face of the Wasatch Mountains rises about 7,000 feet abruptly above the broad valley and constitutes the dominant topographic feature of the region. To the east the range slopes away gradually in a series of broad ridges and narrow valleys to the mountainous plateau region. The western scarp is deeply dissected by canyons, through which the entire Wasatch drainage flows to Great Salt Lake, the chief streams being Bear, Weber, and Jordan rivers.

Utah Lake is a body of shallow water about 21 miles long and 7 miles wide (Pl. III, *A*), covering a maximum area of 93,000 acres. Its depth over much of its extent is only 8 feet or less, and the maximum depth in the main body of the lake is about 13 feet. In its northwestern part, however, recent soundings have revealed the presence of several deep holes, due to springs (p. 49). The shore line of the lake is subject to considerable variation, owing to the changing relations of evaporation, precipitation, and inflow, and the margins are characteristically swampy. Two large, shallow bays extend eastward and southward from the main body of the lake, one south of Provo and the other north of Goshen. West of the lake the Pelican Hills approach close to the shore, and the region is barren, but on the north, east, and south the land rises gently toward the base of the mountains and is dotted with flourishing settlements which are supported by irrigation.

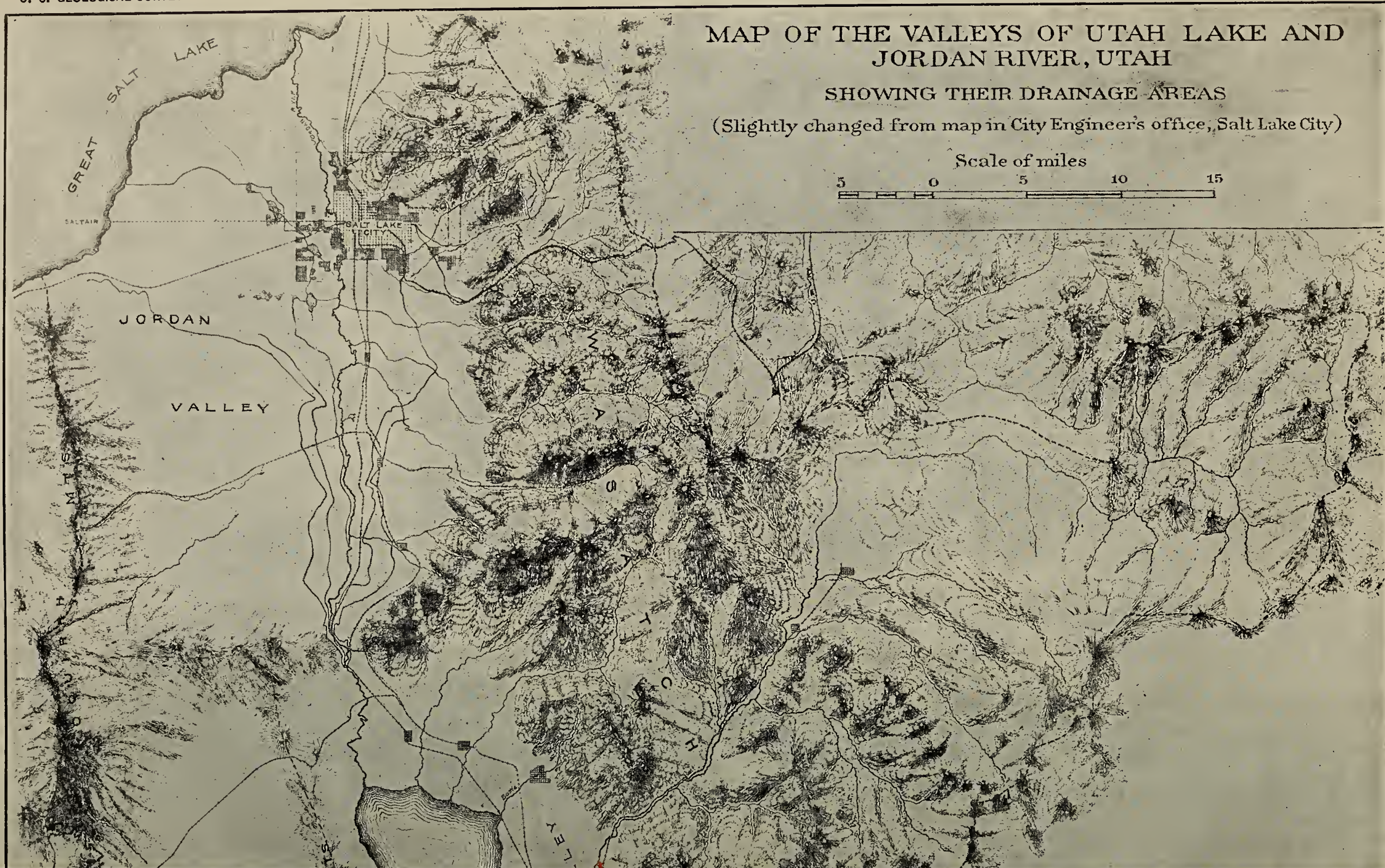
The principal streams tributary to Utah Lake, beginning at the north and proceeding southward, are: Dry, American Fork, Battle, and Grove creeks, Provo River, Hobble Creek, Spanish Fork, and Peteeneet, Santaquin, and Currant creeks. Of these, Provo River is the largest, being approximately 70 miles long and having a drainage area of 640 square miles. It rises in the Uinta Mountains near the sources of Weber, Bear, and Du Chesne rivers, flows westward and southward through Kamas and Provo valleys, and passes through the Wasatch Mountains in a deep canyon. On entering Utah Lake Valley Provo River flows almost due south for 5 miles, skirting the great Provo delta, and thence westward, entering Utah Lake about 3 miles west of Provo.

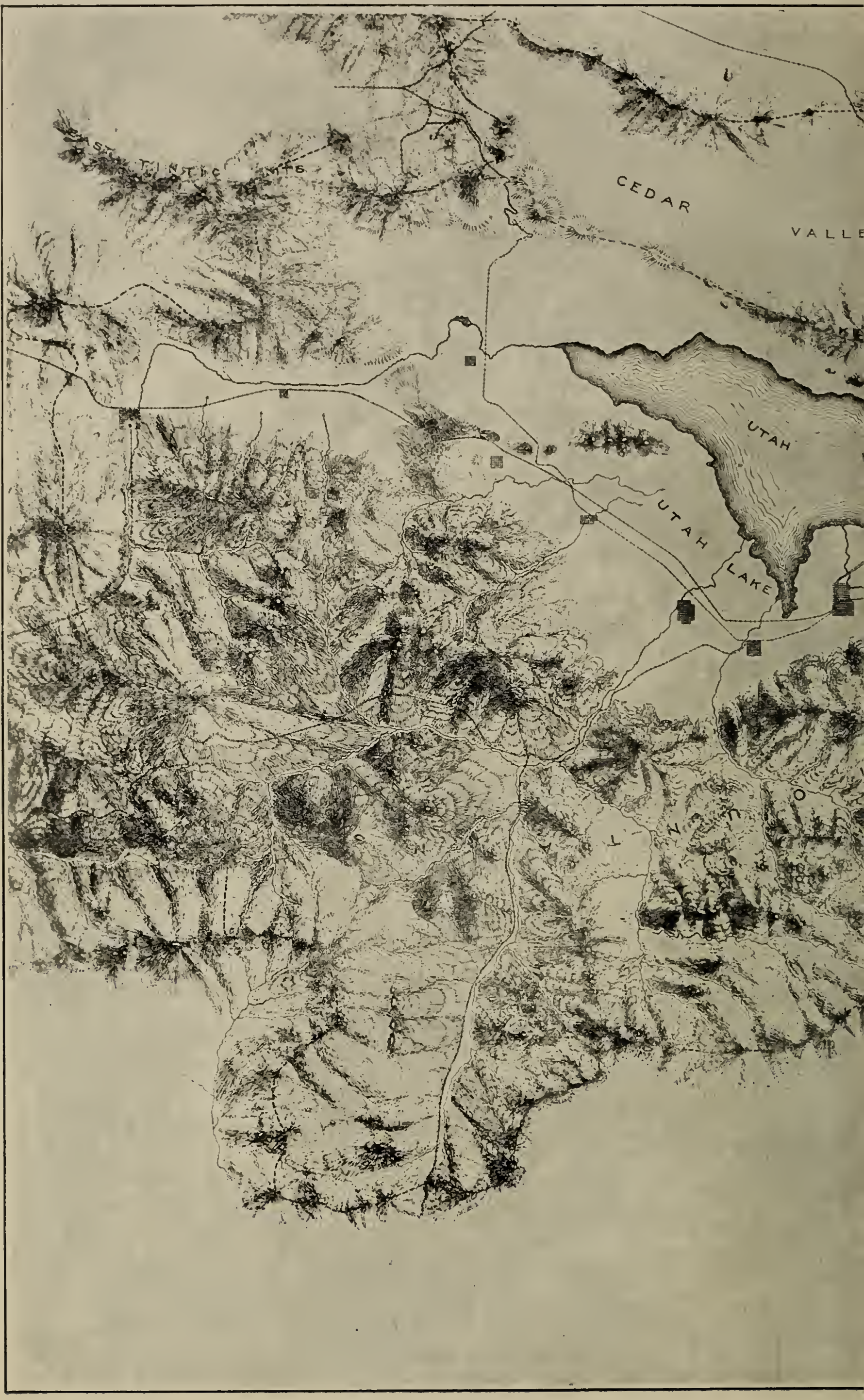
Spanish Fork has a watershed about equal to that of Provo River, but not so great a discharge. It rises near Soldier Summit, and, after receiving two main tributaries, North and Thistle creeks, flows in a canyon through the main ridge of the Wasatch Mountains and enters Utah Lake Valley at the head of the large embayment that extends between Payson and Springville.

Salt Creek rises in the southern Wasatch Mountains, on the eastern slope of Mount Nebo, and, after crossing the border of the plateau region, emerges into the broad valley at the southwestern base of the Wasatch Mountains where, in summer, it ceases to flow at the surface. The drainage way continues, in a narrow canyon, through Long Ridge which partially connects the East Tintic and the Wasatch mountains, and enters the southern end of Utah Lake in Goshen Valley, where the stream, which is fed largely by seepage, is known as Currant Creek.

The other tributaries of Utah Lake are relatively small. The chief ones rise in the Wasatch Mountains and occupy canyons in their mountain courses, where they maintain perennial flows. At the mouths of the canyons canals divert the water and distribute it over the valley, so that in the irrigation season practically all of the available supply is thus used and the beds of the streams in Utah Lake Valley are commonly dry; but in the late spring and early summer, during the period of melting snow, large volumes are discharged directly into the lake.

Jordan River heads at the northern end of Utah Lake and flows northward in a meandering course of about 40 miles to Great Salt Lake. For the first 5 miles the river flows slug-


MAP OF THE VALLEYS OF UTAH LAKE AND JORDAN RIVER, UTAH
SHOWING THEIR DRAINAGE AREAS
(Slightly changed from map in City Engineer's office, Salt Lake City)
Scale of miles
5 0 5 10 15
GREAT SALT LAKE
SALTAIR
SALT LAKE CITY
JORDAN
VALLEY
WASATCH
OQUIRRH MTS


TINTIC MTS
CEDAR
VALLE
UTAH
UTAH LAKE

gishly in a broad valley, and in that distance falls only about 10 feet. In the "narrows," however, the river occupies a constricted channel and descends rapidly; in the first mile below the intake of the canals its fall amounts to about 70 feet. Below the "narrows" the valley spreads out and at its greatest width is about 18 miles wide. The country rises gradually toward the adjacent highlands to the base of the terraces that mark the shore lines of Lake Bonneville, whence the ascent is by successive steps. Between Salt Lake City and Great Salt Lake the topography is almost flat, and a number of small lakes of shifting outline occupy local depressions. As the shore of Great Salt Lake is approached there is a faint slope of the surface which becomes increasingly marshy. This area west of Salt Lake City in general is barren and desolate and the surface in many places is white with alkali. On the uplands, away from the lake, alkali is scarce, but the western part of the valley, because of the lack of water, suffers in comparison with the cultivated eastern part, which is supplied by streams from the Wasatch Mountains.

North of the Traverse Mountains the principal tributaries of Jordan River are City, Red Butte, Emigration, Parleys, Mill, Big Cottonwood, Little Cottonwood, Dry Cottonwood, and Willow creeks, all of which issue from the Wasatch. In their mountain courses these creeks generally occupy narrow canyons from which they emerge on the lowlands and flow in broad open valleys to the Jordan. Within the mountains they are all perennial streams, but at the mouths of the canyons their flow is largely diverted by irrigation ditches, so that, in the dryest part of the year, their lower courses are generally dry. They rise in the main crest of the Wasatch and have small watersheds, Big Cottonwood Creek, draining about 48 square miles, being the largest. This stream rises at the base of Clayton Peak, is fed by a number of small lakes, and discharges a considerable quantity of water through a narrow canyon (Pl. IV, *B*).

The vegetation is scanty. The valleys in their natural state are occupied by sagebrush, greasewood, and kindred desert plants, but wherever water is available there is a marked contrast, and the irrigated areas of these valleys rival in productiveness any in the country. Sugar beets are grown in quantity; alfalfa, potatoes, corn, etc., are common crops; and on the bench lands a variety of fruits are successfully cultivated. The mountains on the western border are generally barren; sagebrush and occasional cacti are the chief growths on the slopes, while scrub oak and stunted spruce and pine here and there grow in patches; the summits are usually bare. The Wasatch Mountains are more favored, but they do not support a heavy growth of trees. At the heads of the valleys scattering pine, juniper, mountain mahogany, and quaking aspen locally occur, and cottonwood, birch, and maple are often found near the stream beds. The slopes are commonly covered with underbrush in varying degrees of thickness, sagebrush and scrub oak being prominent.

GEOLOGY.

LITERATURE.

This area has been studied by prominent geologists and has inspired some classic works on American geology. King, Emmons, and Hague of the Fortieth Parallel Survey[a] interpreted the main features of the region, and Gilbert made it famous by his investigation of Lake Bonneville.[b] But although this interesting region lies contiguous to one of the main transcontinental routes and has been visited by many geologists, yet comparatively little detailed work has been done in it. Walcott[c] has studied the Big Cottonwood Cambrian section, G. O. Smith and G. W. Tower[d] have examined the Tintic district, J. E. Spurr[e] has

[a] King, Clarence, Systematic geology: Rept. Geol. Explor. 40th Par., vol. 1, 1872; Hague, Arnold, and Emmons, S. F., Descriptive geology: Ibid., vol. 2, 1877.

[b] Gilbert, G. K., Lake Bonneville: Mon. U. S. Geol. Survey, vol. 1, 1890.

[c] Walcott, C. D., Bull. U. S. Geol. Survey No. 30, 1886, p. 38.

[d] Tower, G. W., and Smith, G. O., Geology and mining industry of the Tintic district, Utah: Nineteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, p. 601.

[e] Spurr, J. E., Economic geology of the Mercur mining district, Utah. Sixteenth Ann. Rept. U. S. Geol. Survey, pt. 2, 1895, p. 343.

reported on the Mercur mines, and, more recently, work has been carried on in the Park City and Bingham mining districts by J. M. Boutwell.[a] The following sketch is mainly compiled from these reports.

DESCRIPTIVE GEOLOGY OF THE HIGHLANDS.

The Wasatch Mountains are composed of a complex mass of sedimentary, igneous, and metamorphic rocks that have been much folded and faulted. In age the rocks range from pre-Cambrian to Tertiary and constitute a thickness of about 50,000 feet. The following table shows in epitome the main Paleozoic divisions according to the Fortieth Parallel Survey:

Paleozoic section in the Wasatch Mountains.

System.	Formation.	Average thickness.
		Feet.
Carboniferous	Upper Carboniferous limestone (including Permian)	2,500 to 3,000
	Weber quartzites with a few thin beds of limestone	5,000 to 7,000
	Wasatch limestone	7,000
Devonian	Ogden quartzite	1,000 to 1,250
Silurian	Ute limestone	1,000 to 1,250
Cambrian	Big Cottonwood quartzite series (clay slates at top)	12,000
		30,000

The present mountains are the eastern part of a greater mass of rocks, the Wasatch Range having been raised by faulting several thousand feet higher than the western part of this mass, which now lies buried beneath the valley deposits. This great fault is the dominant structural feature of the region. The range rises abruptly 7,000 feet above the wide lowland at its base, where the streams, which in their mountain courses occupy deep-cut narrow gorges, flow in wide valleys. The fault cuts across the range regardless of the structure of the rocks, and the truncated mountain bases abut against the plain in marked alignment.

Beginning at the north and proceeding southward the following features may be noted: The spur that juts out from the Wasatch Mountains north of Salt Lake City marks the southern boundary of a series of pre-Cambrian rocks that constitute the crest and western flanks of the mountains to the northwest, almost as far as Ogden. These rocks for the most part consist of gneisses and mica-schists, considered to be of sedimentary origin, with which are associated quartzites, slates, and some igneous rocks. In general the strike is N. 20° W., and the prevailing dip is westerly at angles ranging from 15° to 20°. A great thickness of coarse Tertiary conglomerate lies high up on the northeastern flanks of the range, but at the southeastern end of the crystalline area Paleozoic sediments abut against the older series and dip southeastward.

An outlying mass of nearly horizontal coarse Tertiary conglomerate, composed chiefly of pebbles of limestone and quartzite, caps the spur of the mountains north of Salt Lake City and conceals the older sediments except along the western base of the spur, where the Wasatch limestone outcrops. A small isolated body of volcanic rock outcrops in the midst of the Tertiary area and is bisected by City Creek. The headwaters and upper course of City Creek lie in Paleozoic rocks, chiefly in the Weber quartzite and Wasatch limestone, which dip southeastward at angles varying from 30° to 65°. Across the divide a large area of flat-lying Tertiary rocks cap the disturbed Paleozoic series.

[a] Boutwell, J. M. Progress reports Park City mining district: Bull. U. S. Geol. Survey No. 213, 1903, pp. 31-40; No. 225, 1904, pp. 141-150; No. 260, 1905, pp. 150-153. Economic geology Bingham mining district: Prof. Paper U. S. Geol. Survey No. 38, 1905 (with a section on areal geology by Arthur Keith and an introduction on general geology by S. F. Emmons).

Between City and Big Cottonwood creeks the summit and western face of the mountains are occupied by an immense syncline striking nearly east and west. Its western end is terminated by the Wasatch fault, which cuts directly across the fold and exposes the structure so that it can be plainly seen from Jordan Valley. The axis of the syncline coincides approximately with the course of Emigration Creek. In detail, however, the structure is complicated by a number of relatively minor disturbances.

East of Salt Lake City upper Carboniferous and Permian strata, consisting chiefly of limestone, outcrop between City and Red Butte creeks, and dip southward, forming the northern limb of the syncline. Red Butte Canyon lies in Permo-Carboniferous rocks, but near the mouth of the canyon "Red Beds" outcrop and continue along its southern divide. The "Red Beds" consist chiefly of red shales and sandstones, aggregating over 1,000 feet in thickness and are overlain by thin-bedded, argillaceous limestones and shales of Jurassic age. These rocks occupy the center of the syncline, and outcrop in the valley of Emigration Creek.

South of Emigration Creek the summit and western face of the Wasatch Mountains are occupied by the southern limb of the syncline as far as Big Cottonwood Creek, and the succession of rocks mentioned above is repeated in reverse order. The dips generally are northward, but there are minor folds and faults.

Parleys Creek rises in the Cretaceous sandstone and conglomerate that, east of the main Wasatch ridge, lie unconformably upon the older rocks. After traversing this area it crosses a narrow belt of Red Beds and, for 5 miles above the mouth of its canyon, flows over calcareous and argillaceous Permo-Carboniferous rocks. Carboniferous strata occupy the divide between Parleys and Mill creeks, the latter of which flows for the greater part of its length in the Weber quartzites.

Between Mill and Big Cottonwood creeks the lower Paleozoic rocks outcrop. Big Cottonwood Creek exposes for 6 miles above the mouth of its canyon a great thickness of Cambrian strata, consisting of siliceous slates and quartzites; in the upper part of its course this creek crosses the Weber quartzite and Wasatch limestone, and heads in the crystalline rocks of Clayton Peak. Little is known of the occurrence of Silurian and Devonian sediments in this area. Their presence was recorded by the early surveys, but the little detailed work that has been done shows that in a few localities at least these systems do not appear to be represented by sediments.

Little Cottonwood Creek for about 8 miles from the mouth of its canyon flows through a crystalline area, and heads in Paleozoic strata and igneous rocks at the foot of Clayton Peak. The western base of the mountains extending north and south of Little Cottonwood Creek is occupied by a belt of schistose rocks about 10 miles long and averaging perhaps 1 mile in width. These rocks are of pre-Cambrian age and are over a thousand feet thick. They consist largely of quartzite, but include also slates and mica-schists, having an apparent steep western dip. Up Little Cottonwood Creek, beyond the pre-Cambrian area, lies a large body of granitic rocks, which forms high peaks north and south of the creek, and through which the stream flows for the greater part of its course. The Paleozoic sediments arch around this granitic area, dipping away from it to the north, east, and south, forming a dome the western part of which has been cut off by the Wasatch fault.

The age of the "Little Cottonwood granite" has been the subject of some discussion. It clearly cuts the pre-Cambrian rocks at the mouth of the canyon, but its relation to the Cambrian was not definitely determined by the early surveys, though the granite was thought to be of pre-Cambrian age. Recently, however, it has been shown [a] that the "granite" is an intrusive mass that cuts the Cambrian quartzite, though the age of the intrusion is not yet known.

Partial topographic connection between the Wasatch and Oquirrh ranges is maintained by the Traverse Mountains near the head of Jordan Valley, but this connection furnishes little information concerning the relations of the two main mountain masses, because the

[a] Emmons, S. F., Am. Jour. Sci., 4th ser., vol. 16, August, 1903, p. 139.

Traverse Mountains are largely composed of younger lavas, which conceal the rocks upon which they lie.

In the "narrows" where Jordan River flows through the Traverse Mountains, practically horizontal Pleistocene gravels, which form the great embankment at the point of the mountain, are unconformably underlain near the river level by fine-textured sediments that dip southeastward at an angle of 40°. The lower part of these sediments consists of light calcareous clay and the upper part of fine sand and gravel. No fossils were found, but the marked unconformity and the character of the material suggest that the age of the lower deposits is Tertiary.

East of Utah Lake the great Wasatch fault is impressively shown by the remarkable alignment of the base of the mountains extending from Spanish Fork Canyon to the Traverse Mountains in an approximately straight line, and by the abrupt rise of the mountains above the broad valley. Second and third lines of faulting, lying parallel to the main fault and east of it, are suggested by the topography, which rises steplike, with two intervening treads between the ascents, to the top of the main ridge, and by the unusual thickness of limestone exposed, which apparently requires repetition by faulting for the explanation of its occurrence.

In this part of the range a disturbed belt of rocks with prevailing steep westerly dips occurs along the western base of the mountains, beyond which the strata dip eastward at low angles and the summits of the main ridge are capped by limestone lying almost flat. The streams that cross the mountains, therefore, flow transversely to the strike of the rocks, in marked contrast to the creeks farther north, whose courses lie approximately parallel to the strike.

Excellent sections can be measured along the canyons, but very little detailed work has yet been done. The rocks in general are quartzite and limestone of Carboniferous age, but locally Cambrian sediments also occur. In Rock Creek Canyon, east of Provo, in the lower end of the gorge, the rocks are much disturbed and are complexly folded. Here a considerable thickness of white quartzite outcrops, overlain by a great mass of limestone. In a thin bed near the base of the limestone G. H. Girty obtained a few Cambrian fossils, and about 600 feet above, in massive gray limestone, the beds being apparently conformable, he found Lower Carboniferous fossils.

South of Hobble Creek easterly dips prevail from the base of the mountains as far as Spanish Fork, beyond which the range has been very little studied. It trends southwestward and terminates at Mount Nebo, the main mass of which is composed of steeply west-dipping limestone and subordinate quartzite of upper Carboniferous age. The highland farther south consists of a series of plateaus, which are underlain by low-lying Mesozoic and Tertiary rocks.

The highlands that border the valleys of Jordan River and Utah Lake on the west are for the most part composed of the same rocks that occur in the Wasatch Mountains, but the structural relations are completely hidden by the deep filling of the intervening valleys.

The Oquirrh Range is composed mainly of Carboniferous limestones and quartzites, which, in the southern part of the mountains, are folded into two parallel anticlines with an intervening syncline. The axes of folding are obliquely transverse to the topography, the range extending in a north-south direction while the structural trend is northwestward. The structure of the northern part of the mountains is little known, but the range is probably terminated by a fault. Rocks of Cambrian age are exposed locally by a fault in the vicinity of Mercur, and igneous rocks, both extrusive and intrusive, also occur. The intrusive rocks include both acidic and basic porphyries, which are conspicuous in the vicinity of the mining camps of Bingham and Mercur; the extrusive rocks, largely andesitic, occur principally along the eastern base of the range and in the Traverse Mountains.

The Lake Mountains, or Pelican Hills, west of Utah Lake, are composed of Carboniferous limestones and quartzites which constitute a low synclinal fold, and are separated from the Traverse Mountains by a narrow strip of Pleistocene deposits. A line of hills, composed chiefly of west-dipping limestone, separate the Lake Mountains from the East Tintic Range—the succeeding highland mass to the south. The northern end of these hills is capped by horizontal basalt with which light pumiceous tuff is associated.

The East Tintic Range, a complex mass of sedimentary and igneous rocks, forms the southwestern border of Utah Lake basin. As in Rock Canyon, the sediments consist of Cambrian quartzite and Carboniferous limestone in juxtaposition, indicating the absence of the Ordovician, Silurian, and Devonian. The main structure of the sedimentary rocks is synclinal, but these constitute a relatively small part of the outcrops, igneous rocks, rhyolite, andesite, monzonite, and basalt occupying most of the region. These are of both extrusive and intrusive origin, and are of Tertiary age. The low spur of the Tintic Mountains known as Long Ridge, which lies south of Goshen and connects with the Wasatch—save for a narrow Pleistocene strip south of Santaquin—consists of andesite in its southern part, while southeast-dipping Carboniferous limestones outcrop in the gorge of Currant Creek.

LATE GEOLOGIC HISTORY.

The above résumé implies for this region a complex geologic history which need not here be discussed. A statement of late geologic events will, however, add to a clearer understanding of the valley deposits in which the underground water is stored.

TERTIARY HISTORY.

After many thousands of feet of sediments had accumulated in Paleozoic and Mesozoic time, during which the general region was occupied by oceanic waters, profound continental uplift occured in early Tertiary time. Since then the ocean has not invaded the interior of the continent and during Tertrary time much of the Cordilleran region is believed to have been occupied by a number of lakes in which a considerable thickness of rocks accumulated. During the Eocene, according to the geologists of the Fortieth Parallel Survey, a great fresh-water lake occupied the Wasatch Mountain area, and toward the close of this epoch the mountains were finally uplifted and the relative depression of the Great Basin originated. The late Tertiary witnessed the formation of several lakes whose positions were determined by different crustal movements, and these lakes persisted with varying relations into the Pleistocene epoch. The end of Tertiary time was marked by further earth movements that divided the Great Basin area into two main depressions, following the bases of the recently uplifted Wasatch Mountains and the Sierra Nevada. In Quaternary time the bordering mountains were occupied by glaciers, and enormous lakes accumulated in the marginal depressions of the Great Basin. The two largest of these have been named after early explorers. Lake Lahontan covered an immense area in western Nevada and Lake Bonneville occupied a considerable part of western Utah and extended into adjacent parts of Nevada and Idaho.

QUATERNARY HISTORY.

The existence of Lake Bonneville is borne witness to by a number and variety of facts, chief of which are the remains of shore lines and shore deposits, and the great thickness of sediments that accumulated in the lake and that now constitute the valley floor. At its greatest extent the water of Lake Bonneville was approximately 1,000 feet above the present surface of Great Salt Lake. This large body of water abutted against the adjacent highlands and the outline of the lake was intricate. Deep bays and jutting promontories marked the shores, and lone mountains, partly submerged, stood out as islands.

The area considered in this report formed part of one of these bays. This—

was divided by a close stricture into an outer bay and an inner, the outer covering the valley of the Jordan River and the inner spreading over Cedar, Utah, and Goshen valleys and a part of Juab Valley. In the inner bay the Goshen Hills made two islands, and the Pelican Hills constituted one large and several small islands. Small estuaries occupied Emigration and Little Cottonwood canyons, connecting with the outer bay, and the inner bay sent an estuary into Provo Canyon.[a]

[a] Gilbert, G. K., Lake Bonneville: Mon. U. S. Geol. Survey, vol. 1, 1890, p. 103.

During the existence of Lake Bonneville sedimentation was practically continuous in its lowest depression, but toward the periphery oscillations of the water level alternately covered the lake deposits and exposed them to subaerial influences. Evidence of the earliest Pleistocene history of the Bonneville region is furnished by alluvial cones that extend nearly to the bottom of the basin. These are composed of detritus derived from the adjacent highlands under subaerial conditions and could not have been accumulated when the level of the lake was high. It is therefore concluded that at this early period in the history of the lake comparatively arid conditions prevailed, for the stage of a lake in a closed basin is determined by the relation of evaporation to water supply. It has also been determined that at this period of the history of the lake it had no outlet and that the time of duration of low water was relatively long.

Next succeeded a period of high water, when yellow clay, locally streaked with sand, was deposited in a large part of the lake. The base of the yellow clay has not been observed and good sections are rare, though an exposure 150 feet thick has been measured. The deposit locally extends to within 120 feet of the highest level attained by Lake Bonneville, but a study of the shore line shows that during the deposition of the yellow clay the water did not rise to the rim of the basin. In the lower part of the basin the yellow clay is unconformably overlain by a deposit of white marl, local streaks of alluvium occurring at the contact. The white marl is composed of a fine calcareous clay consisting of calcium and magnesium carbonates, microscopic siliceous organic remains, and fine clastic débris.

These facts imply (1) that after the deposition of the yellow clay the lake water subsided, (2) that the clay was eroded, and (3) that a second period of high water subsequently ensued when the white marl was deposited. The extent to which the waters subsided is undetermined, but the possibility of complete desiccation is suggested by the difference in character between the yellow clay and white marl. The extent of the second period of high water is determined by the highest shore line traceable along the adjacent mountain flanks. This level is approximately 1,000 feet above Great Salt Lake and is known as the Bonneville shore line. The lake then outflowed through Cache Valley into the Snake River basin.

The Bonneville shore line marks the highest stage of Lake Bonneville and the level of its initial outflow. Beneath this level the drainage channel was cut down by the outflow of the lake to a depth of approximately 375 feet. That the lake maintained its level at the stage of lowest outflow for a relatively long time is attested by the well-developed shore phenomena at the corresponding elevation. This stage determined the Provo shore line, so named from its great development near that town.

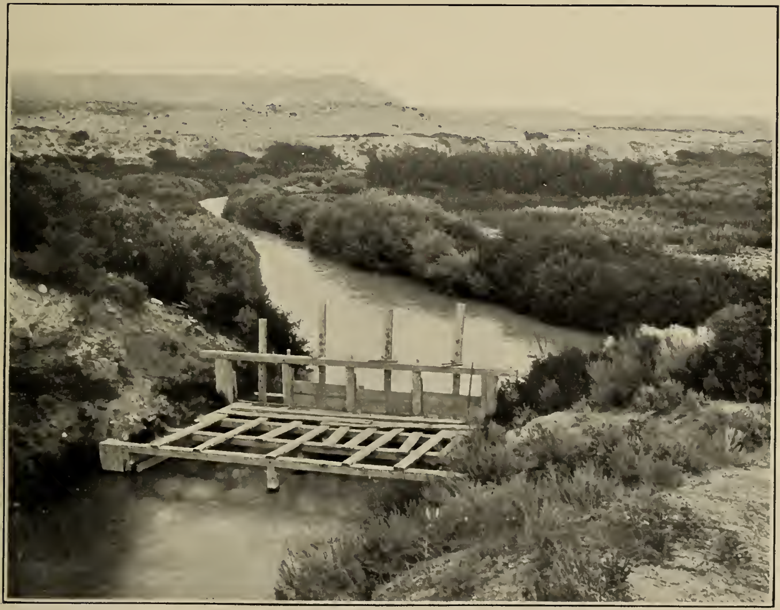
The present conditions have been brought about by the recession of the lake's surface, due to the excess of evaporation over inflow, so that now Great Salt, Utah, and Sevier lakes are the sole remnants of the former great body of water. The recession has uncovered the great expanse of lake beds that underlie the intermontane plains and constitute the fertile lands at the base of the Wasatch Mountains, and has also exposed the remarkable shore phenomena that testify to the history of Lake Bonneville, so completely worked out by Gilbert.

The Bonneville basin is preeminently characterized by its many shore lines (Pl. III, *B*), the highest of which impinges against the mountains and the lowest of which that can be recognized incloses the area covered by the lake sediments. Through a vertical interval of 1,000 feet the story of the rise and fall of this body of water is recorded by the superposition of shore line upon lake sediment and of lake sediment upon shore line. The record is not in all cases perfectly legible, but the main features are unmistakable.

The work of waves is recorded by cliffs and wave-cut terraces, from which the débris was carried along the shore to make benches, bars, spits, and terraces. The streams loaded with the waste of the land areas deposited their burdens in the lake, the coarser detritus being laid down near shore while the finer sand and clay were carried far out before sedimentation occurred. Deltas were formed at the mouths of the larger creeks where so much débris was carried that the shore currents could not distribute it. Since the recession of

A. NORTHERN END OF UTAH LAKE.

Oquirrh Mountains in background.



B. HEAD-GATE OF JORDAN AND SALT LAKE CITY CANAL, LOOKING SOUTH.

Embankment at point of the mountain in background.

the lake from its old shores the streams which formed the deltas have begun their destruction by cutting them in two in their progress toward the shrunken body of water.

The Bonneville is the most conspicuous of all the shore lines, not because of the relative duration of time during which it was formed but because being the topmost of the series, it emphasizes the contrast between the sharply carved subaerial erosion features of the main land and the broad horizontal lines due to the influence of the lake. Study of the levels of bars at this stage shows that the record is complex and that the water surface alternately rose and fell a few feet during the formation of the shore phenomena that mark the general Bonneville level.

Below the Bonneville there are a number of plainly marked shore lines which represent stages in the level of the lake when it was practically constant for relatively long periods. Of these shore lines the Provo is the most remarkable, for it records the longest occupancy of one approximate horizon of any of the stages of the lake. Its embankments are the most massive and its wave-cut terraces are the broadest, notwithstanding the fact that the lake at the Provo stage was considerably smaller than when the surface of the water was 375 feet higher, its area having shrunk from 19,500 to approximately 13,000 square miles. The Provo shore line is characterized particularly by its deltas, which were formed at the mouths of all the larger streams that entered the lake.

The fall from the Bonneville to the Provo level was apparently without interruption and comparatively rapid. But below the Provo stage there are remnants of shore lines and terraces at a number of horizons that record temporary halts of greater or less extent in the gradual shrinkage of the lake. The most conspicuous of these lower shore lines, at an elevation of approximately 750 feet below the Bonneville level, has been named the Stansbury shore line, from its prominent development on Stansbury Island, but the others have not been correlated. As many as ten distinct shore lines can be traced on the west side of Jordan Narrows.

In connection with the different shore lines it is of interest to note that Gilbert has found evidences at a few localities of oscillations of the lake level between the Provo and Bonneville horizons, which appear to record halts in the rise of the lake as it approached its maximum. This is unusual, for most of the observed shore phenomena were formed during the retreat of the lake.

Local deposits of calcareous tufa occur associated with the various shore lines, but are most abundant at the Provo horizon. The tufa appears to have been deposited by precipitation from the lake waters due to aeration of the waves, especially during storms, and consequent loss of carbon dioxide by which the carbonate of lime was held in solution. The tufa occurs as a cement to gravel and as a more concentrated deposit, from a few inches to a few feet in thickness, coating exposed surfaces.

Below the Provo horizon, lake beds consisting of subhorizontal or gently lakeward-sloping sediments are associated with shore deposits until, as the valley bottom is approached, shore markings become indistinct and the lake beds prevail. The deposits of yellow clay and white marl previously mentioned as being widely distributed in the Bonneville basin apparently are not typically developed in the bay of the old lake, which occupied the area under consideration. A number of deep wells have been sunk into the valley deposits and their records indicate the general composition of the sediments (Pl. V). The beds are at least 2,000 feet thick, and consist of gravel, sand, and clay, which constitute the reservoirs in which ground water is stored.

CLIMATE.

Weather observations have been systematically recorded at Salt Lake City for thirty-one years, and at near-by stations, including Provo, Thistle, Heber, and Park City, for eight to fourteen years. The most important meteorologic data, compiled from reports of the United States Weather Bureau, are summarized in the following tables, which give details of precipitation, temperature, wind velocity, humidity, and evaporation, on which the supply of underground water directly depends.

PRECIPITATION.

Monthly and annual precipitation at Salt Lake City, 1875 to 1904.

[Inches.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1875	3.05	0.79	2.81	1.50	2.91	0.90	1.01	0.25	1.22	1.36	5.81	2.03	23.64
1876	1.23	1.52	4.00	2.09	4.30	.09	.83	.92	.42	3.27	.81	1.80	21.28
1877	.87	.38	2.93	2.14	3.49	.80	.02	.28	.90	2.41	1.02	1.11	16.35
1878	1.07	3.49	2.54	2.63	2.50	.35	1.08	.81	3.15	1.39	.63	.11	19.75
1879	1.87	.71	.67	3.26	.10	1.34	.07	.06	.01	1.62	.32	3.08	13.11
1880	.29	1.02	.43	2.37	1.85	.01	.20	.74	.56	.40	1.17	1.90	10.94
1881	1.24	2.44	.88	2.37	2.55	.28	.21	1.61	.43	2.19	1.44	1.24	16.88
1882	1.50	.42	1.12	3.81	.26	2.24	.30	1.61	.37	2.89	.54	.92	15.98
1883	1.47	.72	1.75	2.92	.98	.33	.10	.62	.13	2.24	1.78	1.20	14.24
1884	.71	2.23	3.69	2.89	1.78	.33	.27	.73	1.91	.36	.50	2.12	17.52
1885	1.48	1.56	2.64	3.47	2.49	2.67	.58	.90	1.29	.59	3.10	.92	21.69
1886	1.91	1.36	2.60	4.43	.06	1.02	T.	.59	1.88	1.98	1.79	1.27	18.89
1887	2.36	1.41	.35	1.87	.73	.37	1.23	.69	.55	.30	.25	1.55	11.66
1888	1.52	1.22	2.18	.99	.34	.98	.24	.63	.51	.80	2.00	2.21	13.62
1889	.73	.81	1.64	1.52	2.97	.01	.08	.92	.52	3.85	1.04	4.37	18.46
1890	3.07	2.05	1.12	.94	.16	.32	.02	.79	T.	1.44	T.	.42	10.33
1891	.74	.76	4.66	1.49	.72	1.08	.47	.46	1.19	1.26	.90	2.19	15.92
1892	1.61	.68	2.21	1.90	1.65	1.21	T.	.05	.12	1.58	.72	2.35	14.08
1893	.82	1.64	2.68	2.72	1.68	.04	1.19	.71	1.30	1.02	1.18	2.37	17.35
1894	1.31	.83	1.73	1.67	1.22	1.38	.82	.87	2.87	1.01	.28	1.28	15.27
1895	1.32	.85	.81	.73	2.29	.99	.42	.02	.95	.24	2.44	.89	11.95
1896	1.26	.69	1.99	2.53	3.67	.25	1.35	1.47	.52	.70	3.15	.84	18.42
1897	1.16	3.81	2.20	2.00	.98	.52	.69	.33	.48	1.91	1.19	1.47	16.74
1898	.58	.38	1.71	1.30	4.19	1.45	.18	1.35	.15	1.57	1.95	1.28	16.09
1899	.84	2.98	2.93	.81	2.50	.96	.42	1.06	T.	2.85	1.52	.61	17.57
1900	.44	1.30	.33	2.91	.44	.08	.32	.72	1.44	1.99	1.40	.16	11.53
1901	.95	1.77	2.48	.87	4.27	.49	.31	1.22	.66	.98	.92	1.16	16.08
1902	.80	1.17	1.22	3.69	.33	.37	.56	.15	.05	.52	1.24	1.31	11.41
1903	2.11	.82	1.35	1.11	3.55	.74	.14	.43	.84	.81	2.21	.51	14.62
1904	1.45	2.25	3.99	2.20	3.08	.27	.59	.28	.12	1.18	.00	.90	16.31
Mean	1.44	1.33	2.03	2.21	1.62	.79	.53	.72	.93	1.54	1.36	1.64	16.19

Monthly and annual precipitation at Park City, 1899 to 1904.

[Inches.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1899	......	......	......	......	......	......	......	......	......	......	0.90	1.80	....
1900	0.93	1.87	0.38	3.56	0.30	T.	0.10	0.32	2.23	0.90	3.50	1.30	15.39
1901	2.24	2.35	3.15	1.92	1.50	0.20	.90	1.40	.45	.18	1.40	2.20	17.89
1902	1.90	1.18	4.04	1.96	.67	......	......	......	......	......	......	......	....
1903	3.88	1.34	2.60	.95	2.89	T.	......	......	.92	.30	.55	.95	....
1904	2.15	5.00	7.85	1.69	2.44	......	......	1.99	......	......	.00	......	....

Monthly and annual precipitation at Provo, 1899 to 1904.

[Inches.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1899	1.54	2.89	2.45	0.39	1.37	......	......	......	0.00	2.79	0.94	1.05	....
1900	.45	.35	.05	1.65	.32	......	......	......	1.13	.66	3.50	.12	....
1901	.22	2.06	1.09	.29	.39	0.18	T.	......	......	T.	.85	.98	....
1902	.35	1.12	1.30	2.14	.36	.10	0.11	0.20	......	.68	1.55	1.28	....
1903	2.65	.65	1.80	.51	2.69	.30	.39	.42	.72	.55	1.14	.49	12.31
1904	1.72	2.27	3.75	1.56	2.11	.42	.39	.45	.04	1.56	.00	1.05	15.32

Monthly and annual precipitation at Heber, 1899 to 1904.

[Inches.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1899	2.95	5.85	3.00	0.89	1.14	0.97	1.61	2.10	0.15	3.20	0.85	1.55	14.26
1900	1.06	1.50	.34	2.53	.16	.20	.25	.31	1.20	1.47	4.42	.22	13.66
1901	2.20	2.20	1.56	.31	1.72	.08	.40	2.06	.16	1.70	1.40	1.50	15.29
1902	.50	1.03	1.46	1.88	.49	.37	.15	.50	.45	.45	1.77	1.04	10.09
1903	2.17	.07	1.95	.78	1.42	.25	.69	.02	1.17	.76	1.90	1.33	13.32
1904	2.10	3.00	3.48	.96	2.01	.73	.29	.88	.16	1.22	.00	1.91	16.74

Monthly and annual precipitation at Thistle, 1899 to 1904.

[Inches.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1899	1.60	2.40	1.30	0.05	0.88	T.	......	......	......	0.40	2.08	......	....
1900	.30	.47	.00	1.77	.05	0.10	0.10	0.46	1.00	.75	1.80	0.30	7.10
1901	......	2.35	2.40	1.15	.85	.05	.11	3.05	.25	1.15	.93	2.00	....
1902	1.90	2.05	2.00	2.23	.35	.00	.35	.20	.85	.41	2.10	1.45	13.89
1903	......	......	......	1.75	1.60	.35	.53	.10	.66	1.43	.80	1.40	....
1904	1.90	1.55	......	.90	2.65	......	.32	.46	1.90	.27	.00	1.50	....

TEMPERATURE.

Mean monthly and annual temperature at Salt Lake City, 1873 to 1904.

	° F.		° F.
January	27.9	August	74.8
February	33.0	September	64.3
March	41.6	October	52.3
April	49.5	November	39.8
May	57.8	December	32.7
June	67.0		
July	75.5	Annual	51.4

Mean monthly and annual temperature at Provo, 1890 to 1904.

	° F.		° F.
January	26.6	August	70.7
February	29.3	September	59.8
March	39.3	October	48.7
April	49.1	November	38.4
May	58.0	December	29.2
June	64.7		
July	73.2	Annual	49.2

Monthly maximum temperature at Salt Lake City, 1899 to 1904.

[° F.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1899	54	51	67	80	83	96	97	91	91	73	63	59
1900	57	55	72	78	89	101	99	94	88	76	68	56
1901	51	55	65	79	88	90	101	95	86	85	67	59
1902	43	62	58	78	88	98	96	98	92	81	70	58
1903	53	42	65	80	86	91	96	98	92	77	70	45
1904	48	66	63	78	83	92	97	94	92	83	66	55
Mean	51	55	65	79	86	95	98	95	90	79	67	55

Monthly minimum temperature at Salt Lake City, 1899 to 1904.

[° F.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1899	16	−10	20	30	25	34	51	46	46	30	28	9
1900	20	10	26	30	40	47	53	52	32	27	28	2
1901	4	15	25	15	43	40	49	56	39	36	29	11
1902	− 4	12	21	32	35	42	43	52	35	36	21	15
1903	15	− 4	14	25	33	54	46	48	37	32	17	14
1904	7	6	19	30	36	44	51	46	38	28	26	7
Mean	11	10	21	27	35	44	49	50	38	32	25	10

WIND VELOCITY.

Average wind velocity at Salt Lake City, 1900 to 1904.

[Miles per hour.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1900	3.4	5.2	6.3	7.3	6.8	6.5	6.0	6.4	6.5	6.5	5.0	4.5	5.9
1901	5.0	4.0	6.2	7.8	7.3	6.6	6.3	5.8	7.0	5.0	4.9	4.8	5.9
1902	3.8	5.5	6.9	6.7	7.1	6.7	6.7	6.5	6.7	5.7	6.0	4.7	6.1
1903	4.8	4.5	6.8	7.3	6.1	6.6	7.2	6.2	6.3	5.3	5.4	3.7	5.8
1904	4.1	6.3	7.3	7.2	6.8	6.5	6.5	5.7	6.0	5.4	4.7	4.9	6.0
Mean	4.2	5.1	6.7	7.2	6.8	7.0	6.5	6.1	6.5	5.6	5.2	4.5	5.9

HUMIDITY.

Mean relative humidity at Salt Lake City, 1900 to 1904.

[Per cent.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1900	78	65	40	59	41	25	24	24	36	48	62	63	47
1901	69	73	55	42	44	36	26	39	30	50	57	71	49
1902	83	62	58	48	43	31	27	27	32	40	56	65	48
1903	73	74	52	44	48	38	30	28	38	45	64	75	51
1904	75	62	64	46	49	38	33	38	34	53	45	60	50
Mean	76	67	54	48	45	34	28	31	34	47	57	67	49

EVAPORATION.

Depth of evaporation at Utah Lake [a] from August, 1903, to August, 1904.

[Inches.]

Month	Inches
1903.	
August	8.40
September	6.78
October	3.86
November	2.50
December	1.50
1904.	
January	1.50
February	2.00
March	3.50
April	4.63
May	7.72
June	8.80
July	9.41
Total	60.60

SUMMARY.

The climate of the valleys of Utah Lake and Jordan River is controlled by their location in the central eastern part of the Great Basin, but is modified somewhat by the proximity

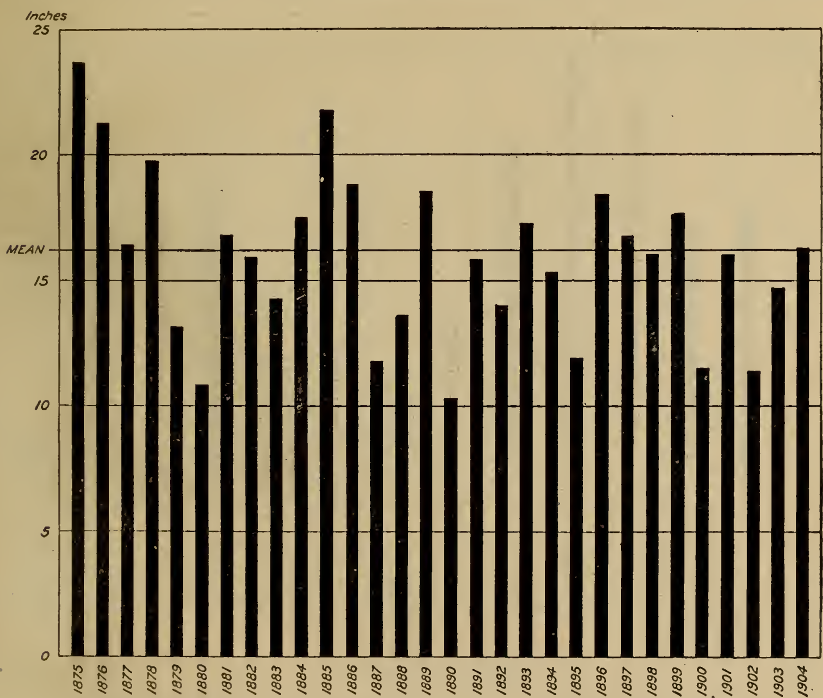


FIG. 1.—Diagram showing variation of annual precipitation at Salt Lake City.

of Utah and Great Salt Lakes and the Wasatch Mountains. The tables show that the climate is characterized by low annual precipitation, moderate temperature, moderate wind velocity, low relative humidity, and considerable evaporation.

The mean annual precipitation at Salt Lake City is 16.19 inches, ranging between a maximum of 23.64 inches in 1875 and a minimum of 10.33 inches in 1890. Since 1900 it has averaged 2.2 inches below normal (fig. 1). Only about 18 per cent of the annual total

[a] Computed from daily measurements of a tank 3 feet in diameter. Tests were made by the engineer of Salt Lake City from 1901 to 1903, and since then they have been kept up by the Reclamation Service under G. L. Swendsen. See also Newell, F. H., Fourteenth Ann. Rept. U. S. Geol. Survey, pt. 2, 1894, p. 154.

occurs from June to September, and for these four months amounts to less than 3 inches. Between October and May the variation is not marked, but the greatest precipitation occurs in March and April (fig. 2). This precipitation is unusually high for the Great Basin. The Wasatch Mountains serve to condense the moisture, originally derived in large part from the westerly winds from the Pacific Ocean, that remains in the air after crossing the Sierra Nevada.

Probably the precipitation is greater on the summits than at the stations where records have been kept, but data are not available. The melting snow of the winter's accumulation is the chief supply of the streams of the area under consideration.

The mean annual temperature of Salt Lake City is 51.4°. The mean monthly maximum ranges from 98° in July to 51° in January, while the mean monthly minimum varies between 10° in December and February and 50° in August.

The dryness of the atmosphere is indicated by the mean relative humidity of 49 per cent, varying from 28 per cent in July to 76 per cent in January, and by the amount of evaporation from a free water surface, which, according to the latest measurements, is about 60

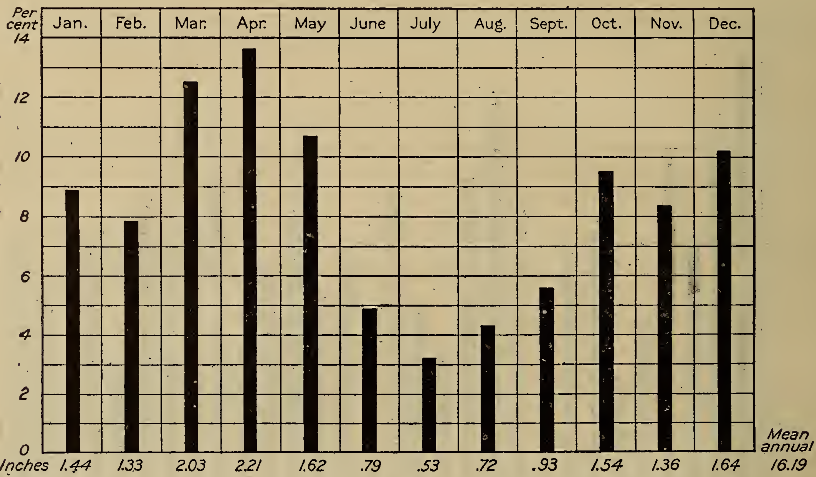


FIG. 2.—Diagram showing mean monthly precipitation at Salt Lake City.

inches a year. Yet the climate is not nearly as dry as in other parts of the Great Basin. The dryness lessens the effect of the summer's heat, so that the "sensible temperature" is not so great as would be suggested by the thermometer, being modified by the cooling effects of evaporation.

HYDROGRAPHY.

STREAMS TRIBUTARY TO UTAH LAKE AND JORDAN RIVER.

Seepage from surface streams, as shown hereafter, is the most important source of supply of underground water in the valleys of Utah Lake and Jordan River. A summary of discharge measurements therefore throws important light on the subject and, with other data, furnishes facts for roughly estimating the amount of water available for the annual replenishment of the underground reservoirs. The figures here given have been compiled from records of the United States Geological Survey and from data obtained through the courtesy of the city engineer of Salt Lake City, and are now published for the first time.

Satisfactory measurements of the flow of all the streams in the two valleys have not been made. However, records have been kept for a number of years of the discharge of several of the more important, and the combined data, with due consideration for varying conditions, may be taken as typical of the drainage of the entire watershed. The measurements were made at the mouths of the canyons. Below these points, during the irrigation season, the water is diverted and conducted over the valley in an intricate system of ditches, so that the stream beds in their lower stretches are then often dry. During the flood season the streams discharge directly into either Utah Lake or Jordan River. Following are tables of monthly measurements for 1904, to which annual summaries for several years are added where figures are available:

Estimated discharge (at mouths of canyons) of streams tributary to Jordan River and Utah Lake.

CITY CREEK.

[Drainage area, 19 square miles.]

Date.	Discharge.			Total.	Run-off.			Rainfall.[a]
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.	Relation to rainfall.	
1904.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*	*Per cent.*	*Inches.*
January	6.7	6.0	6.2	381	0.326	0.376	20.9	1.80
February	7.9	6.0	6.6	380	.347	.374	10.3	3.62
March	11.0	7.3	8.1	516	.442	.510	8.6	5.92
April	28.8	11.0	22.1	1,315	1.160	1.294	66.7	1.94
May	70.1	28.8	55.6	3,419	2.926	3.373	122.2	2.76
June	57.0	26.6	39.2	2,332	2.063	2.301	852.2	.27
July	26.5	16.2	19.7	1,211	1.037	1.195	202.5	.59
August	15.3	11.5	13.4	824	.705	.813	71.9	1.13
September	11.4	9.4	10.4	619	.547	.610	508.3	.12
October	9.3	8.7	9.1	609	.479	.551	46.7	1.18
November	8.7	8.2	8.5	506	.447	.499	....	.00
December	9.2	7.7	8.0	492	.421	.485	53.9	.90
Year	70.1	6.0	17.2	12,604	.908	12.381	61.2	20.23
1903	63.1	4.3	13.0	9,440	.685	9.323	63.1	14.77
1902	58.2	3.6	12.3	8,910	.647	8.811	69.5	12.67
1901	72.0	5.0	12.7	9,251	.668	9.126	53.9	16.94
1900	31.3	5.4	9.8	7,054	.517	7.040	52.5	13.41
1899	121.9	3.2	20.0	14,491	1.053	14.306	80.1	17.85

EMIGRATION CREEK.

[Drainage area, 19 square miles.]

1903.								
January	6.3	0.7	1.1	68	0.058	0.069	2.3	2.99
February	.8	.5	.6	33	.032	.033	3.1	1.08
March	11.7	.4	3.0	184	.158	.182	9.2	1.97
April	12.8	3.7	8.0	476	.421	.470	45.6	1.03
May	19.3	5.5	9.5	584	.500	.576	17.9	3.22
June	18.1	4.0	8.6	512	.453	.505	136.5	.37
July	4.0	1.6	2.8	172	.147	.169	120.7	.14
August	1.7	.6	1.0	61	.053	.061	14.2	.43
September	1.1	.6	.8	48	.042	.047	5.3	.88
October	2.0	1.1	1.2	74	.063	.073	13.3	.55
November	3.2	1.0	1.3	77	.068	.076	5.5	1.38
December	.8	.6	.7	43	.037	.043	5.9	.73
Year	19.3	.4	3.2	2,332	.169	2.304	15.6	14.77

[a] The record of rainfall given under City, Emigration, Parleys, and Mill creeks is the mean precipitation for Salt Lake City and Park City; that under American Fork and Provo River is for Provo and Heber; that under Spanish Fork is for Provo, Thistle, and Soldiers Summit.

Estimated discharge (at mouths of canyons) of streams tributary to Jordan River and Utah Lake—Continued.

PARLEYS CREEK.

[Drainage area, 50 square miles.]

Date.	Discharge.			Total.	Run-off.			Rainfall.
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.	Relation to rainfall.	
1904.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*	*Per cent.*	*Inches.*
January	9.2	4.8	7.1	437	0.142	0.164	9.0	1.80
February	18.1	4.2	10.3	592	.206	.222	6.1	3.62
March	39.3	9.4	19.6	1,205	.392	.452	7.6	5.92
April	207.3	69.8	123.2	7,331	2.464	2.749	141.8	1.94
May	208.5	88.1	168.5	10,361	3.370	3.886	140.8	2.76
June	137.5	28.5	52.6	3,130	1.052	1.174	434.8	.27
July	41.1	19.5	26.1	1,605	.522	.602	102.0	.59
August	20.2	11.8	16.0	984	.320	.369	32.7	1.13
September	13.0	9.4	11.4	679	.228	.254	211.7	.12
October	13.7	11.8	12.9	793	.258	.297	25.2	1.18
November	11.8	8.8	10.3	613	.206	.230	....	.00
December	10.8	2.5	8.3	510	.166	.191	21.2	.90
Year	208.5	2.5	38.9	28,240	.777	10.590	52.3	20.23
1903	133.7	2.1	20.5	14,879	.410	5.581	37.8	14.77
1902	95.3	2.2	16.7	12,116	.334	4.544	35.9	12.67
1901	109.5	3.0	19.9	14,490	.398	5.429	32.0	16.94
1900	39.0	2.9	12.6	9,038	.251	3.431	25.6	13.41
1899	227.5	4.0	59.8	39,722	1.196	14.884	83.4	17.85

MILL CREEK.

[Drainage area, 21 square miles.]

1904.								
January	13.0	6.6	9.9	609	0.471	0.543	30.2	1.80
February	13.0	3.7	9.9	569	.471	.508	14.0	3.62
March	13.0	9.3	11.2	689	.486	.560	9.4	5.92
April	25.1	11.3	18.8	1,120	.895	.999	51.5	1.94
May	58.2	25.1	41.4	2,545	1.971	2.272	82.3	2.76
June	55.9	29.7	40.9	2,434	1,948	2.173	804.8	.27
July	29.7	20.8	25.7	1,580	1.224	1.411	239.2	.59
August	16.8	13.0	14.9	916	.710	.819	72.5	1.13
September	15.9	13.0	15.0	893	.714	.797	664.2	.12
October	14.0	13.0	13.7	842	.652	.752	63.7	1.18
November	13.0	11.3	12.4	738	.590	.658	....	.00
December	11.3	1.0	8.6	529	.410	.473	52.5	.90
Year	58.2	1.0	18.5	13,464	.878	11.965	59.1	20.23
1903	34.4	2.9	12.3	8,916	.586	7.964	53.9	14.77
1902	39.5	1.9	12.1	8,753	.575	7.814	61.7	12.67
1901	47.4	1.4	12.9	9,391	.615	8.383	49.5	16.94
1900	30.8	1.4	11.5	8,296	.549	7.466	55.7	13.41
1899	66.0	2.4	19.6	14,193	.932	12.669	77.1	17.85

Estimated discharge (at mouths of canyons) of streams tributary to Jordan River and Utah Lake—Continued.

BIG COTTONWOOD CREEK.

[Drainage area, 48 square miles.]

Date.	Discharge.			Total.	Run-off.		Relation to rainfall.	Rainfall.
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.		
1902.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*	*Per cent.*	*Inches.*
January	27.6	13.6	23.1	1,421	0.481	0.555		
February	28.4	17.2	24.2	1,344	.504	.525		
March	27.7	20.4	24.6	1,513	.512	.590		
April	142.9	27.0	70.4	4,189	1.470	1.640		
May	369.7	108.9	210.2	12,925	4.380	5.050		
June	309.5	91.7	194.5	11,574	4.050	4.519		
July	92.3	40.9	62.2	3,825	1.300	1.499		
August	38.9	28.4	33.0	2,029	.688	.793		
September	31.6	25.2	27.9	1,661	.581	.648		
October	29.0	21.4	26.3	1,617	.548	.632		
November	28.8	21.8	24.8	1,476	.517	.577		
December	29.3	16.1	22.8	1,402	.475	.548		
Year	369.7	13.6	62.0	44,976	1.292	17.576		
1901	407.3	11.3	68.3	49,639	1.422	19.381		

AMERICAN FORK.

[Drainage area, 66 square miles.]

Date.	Maximum.	Minimum.	Mean.	Total.	Per square mile.	Depth.	Relation to rainfall.	Rainfall.
1904.								
January	17	15	16.1	990	0.244	0.281	14.7	1.91
February	16	15	15.4	886	.233	.251	9.5	2.64
March	24	15	19.1	1,174	.289	.333	9.2	3.62
April	109	23	46.9	2,791	.711	.793	63.0	1.26
May	379	95	216.0	13,280	3.27	3.77	183.0	2.06
June	310	131	201.0	11,960	3.05	3.40	596.0	.57
July	147	66	95.3	5,860	1.44	1.66	488.0	.34
August	64	44	52.8	3,247	.800	.922	140.0	.66
September	43	35	38.1	2,267	.577	.644	644.0	.10
October	41	34	35.9	2,207	.544	.627	45.1	1.39
November	34	28	30.0	1,785	.454	.507		.00
December	28	18	25.3	1,556	.383	.442	29.8	1.48
Year	379	15	66.0	48,000	1.00	13.62	85.0	16.03

Estimated discharge (at mouths of canyons) of streams tributary to Jordan River and Utah Lake—Continued.

PROVO RIVER.

[Drainage area, 640 square miles.]

Date.	Discharge.			Total.	Run-off.			Rainfall.
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.	Relation to rainfall.	
1904.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*	*Per cent.*	*Inches.*
January	290	196	244	15,000	0.381	0.439	23	1.91
February	861	253	373	21,460	.583	.629	24	2.64
March	667	331	388	23,860	.606	.699	19	3.62
April	680	353	486	28,920	.759	.847	67	1.26
May	2,153	461	1,145	70,410	1.79	2.06	100	2.06
June	1,625	371	1,131	67,300	1.77	1.98	347	.57
July	326	136	202	12,420	.316	.364	107	.34
August	182	134	149	9,162	.233	.269	41	.66
September	184	80	117	6,962	.183	.204	204	.10
October	146	79	113	6,948	.177	.204	15	1.39
November	190	113	139	8,271	.217	.242	....	.00
December	205	113	149	9,162	.233	.269	18	1.48
Year	2,153	79	386	279,900	.604	8.20	51	16.03
1898	1,212	146	386	279,000	.60	8.19	49	16.71
1897	2,600	225	[a] 571	414,000	.89	12.12	68	17.76
1895	1,760	192	423	306,400	.66	9.07	62	[a] 14.63

[a] Approximate.

SPANISH FORK.

[Drainage area, 670 square miles.]

1904.								
January	113	58	77.6	4,771	0.116	0.134	8.1	1.66
February	126	58	79.1	4,550	.118	.127	7.4	1.71
March	240	63	85.8	5,276	.128	.148	4.4	3.36
April	229	110	174.0	10,350	.260	.290	28.0	1.02
May	415	236	343.0	21,090	.512	.590	25.0	2.33
June	255	111	162.0	9,640	.242	.270	41.0	.66
July	121	80	94.6	5,817	.141	.163	39.0	.42
August	92	67	75.8	4,661	.113	.130	19.0	.69
September	75	65	68.0	4,046	.101	.113	13.0	.85
October	69	65	67.8	4,169	.101	.116	11.0	1.01
November	69	49	61.5	3,660	.092	.102	....	.00
December	77	40	54.3	3,339	.081	.093	8.7	1.07
Year	415	40	112.0	81,370	.167	2.28	15.4	14.78

Comparison of the discharge of several streams shows marked differences. For instance, during 1901 and 1902, the only years when complete measurements of both Parleys and Big Cottonwood creeks are available, the discharge of Big Cottonwood (drainage area, 48 square miles) averaged 47,308 acre-feet, while that of Parleys, with a drainage area slightly greater (50 square miles), averaged only 13,303 acre-feet. Again, during 1904 the discharge of City and Emigration creeks, each having drainage areas of approximately 19 square miles, amounted, respectively, to 12,604 and 2,332 acre-feet. Provo and Spanish Fork rivers also afford similar results. The drainage area of Provo River (640 square miles) is slightly less than that of Spanish Fork (670 square miles), yet the discharge of the former in 1904 was more than three times that of the latter.

It will be noticed that the flows of Spanish Fork and of Emigration Creek, streams which in the above comparisons figured poorly, have much in common, though their drainage areas differ greatly. The flow of the two streams, expressed in second-feet per square mile of their drainage areas, averaged 0.167 for Spanish Fork and 0.169 for Emigration Creek, which may be compared with an average of 0.746 for City Creek and 0.69 for Provo River. The amount of discharge, expressed in depth of inches, over the watershed is 2.28 for Spanish Fork 2.30 for Emigration Creek, and 10.33 for City Creek. The run-off is approximately 15 per cent of the precipitation for Spanish Fork and Emigration Creek, and about 63 per cent for City Creek.

These and other discrepancies are due to a complex set of causes, chief of which are differences in precipitation, topography, vegetation, soils, and rocks of the several drainage areas, and the care that is taken to prevent fires, grazing, and destruction of timber on the watersheds. Though in general the main streams in the Wasatch Mountains have many features in common, the valleys of some of them are narrow and steep, while those of others are broader and more open. Some valleys are better adapted than others, by configuration and position, to collect and keep snow. Some of the streams head in lakes, while others do not. All are poorly clothed with trees, but some are less fortunate in this respect than others. The soil covering in general is thin, particularly on the steep slopes and in areas where the absence of much vegetation allows the products of rock disintegration to be washed into the valleys. But where the slopes are comparatively gentle and vegetation protects the accumulated rock débris, more of the precipitation is absorbed and (escaping flood discharge) seeps slowly into the valleys to maintain the perennial flow of the streams. Differences in the porosity of the bed rocks and in the character and quantity of débris in the stream beds, whereby greater or less amounts of water are absorbed, also greatly influence the amount of run-off.

UTAH LAKE.

Utah Lake is fed from several sources, including surface streams, seepage, springs beneath the lake, and the precipitation that falls upon it. The measurable factors were determined

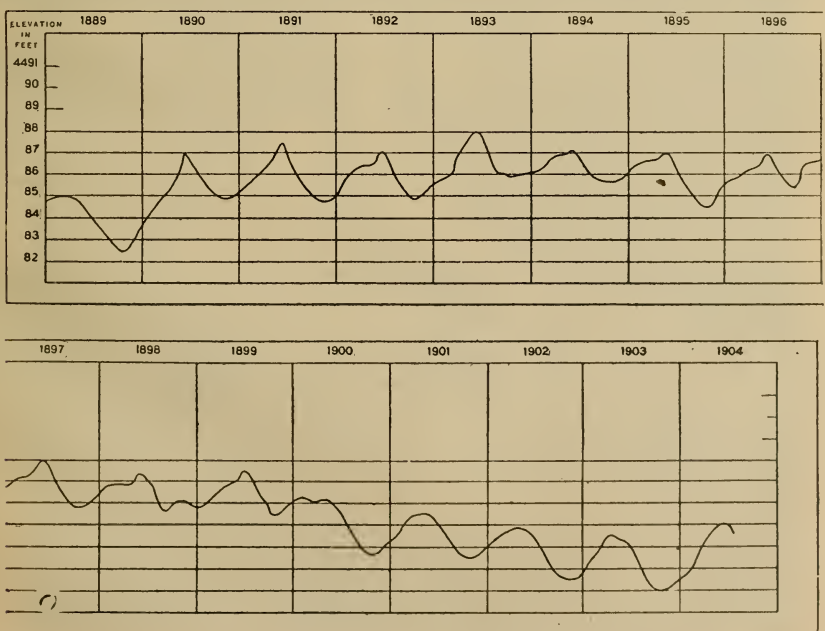


FIG. 3.—Diagram showing fluctuations of the surface of Utah Lake, 1889–1904.

for the period August 1903, to August, 1904, under the direction of G. L. Swendsen,[a] of the United States Reclamation Service, who found that of the total supply of 604,010 acre-feet only 471,140 were contributed by rainfall on the lake and by the measurable surface streams, leaving an unmeasured supply of 132,870 acre-feet. This considerable amount appears to be contributed by seepage and by springs, some of which have recently been found in the northwestern part of the lake.

The surface of the lake is subject to considerable variation in elevation in consequence of the changing relations of evaporation, precipitation, inflow, and outflow. Fig. 3, prepared by the Reclamation Service, shows fluctuations of the surface from 1889 to 1904.

There is a seasonal variation of 1 to 4 feet, ranging from a minimum in the late fall to a maximum in late spring and early summer. The diagram also shows the variation in the mean level of the lake. The lowest elevation shown occurred in 1903, when the lake was about half a foot lower than it was in 1889. Following 1889 was a period of ten years of relatively high water.

JORDAN RIVER.

During the last few years anomalous conditions have existed at the outlet of Utah Lake. The water level of the lake has fallen so low that the normal flow has ceased, and in order to supply the canals in Jordan Valley it has been necessary to resort to pumping. Accordingly a pumping plant has been in operation at the head of Jordan River since August, 1902. (Pl. IV, *A*.)

The following table of discharges has been prepared by Mr. J. Fewson Smith, jr., water commissioner:

Discharge of Jordan River and the canal systems in Jordan Narrows, and of Jordan River at pumping plant, April to October, 1904.

[Acre-feet.]

Month.	North Jordan.	East Jordan.	City.	South Jordan.	Utah and Salt Lake.	Jordan River at weir.	Sum of preceding.	Jordan River at pumping plant.[a]
1904.								
April	....	650	....	647	720	75	2,092	222
May	963	3,036	596	5,167	4,150	2,911	16,823	18,090
June	2,970	5,701	452	6,648	7,878	4,225	27,874	25,110
July	3,384	5,369	3,199	5,407	6,719	3,894	27,972	25,210
August	3,233	5,186	3,090	5,031	7,110	3,668	27,318	24,720
September	2,662	5,280	1,373	5,357	7,992	2,767	25,431	23,330
October	753	1,920	399	2,134	3,367	310	8,883	8,363
Total	13,965	27,142	9,109	30,391	37,936	17,850	136,393	125,045

[a] Figures furnished by G. L. Swendsen.

From these figures it appears that the gain in the flow of Jordan River between the pumping plant and the intake of the canals in Jordan Narrows, a distance of about 13 miles, April to October, 1904, was 11,348 acre-feet. The gain is partly supplied by seepage and partly by the flow of wells and springs. Between Jordan Narrows and the head of North Jordan canal, a distance of about 9 miles, Mr. J. Fewson Smith, jr., found that the seepage into Jordan River between May and September, 1904, amounted to 13,789 acre-feet.

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[a] The writer acknowledges his indebtedness to Mr. Swendsen for many courtesies extended, both in the field and office, during the prosecution of the work.

A. GATE AT HEAD OF JORDAN RIVER.

B DEAD MAN'S FALLS, COTTONWOOD CANYON.

No systematic data have been collected below the head of North Jordan canal, but in December, 1904, the following measurements were made by Mr. Caleb Tanner and the writer:

Discharge of Jordan River and tributaries between Little Cottonwood Creek and the ford, in sec. 4, T. 1 N., R. 1 W., December 6–7, 1904.

		Second-feet.
Jordan River above mouth of Little Cottonwood Creek		61.38
Little Cottonwood Creek		8.14
Flume at Taylorville roller mill		39.0
Big Cottonwood Creek		51.2
Ditch south of Mill Creek		2.12
Mill Creek		23.94
Ditch, outlet of Decker Lake		2.93
Parleys Creek, north and south ditches		8.78
Eighth South street ditch		6.09
Total		203.58
Jordan River below North Temple Street Bridge	190.22	190.22
Loss between mouth of Little Cottonwood Creek and North Temple street		13.36
Outlet of Hot Springs Lake	7.64	
Sewer ditch (estimate)	7.50	
Jordan River at ford, sec. 4, T. 1 N., R. 1 W		214.00
Total	205.36	205.36
Gain between North Temple Street Bridge and ford		8.64

Loss in the flow of Jordan River, instead of expected gain, is thus shown between the mouth of Little Cottonwood Creek and North Temple Street Bridge at the time the measurements were made, while a slight gain is shown between the bridge and the ford in sec. 4, T. 1 N., R. 1 W. It appears that the seepage drains into the tributaries rather than directly into Jordan River in the area where the tributary streams are numerous and that farther north, where there are fewer tributaries, a small amount of seepage drains directly into the river. How far these figures represent conditions the year round remains to be determined.

GREAT SALT LAKE.

Except during a lapse from 1893 to 1896, instrumental records of the surface fluctuation of Great Salt Lake have been kept since 1875, and there is evidence less exact dating back to the survey of the lake by Stansbury in 1849–50. When that survey was made the level of the lake was extremely low, and since then it has varied considerably. In 1869 the water surface was approximately 11 feet higher than it was in 1850; a comparatively low stage was reached in 1873, after which the lake rose about 4 feet to a maximum in 1876, about equal to that attained in 1869. In 1883 the lake was about 7 feet below the maximum; then it rose 4 feet until 1886, since when it has gradually fallen until now it is at an extremely low stage, about 15 feet lower than the maxima of 1869 and 1876. Fig. 4 illustrates the changes since 1875.

Besides the irregular fluctuations there is a regular annual variation ranging between 1 and 2 feet, the maximum occurring in June and the minimum in the winter This annual variation is due to the changing relations of precipitation, inflow, and evaporation, high water occurring after the spring floods, and low water during the season of feeble stream discharge and after the period of excessive evaporation. The irregular variation of the past can be accounted for chiefly by changes in rainfall, the earlier maxima being associated with unusually large amounts of precipitation. The gradual decrease of late years in the volume of the lake, after allowing for recent dry seasons, is apparently due to largely increased irrigation, by which the inflow of surface streams has been checked through diversion into ditches. Because of the considerable evaporation and transpiration incident to such use of the water, only a small per cent of the run-off reaches the

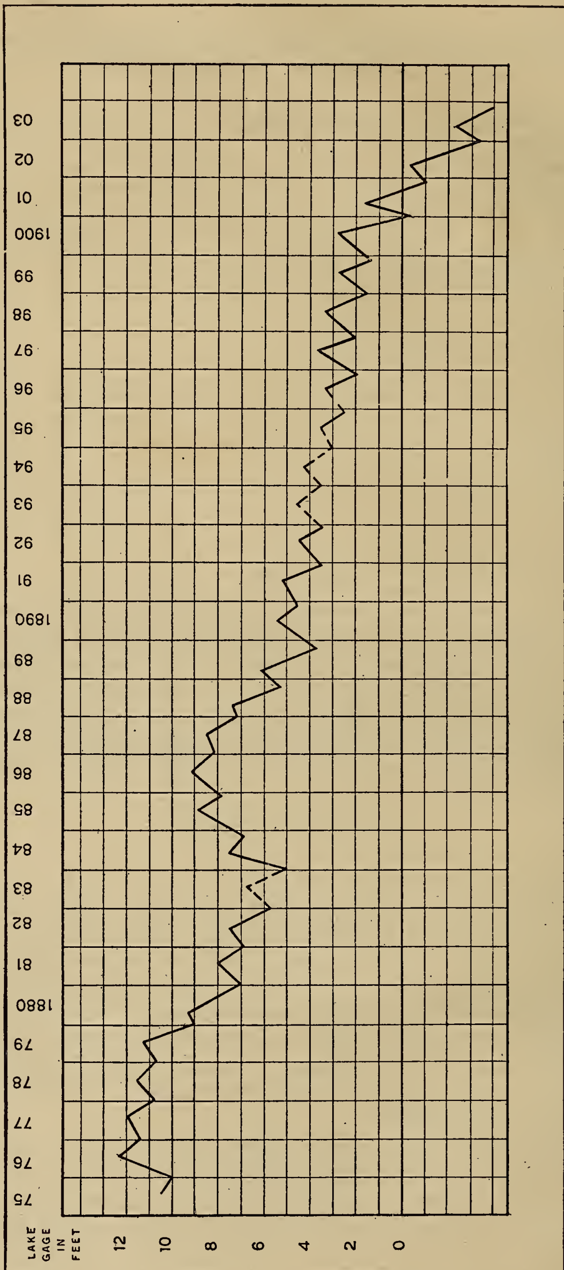


Fig. 4.—Diagram showing fluctuations of the surface of Great Salt Lake 1873-1903.

lake, and with the spread of irrigation it may be expected that this cause will increasingly tend to keep the lake level at a low stage.

UNDERGROUND WATER.

GENERAL CONDITIONS.

SOURCE.

The underground water supply in the valleys of Utah Lake and Jordan River, as is well known, is maintained by the snow and rain that fall on their drainage areas. In considering the sources of the supply, the precipitation tributary to Utah Lake and Jordan River can conveniently be divided into that on the mountains and that on the main valley.

It has been stated that the actual precipitation in the mountains probably exceeds the amount shown by the recorded data. Moreover, neither the rainfall nor the snowfall is evenly distributed. The precipitation is greater in the northern than in the southern half of the area under consideration, and in contiguous localities there are differences due to varying topographic conditions. More precipitation is likely to occur in the vicinity of the higher peaks, and in the mountain recesses that are well protected from the sun large quantities of snow linger long after the general mantle has disappeared.

Of the total precipitation on the mountains, part is evaporated, part joins the run-off, and part becomes underground water. Evaporation occurs either directly—from snow, from a free surface of water, and from water contained in soils and brought to the surface by capillary action—or indirectly by transpiration through the growth of plants. Of the portion which joins the run-off part runs directly out of the mountains, part flows to small lakes at the head of Big Cottonwood Creek and Provo River, and part is absorbed by the soil and rocks over which the streams flow and joins the subterranean store. A final portion of the precipitation on the mountains becomes underground water directly by absorption by the surface on which the rainfall occurs. Part of this underground water reaches the surface again by capillary action in the soils and by the life activity of plants and is finally evaporated; another part after remaining underground a shorter or longer time reaches the surface again by springs and seepage, and, joining the run-off little by little, maintains the perennial flow of the streams; another part joins the more permanent supply of underground water. It is impossible, because of the complexity of the subject and the lack of data, to state the amount of water which annually replenishes this more permanent supply of underground water, but the quantity is equivalent to the precipitation minus the run-off and the amount evaporated. From the incomplete facts at hand it appears that the run-off, measured at the mouths of the canyons, although varying greatly, approximates 50 per cent of the precipitation, but the total evaporation is unknown. Although exact figures representing the amount evaporated can not be obtained, yet experiments on evaporation from snow, soils, and vegetation in the mountain areas would afford valuable data.

The amount of precipitation in the valley is better known, and the figures for Salt Lake City and Provo are typical. Here, as in the mountains, part of the precipitation joins the run-off, part is evaporated, and part becomes underground water; but there are practically no measurements of these different quantities. Direct run-off of the precipitation on the valley is comparatively small, owing to the open nature of the country and to the fact that no great accumulations of snow occur, and the seepage run-off probably constitutes the main amount. Evaporation from soils and vegetation dissipates probably the largest part of the rain that falls on the valley, especially during the summer. The increase of the more permanent underground water supply due to the rainfall on the valley is consequently small. A basis for judgment is furnished by comparing the condition of the valley east and west of Jordan River. Precipitation is perhaps slightly less in the western part of the valley, but the difference is not enough to cause the marked contrast. The scarcity of ground water within easy reach of the surface in the western part of the valley, compared with the abundance easily accessible in the eastern part, implies that the rainfall on the valley contributes a proportionally small amount to the store of underground water. Existing conditions are due to the fact that on the west only a few feeble and generally intermittent streams are tributary to the valley, whereas on the east a number of large perennial streams flow from the Wasatch Mountains, supplying water that is distributed over the valley by canals. Seepage from these streams is the main source of underground supply in the valleys.

The amount of water contributed to the valleys by streams from the Wasatch Mountains is capable of rough numerical statement. The drainage area in these mountains tributary to Jordan Valley is approximately 220 square miles, and measurements of five creeks in that region, given in the section devoted to hydrography, show an average flow of 0.66 second-foot per square mile of watershed. This amount is equivalent to a stream discharging 145 second-feet, or a total amount approximating 105,000 acre-feet a year. The average of measurements of Provo River and Spanish Fork in Utah Lake Valley gives a flow of 0.43 second-foot per square mile of drainage area, which, assuming the flow to be derived from rainfall on a watershed of about 1,670 square miles, is equivalent to a stream discharging 718 second-feet, amounting to 520,000 acre-feet a year.

Of this amount of water annually contributed by streams to the valleys of Utah Lake and Jordan River, part permanently runs off and is added to the supply of Great Salt Lake by Jordan River. This quantity has not yet been systematically measured, but it is estimated to average about 200 second-feet. The residue either evaporates, directly and indirectly, or becomes underground water. Unfortunately, no figures are available whereby the amount lost by evaporation can be estimated, so that the annual replenishment of the underground supply is unknown. Only the crude statement can now be made that, in the presence of influences sufficient to cause an evaporation of 60 inches a year from a free body of water, the amount which is not thus lost from a supply of somewhat more than 600 second-feet joins the underground store.

Seepage measurements which have been made at different times in both valleys from creeks and ditches offer concrete demonstrations of the manner in which the underground supply is maintained. Only a few such measurements have been made in Utah Lake Valley, but it has been shown that in 1½ miles the Timpanogas canal lost slightly more than 25 per cent of the water taken in at its head.[a] Another set of measurements has been made on Provo River. The discharge a short distance above the mouth of the canyon was found to be 175.04 second-feet; at a station a mile west of Provo the river was dry, while the sum of several intermediate diversions amounted to 186.22 second-feet. The difference—11.18 second-feet—represents the return seepage from the various canals.[b] In the valleys of creeks tributary to Jordan River more measurements have been made, of which those in Big Cottonwood and Mill valleys are typical. In Big Cottonwood Creek Valley Mr. E. R. Morgan selected for measurement two sections of the creek on which different conditions exist. In the upper section, immediately below the mouth of the canyon, the bed of the stream is composed of large loose bowlders resting on coarse gravel, and the land on either side is covered with comparatively scanty vegetation. In the lower section, below the head of Green ditch, the bed of the creek is comparatively smooth, and the land on both sides is irrigated and covered with abundant vegetation The loss in the first section, in a distance of 2½ miles, was 7.36 second-feet, a percentage of 22 6, while in the second section, also 2½ miles long, the loss was only 0.30 second-feet, a percentage of 2.4.[c] In Mill Creek Valley Mr. Morgan also made measurements in two sections where different conditions exist. In one section, 2 miles long, he found a loss of 22.7 per cent; in the other, three-quarters of a mile long, he found a loss of 3.6 per cent.[d]

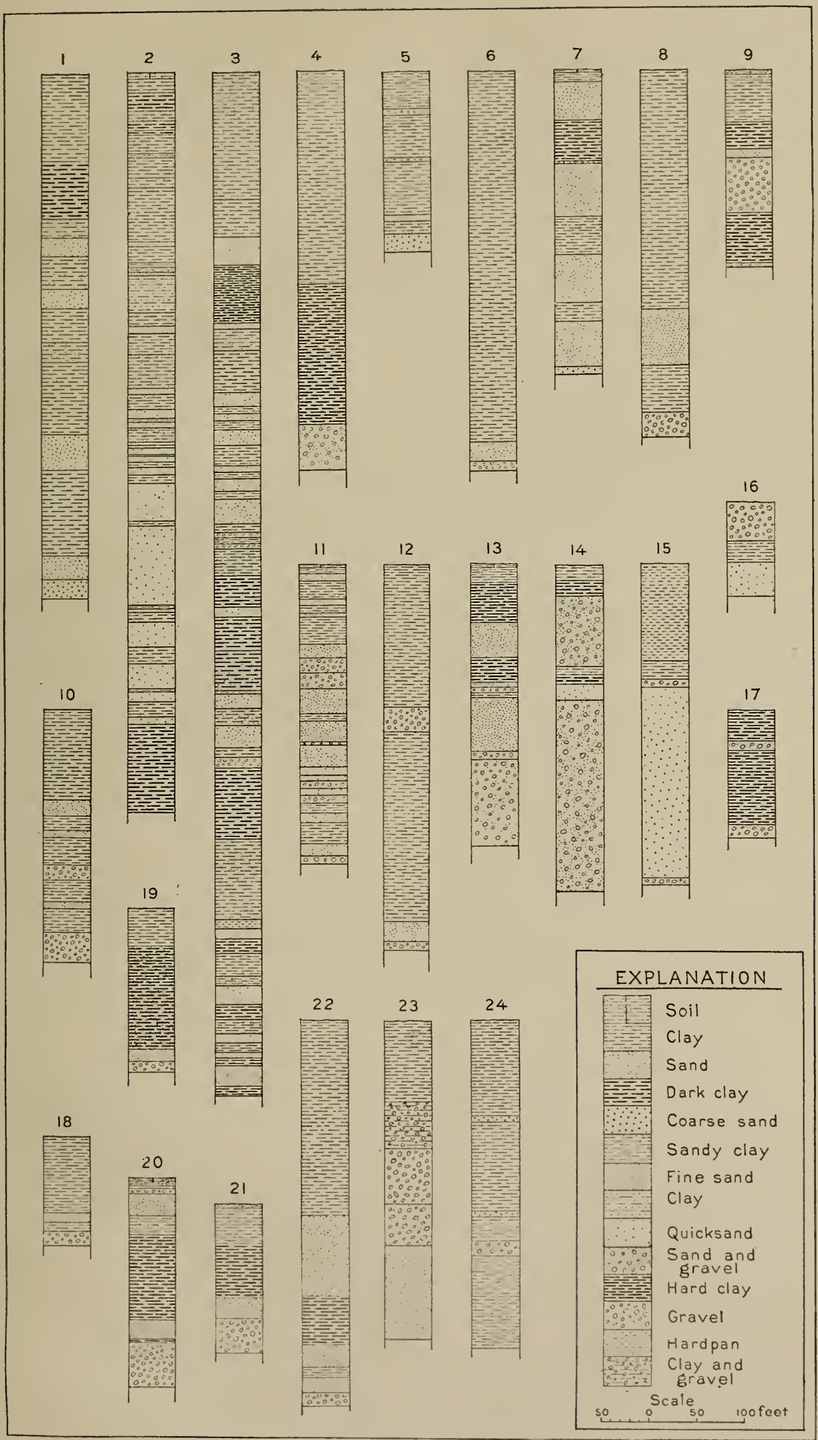
While seepage from the flow of the creeks and canals furnishes the chief supply of underground water to the valleys of Utah Lake and Jordan River, other sources are the underflow of the creeks at the mouths of the canyons, springs from bed rock, seepage at the base of the mountains, and the small addition, already mentioned, derived from rainfall on the valley. The underflow of the creeks at the mouths of the canyons is an important source, but the amount thus contributed is unknown. The quantity equals the remainder after subtracting the sum of run-off and evaporation from the precipitation, of which factors only the run-off is established, the precipitation being only approximately and the evaporation not at all known. The amount of the underflow can be directly determined, however, by a series

[a] Bull. U. S. Dept. Agric. No. 124, Office Expt. Stations, 1903, p. 123.

[b] Ibid., p. 126.

[c] Morgan, E. R., Irrigation in Mountain water district, Salt Lake County, Utah: Bull. U. S. Dept. Agric. No. 133, Office Expt. Stations, 1903, pp. 60-61.

[d] Ibid., pp. 44-45.



WELL SECTIONS.

No. 1, Oregon Short Line well at Kaysville; No. 2, Southern Pacific Company's well at Strongs Point; Nos. 3-24, location shown on Pls. VII and VIII.

of measurements which should be made in estimating the feasibility of constructing subsurface dams. The amount of water contributed to the valleys from bed-rock sources is also important. A remarkable series of thermal springs is associated with the great fault at the western base of the Wasatch Mountains. These occur at intervals along the entire extent of the range, and other warm springs, which may also be connected with faults, are located within the area under consideration. Association with faults suggests a deep-seated origin, which accounts for the high temperature of the water. The last source of the valley water supply to be mentioned is the comparatively small amount which is derived by seepage from the base of the mountains from areas that are not drained by creeks.

DISTRIBUTION OF UNDERGROUND WATER.

From the outline of the geology given on pages 7–13 it will be seen that the valleys of Utah Lake and Jordan River are occupied by a considerable but unknown thickness of gravel, sand, and clay derived from the disintegration of the adjacent mountains and deposited in the valley under alternating subaerial and lacustrine conditions. In general, the deposits are arranged in broad, sheet-like accumulations, the coarser-textured materials abounding adjacent to the highlands and the finer débris preponderating farther out. The beds lie practically flat in the center of the basins, but are inclined slightly away from their source, the attitude of deposition being practically unaltered. Conditions of deposition, however, were so varied that over large parts of the area considered the deposits are not widely uniform. For instance, while clay was being laid down in one place sand was accumulating in an adjacent area and at their border the two deposits were merged. Consequently the arrangement of the beds is broadly lenticular, as is illustrated by the well records (Pl. V). No two records are exactly alike, and in most cases it is impossible to correlate deposits in the different sections. Beds of clay are most widely distributed, but the more localized accumulations of sand and gravel, which are the most important reservoirs of underground water, are irregularly distributed.

Underground water derived from the sources stated above occupies the spaces between the solid particles of the clay, sand, and gravel which constitute the valley filling. In general, these deposits are saturated below the horizon which marks the surface of ground water. The position of this surface varies, depending on the supply, on the amount used or the intensity of evaporation, and on the character and slope of the sediments. The water is seldom stagnant, but tends to flow with extreme slowness from a higher to a lower level, the chief factors in the movement being the number and size of the interstitial spaces in the deposits and the pressure gradient due to gravity. The highest velocity of ground water ever determined is about 100 feet in twenty-four hours, but the ordinary velocity is much less than this, common rates in sand being between 2 and 50 feet a day.

The fluctuation of the surface of ground water is considerable. Since the chief replenishment of the supply occurs when the creeks discharge the most and when the irrigation canals are in full operation, ground water occurs nearer the surface in summer than in winter. Conditions in different areas cause a varied annual range, but 10 feet is common and 15 feet is not infrequent. In addition to the annual fluctuation a cumulative change is in progress, the ground-water surface being gradually raised in the lower parts of the valley in consequence of irrigation and the custom of allowing artesian wells to flow unceasingly, leading to swampy conditions in the valley bottom. Details regarding these changes are given on subsequent pages.

Pl. VI illustrates the approximate average depths at which ground water occurs in the valleys of Utah Lake and Jordan River. The boundaries between the different areas fluctuate and can not accurately be determined. A narrow belt contiguous to the base of the mountains is left blank on the map because of the varying and often unknown conditions that exist there, owing to seepage and the irregular distribution of water in the adjacent bed rocks. In the absence of topographic maps the position of the water table can not be shown by contours.

Below the surface of ground water the saturated beds contain varying amounts, depending on the character of the deposits. Coarse-textured gravel and sand, having a greater porosity than fine-textured clay, hold and transmit relatively more water. Beds of sand and gravel therefore constitute the chief underground reservoirs. Typical illustrations of the distribution of sand and gravel are shown in Pl. V. In sinking wells in this region, beds of sand and gravel, ranging from a few inches to a hundred feet or more and separated by varying thicknesses of clay, are encountered, water being commonly found in each porous deposit. Because of the prevailing inclination of the deposits away from the mountains, and of the presence of relatively impervious beds of clay above more porous sand and gravel, the contained water is under pressure. In the lowland areas this pressure is sufficient to cause the deep-seated water, when it is reached in a well, to rise and flow at the surface, and consequently artesian water is an important source of supply. Above the lowlands, where the surface elevation is too great for a flow to occur at the surface, the water rises in deep wells to a greater or less height according to the amount of pressure.

QUALITY OF UNDERGROUND WATER.

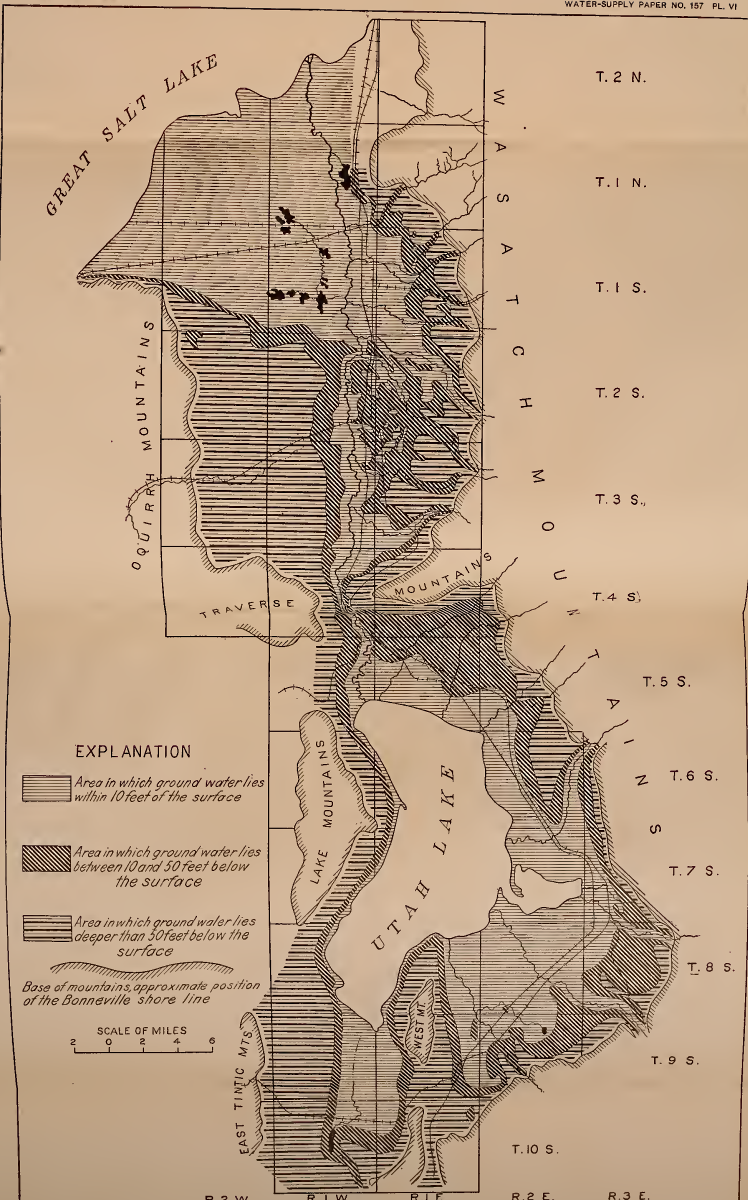
The accompanying analyses, gathered from a number of sources and reduced to common terms, illustrate the character of the water in the valleys of Utah Lake and Jordan River.

Analyses of water from streams and springs in valleys of Utah Lake and Jordan River.[a]

[Parts per million.]

No.	Source and date.	Ca.	Mg.	Na.	K.	Al_2O_3	Fe_2O_3	SiO_2.	SO_4.	HCO_3.	CO_2.	Cl.	Total.
	CREEKS.												
1	City, Dec., 1882	55.3	18.9	2.6	24.3	2.0		19.9	7.3	......	95.1	19.5	244.9
2	Red Butte, Dec., 1882	88.8	31.3	25.6	Trace	3.3		35.2	100.6	......	108.8	22.9	416.5
3	Emigration, Dec., 1882	101.0	31.6	18.1	9.9	2.6		24.4	126.2	......	102.7	28.6	445.1
4	Parleys, Dec., 1882	85.1	22.5	31.5	2.6	1.8		27.2	56.5	......	122.1	19.7	369.0
5	Big Cottonwood, Oct., 1884	48.1	18.9	Trace.	8.6	1.6		12.6	42.1	......	63.6	7.9	203.4
6	Little Cottonwood, Oct., 1884	17.5	8.2	5.9	1.7	1.3		39.9	12.3	......	32.2	2.8	121.8
7	Dry Cottonwood	17.0	27.0	15.0	14.0	......	......	......	34.0	121.0	......	14.0	242.0
8	American Fork	45.0	24.0	4.0	10.0	......	......	......	42.0	145.0	......	Trace.	270.0
9	Payson	12.0	17.0	22.0	3.0	......	......	......	32.0	121.0	14.0	......	221.0
10	Santaquin	12.0	31.0	31.0	5.0	......	......	......	33.0	212.0	14.0	......	338.0
11	Currant	47.0	54.0	89.0	44.0	......	......	......	115.0	181.0	15.0	211.0	756.0
12	Warm	114.0	48.0	381.0	92.0	......	......	......	114.0	333.0	28.0	703.0	1,813.0
	RIVERS.												
13	Provo	51.0	29.0	28.0	22.0	......	......	......	44.0	205.0	......	28.0	397.0
14	Spanish Fork	68.0	36.0	46.0	17.0	......	......	......	64.0	277.0	......	28.0	536.0
	Jordan:												
15	Utah Lake (outlet), 1899	67.6	13.8	233.7	2.0	......	......	......	236.7	......	23.7	316.5	894.0
16	Salt Lake City (near), 1899	111.8	13.7	251.1	......	......	......	......	334.5	......	Trace	378.9	1,090.0
	WARM SPRINGS.												
17	Salt Lake City, Oct., 1881	535.2	138.4	3,039.0	178.0	0.7		21.3	787.5	......	442.9	4,968.0	10,284.0
18	Beck's (hot)	694.3	109.5	3,754.9	196.9	9.0	......	31.5	840.5	......	204.5	6,743.8	12,584.9
19	Sandy (8 mi. s.), Mar. 1882	141.5	27.7	405.0	55.0	5.1		50.5	53.8	......	272.7	635.6	1,658.0
	UTAH LAKE.												
20	1883	55.8	18.6	17.7	2.0	......	......	10.0	130.6	......	60.9	12.4	308.0
21	1904	67.0	86.0	230.0	22.0	......	......	28.0	378.0	194.0	11.0	337.0	1,353.0

[a] AUTHORITIES.—Nos. 1–5, 17, 19, Kingsbury, J. T. Nos. 6–14, Soil survey of the Provo area, Utah: Bureau of Soils U. S. Dept. Agric., 1904, p. 22. Nos. 15, 20, and 21, Cameron, F. K. Water of Utah Lake: Jour. Am. Chem. Soc., vol. 37, No. 2, 1905. No. 16, ibid., Rept. No. 64 U. S. Dept. Agric. No. 18, Riggs, R. B., Bull. U. S. Geol. Survey No. 42, 1887, p. 148. No. 20, Clarke, F. W. No. 21, Brown, R. E.



SKETCH MAP SHOWING DEPTH TO GROUND WATER IN THE VALLEYS OF UTAH LAKE AND JORDAN RIVER.

The average of analyses of 12 streams [a] coming from the Wasatch Mountains shows a total solid content of 319 parts per million, ranging from 122 to 536, the varying character of the water being due to differences in the rocks of the respective watersheds. Examination of these analyses shows that calcium is usually the most abundant base, with magnesium a poor second, while sodium and potassium generally are much less plentiful and vary in relative amounts. Among the acid radicals, carbonic commonly preponderates, being often several times more abundant than the others; sulphuric ranks next, and in a few streams is important, while chlorine is generally of minor occurrence. Little Cottonwood Creek ranks first, having only 121.8 parts per million of dissolved solids. It flows for most of its course through granitic rock and therefore contains but little calcium carbonate. The total solids in Big Cottonwood Creek water are also low and relatively little lime is present because a large part of the drainage is over silicious rocks. The great abundance of limestone on most of the watersheds accounts for the abundance of calcium carbonate. Red Butte, Emigration, and Parleys creeks make a relatively poor showing, the sulphates being especially abundant, because these streams flow over Permo-Carboniferous and Mesozoic rocks containing more or less gypsiferous matter. Provo River and Spanish Fork drain large areas occupied by a variety of rocks, among which limestone is prominent, and the analyses show rather high amounts of total solids, the carbonates being particularly abundant. Currant and Warm creeks are exceptional. The unusual amount of sodium chloride present in Currant Creek is derived from salt deposits above Nephi. Warm Creek rises in the springs west of Goshen, and the character of its water, like that of similar springs in this area, is due to unusual conditions.

The few analyses of the thermal springs in the area under consideration show the presence of abundant dissolved salts, of which the chlorides are the most plentiful, though considerable quantities of sulphates and carbonates are also present. Sodium is several times more abundant than any other base, calcium ranks second, and magnesium and potassium are present in small amounts. Some of the hot springs contain considerable hydrogen sulphide. Most, if not all, of these springs are associated with faults and have a deep-seated origin, to which their temperature and composition are due. The mineral matter is leached from the deposits through which the waters pass, much of the salt content being probably derived from old lake beds.

Analyses of water from flowing wells are similar to those of surface streams. Different wells give different results, the quality of the water varying with the source and the nature of the deposits passed through underground. Analyses from the "Murray" and "Germania" wells show an unusually small content of total solids, while those from the wells of the Utah Sugar Company at Lehi and near Provo show amounts above the average. In the area contiguous to Great Salt Lake the well water contains considerable salt, but no analyses were obtained. In general the water from flowing wells is of admirable quality and often forms a marked contrast to the supply from shallow wells.

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[a] Omitting Currant and Warm creeks, which are exceptional.

Analyses of water from wells, etc., in valleys of Utah Lake and Jordan River.[a]

[Parts per million.]

No.	Source and date.	Ca.	Mg.	Na.	Al_2O_3. Fe_2O_3.	SiO_2.	SO_4.	CO_3.	Cl.	Na_2CO_3 K_2CO_3.	Na_2SO_4 K_2SO_4.	NaCl KCl.	Total solids.
22	Mill Pond at Lehi, July, 1895	82	54	.....	16.0	11	*d* 196	*b* 135	....	124	30	152	800
23	Artesian well, Murray Plant, Am. Smelting and Refining Co	23	6.6	.....	1.4	14	*d* 14	42	....	.....	Tr.	11	114
24	Artesian well, Germania Plant, Am. Smelting and Refining Co	24	8.7	.....	1	9.7	*d* 12	64	....	.....	6.8	28	140
25	U. S. Mining Co. well, Bingham Junction, Aug., 1902	37	13	.....	2.4	14	*d* 50	56	....	.....	27	87	290
26	U. S. Mining Co. well, West Jordan, Aug., 1902	11	5	.....	1	13	......	*c* 30	68	.....	44	58	232
27	Wm. Cooper's well, Bingham Junction	34	11	.....	1.2	16	*d* 16	66	....	.....	45	87	284
28	Beet-cutting station, Utah Sugar Co. well, near Provo, Jan., 1899	74	29	.....	5	58	......	*c* 180	89	.....	116	103	656
29	Artesian well, Utah Sugar Co., Lehi, Jan., 1899	62	38	.....	Tr.	12	154	*c* 91	21	.....	......	287	648
30	R. G. W. Rwy. well, Springville, May, 1901	157	19	14	4	18	41	120	21	.....	......	.....	......
31	R. G. W. Rwy. well, Goshen, May, 1901	85	32	104	90	80	47	127	160	.....	......	.....	......

[a] AUTHORITIES.—Nos. 22, 28, and 29, Dearborn laboratories. Nos. 25 and 26, Converse, W. A. No. 27, J. H. Parsons Chemical Co. Nos. 30 and 31, De Bernard, J. H.
[b] From $MgCO_3$.
[c] From $CaCO_3$ and $MgCO_3$.
[d] From $CaSO_4$.

No analyses of ground water obtained from shallow wells are available, but the general character of such water is known. In the upland areas above the canals the water from shallow wells is much like that commonly obtained throughout the region in deeper ones; it contains a moderate amount of dissolved salts, largely calcium carbonate, and is usually of good quality. But in the lowlands the surface water is quite different, generally containing considerable dissolved salts, among which alkalies are abundant. Where ground water lies within the scope of capillary attraction from the surface, evaporation causes the mineral matter which is held in solution to accumulate, and in this manner the soil becomes tainted with alkali. Consequently the water from surface wells in the lowlands is characteristically rich in dissolved salts.

Abnormal conditions prevail locally in the vicinity of the smelters in Jordan Valley south of Salt Lake City. Smelter smoke has lately become a nuisance to farmers by injuring crops and animals in the path of prevailing winds. Sulphur dioxide is the most abundant deleterious substance contained in the smoke, and to a minor extent locally finds its way into the water supply. Occasionally also ground water may become poisoned from accumulations of flue dust containing copper and arsenic.[a]

Natural gas occurs in a number of water wells in the area under consideration. Well drivers report the common presence of vegetable matter, chiefly fragments of wood, at different depths in many localities. This was entombed in the old lake deposits, and its decomposition may account for the origin of the gas. Though gas occurs in numerous wells it has been found in quantity in only a few localities, the greatest development occurring near the shore of Great Salt Lake, about 12 miles north of Salt Lake City.[b] Here several wells were drilled averaging about 500 feet in depth; and from September, 1895,

[a] Widtsoe, J. A., Relation of smelter smoke to Utah agriculture: Bull. Agricultural College of Utah No. 88, 1903.
[b] Richardson, G. B., Natural gas near Salt Lake City: Bull. U. S. Geol. Survey No. 260, 1905, p. 480.

to March, 1897, Salt Lake City was supplied with natural gas from this source, the total yield being approximately 150,000,000 cubic feet. But the supply finally became insufficient and the field was abandoned. Gas continues to be found in various parts of the valley and possibly other fields similar to that north of Salt Lake City may yet be found; but there is little reason for expecting much better results than already obtained and it is impossible to predict the localities where such supplies may be found.

The water of Utah Lake represents the varied sources of its supply; part is derived directly from surface streams, another part from seepage, still another portion from springs, and the whole is concentrated by evaporation. The analysis by the Bureau of Soils on page 30 shows the present condition of the water. Sodium predominates, magnesium and calcium are subordinate, and the corresponding salts are principally sulphates and chlorides. Comparison with an analysis of Utah Lake by F. W. Clarke twenty-one years earlier affords interesting data.[a] The total solids have increased from 308 to 1,353 parts per million, and the character of the water has changed from a preponderating sulphate solution to one containing large amounts of chlorides; the sodium has increased remarkably and magnesium is now in excess of calcium. These changes appear to be mainly due to man's occupancy of the region. The streams have been diverted for irrigation and an increasing supply has reached the lake as seepage after passing through the alkaline soils of the lowlands. Evaporation in the shallow lake also has tended to concentrate its waters.

The composition of the water of Great Salt Lake has been the subject of much investigation, and a list of the more important analyses is given on page 34. The lake receives the drainage of an enormous area, but by far the greater part of its supply is derived from the Wasatch Mountains, from Bear, Weber, and Jordan rivers. The mineral content of Great Salt Lake is the result of the concentration of a vast body of water during a long period of time, in which Lake Bonneville has given place by evaporation to the present lake. Great Salt Lake is shallow, and the seasonal and annual fluctuations in its level cause considerable differences in volume, with consequent changes in composition of the water. These changes are indicated by the increase of salinity from 13 per cent in 1873 to about 24 per cent in 1892.

In August, 1892, the water of Great Salt Lake contained 238 parts per thousand of total solids, consisting of predominating sodium and smaller amounts of magnesium, potassium, and calcium, in the order named, the corresponding salts being chlorides and sulphates. The water of the lake is thus a concentrated brine, and in the winter months the point of saturation for sodium sulphate is actually reached and crystals of mirabilite[b] are deposited. The critical point for calcium carbonate is passed, so that, in spite of its abundance in the waters that supply the lake, none has been found in it. Apparently calcium carbonate is precipitated soon after entering the dense body of water.

[a] Cameron, F. K., Jour. Am. Chem. Soc. vol. 37, 1905, p. 113.
[b] Talmage, J. E., "Great Salt Lake, Present and Past," 1900, p. 64.

Analyses of water of Great Salt Lake. [a]

[Parts per thousand.]

Analyst and date.	Ca.	Mg.	Na.	K.	SO_4.	Cl.	B_2O_3.	P_2O_5.	Total.	Specific gravity
Gale, L. D., 1850	Trace.	0.6	85.3	....	12.4	124.5	....	....	222.8	1.170
Allen, O. D., summer, 1869	0.2	3.8	49.6	2.4	9.9	84.0	Trace.	Trace.	149.9	1.111
Bassett, H., Aug., 1873	.6	3.0	38.3	9.9	8.8	73.6	....	....	134.2	1.102
Talmage, J. E.:										
Dec., 1885	.4	2.9	58.2	1.9	13.1	90.7	....	....	167.2	1.122
Aug., 1889	.8	5.1	65.3	2.1	11.7	110.5	....	....	195.5	1.157
Waller, E., Aug., 1892	2.424	2.844	75.825	3.925	14.964	128.278	Trace.	....	[b]238.12	1.156

[a] Waller, E., Water of Great Salt Lake: School of Mines Quart., vol. 14, 1893, p. 59.
[b] By evaporation, duplicate test gave 237.93.

Too little care is given to the sanitary character of the waters in the valleys of Utah Lake and Jordan River. The mountain streams are a source of excellent purity, yet they are liable to contamination. General supervision of the watersheds of the creeks that supply Salt Lake City is maintained by the municipality, especially on City Creek, but elsewhere few precautions are taken to safeguard the supply. Commonly the character of water obtained from the deep wells is of good quality, as is also that of surface wells in the thinly settled uplands adjacent to the base of the mountains. But surface water generally, especially in the thickly settled lowlands, where, moreover, the mineral content is high, is undesirable for domestic use because of its liability to contamination.

Salt Lake and Provo are the only cities in the area that have sewer systems. The Provo sewer discharges through an open ditch into Utah Lake, and thereby pollutes that body of water. Salt Lake City's sewage is well disposed of on a "sewer farm" below Hot Springs Lake, and the surplus enters Jordan River near its mouth. Elsewhere no systematic sanitary precautions are taken, and locally conditions are bad, with consequent frequent typhoid fever epidemics.

It can not be too strongly impressed upon inhabitants of country districts that the welfare of the community is intimately concerned with preserving the water supply uncontaminated, and in this connection it may be of service to reproduce a section from the ninth annual report of the Massachusetts State board of health: [a]

There are a few points to be borne in mind with reference to water supply, drainage of houses, and sewerage, which have been suggested by the examination of the board in this State, and may properly be summarized here.

1. The privy system, so common throughout the State, by which filth is stored up to pollute the air, soil, and water near dwellings, should in all cases be abolished.

2. Cesspools, unless extraordinary precautions be taken as to ventilation and prevention of pollution of soil and air, are little better, and should be given up for something less objectionable as soon as practicable.

3. Wells can not be depended on for supplies of wholesome water unless they are thoroughly guarded from sources of surface and subsoil pollution. Some of the foulest well water examined by the board has been clear, sparkling, and of not unpleasant taste.

4. Where wells have already been polluted and it is not practicable to dig new deep wells remote from sources of contamination or to introduce pure public water supplies, the storage of rain water, properly filtered, is a satisfactory method of procedure.

5. In small towns where public water supplies have not been introduced, and, indeed, wherever water-closets are not used, some method of frequent removal and disinfection with earth or ashes should be adopted in place of privies, by which it should be impossible for the filth to soak into the soil or escape into the air. Cemented vaults are not always to be depended upon, as their walls crack from frost or through settling of the ground, and they thus sometimes become sources of pollution of wells, besides contaminating the air. Nor is the fact of a privy being on a downward slope from the well a sufficient safeguard, for even then the direction of the subsoil drainage may be toward the well.

[a] Rafter, G. W., and Baker, M. N., Sewage Disposal in the United States, 1894, p. 40.

6. Earth closets, with proper care, may be satisfactorily adopted, but the earth, after having been once used, should be placed upon the land, not stored within doors and dried to be again used, for in the process of drying there are emanations from it which are, perhaps, not less dangerous from the fact of their being imperceptible by the unaided senses or through chemical examination. With earth closets a plan similar to that in use at the Pittsfield Hospital [a] may well be used for the chamber slops, and the kitchen waste may be utilized (with the chamber slops too, if desired) in the manner used by Mr. Field and Colonel Waring. * * * Less intricate methods are used in scattered dwellings, but with the effect of having the slop water absorbed by the ground and taken up by vegetation so far from the house as not to involve a nuisance or danger to health.

7. Where water supplies, water-closets, etc., are introduced, sewers should follow immediately in most kinds of soil. Cesspools should not be used, unless with extraordinary precautions; but with a few hundred feet square of lawn the irrigation system by agricultural drain pipes is to be recommended, whereby the filth is at once taken up by the roots of grass. In all cases, of course, with or without cesspools, there should be thorough ventilation of the system of house drainage, with disconnection from the main outlet drain by means of either a ventilating pipe or rain-water spout between the sewer trap and the house, and whose openings at the top should be only at points remote from windows and chimney tops.

On the whole, a thoroughly satisfactory arrangement of this kind, if properly looked after, is in many respects to be preferred to connecting with public sewers.

RECOVERY OF UNDERGROUND WATER.

A crude estimate of the amount of underground water in the valleys of Utah Lake and Jordan River might be made, based on an assumed thickness and porosity of the unconsolidated sediments, and the result would be many cubic miles, yet the figures would be valueless. The important fact is the amount of available water that can be recovered economically; but, unfortunately, this too, because of lack of detailed knowledge concerning the distribution and thickness of the beds of sand and gravel which constitute the reservoirs, can not be determined. Though definite figures are not available, the general fact is well known that the lowlands are amply supplied with underground water within easy reach of the surface and that on the highlands the underground supply is relatively small.

Underground water becomes available for use both naturally and artificially. It reaches the surface again naturally in springs and by seepage into drainageways, and is commonly recovered artificially by means of wells, though occasionally tunnels and subsurface dams prove efficacious. Wells are the main recourse in the area under consideration, and they can be conveniently grouped into two classes, flowing and nonflowing.

The areas in which flowing wells are obtained in the valleys of Utah Lake and Jordan River are shown on Pls. VIII and IX, and the list of wells, together with the descriptions of the different localities, gives detailed information concerning the occurrence of artesian water.

The date when the first flowing well was put down has not been ascertained, but it appears to have been about 1878. Since then many have been sunk, and the limits of the areas in which flows can be obtained have been determined with fair accuracy by experiment. The map shows that flowing wells exist only in the lower portions of the valley, the area of flows corresponding closely with that in which ground water lies within 10 feet of the surface. Higher up on the benches the elevation is too great to obtain flows.

Locally, flowing wells may be obtained at a depth of less than 50 feet, but generally they range between 100 and 400 feet, while the few that have been sunk to 1,000 feet and more encountered water under pressure in the successive beds of sand and gravel. As many as 25 distinct water horizons from which flows at the surface were obtained are reported in the Rudy well, sec. 6, T. 1 N., R. 1 W. The wells are usually 2 inches in diameter, though occasionally the shallower ones are only 1 inch, while the deeper ones are 4 and 6 inches. In yield the wells vary considerably, according to location, depth, and size of pipe. The greatest flow measured was that in the Harry Gammon well, sec. 7, T. 6 S., R. 2 E., which supplies about 266 gallons a minute from a 3-inch pipe. A number of wells flow less than 1 gallon a minute, though a common yield is between 10 and 60 gallons. The pressure is comparatively low, the highest measurements obtained being only 15½ pounds per square

[a] Cottage Hospitals: Ninth Ann. Rept. Mass. State Board of Health, pp. 83-95.

inch, and generally the greatest pressures are little more than sufficient to raise the water into railroad tanks.

Temperature measurements of the water from flowing wells afford some data bearing on the downward increment of heat in the unconsolidated valley deposits, but there are a number of disturbing factors. Adjacent to the mountains the waters are unusually cool; the presence of hot springs tends to disturb conditions, and the depths from which the waters flow are often not known. The common rate of downward increase in temperature appears to be slightly less than 1° F. in 50 feet, but the facts obtained do not warrant a closer statement. It may be of local interest, however, to observe that in general the temperature of the water increases with the depth of the wells at approximately that rate.

Few measurements have been made, but it is common experience that the yield of many flowing wells in the area under consideration has decreased. The most comprehensive measurements are those made of the wells owned by Salt Lake City near Liberty Park (p. 44). Comparing the discharge of 12 of these wells in August, 1890, with the yield of the same wells in September, 1902, it appears that in the interval of twelve years the flow of one had increased, but that those of the others had materially decreased. Such decrease, however, may be due largely to clogging of the pipes, for the total yield of the Liberty Park area has been maintained with little decrease by sinking new wells.

Decrease in yield is conspicuously apparent in Lehi and Spanish Fork, where flowing wells formerly could be obtained much more generally than now, and is notable elsewhere throughout the valley, especially adjacent to the boundary of the flowing area. Decrease in flow of individual wells is sometimes due to clogging up with sand and clay, and often can be remedied by cleaning or by the use of casing. But the general decrease is to be explained chiefly by the large increase in the number of wells which draw on the general supply. It is also to be remembered that for the past few years the annual precipitation has been considerably below the mean.

The artesian wells are used for stock, irrigation, and domestic purposes. The amount used for stock is comparatively small, and, save for watering small gardens, artesian water as yet is not extensively used for irrigation, except locally. Probably over a thousand acres are thus irrigated in Utah Lake Valley, the principal areas being below Lehi and Payson. The artesian supply is much used for domestic purposes, and in general furnishes an admirable quality of water, containing much less dissolved salts and being much purer than shallow ground water.

An attempt was made to estimate the total number of flowing wells in the area studied, but the result is to be taken only as a rough approximation. There are about 5,000 flowing wells in the valleys of Utah Lake and Jordan River, and possibly somewhat more than half of these occur in the southern valley. Assuming an average of 15 gallons a minute, a total yield of about 150 second-feet is thus indicated.

Outside of the area in which flowing wells are obtained underground water is recovered either from shallow dug wells that tap the upper surface of underground water or from driven wells in which the water comes from a relatively deep horizon and is under pressure which causes it to rise toward the surface. To save the expense of "driving," shallow wells are often dug within the area in which flowing wells can be obtained. Occupying the center of the valley and extending approximately to the limit at which flowing wells can be obtained, ground water lies within 10 feet of the surface, and locally, as has been mentioned, swampy conditions exist. As the base of the mountains is approached the depth to ground water increases and is over 50 feet on much of the upland where, over large areas, the distance to water is unknown.

Water is recovered from these wells generally by buckets and hand pumps. Comparatively few windmills are in operation. An average wind velocity of not less than 6 miles an hour[a] is stated to be required to drive a windmill; and since the mean wind velocity at Salt Lake

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[a] Wilson, H. M., Pumping for irrigation: Water-Sup. and Irr. Paper No. 1, U. S. Geol. Survey, 1896, p. 27.

City from June to September, inclusive, is 6.5 miles an hour and for the entire year averages only 5.9 miles, the natural conditions are not very favorable for this form of power. Steam pumps are used only to a limited extent. The Bingham Consolidated Company has three 3-inch wells 250 to 300 feet deep in which the water rises to within about 70 feet of the surface; 125 gallons per minute are reported to be supplied by each, the water being raised by compressed air. Another instance of successful pumping is at the brickyard in sec. 29, T. 1 S., R. 1 E., where 40 gallons a minute are reported to be obtained from a well 30 feet deep. Gasoline for pumping has not been much used. Electric power can be cheaply developed in the canyons and affords a valuable asset. In the valleys of Utah Lake and Jordan River pumping on a large scale has not yet been resorted to. There is, however, a considerable quantity of water within easy reach of the surface which probably will not much longer remain unused.

Underground water is recovered in exceptional circumstances by means of subsurface dams, or similar contrivances, which impound the underground supply. In unconsolidated materials, in order that this may be successfully accomplished, certain conditions are necessary. Practically impervious bottom must exist within easy reach of the surface to prevent excessive lowering of the ground-water level, and competent side walls, not too far apart, should be present to intercept lateral escape. The presence of the necessary conditions can be determined only by prospecting, and the practicability of such structures is an independent question, but because of the value of water in the area under consideration their feasibility should be investigated. Possible locations of subsurface dams are suggested by rock walls at the mouths of the narrow canyons, where borings in search of suitable bottom should be made. Tests of the amount and porosity of the valley filling at and above the mouths of the canyons, together with measurements of the velocity of the underflow, would indicate the quantity of available underground water. On Emigration Creek, for instance, the comparatively low run-off, suggesting an unusual amount of underdrainage, and the quantity of water obtained from the inefficient city trench invite further testing of the possibilities. Below the mouths of the canyons in the several creek valleys favorable conditions also may be discovered by the drill to warrant the construction of infiltration galleries.

In the section devoted to geology it is stated that the rocks of this region are more or less disturbed and broken, and an important part of the precipitation on the mountains finds its way into the bed rock. The water occurs in the small interstices or pores which are present in all rocks, in larger spaces such as fissures or solution channels, and along joints, bedding planes, and igneous contacts. As would be expected, less water is found in the Oquirrh Mountains than in the Wasatch. Bingham is a dry camp, though more or less water is encountered in the workings, while the mines of Park City are wet. The Ontario tunnel, which drains most of the large mines of the latter district, is stated by J. M. Boutwell to discharge from 6,000 to 9,000 gallons a minute. Considerable water is being recovered by tunnels driven into bed rock along the base of the mountains. In some instances the site of the tunnel marks the presence of a former spring, as, for instance, Wadleys, near Pleasant Grove, and those in Butterfield Canyon. But in one, the Dalton and Lark tunnel, east of Bingham, water in quantity was not encountered until several thousand feet of rock were penetrated.

Another method of recovering water from bed rock is suggested by the structure of the mountains southeast of Salt Lake City. It will be recalled from the outline of the geology that a great syncline, modified by local undulations, is there developed, whose axis extends along the valley of Emigration Creek. The general structure is favorable for the occurrence of artesian water, but there are unfavorable complications. The rocks are chiefly compact limestones, the general disturbed and fissured conditions tend to relieve the pressure on the interstitial water, and the Wasatch fault has cut across the strata. Nevertheless, it is possible that locally the red sandstones contain water under pressure, but because of the limited intake area a large supply is not to be expected.

SUGGESTIONS.

It is evident that in general a high degree of efficiency in the use of the water resources of the valleys of Utah Lake and Jordan River is not maintained. Conditions can be greatly benefited by preventing waste whenever possible. Most prominent in this connection is the conservation of storm waters. Besides the construction of large impounding reservoirs small ones can profitably be built at many localities within the mountains. Also to a certain extent storm waters can be utilized by diverting them on the uplands and permitting them to spread over a larger area instead of allowing the run-off to escape rapidly in the natural channels. The effect would be an appreciable increase of the downstream seepage and of the replenishment of the underground store. Moreover, storm discharge may be lessened by planting trees and by protecting the watershed from fire, lumbering, and grazing, thereby promoting retention of the water by absorption and the increase of seepage run-off long after the storms are over. Another important loss of water occurs because of faulty methods of transportation for use in irrigation. As the need of economy increases more efficient conduits will replace crudely constructed ditches. Water thus saved, however, proportionally diminishes the replenishment of the underground store. Loss also occurs by allowing artesian wells to flow when the water is not needed. Either the wells should be capped or the flow at least be partly checked when water is not used, or it should be collected in reservoirs.

The abundance of water in the lowlands and a dearth of it in the uplands, where the soil is generally fertile, free from alkali, and well adapted to the growth of fruit, suggest that a more efficient application of the available water supply should be practiced. Because of the scarcity of the underground supply on the uplands and the possibility of distributing creek water there by high-level canals, and since there is not enough water in the creeks to directly serve both the uplands and lowlands, it would appear that steps should be taken to increase the upland supply from the creeks and to use wells, either flowing or pumped, in developing the lowlands. The popularity of pumping plants in irrigation elsewhere, the proximity of underground water to the surface in the lowlands, and the availability of electric power that can be developed in the adjacent canyons are facts favorable to the proposed change. Moreover, seepage from the greater use of creek water on the uplands will increase the available underground supply in the lowlands. The upland water supply may also be increased by the development of springs, by tunneling into the mountains, and possibly by the construction of subsurface dams and infiltration galleries at favorable localities.

More attention should be given to developing and preserving a pure water supply for domestic purposes. Surface streams should be protected from pollution, and care should be taken to reduce to a minimum the contamination of water in wells by using modern methods in the disposal of household refuse. The common location of the towns, near the base of the mountains, where sufficient amounts of pure water are generally available either from creeks or springs renders the problem of public water supply relatively simple; yet it is a remarkable fact that only a few towns utilize their opportunities.

OCCURRENCE OF UNDERGROUND WATER.

WEST OF JORDAN RIVER.

DIVISIONS OF AREA.

The area west of Jordan River within the region covered by this report is naturally divided into two parts. One is the lowland which extends from Great Salt Lake eastward to Jordan River and thence continues in a narrow belt southward, adjacent to the river; the other is the upland which, from the southern and western border of the lowland, extends with increasing elevation to the base of the Oquirrh Mountains. No sharp line of division can be drawn between these areas, for they grade into each other, yet on the whole they are distinct. The distribution of underground water in the two areas also is distinct, a convenient line of separation being that which marks the boundary between flowing and

MAP SHOWING THE AREA IN WHICH FLOWING WELLS ARE OBTAINED IN JORDAN VALLEY.

nonflowing wells. As shown by Pl. VII, this line lies close to the Jordan in the southern part of its course, but across the river from Murray takes a westward turn, and, following the base of the upland, extends to Great Salt Lake at the northern base of the Oquirrh Mountains. This line also roughly marks the boundary between shallow and deep ground water. In the lowland area ground water is abundant and generally lies within 10 feet of the surface, while on the upland water is generally scarce and is found only at a depth of over 50 feet.

UPLAND AREA WEST OF JORDAN RIVER.

In general the upland has the aspect of a rolling plain which gradually rises to the base of the mountains, but in detail the plain is varied by the presence of benches and escarpments, relics of Lake Bonneville and of a few drainage ways that have incised channels across the plain. Locally, especially at the northern end of the Oquirrh Mountains and at the Narrows, where Jordan River flows through the Traverse Mountains, the shore lines of Lake Bonneville are unusually well marked. Different stages of the lake's history are recorded by a series of distinct benches, which descend one below another from the Bonneville level; at Jordan Narrows, for instance, no less than ten periods of pause in the lake level are thus recorded. Shore phenomena in general, however, are less prominently marked on the western margin of Jordan Valley than on the eastern, adjacent to the Wasatch Mountains.

Bingham Creek is the only perennially flowing stream which runs for any considerable extent across the plain, though Butterfield Creek flows for a short distance after it emerges from the mountains southwest of the town of Herriman. This area is also traversed by a number of arroyos which contain water only for a few days after storms and during the time of rapidly melting snow. The Utah and Salt Lake and the South Jordan canals, carrying water from the upper part of Jordan River, extend along the eastern border of the upland and supply irrigation water to a narrow belt. Above the upper canal the area is desert and practically uninhabited, except for the town of Herriman and a few scattering ranches which obtain local supplies of water. The Utah Lake project of the Reclamation Service plans to make available for irrigation a belt from 2 to 4 miles wide west of the Utah and Salt Lake canal, but a large part of this upland area west of Jordan River has too great an elevation to be cheaply irrigated from Jordan River. Some amelioration of the present arid conditions may be effected by constructing reservoirs at the base of the mountains, but the collecting area is small and no very extensive additions to the water supply are likely to be derived from this source. More or less dry farming is already practiced here. The land is fertile, is practically free from alkali, and because of its location would be very valuable if an adequate supply of water could be obtained. Unfortunately, so far as known, underground water conditions afford little prospect of a large supply from that source, though valuable quantities can locally be recovered.

This upland area is largely underlain by gravel and sand, and along the base of the mountains coarse gravel predominates. The material was derived from the disintegration of the adjacent highlands and mostly deposited offshore in the ancient lake. The constituents have been worked over and sorted during the different stages of the lake's history, both by wave action and by subaerial influences, so that the resulting material is heterogeneous both as to its composition and arrangement.

Drills have recorded only to a very limited extent the nature of the deposits that underlie the surface. Judging from the records and from conditions elsewhere, it is probable that bed rock lies not far from the surface contiguous to the base of the mountains, and that at a distance from the highland bed rock lies at a considerable, though unknown, depth. Nearer the mountains the unconsolidated valley filling is doubtless of coarser texture than farther away, and it is likely that the materials are arranged lenticularly rather than in continuous beds. That portion of the slight precipitation on the low, small watershed of the Oquirrh and Traverse mountains that is not evaporated or does not join the permanent run-off is absorbed by the porous deposits. Under the influence of gravity the water penetrates downward until a relatively impervious layer is reached, when it tends to spread laterally and to slowly move toward a lower level, at the same time filling, to a greater or less extent, the voids in the overlying material.

In the greater part of the area occupied by Lake Bonneville bed rock is so deeply covered by valley deposits that it is impracticable to recover the water contained in it; but along the border of the old lake, where the rock outcrops, water is obtained from tunnels in a number of places. In the development of the Bingham mines more or less water has been encountered, and the town is supplied from mine tunnels. Water has also been found in two tunnels constructed for mining purposes near the base of the mountains. The Butterfield tunnel, in Butterfield Canyon, a few miles west of Herriman, encountered considerable water, which has caused some litigation. After the construction of the tunnel a number of springs tributary to Butterfield Creek ceased to flow, and suit was brought against the mining company by the inhabitants of Herriman. Apparently the source of the springs was tapped by the tunnel, and judgment was awarded against the mining company. The Dalton and Lark tunnel, west of the town of Lark, struck water in the spring of 1903. The tunnel was driven 5,000 feet through igneous rock before the water was found. It occurs in quartzite that is reported to be much broken and fissured. The supply was estimated at first to be 2,500 gallons a minute, but in the summer of 1904 this had decreased to about 1,500 gallons, most of which was used for irrigation at a ranch about 2 miles east of the mouth of the tunnel. The quantity is reported to be greatest shortly after the time of melting snow, thus indicating the source. The experience of these tunnels indicates in general what may be expected by driving into the Oquirrh Range.

Springs of greater or less magnitude occur in a number of places along the base of the mountains. These are either supplied by seepage or by water from a deeper-seated source. In Rose, Butterfield, and Bingham canyons a number of springs occur, which help maintain the flow of the streams. Also at irregular intervals along the border of the upland there are springs which, in general, supply only a few gallons a minute. A conspicuous locality is in the northwestern part of T. 2 N., R. 2 W., where a local area of shallow ground water occurs. Along the northern base of the Oquirrh Range there is a group of large springs, which occur in notable alignment and apparently are associated with a fault. The water issues from unconsolidated débris and is slightly warm and brackish. The springs have an elevation of only a few feet above the lake, however, and are too low to be of much service without pumping. Analysis of one, known as the Jap Pond, shows a content of 114 grains per gallon of dissolved salts, chiefly sodium chloride. The total discharge of 9 of these springs in April, 1905, amounted to 8.5 second-feet, and it is reported that the flow remains practically constant throughout the year.

On the upland, between the base of the mountains and the canals, the little underground water that is recovered is obtained from wells, but in this entire region, with very few exceptions, ground water lies over 50 feet beneath the surface. A few wells have been sunk on the upland away from the lines of surface drainage, and in general they have been failures. The most successful wells are along the courses of creeks and arroyos, and future search may be carried on with the best prospect by following these drainage ways where the water tends to accumulate.

Development in Bingham Canyon illustrates the occurrence of underground water beneath a surface-drainage way. More or less placer mining has been carried on in the creek gravels, but near the mouth of the canyon, where there is a considerable amount of débris, work has been seriously interrupted by the abundance of water beneath the bed of the creek. It is in such places, where rock walls confine a narrow channel, that tests might well be made with the view of constructing subsurface dams to impound the underflow.

Below the canals ground water lies nearer the surface, because of the lower elevation of the country and the increased supply derived by seepage from the canals. Ground water lies at a greater depth than 50 feet only in a narrow belt below the Utah and Salt Lake Canal, and in most of the area between the canals and the line of flowing wells ground water can be obtained at 10 to 50 feet from the surface. The effect of irrigation on ground water in this area, as elsewhere, is marked. Before irrigation was practiced the depth to water was considerably greater than at present; for instance, it is reported that the average level of ground water in several wells in T. 2 S., R. 1 W., now lies 30 to 65 feet nearer the surface than formerly. Besides this more permanent effect, the ground-water level fluctuates annually from 10 to 15 feet. It is also stated that the quality of ground water has deteriorated in recent years, containing now much more alkali than formerly. So marked has this change been that surface wells are but little valued, and generally water for domestic use is obtained from deep wells.

Inspection of the list of wells will show the typical facts of distribution and occurrence of underground water in this region. It will be observed that many wells are about 250 feet deep and that the range is from less than 100 feet to 1,000 feet. No careful logs have been kept, but from fragmentary information it appears that there is considerable variation in the material encountered in drilling, implying that the sediments are irregularly sorted and that they exist in more or less lenticular arrangement. Accordingly there are no persistent water horizons. Water is generally found in wells wherever sand and gravel are encountered. In several wells a number of water beds are recorded. This water is always under pressure; the height to which it rises varies, according to location and elevation, from close to the surface down to 100 feet below it. Generally, fairly good water, within easy pumping distance, is obtainable in this belt of country between the canals and the line of flowing wells.

At the Cannon farm, in sec. 34, T. 2 S., R. 1 W., a well was sunk 1,000 feet in an attempt to get a flow, but although two thin water-bearing beds were found between 600 and 800 feet, from which the water rose to within 30 feet of the surface, flowing water was not obtained.

LOWLAND AREA WEST OF JORDAN RIVER.

The lowland that lies topographically below the line of flowing wells west of Jordan River is almost a level plain which, along its margin, rises gradually toward the southwest. Local depressions in the plain are occupied by shallow alkaline lakes, which formerly had no outlet but now are drained into Jordan River. The soils of the lowland are chiefly loam and sandy loam, but adjacent to the lake and in local low areas considerable clay is present.[a]

The nature of the underlying deposits is revealed by a number of well records, and (as would be expected) fine-textured materials are more abundant than nearer the mountains. A few deep wells have been sunk in this general region, proving the great thickness of the old lake deposits. The deepest is the Guffey-Galey well, drilled near the shore of the lake, 2 miles southwest of Farmington and about 10 miles north of Salt Lake City, in an unsuccessful search for oil.[b] This well was put down 2,000 feet without encountering bed rock. Another deep well is that of the Rio Grande Western Railway at Salt Lake City, which was sunk through alternating beds of sand and clay, with very little gravel, to a depth of 1,073 feet. This is the deepest well in the area under consideration, and its record (p. 42), as given by the driver, Gus Westphal, is as follows:

[a] A soil survey in Salt Lake Valley: Bull. U. S. Dept. of Agriculture No 64, 1900.

[b] Boutwell, J. M., Oil and asphalt prospects in Salt Lake basin: Bull. U. S. Geol. Survey No. 260, p. 471.

Record of Rio Grande Western Railway Company's well at Salt Lake City.

	Thickness in feet.	Depth in feet.
Thin strata of clay and sand	130	1–130
Clay and hardpan	40	130–170
Red sand	30	170–200
Clay and hardpan	60	200–260
Gray sand	5	260–265
Clay and sand	44	265–309
Sand	8	309–317
Clay	20	317–337
Sand	13	337–350
Hard clay	6	350–356
Sand	8	356–364
Clay	10	364–374
Sand	18	374–392
Clay	20	392–412
Sand	4	412–416
Clay	10	416–426
Blue sand	12	426–438
Clay	5	438–443
Blue sand	30	443–473
Hard clay	10	473–483
Sand and gravel	1	483–484
Clay	12	484–496
Gravel	4	496–500
Gray sandy clay	28	500–528
Tough blue clay	30	528–558
Hardpan	3	558–561
Sand	8	561–569
Soft blue clay	40	569–609
Sandy blue clay	40	609–649
Hardpan	2	649–651
Sand	16	651–667
Sandy gray clay	18	667–685
Red sand	36	685–721
Gravel	10	721–731
Blue clay	76	731–807
Clay and sand, alternating every 12 or 18 inches	84	807–891
Hardpan	8	891–899
Sand and gravel	11	899–910
Blue clay	16	910–926
Gray clay	24	926–950
Sandy gray clay	13	950–963
Quick sand	15	963–978
Blue clay	21	978–999
Sandy blue clay	11	999–1,010
Quicksand	10	1,010–1,020
Gray clay	11	1,020–1,031
Fine blue sand	3	1,031–1,034
Tough blue clay	12	1,034–1,046
Hardpan	2	1,046–1,048
Fine sand	21	1,048–1,069
Hard blue clay	4	1,069–1,073

Although the general composition of the old lake deposits is known, not enough information has been accumulated to enable very definite statements to be made concerning the detailed distribution of the sediments. A comparison of available well records shows that the alternating beds of sand, clay, and gravel, generally, can not be recognized as being equivalent in the several wells, and from the present evidence it appears that while there are great thicknesses of both sand and clay, which must have a more considerable lateral extent than the beds nearer the mountains, the lake deposits are lenticularly arranged. Since no correlation has been established, the structure of the lake deposits is not known. Apparently they are approximately horizontal, but with a slight inclination toward the lake from the highlands. This is indicated by the pressure obtained in artesian wells and is proved in a few instances by well records.

In the broad lowland west of Jordan River there is an abundance of water. Throughout practially all of this area ground water lies within 10 feet of the surface, and water is contained in the underlying deposits down to an unknown but considerable depth. Apparently flowing wells can be obtained anywhere within this area. Although the water is so generally distributed, it is profitably recovered only from the more porous, coarser textured deposits of sand and gravel, which constitute natural reservoirs and in which the water moves more readily. Accordingly, water is found at several horizons in the course of sinking a deep well. In the Rudy well, for instance, 1,002 feet deep, situated in sec. 5, T. 1 N., R. 1 W., 25 water horizons from which surface flows were obtained are reported. A record of this well is not available, but "good strong" flows besides minor ones were recorded, respectively, at 400, 508, 685, 753, and 881 feet.

Though water is so abundant, this lowland region is thinly populated, the chief drawback to its settlement being the presence of much alkali in the soil over a considerable part of the area. The Bureau of Soils of the United States Department of Agriculture, in cooperation with the Utah Experiment Station, is at present engaged in a demonstration of the feasibility of reclaiming this land on a farm 3 miles west of Salt Lake City. But by no means all of the soils in this lowland area contain excessive amounts of alkali,[a] especially along Jordan River and adjacent to the border between the lowland and highland areas there are thriving settlements.

The map and list of wells show general conditions. The wells are grouped along the margins of the area, and few are located in the interior. In general they are 2 inches in diameter, but they vary in depth greatly. Although flows are obtained locally at only 30 feet below the surface, commonly they are not encountered above 150 feet. Perhaps the average well is between 200 and 300 feet in depth. It is a striking fact that flows may be obtained throughout the entire area at similar, but not at regular depths, indicating only a slight inclination of the water-bearing horizons and their lenticular character. The flows are usually small, averaging perhaps under 5 gallons a minute, though there are a number of 15-gallon flows. The supply generally is reported rather constant, except that the shallower wells are subject to seasonal variation. The pressure obtained, too, generally is small, being only enough to cause the water to rise either barely to the surface or a few feet above. In general the pressure and the flow are reported to increase with the depth but measurements are not available. Both the flow and the pressure are considerable in the deep Rudy well, sec. 5, T. 1 N., R. 1 W.

The conditions here noted apply mostly to the areas contiguous to the eastern and southern borders of the lowland west of Jordan River. Little information is available concerning the rest of this area (see list of wells pp. 59–75.) The few wells near Great Salt Lake were sunk to unusual depths before flowing water was obtained, this being apparently due to the greater development of clay in that region, though no complete logs have been kept. The well at the Inland Crystal Salt Company's works, in which, at a depth of 560 feet, water was struck which rises about 9 feet above the surface and flows about 10 gallons a minute, is reported 720 feet deep. Underground water in the Pleistocene deposits near the lake contains considerable salt.

EAST OF JORDAN RIVER.

East of Jordan River the occurrence of underground water will be described under the following heads: Salt Lake City, lowland area south of Salt Lake City, and upland area south of Salt Lake City.

SALT LAKE CITY.

Salt Lake City is built principally on the floor of the main valley, but its outskirts extend northward on the old delta of City Creek and eastward on the benches at the base of the Wasatch Mountains. Adjacent to the highlands the underlying deposits are very irregular in composition and distribution, consisting of sand and gravel with intercalated streaks of clay. But toward the valley proper the conditions become more regular and the prevailing clay is interbedded with sand and gravel, though from the records obtained no definite sequence appears to be applicable to any considerable area.

In the lower part of the city marshy areas occur, but conditions there have been much improved since the early days of settlement. Formerly the lower channels of City, Red Butte, Emigration, and Parleys creeks were ill defined and at high-water stage the part of the city adjacent to Jordan River was a great slough. But by erecting embankments, by confining the creeks to definite channels, and by draining the western part of the city much of the swampy land has been reclaimed. Shallow ground water, except on the benches, generally lies within 10 feet of the surface.

The line separating flowing and nonflowing wells skirts the lower benches, so that in the larger part of the area occupied by the city artesian wells are obtained. Flows are found

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[a] Soil survey in Salt Lake Valley: Bull. U. S. Dept. Agric. No. 64, 1900. Reclamation of Alkali ands: Fifth Rept. Bureau of Soils, 1903, p. 1144.

at different horizons from about 50 feet downward, a common depth of wells being between 100 and 300 feet. The deepest well is that of the Rio Grande Western Railway Company near its station, the record of which appears on page 42. This well is 4 inches in diameter and 1,073 feet deep. It was put down in 1895 and 15 horizons were passed through from which flows were obtained. At a depth of 1,048 feet the greatest flow occurred, amounting to 78 gallons a minute at 4 feet above the surface and to 37.5 gallons at 25 feet above.

The most notable group of wells in this vicinity is that put down by Salt Lake City adjoining Liberty Park. There are 16 or more of these ranging from 2 to 9 inches in diameter and from 100 to 600 feet in depth. About half a dozen different water-bearing horizons, each furnishing a flow, are said to have been encountered in driving the wells. The greatest pressure reported caused the water to rise in a pipe 35 feet above the surface. Discharge measurements, as furnished by the city engineer, are given in the following table:

Discharge of city wells near Liberty Park, Salt Lake City.

No. of well.	Diameter.	Date of measurement.			No. of well.	Diameter.	Date of measurement.		
		Aug. 10, 1890.	July 17, 1900.	Sept. 29, 1902.			Aug. 10, 1890.	July 17, 1900.	Sept. 29, 1902.
	Inches.	*Gallons.*	*Gallons.*	*Gallons.*		*Inches.*	*Gallons.*	*Gallons.*	*Gallons.*
1....	9	201,600	120,000	96,941	10....	2	43,200	38,000	35,644
2....	9	180,000	297,000	60,588	11....	2	33,230	19,000	15,892
3....	8	279,132	280,000	302,940	12....	2	36,000	16,000	14,213
4....	8	....	215,000	193,882	13....	2	54,000	35,000	20,626
5....	8	59,040	5,000	11,459	14....	2	....	18,000	13,316
6....	2	14,400	10,000	5,876	15....	9	....	98,000	36,172
7....	2	16,000	1,000	610	16....	2	....	6,000	2,844
8....	2	27,000	500	206					
9....	2	54,000	25,000	19,784			997,602	1,183,500	830,993

In the immediate vicinity of these wells there are a number of springs whose supply is maintained chiefly by seepage. The combined flow from these springs and wells is estimated to amount to a maximum of 2,500,000 gallons a day. In order to utilize this supply in the city mains a pumping plant would have to be installed, and a further disadvantage is the doubtful quality of the water. At present this source is used for street sprinkling and for feeding the lake in Liberty Park (Pl. I).

In the northern part of Salt Lake City several thermal springs occur, the most conspicuous of which are the hot and warm springs. The hot springs issue at a temperature of about 130° from the Wasatch limestone at the western end of the spur of the mountains, with a discharge of about three-fourths second-foot,[a] and flow into Hot Springs Lake. The warm springs issue from unconsolidated deposits at the base of the spur about 2 miles southeast of the hot springs. The water is pumped to a slight elevation, from which it is piped to a sanitarium, the amount delivered being reported to average 350 gallons a minute. The temperature is 118° at the springs and about 100° at the sanitarium. Several other similar, but less important, springs occur, associated with the great Wasatch fault, along the base of the mountains between hot and warm springs.

The municipal water supply of Salt Lake City is derived from mountain streams and distributed through city mains. From this source there is an excellent supply of pure water under good pressure. The chief near-by available streams are City, Red Butte, Emigration, Parleys, Mill, Big Cottonwood, and Little Cottonwood creeks. The discharges of some of these are given on pages 19–22. None of these except City Creek is entirely controlled by the city. Red Butte Creek is reserved for the army post at Fort Douglas, Emigration and Parleys creeks partly contribute to the city supply, and the others are used entirely for

[a] Measured by A. F. Doremus.

irrigation and domestic purposes, under water rights owned by farmers. In order for Salt Lake City to utilize these streams it must buy the water rights or exchange with the farmers an equivalent amount of water obtained either from Utah Lake or from pumping plants.

The present public supply accordingly is obtained from City, Parleys, and Emigration creeks. The watershed of City Creek is protected from forest fires and from contamination, and many of its springs are developed. The flow is distributed from settling tanks near the mouth of the canyon and from a reservoir on Capitol Hill having a capacity of approximately 1,000,000 gallons. The surplus waters of City Creek are allowed to escape through flood ditches. Water from Parleys Creek to the extent of 81.8 per cent of its flow has been obtained by Salt Lake City in exchange for an equivalent amount of water from Utah Lake delivered through the Jordan and Salt Lake City canal. A settling reservoir, holding somewhat less than 1,000,000 gallons has been constructed at the mouth of Parleys Canyon, whence the water is conducted through a concrete conduit to a storage reservoir with a capacity of about 5,000,000 gallons situated on Thirteenth East street. An additional supply is obtained from a trench in the bed of Emigration Creek half a mile above the mouth of the canyon. This trench is approximately 150 feet long, 10 feet wide, and 18 feet deep. It was dug in sand and gravel in the bed of the creek and at right angles to its course. A supply estimated to amount to 1,000,000 gallons a day is thus obtained, which is piped to the Thirteenth East street reservoir.

No direct record is kept of the amount of water used by Salt Lake City, but discharge measurements of the creeks at the mouths of the canyons show the amount available. This is insufficient during the dry months and the use of water is restricted to a per capita consumption of 120 gallons a day, although it is considered desirable, in this dry climate, where lawns and gardens have to be irrigated, to maintain a per capita supply of approximately 300 gallons a day. It is planned to obtain in the immediate future a portion of the flow of Big Cottonwood Creek, by exchanging therefor water from Jordan River, delivered through the City canal, as is being done in the case of Parleys Creek, and to make the new supply available by constructing a pipe line from the mouth of Big Cottonwood Canyon to the mouth of Parleys Canyon, a distance of about 7 miles.

SOUTH OF SALT LAKE CITY.

Lowland area.—It will be convenient to divide the area south of Salt Lake City into a lowland and an upland portion, taking as the dividing line that which separates flowing and nonflowing wells. Pl. VIII shows that this line extends contiguous to, but below, the Jordan and Salt Lake City canal as far as Little Cottonwood Creek, after crossing which it turns westward to the flood plain of Jordan River. The lowland area is traversed by Parleys, Mill, Big Cottonwood, and Little Cottonwood creeks, which flow in open valleys, with broad and low intervening divides. The general aspect of the country is that of a slightly dissected plain that rises gently toward the upland terraces. This area is relatively thickly populated, and intensive farming is widely practiced.

The detailed character of the underlying lake sediments is not satisfactorily known, but from the well records conditions appear to be similar to those found elsewhere in the area under consideration. Beneath the lowlands the stratigraphy is more uniform than nearer the base of the mountains; fine-textured sediments are more abundant than coarse, and clay predominates. But a comparison of available well records fails to establish a correlation between the different beds of sand and gravel throughout the lowland. Well drivers state that all logs are different, and yet that, on the whole, general sections persist for certain areas in which the differences are minor. It is believed that the sediments slope toward Jordan River at about the same angle as does the surface. The best-defined sequence that has been reported occurs immediately south of Salt Lake City, where in general light-colored clay at the surface overlies blue clay ranging from 30 to 70 feet in thickness, beneath which water-bearing sands and gravels occur at a depth of about 100 feet. At greater depths the succession appears to be more variable, but there are few satisfactory well records.

Ground water now lies within 10 feet of the surface over practically the entire lowland area, but it is reported that in the early days it did not lie so near over so large an area. Present conditions are largely due to irrigation. Several old residents state that below the level of the Jordan River canals the ground-water surface has locally risen 40 or 50 feet since their construction. It has already been mentioned that along several of the drainage ways seepage water reappears at the surface and occasionally forms considerable streams, as at Spring Creek near its junction with Big Cottonwood Creek, where the September flow is estimated to amount to 14,000,000 gallons a day. In many places also, especially along the bases of benches, lines of seep springs occur that furnish considerable flows, a notable occurrence being those at the nursery in the southeastern part of Salt Lake City. But locally, as along the bluff east of Jordan River, north of the Bingham Junction smelters, the water appears at so low an elevation as to be of comparatively little use. When pumping becomes more generally practiced in the valley this ground water that lies so near the surface can be easily developed.

Flowing wells in this area are numerous. They are generally 2 inches in diameter and 100 to 400 feet in depth, and they commonly yield between 20 and 50 gallons a minute, though there are many variations. The pressure is low, generally less than 10 pounds. Well drivers say that their best results are obtained in belts extending northwest and southeast, parallel with the creeks, and that these productive belts are separated by relatively barren ones. The water-bearing sands and gravels apparently mark the courses of old waterways, while finer-textured material was deposited in the intervening areas. These distinctions have been noticed only in the upper parts of the lowland area, and near the river they are said to disappear. One of the best wells is at the plant of the American Smelting and Refining Company at Murray. It is 4 inches in diameter, 400 feet deep, and is reported to flow about 400 gallons a minute under a pressure of 3 pounds per square inch. The record of this well is given as follows, on the authority of H. F. Yeager, well driller:

Record of American Smelting and Refining Company's well at Murray.

	Thickness in feet.	Depth in feet.
Sand and gravel	5	0–5
Mud	3	5–8
Sand and gravel	4	8–12
Blue clay	6	12–18
Quicksand	10	18–28
Blue clay	8	28–36
Loose sand and gravel (good pump well at 42 feet)	16	36–52
Blue clay	8	52–60
Quicksand (flow at 63 feet)	6	60–66
Blue clay	18	66–84
Yellow clay	6	84–90
Loose sand and gravel (strong flow at 95 feet)	15	90–105
Yellow clay	3	105–108
Coarse gravel and rock (strong flow at 112 feet, and at this point the well at office stopped flowing)	8	108–116
Coarse gravel and rock	6	116–122
Quicksand	20	122–142
Clay, very hard	10	142–152
Quicksand	6	152–158
Gravel (small flow at 165 feet)	11	158–169
Hard pan, very hard	8	169–177
Blue clay	6	177–183
Quicksand (flow at 203 feet)	20	183–203
Quicksand	16	203–219
Blue clay	4	219–223
Quicksand	7	223–230
Blue clay	8	230–238
Quicksand	18	238–256
Blue clay and quicksand in layers 2 feet thick	22	256–278
Quicksand	8	278–286
Blue clay, very hard	12	286–298
River sand	2	298–300
River sand	7	300–307
Cemented gravel	12	307–319
Yellow clay	7	319–326
Cemented gravel	17	326–343
Loose gravel	23	343–366
Yellow clay	2	366–368
Gravel	7	368–375
Cemented gravel	12	375–387
Loose gravel	12	387–399

Decrease in flow and complete failure of some wells are reported throughout this area and are especially apparent in the vicinity of Murray. These results are directly traceable to the increased number of wells that have been sunk in recent years and to the fact that little economy is exercised in the use of the water. Well owners should more fully realize that the limited water supply comes from a common source, that the wastefulness of one counteracts the prudence of another, and that the common interest of all demands that the supply be conserved.

Upland area.—The upland south of Salt Lake City includes the area lying between the base of the Wasatch and Traverse mountains and the area in which flowing wells can be obtained. This region is characterized topographically by the abundance and perfection of development of shore phenomena which mark different stages in the history of Lake Bonneville. As on the western side of the valley, the upland is in general a plain that rises toward the base of the mountains, but is interrupted by benches and escarpments and deeply cut by the creeks flowing from the Wasatch Mountains.

The Bonneville terrace extends along the mountains like a narrow shelf, its horizontal lines contrasting strongly with the deep, vertical furrows on the mountains. Broad deltas formed by the larger creeks at the Provo stage extend down to the lowlands, and successive escarpments mark halting places in the retreat of Lake Bonneville. The most prominent of all the shore phenomena in the area covered by this report is the great embankment at the point of the mountains east of Jordan Narrows. Here the waves, gaining energy from the wide expanse of the old lake, carved a great sea cliff against the mountains and distributed the débris to form an enormous accumulation of sand and gravel.

Prominent local features of this upland belt are the relics of glaciers adjacent to the mouth of Little Cottonwood Canyon and the evidences of recent faulting along the base of the mountains. Little Cottonwood Creek in Pleistocene time was occupied by a glacier which carved a broad U-shaped valley and deposited lateral and terminal moraines composed of a heterogeneous mass of coarse- and fine-textured débris. Along the entire front of the Wasatch Mountains Gilbert has found indications of recent dislocation associated with the great Wasatch fault. The evidence is varied, but escarpments in unconsolidated material breaking the even trend of alluvial slopes are conspicuous.

The underlying deposits of the upland are mostly coarse textured, being near their origin, and consist chiefly of sand and gravel. The creeks, where they have cut deeply, expose good sections, but few deep-well records were obtained.

This region in general is thinly populated, but where water is available there are settlements, and wherever the canals extend there are thriving farms. The contrast between the flourishing area which is supplied with water and the dry, barren region is striking. The map shows the distribution of the principal canal systems, which are supplied by the several creeks that flow from the Wasatch Mountains and by Jordan River. Underground water is used only to a limited extent. Pl. VI and the list of wells illustrate conditions. Underground water is recovered chiefly in the lower (western) part of the upland, where it lies at depths ranging from the surface to 50 feet below. In this productive area both dug and driven wells are used. The driven wells are commonly 50 to 200 feet in depth, and water is generally found beneath a bed of clay in sand or gravel under sufficient pressure to cause it to rise within pumping distance of the surface.

In the eastern part of the upland area ground water generally lies at a greater depth than 50 feet below the surface, and in a number of places has not been found in test wells over 100 feet deep. In this (eastern) division of the upland, where the greater part of the valley deposits are coarse textured, the ground water sinks deep before a relatively impervious bed is encountered, and then it tends to move to the lower part of the valley. Away from the influence of seepage from the creeks little water is supplied to this area. Between the creeks the chief source of supply is seepage from the mountains. The most likely localities for sinking wells are along the courses of waterways, but over a large part of the upland the prospect is poor for obtaining underground water in quantity within easy reach of the surface. In the mouths of the canyons there is the chance of developing the underflow by subsurface dams or by tunnels, mentioned on page 40. Other favorable localities for prospecting are adjacent to the base of the mountains, where water may be had by developing springs and by tunneling into the bed rock.

Seep springs occur at several localities along the base of the mountains south of Salt Lake City, the most important, perhaps, being those about midway between Mill and Big Cottonwood canyons. The feeble springs there issuing from sand and gravel were formerly allowed to go to waste, but by developing them a flow of about 2 second-feet was obtained, and a considerable tract of land thus became available for agriculture. About 4 miles southwest of the town of Draper, in sec. 12, T. 4 S., R. 1 W., at some distance from the base of the mountains, there are four warm-water lakes that are fed by springs, some of which are said to be quite hot. The westernmost of the group is the largest and covers an area of about 5 acres. The temperature is reported to remain at about 70° the year round.

Since underground water is so scarce beneath the upland, the most efficient manner of developing this area appears to be by the use, as suggested above (p. 38), of creek water in high-level canals to a greater extent than is now practiced.

UTAH LAKE VALLEY.

The following description of the occurrence of underground water in the valley of Utah Lake begins at the north and proceeds east, south, and west around the lake, the several towns affording subheadings for convenient reference. (Pl. VIII.)

LEHI AND VICINITY.

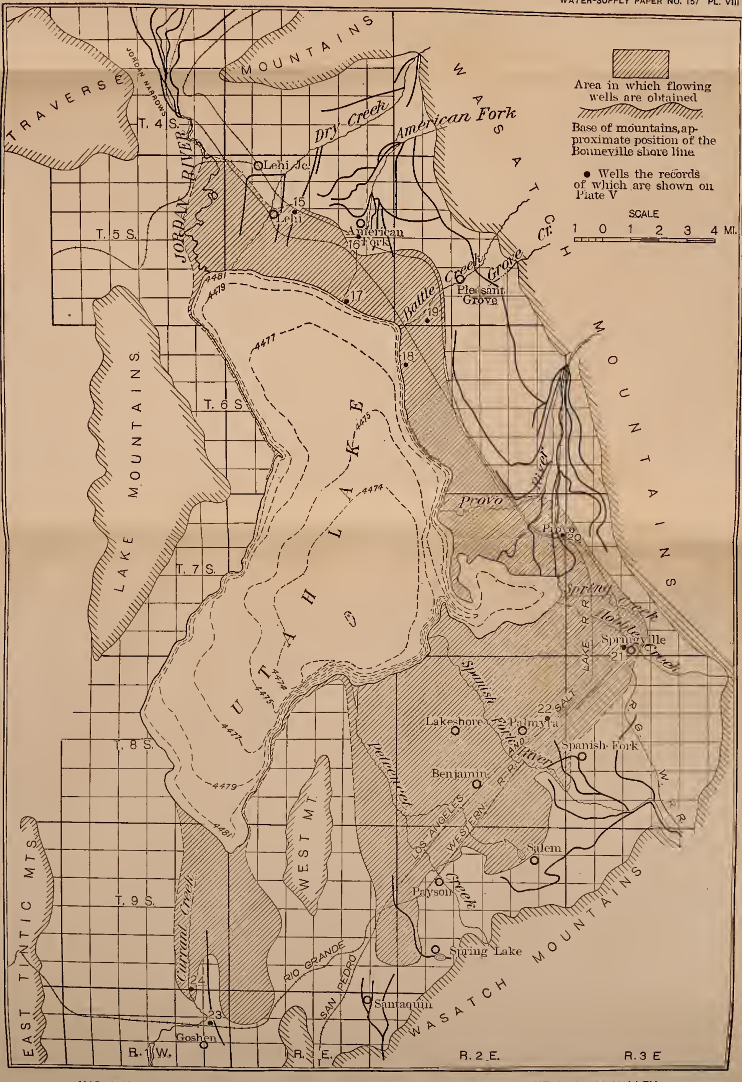
Lehi is situated in the main valley at some distance from the distinct terraces. Dry Creek lies adjacent to the town, but, as its name signifies, the creek, after supplying a number of irrigation ditches, usually carries little or no water in its lower course. There is no public water system in the town, and the supply for domestic purposes is derived from numerous wells. A few shallow dug wells tap ground water at depths of 5 to 30 feet, but the majority are deeper and reach water under pressure. The sugar-plant mill pond is fed by springs and is an important local source of supply.

Lehi was one of the first towns where artesian water was found in the Bonneville area, flowing wells having been obtained there about 1880. Formerly a feeble first flow was found in gravel about 60 feet from the surface and a stronger supply at a depth of about 160 feet, but in recent years flows, even from the second horizon, have failed during part of the season in consequence of the increased use of artesian wells in the area nearer the lake, and at times pumping has to be resorted to. However, when water does not actually flow it rises in the wells to within a few feet of the surface.

The general section in the vicinity of Lehi, as reported by H. C. Comer, shows blue clay to a depth of 50 or 60 feet. Below this is the first water bed, consisting of about 50 feet of sand and gravel, separated from the second water horizon by 40 feet of light clay. This section does not apply in the eastern part of the town, where the log of the San Pedro Railroad well shows coarse-textured material within 100 feet of the surface. In this well the main supply is derived from a depth of 330 feet, the water rising to within a few feet of the surface. These two logs illustrate the variability of adjacent sections.

The Utah Sugar Company's plant at Lehi has several 2-inch wells, and the following flows in gallons per minute are reported: 80 feet, 15 gallons; 120 feet, 25 gallons; 150 feet, 20 gallons. Logs of these wells were not kept. The Rio Grande Western Railway well near the sugar factory is 3 inches in diameter and 165 feet deep. The water is reported to rise in a pipe to a point 30 feet above the surface and to flow about 50 gallons a minute at the level of the ground.

Toward Utah Lake, below Lehi, there is a considerable development of flowing wells from which a number of square miles are irrigated. In this district there are several hundred flowing wells which average about 150 feet in depth. A close relationship has been established between the flow of the wells in the fields below Lehi and those in town.



MAP SHOWING THE AREA IN WHICH FLOWING WELLS ARE OBTAINED IN UTAH LAKE VALLEY.

During the irrigation season, when the field wells are all flowing, those in Lehi practically stop, but during the winter it is a general custom to plug the wells used for irrigation, after which those in town begin to flow. Measurements have not been made, but the general facts are well established.

Northwest of Lehi the line separating the areas of flowing and nonflowing wells continues to Jordan River, reaching it 3 to 4 miles north of Utah Lake. The line extends about half a mile west of the river and approaches close to the northwest corner of the lake near Saratoga Springs. In the flood plain of Jordan River flows can probably be obtained continuing into Salt Lake Valley, but outside of the line indicated the surface elevation is too great.

The Salt Lake City authorities, about 1890, sank a number of wells in the flood plain of Jordan River in sec. 12, T. 5 S., R. 1 W., with the object of increasing the supply of the Jordan and Salt Lake Canal. These wells, about 130 in number, were mostly 2 inches in diameter, though a few were 6 inches, and are said to average 100 feet deep. Clay was encountered down to the bottom of the wells, which were in gravel. It is stated that water rose in pipes 30 to 40 feet above the surface, and that individual wells flowed 125 gallons a minute. It is also stated that the combined flow amounted to 3,000,000 gallons a day. These wells soon interfered with neighboring ones, stopping their flow, and suit was brought against the city, with the result that the municipality was compelled to plug up its wells. After these had been plugged for some time a number of them were temporarily opened, and in about twenty-four hours thereafter the water in one of the wells, the flow of which was interfered with, situated about half a mile above the city wells, had fallen 2½ feet. The city wells were then capped again and in five hours the water in the well referred to had regained 7 inches of its lost level.

Near the northwestern end of Utah Lake there is a group of hot springs which occur both on shore and in the lake. On the shore there are several springs which support the Saratoga resort where the water, having a temperature of 111°, issues through the lake deposits and is used for bathing and to a limited extent for irrigation. In the summer of 1904, during the survey of Utah Lake by G. L. Swendsen of the Reclamation Service, three groups of springs were found beneath the water of the lake. Their existence was shown by the presence of depressions occupying areas of 100 square feet to 3 acres in extent and having depths of 20 to 80 feet. Since the prevailing depth of the lake is much less and the bottom is composed of slimy mud, a considerable discharge is thus indicated. Hot water that flowed above the lake surface was obtained by sinking pipes a short distance into the bottom.

About 5 miles up Dry Creek from Lehi is the town of Alpine, located near the mouth of the canyon on the dissected Bonneville terrace. The settlement is supplied with water from irrigation ditches, and possibly not more than half a dozen wells have been sunk. These are 25 to 80 feet deep, and the water level is reported to vary considerably between winter and summer. Springs occur in Dry Creek Canyon, but they have not been developed.

AMERICAN FORK, PLEASANT GROVE, AND VICINITY.

The towns of American Fork and Pleasant Grove receive their main water supplies, respectively, from American Fork and from Battle and Grove creeks. These streams feed a number of irrigation canals, and are the chief source of underground water in this vicinity. (Pl. IX, *B*.)

American Fork is built at the base of a series of terraces on both sides of American Fork (creek), which has cut a narrow channel through the old lake deposits. Ascending the valley from American Fork, five distinct terraces can be traced up to the broad Provo bench, between which and the Bonneville level, which forms a shelving bench against the mountains, traces of shore lines of pre-Bonneville age have been reported. In its lower course American Fork is dry throughout most of the year in consequence of the draft upon its waters for the canal system which supplies the uplands.

Shallow wells in American Fork are commonly less than 50 feet in depth, averaging possibly 25 to 30 feet, and the ground-water level is reported to vary 10 to 15 feet between the winter minimum and summer maximum. The water generally is found in gravel.

Deep wells have been sunk in the extreme southwestern part of the town in search of flowing water. The water rises in these nearly to the surface, and furnishes the main supply for domestic purposes. Well records show a variable succession of sand and gravel, with comparatively little clay. The city well is typical, and probably is the deepest in this vicinity. It is 440 feet deep and 6 inches in diameter. Two principal water horizons are reported, at 240 and 340 feet, and the water stands in the well at a depth of 22 feet. An electric motor pump supplies water for public purposes, but there is no waterworks system. Individual families or groups of families maintain their own wells.

The line separating the areas of flowing and nonflowing wells as mapped between Lehi and Pleasant Grove lies contiguous to the San Pedro Railroad, and here, as elsewhere, ground water commonly lies within 10 feet of the surface. Extensive areas of marshy land lie contiguous to the lake shore, where conditions have grown worse since the introduction of irrigation. The flowing wells in this vicinity vary in depth, but are commonly about 100 feet deep. As Utah Lake is approached more nearly uniform conditions are revealed by the logs. Clay is commonly present at the surface and continues to a depth of 90 or 100 feet, below which the water-bearing gravel occurs. In the deeper wells alternating sand, clay, and gravel are reported below the first gravel, and flows are obtained from every coarse-textured bed. One of the best wells in this vicinity is in sec. 23, T. 5 S., R. 1 E. It is 147 feet deep, 2 inches in diameter, and throws a stream 3 feet 8 inches above the pipe, having a capacity, therefore, of about 150 gallons a minute.

A disturbed belt of rocks, dipping eastward, and locally covered by débris, lies near the foot of the Bonneville terrace between American Fork and Grove creeks. Springs occur at about this horizon, and prospecting for water in this belt, in sec. 17, T. 5 S., R. 2 E., has brought notable results. William Wadley & Sons, by tunneling into bed rock, have developed enough water to irrigate a number of acres of fruit land, which is bringing in handsome returns. Several tunnels have been dug, the most important of which lies about 200 feet below the Bonneville level and was driven 318 feet through black shale into broken and cavernous gray limestone, in which the water occurs.

Pleasant Grove is located on alluvial slopes formed by Battle and Grove creeks. Its situation is so high that flowing wells can be obtained only in the extreme lower part of the town, which depends for its chief underground supply on wells from which water has to be pumped. Ground water can usually be obtained at 10 to 50 feet from the surface. No regular sequence of deposits underlies the town, but a variable succession of clay, sand, and gravel is encountered in wells, the water horizon usually being underlain by clay. In the southeastern part of Pleasant Grove no successful wells have yet been obtained, though prospecting for them has extended to a depth of 100 feet; not deep enough to find an impervious stratum. A continuous succession of gravel beds is reported.

The high, almost flat Provo delta between Pleasant Grove and Provo is scantily provided with water. The surface is generally gravel covered, and gravel is commonly found in wells to depths of 30 to 60 feet, below which sand is reported. Only a small amount of clay appears to be present. This tract of land is well adapted for the cultivation of fruit, but the present supply of water is insufficient for its complete development. Water was first brought to the delta by canals from Provo River in 1868, and the present supply, whereby a maximum diversion of about 116 second-feet is obtained, was established in 1888. Before irrigation was practiced on the bench the depth to ground water was considerably greater than it is now. Old wells are over 100 feet deep, but of late years the ground-water surface has risen so that on a large part of the area water can be obtained in wells averaging 50 to 75 feet deep. Toward the lower margins of the bench the depths to ground water is less than 50 feet. Here, as elsewhere throughout this entire area, ground water is lowest in the winter and highest during the irrigation season. The annual variation on Provo bench appears to range from 5 to about 17 feet. A few examples will illustrate general conditions. In 1875 a dry well 100 feet deep was dug in sec. 14, T. 6 S., R. 2 E. In the same section, during the winter of 1878–79, N. Knight dug a well 110 feet deep which afforded 3 feet of water in winter and 15 to 20 feet in summer. In 1899 N. J. Knight

A. VALLEY OF PROVO RIVER BELOW MOUTH OF CANYON, LOOKING NORTH.

Shows Provo Bench and Bonneville terrace.

B. AMERICAN FORK AT MOUTH OF CANYON.

dug a third well only 60 feet deep, near the second, which afforded about 3 feet of water in winter and 20 in summer.[a]

Flowing wells can not be obtained on the bench because of its elevation, though several attempts have been made, without success. In 1887 and 1888 two deep wells were driven in the same section as those just referred to. The Colorado Fish Company put down a 3-inch well 250 feet deep and obtained water which rose to within 80 feet of the surface. This was pumped for several years. In 1888 Mr. Knight drove a 2-inch well 300 feet deep in which water rose to within 90 feet of the surface. Both of these wells are now abandoned.

From Provo to Pleasant Grove along the narrow belt of lowland lying between Provo bench and Utah Lake there is an abundance of underground water. The line that separates flowing and nonflowing wells coincides approximately with the San Pedro Railway, which also marks roughly the upper limit of the area in which ground water lies within 10 feet of the surface. Between the railroad and the base of the bench few wells have been driven and little is known of the conditions, but it is thought that water can be obtained at depths of 10 to 50 feet.

Contiguous to the railroad a number of feeble seep springs occur along the base of a low bluff between which and the lake the ground is almost flat. Water occurs on the surface in many places, rendering the land unfit for use. Before irrigation was so extensively practiced it is reported that this lowland belt was fertile farming land, but in late years, due to the rise of the ground-water level, the land has materially decreased in value. Considerable areas of available land, however, are yet to be found in this area, and flowing wells are used to irrigate several hundred acres. Conditions can be much improved by drainage. The map and list of wells show the general conditions. The deep wells in this belt average slightly over 100 feet and generally are 2 inches in diameter. North of Provo River the yield is inconsiderable, averaging, possibly, less than 15 gallons a minute per well; but in the vicinity of Geneva, a resort on the lake below Pleasant Grove, the effect of Battle Creek drainage is experienced, and some of the strongest wells of the entire area covered by this report occur. Harry Gammon's wells, in sec. 7, T. 6 S., R. 2 E., are among the best. One of these is 3 inches in diameter, 110 feet deep, and yields a flow of about 266 gallons a minute, the water rising in a pipe to approximately 28 feet above the surface. The section in this vicinity is shown on Pl. V, the water occurring in gravel in the bottom of the well.

PROVO AND VICINITY.

Provo derives its water supply from Provo River. A number of canals tap the river (as shown on the map, Pl. VIII), and distribute a good supply to the town; and water for household purposes is delivered through city mains from a direct source in the river near the mouth of the canyon. The quality is unsatisfactory, however, and a new system is being installed whereby a better supply is obtained from a number of springs that issue from unconsolidated débris along the base of the canyon for several miles above its mouth.

Well records show fairly uniform stratigraphic conditions about Provo. Gravel usually underlies the surface to a depth of from 10 to 20 feet, and is succeeded by 20 to 30 feet of sand, below which is a considerable thickness of clay, averaging possibly 100 feet, the upper 20 or 30 feet of which is yellowish and the lower part blue. Underlying the clay a bed of gravel occurs, which is said to be underlain by clay, though about Provo it has seldom been penetrated. With minor variations this section appears to hold good over a large part of the territory adjacent to the east shore of Utah Lake. Northwest from Provo the surface gravel disappears, but clay, light above and dark below and underlain by sand and gravel, is reported in the vicinity of Geneva, American Fork, and Lehi. South of Provo, in the vicinity of Springville, similar conditions prevail. (Pl. V.)

[a] These facts were obtained from Mr. Caleb Tanner, to whom the writer is indebted for many courtesies.

The beds about Provo appear to dip toward the lake at a low angle, approximately corresponding to the slope of the surface, this being indicated by the fact that the depth at which the water-bearing gravel is found over large areas is approximately constant. In the vicinity of Provo some direct data were obtained on this point. Wells have been driven along Center street from Academy street in Provo westward to the shore of the lake. The depths at which the top of the gravel was struck in some of these wells was obtained from the driver, J. Westfall, and a line of levels was run along the surface by the United States Reclamation Service, from which it appears that the lakeward inclination of the gravel is approximately 9 feet per mile, the rate decreasing as the lake is approached. Similar conditions probably exist throughout the area studied, the slope being greatest near the mountains, while beneath the broad lowlands the strata lie more nearly horizontal.

Ground water in the vicinity of Provo can generally be obtained in the upper gravel within 10 feet of the surface. In the vicinity of the lake the gravel disappears and clay generally occupies the surface. Here, as is so general throughout the entire area, swampy conditions prevail, owing to the lowness of the region, the recession of the lake, and the rise of ground water due to irrigation.

Flowing wells exist in great number in this well-populated region, and in general an abundance of good water is obtained within 200 feet of the surface. The main water-bearing horizon is the bed of gravel that underlies the blue clay. Water is generally reached in this gravel at 150 to 200 feet from the surface, but conditions are not absolutely uniform at all places, and where the prevailing section is varied by local streaks of clay, sand, and gravel corresponding differences exist. Feeble flows are sometimes found at 100 feet, and a few wells obtain water from a depth of 360 feet, but this depth is unusual in the vicinity of Provo. The wells about Provo are generally 2 inches in diameter, and their flow may possibly average 50 gallons a minute. Among the best wells in this vicinity are those at the stations of the San Pedro, Los Angeles and Salt Lake Railroad and the Rio Grande Western Railway. These are 3 inches in diameter and 190 and 176 feet deep, respectively. In November, 1904, the Rio Grande Western well was found to flow approximately 120 gallons a minute at 2 feet above the surface under a pressure of 15½ pounds per square inch.

SPRINGVILLE AND VICINITY.

Between Provo and Springville the lowland contiguous to Utah Lake extends to the Rio Grande Railroad, above which the surface rises at a steep grade to the base of the mountains. The lowland for the most part is marshy, and the line that separates flowing and nonflowing wells lies only a short distance east of the railroad. A low scarp, which apparently marks a Pleistocene fault, can be traced immediately west of the county road for a mile or more beyond the Utah County Infirmary toward Springville. Springs occur at the base of the scarp, and the large springs at the head of Spring Creek may be associated with faulting. A number of small lakes mark the presence of these springs, and Spring Creek, whose main supply is thus derived, flows about 1,600 second-feet.

The deepest well in this area is that of the infirmary, situated near the road about midway between Provo and Springville. The well is 3 inches in diameter and 270 feet deep, and water is reported to rise in a pipe to a point 3 feet above the surface, flowing about 30 gallons a minute. In this vicinity a feeble first flow is reported at depths of 65 to 80 feet.

Springville is situated on the plain about 3 miles below the mouth of Hobble Creek Canyon, the channel of the creek passing through the town. During the irrigation season practically all of Hobble Creek water is diverted by canals that head near the base of the mountains.

Ground water in Springville is obtained from wells that usually range in depth from 20 to 30 feet, the water occurring in the top gravel. The general level of ground water in the town is reported not to have changed since the early days, and only an annual difference of a few feet is noticed between winter and summer conditions.[a]

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[a] Stevenson, J. B., well driver.

Records of wells in the vicinity of Springville show rather uniform conditions. The town generally is underlain by gravel 5 to 40 feet thick, below which blue clay occurs to a depth of about 130 feet, underlain by sand and gravel down to 180 feet; then about 50 feet of light-colored clay is encountered, followed by sand and gravel at a depth of about 230 feet. In the area nearer the lake the top gravel generally is wanting, but otherwise similar sections are reported in that locality.

Flowing wells are obtained from the two lower gravel horizons at depths of approximately 130 and 230 feet. The common occurrence of water at these two horizons implies unusual uniformity of underground conditions, and suggests a low lakeward dip, approximately corresponding to the surface inclination. The wells are commonly 2 inches in diameter, though a few are 3 inches, and they yield on an average possibly 20 to 50 gallons a minute. One of the best in Springville is a 3-inch well belonging to A. Cox. It is 230 feet deep, flows about 120 gallons a minute, and its water is reported to rise in a pipe to a point 18 feet above the surface. The Rio Grande Railway Company has two wells in Springville, which are 216 and 304 feet deep. In the deeper the first flow was struck at 126 feet, a second at 216, a third at 260, and a fourth at 292. The shallower well is 3 inches in diameter, and is reported to flow about 200 gallons a minute at the surface, which is reduced to about 12 gallons a minute at the top of a tank about 30 feet above the surface.

Mapleton Bench is the local name for the Provo Delta, lying between Spanish Fork and Hobble Creek. The delta is here prominently developed, and constitutes valuable farming land. Flowing wells are not obtained on Mapleton Bench because of its elevation, but there are a number of dug wells. It is reported that in the early days the wells on the bench were 60 feet or more in depth, but since irrigation has been practiced the groundwater level has been considerably raised, and now the wells average possibly only 30 feet in depth. There is a marked difference in the depth to ground water in winter and summer, the range in some instances amounting to over 10 feet. Along the outer margin of the bench there is a line of springs, many of which did not exist before the ditches were dug. Big Hollow Creek, a stream that flows from the bench about 2 miles south of Springville, is a conspicuous example. In the early days scarcely any water is said to have flowed in its channel, whereas it now irrigates over 100 acres.

Considerable amounts of water are obtained by a few tunnels that have been dug along the eastern edge of Mapleton Bench. The entrances to the tunnels are commonly at the sites of springs. Some begin and end in unconsolidated materials, while others penetrate bed rock. The longest noted is in sec. 24, T. 8 S., R. 3 E. Its length is 275 feet. Water enough to irrigate about 100 acres comes through crevices in bed rock.

SPANISH FORK, PAYSON, AND VICINITY.

The town of Spanish Fork is situated on the general lowland at the base of Mapleton Bench and immediately north of Spanish Fork, about 5 miles below the mouth of its canyon. From the few well records available it appears that sand and gravel commonly underlie the surface to a depth of about 30 feet and are succeeded by 150 feet of clay, below which water-bearing gravel is usually encountered at a depth of 180 feet. The log of the well recently completed at the San Pedro station, about a mile west of the town, shows a greater thickness of clay, amounting to 205 feet, beneath which sand and clay were found to 390 feet, where water-bearing gravel occurs.

Spanish Fork is rather poorly supplied with underground water. Dug wells commonly reach water at depths ranging from 10 to 25 feet, but its quality is not good. Flowing wells were formerly obtained, but in recent years the flows generally have ceased and pumping has to be resorted to. A city waterworks system was installed in 1904, the supply being derived from Evans Spring, near the mouth of Spanish Fork Canyon, about 5 miles above the town, and an excellent supply is now available. The line separating flowing and nonflowing wells now lies in the extreme northwest corner of the town. The first flow occurs at a depth of about 180 feet and a second flow between 350 and 400 feet. The creamery well, 2 inches in diameter and 220 feet deep, is typical. Water was struck at 180 feet which in 1900 flowed 9 gallons a minute, while in 1904 it stood about 4 feet below the surface with little or no variation. In 1904 the San Pedro, Los Angeles and Salt Lake Railroad Company put down a well 415 feet deep at its Spanish Fork station and obtained a flow of 36 gallons a minute through a 2-inch pipe from gravel in the bottom of the well.

Between Spanish Fork and the Goshen divide there are a number of settlements that are adjacent to the line separating flowing and nonflowing wells.

Salem is situated at the lower end of the Provo Bench, about midway between Spanish Fork and Payson. In the northwestern part of the town the water table lies close to the surface and throughout the greater part of the settlement water can be obtained within 10 feet of the surface. There are many springs, the most important of which supply Salem Pond, which covers about 13 acres and averages possibly 12 feet in depth. The line separating flowing and nonflowing wells passes about midway through Salem. The flowing wells are generally feeble and the quality of the water is poor. A first flow is commonly obtained at about 160 feet and a second at about 250 feet.

Payson is situated on and near the delta formed by Peteneet Creek at the Provo stage of Lake Bonneville, part of the town being built on the delta and part on the subjacent plain. Flowing wells are not obtainable because of the elevation, and the underground water supply is furnished by dug wells. These vary considerably in depth because of the irregular distribution of the delta deposits. Their depth ranges from 15 to 115 feet and probably averages between 30 and 40 feet. As an instance of local variation it may be mentioned that in one well ground water is obtained at 18 feet while on the opposite side of the street a well was dug 90 feet without encountering water. The level of ground water is reported to fluctuate but little. A number of families in Payson are supplied by pipe lines, the water being derived from tunnels driven into the base of the bench.

The town of Spring Lake is situated near the base of the mountains. The line separating flowing and nonflowing wells passes along the foot of the Provo Bench and lies about half a mile west of the town. In this locality ground water is found commonly within 10 feet of the surface and there are a number of shallow wells, but the chief supply comes from springs. Spring Lake covers an area of about 12 acres and discharges a stream of about 2 second-feet. It is made by damming a small creek that is fed by springs. Springs occur in the vicinity of the base of the mountains between Spanish Fork and Spring Lake. Most of them appear to be seep springs, but some that lie near faults that adjoin the base of the mountains may be of deeper seated origin. Many of the springs flow 20 to 50 gallons a minute.

Santaquin is built on a delta of Santaquin Creek, near the base of the mountains, far above the general level at which flowing wells are obtained. The town is chiefly supplied with water for both household and irrigation uses by Santaquin Creek, and only a few wells have been dug. About a dozen wells strike water in gravel at depths of between 15 and 25 feet on a low bench in the southeastern part of the town. Tunnels are also dug into this bench, from which two pipe lines supply a number of families with water. Below the bench in Santaquin there are very few wells; two had to be dug about 80 feet before water was obtained.

Below the line separating flowing and nonflowing wells between Hobble and Santaquin creeks the valley plain slopes gently to Utah Lake. Throughout this area ground water lies within 10 feet of the surface, and adjacent to the lake and in certain isolated localities swampy conditions occur. This area is mostly underlain by clay, which is reported to predominate in all of the wells. Little or no gravel is encountered in well driving and the layers of clay alternate with layers of sand. Few satisfactory well records from this region have been obtained, and no correlation of the underground deposits has been possible. Different conditions seem to exist in neighboring wells, indicating a lenticular arrangement of the deposits.

The towns of Palmyra, Lake Shore, and Benjamin are situated below the line of flowing wells. Many farms are scattered over this area, but in a few localities—north of Spanish Fork, for instance—alkali is so prevalent as to discourage settlement. Much of the water used in irrigating this tract is derived from canals supplied by Spanish Fork, but flowing wells also are used to a considerable extent.

Flowing wells have been obtained throughout this area at depths of 50 to 500 feet, as shown by the list. Flows are usually found in every considerable bed of sand encountered in drilling, and six or more water-bearing beds are sometimes struck in a 400-foot well. Shallow wells are not the rule in this region, for, though many are 150 to 200 feet deep, the majority are nearer 400 feet deep. Because of the general absence of gravel and of persistent beds of sand there are few especially good wells. The flows obtained are generally under 50 gallons a minute and frequently are less than 10. The pressure is low, seldom being sufficient to cause the water to rise more than a few feet above the surface.

At the southern end of the lake, north of West Mountain, just above low-water level there is a warm spring that was estimated to flow 200 gallons a minute. Its temperature is 88°.

GOSHEN VALLEY.

Goshen Valley can be divided into a highland and a lowland portion, a convenient line of division for present purposes being that which separates areas where ground water lies above 10 feet from the surface, from those in which it lies below that depth. The highland lies contiguous to the mountains and merges into the lowland which adjoins the lower course of Currant Creek and the southern extremity of Utah Lake. The lowland is chiefly underlain by clay and the soils contain abundant alkali.[a] Throughout the entire area ground water lies close to the surface and marshy conditions exist, especially toward the lake.

The area of flowing wells in Goshen Valley embraces about 15 square miles and extends from Utah Lake to within about a mile of Goshen. Within it flowing wells are obtained at depths ranging from 50 to 400 feet. From the few available records it appears that varying stratigraphic conditions exist in this area, the prevailing clay being irregularly interbedded with sand, usually in thin streaks, with very little gravel. The flows obtained are small, averaging possibly about 5 gallons a minute, and the pressure is sufficient to cause the water to rise only a few feet above the surface.

Goshen itself is furnished with surface water from ditches supplied by Currant Creek and by springs located at the base of the hills about 2 miles east of the town. The underground supply is derived from wells that usually range from 25 to 75 feet in depth. The wells are put down through clay to sand in which water is found under pressure sufficient to cause it to rise almost to the surface, the usual depth to water being 3 to 20 feet. A number of unsuccessful attempts to get flowing wells have been made, the deepest being the railroad well put down near the station. It is 334 feet deep, and water is reported to have risen in it to within a few feet of the surface.

The highland area is underlain chiefly by coarse detritus derived from the adjacent mountains and distributed either as shore deposits in Lake Bonneville or as alluvial accumulations. This higher portion of Goshen Valley is poorly supplied with water, the chief sources being Kimball Creek, a small stream which seldom flows below its mountain course, and Currant Creek, which flows perennially and supplies the lower valley. The discharge of Currant Creek, however, is insufficient for the needs of the upland. A reservoir has been built by damming Currant Creek at the entrance to its canyon course through Long Ridge, and a canal constructed which skirts the upper part of Goshen Valley, but the enterprise has been a failure.

A few springs occur along the eastern base of the Tintic Mountains and some successful attempts have been made there to develop underground water by tunneling. In the upper valley of Kimball Creek there are a number of springs which flow about 100 gallons a minute, and smaller ones occur in several gulches. About 2 miles east of Goshen there is a group of springs at the base of Long Ridge, where water issues through débris and accumulates in several small ponds, the temperature of which is reported to stay at about 70° F. throughout the year. These springs constitute the source of Warm Creek, and their combined flow in November, 1904, was estimated at about 5 second-feet. Water has been developed

[a] Sanchez, A. M., Soil survey of the Provo area, Utah: Bull. Bureau of Soils, U. S. Dept. Agric., 1904.

by tunneling at several localities along the eastern slope of the Tintic Mountains. In the valley of Kimball Creek, in sec. 11, T. 11 S., R. 2 W., there is a tunnel 200 feet long in volcanic rock, which furnishes about 20 gallons a minute, and water sufficient for milling purposes has been developed by drifting into the alluvium and bed rock at the head of Homansville Canyon.[a]

Away from the bordering mountains in the highland portion of Goshen Valley, very little underground water has been obtained, and considering the slight run-off and the small tributary drainage area, not much can be expected. The most favorable locations for sinking wells are along the courses of drainage ways. The most successful are along the course of Kimball Creek, but even there water commonly is not obtained at depths less than 150 feet. A number of dry wells have been sunk in the upland area.

WEST OF UTAH LAKE.

The narrow strip of lowland between the western shore of Utah Lake and the Lake Mountains is very scantily provided with water. The low, narrow mountains catch relatively little precipitation; there are no perennial streams, and the arroyos carry water only for a few days during the year. From the foot of the Bonneville and Provo terraces that extend along the base of the mountains the surface slopes gradually lakeward and is underlain chiefly by coarse-textured deposits.

Along the shore of the lake a number of seep springs occur near water level. They are most abundant from Lehi southward, and there are also a few 2 or 3 miles beyond Pelican Point, where their presence is marked by low, marshy areas, one of which is utilized in the cultivation of a few acres of alfalfa. Near Pelican Point there is a feebly flowing well 90 feet deep, in which water was obtained at a depth of 60 feet; and in a near-by well a feeble flow is also obtained, which is said to come from a depth of 154 feet.

Few if any other attempts have been made to recover underground water in this region. Judging from the wells at Pelican Point one might expect to obtain similar results along the western shore of the lake, but if flows were obtained the water would be at so low an elevation as to make it of little use without pumping. Away from the shore flows can hardly be expected. It may be, however, that limited amounts of water can be found to rise in wells to within pumping distance. Prospecting for shallow wells might be attempted in the arroyos, but because of the limited watershed and precipitation the prospect is not good for obtaining enough underground water for extensive irrigation. Pumping directly from the lake presents attractive possibilities.

WELL DATA.

The writer is indebted for the subjoined list of wells to Messrs. F. D. Pyle and T. F. McDonald. Mr. Pyle worked in Utah Lake Valley and west of Jordan River. Mr. McDonald, whose assistance was obtained through the courtesy of Mr. George W. Snow, engineer of Salt Lake City, collected data east of Jordan River. The yield of flowing wells was commonly measured by means of tables which are here inserted, together with accompanying explanation, because the method aroused popular interest and because the edition of the bulletin in which the tables were published has been exhausted.

METHOD OF MEASUREMENT.[b]

Tables for determining the discharge of water from completely filled vertical and horizontal pipes were prepared a number of years ago by Prof. J. E. Todd, State geologist of South Dakota, who issued a private bulletin describing simple methods of determining quickly, with fair accuracy and with little trouble, the yield of artesian wells. In the following notes the tables and explanations relating to vertical and horizontal pipes are taken from this bulletin. The explanations have been appended by the present writer.

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[a] Smith, G. O., and Tower, G. W., Description of the Tintic district: U. S. Geologic Atlas, special folio 65, U. S. Geol. Survey, 1900.

[b] Slichter, C. S.: Water-Sup. and Irr. Paper No. 110, U. S. Geol. Survey, 1905, pp. 37-42.

In determining the flow of water discharged through a pipe of uniform diameter all that is necessary is a foot rule, still air, and care in taking measurements. Two methods are proposed—one for pipes discharging vertically, which is particularly applicable before the well is permanently finished, and one for horizontal discharge, which is the most usual way of finishing a well.

The table [on page 58] is adapted to wells of moderate size, as well as to large wells. In case the well is of other diameter than given in the table its discharge can without much difficulty be obtained from the table by remembering that, other things being equal, the discharge varies as the square of the diameter of the pipe. If, for example, the pipe is one-half inch in diameter its discharge will be one-fourth of that of a pipe 1 inch in diameter for a stream of the same height. In a similar manner the discharge of a pipe 8 inches in diameter can be obtained by multiplying the discharge of the 4-inch pipe by 4.

In the first method the inside diameter of the pipe should first be measured, then the distance from the end of the pipe to the highest point of the dome of the water above in a strictly vertical direction—*a* to *b* in the diagram [fig. 5]. Find these distances in table [p. 58, A] and the corresponding figure will give the number of gallons discharged each minute. Wind would not interfere in this case so long as the measurements are taken vertically.

The method for determining the discharge of horizontal pipes requires a little more care. First measure the diameter of the pipe, as before, then the vertical distance from the center of the opening of the pipe, or some convenient point corresponding to it on the side of the pipe, vertically downward 6 inches, *a* to *b* of the diagram, then from this point strictly horizontally to the center of the stream, *b* to *e*.

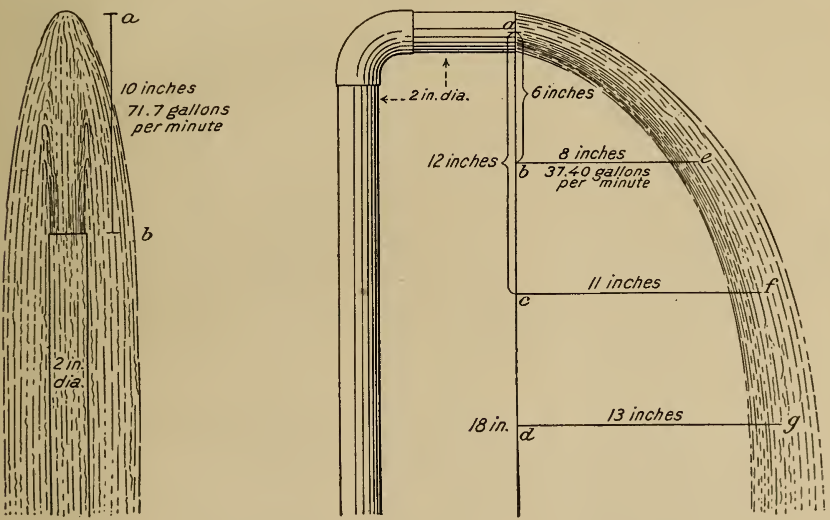

FIG. 5.—Diagram illustrating flow from vertical and horizontal pipes.

With these data the flow in gallons per minute can be obtained from table [p. 58, B]. It will readily be seen that a slight error may make much difference in the discharge. Care must be taken to measure horizontally and also to the center of the stream. Because of this difficulty it is desirable to check the first determination by a second. For this purpose columns are given in the tables for corresponding measurements 12 inches below the center of the pipe. Of course the discharge from the same pipe should be the same in the two measurements of the same stream. Wind blowing either with or against the water may vitiate results to an indefinite amount. Therefore measurements should be taken while the air is still.

Whenever fractions occur in the height or horizontal distance of the stream, the number of gallons can be obtained by apportioning the difference between the readings in the table for the nearest whole numbers, according to the size of the fraction. For example, if the distance from the top of the pipe to the top of the stream in the first case is 9⅓ inches, one-third of the difference between the reading in the table for 9 and 10 inches must be added to the former to give the correct result.

In case one measures the flow of a well by both methods he may think that the results should agree, but such is not the case. In the vertical discharge, there being less friction, the flow will be larger; so, also, in the second method differences will be found according to the length of the horizontal pipe used.

As pipes are occasionally at an angle, it is well to know that the second method can be applied to them if the first measurement is taken strictly vertically from the center of the opening and the second measurement from that point parallel with the axis of the pipe to the center of the stream, as before. The measurements can then be read from the table.

Table for determining yield of artesian wells.

[Gallons per minute.]

A.—Flow from vertical pipes.

Height of jet.	Diameter of pipe in inches. 1.	1¼.	1½.	2.	3.
Inches.					
½	3.96	6.2	8.91	15.8	35.6
1	5.60	8.7	12.6	22.4	51.4
2	7.99	12.5	18.0	32.0	71.9
3	9.81	15.3	22.1	39.2	88.3
4	11.33	17.7	25.5	45.3	102.0
5	12.68	19.8	28.5	50.7	113.8
6	13.88	21.7	31.2	55.5	124.9
7	14.96	23.6	33.7	59.8	134.9
8	16.00	25.1	36.0	64.0	144.1
9	17.01	26.6	38.3	68.0	153.1
10	17.93	28.1	40.3	71.6	161.3
11	18.80	29.5	42.3	75.2	169.3
12	19.65	30.7	44.2	78.6	176.9
13	20.46	31.8	45.9	81.8	184.1
14	21.22	33.0	47.6	84.9	190.9
15	21.95	34.2	49.3	87.8	197.5
16	22.67	35.2	50.9	90.7	203.9
17	23.37	36.3	52.5	93.5	210.3
18	24.06	37.5	54.1	96.2	216.5
19	24.72	38.6	55.6	98.9	222.5
20	25.37	39.6	57.0	101.6	228.5
21	26.02	40.6	58.4	104.2	234.3
22	26.66	41.6	59.9	106.7	240.0
23	27.28	42.6	61.4	109.2	245.6
24	27.90	43.5	62.8	111.6	251.1
25	28.49	44.4	64.1	114.0	256.4
26	29.05	45.3	65.3	116.2	261.4
27	29.59	46.1	66.4	118.2	266.1
28	30.08	46.9	67.5	120.3	270.4
29	30.55	47.5	68.5	121.9	274.1
30	30.94	48.2	69.4	123.4	277.6
36	34.1	53.2	76.7	136.3	306.6
48	39.1	61.0	88.0	156.5	352.1
60	43.8	68.4	98.6	175.2	394.3
72	48.2	75.2	108.0	192.9	434.0
84	51.9	81.0	116.8	207.6	467.0
96	55.6	86.7	125.0	222.2	500.0
108	58.9	92.0	132.6	235.9	530.8
120	62.2	98.0	139.9	248.7	559.5
132	65.1	102.6	146.5	260.4	585.9
144	68.0	106.4	153.1	272.2	612.5

B.—Flow from horizontal pipes.

Horizontal length of jet.	1-inch pipe. 6-inch level.	1-inch pipe. 12-inch level.	2-inch pipe. 6-inch level.	2-inch pipe. 12-inch level.
Inches.				
6	7.01	4.95	27.71	19.63
7	8.18	5.77	32.33	22.90
8	9.35	6.60	36.94	26.18
9	10.51	7.42	41.56	29.45
10	11.68	8.25	46.18	32.72
11	12.85	9.08	50.80	35.99
12	14.02	9.91	55.42	39.26
13	15.19	10.73	60.03	42.54
14	16.36	11.56	64.65	45.81
15	17.53	12.38	69.27	49.08
16	18.70	13.21	73.89	52.35
17	19.87	14.04	78.51	55.62
18	21.04	14.86	83.12	58.90
19	22.21	15.69	87.74	62.17
20	23.37	16.51	92.36	65.44
21	24.54	17.34	96.98	68.71
22	25.71	18.17	101.60	71.98
23	26.88	18.99	106.21	75.26
24	28.04	19.82	110.83	78.53
25	29.11	20.64	115.45	81.80
26	30.38	21.47	120.07	85.07
27	31.55	22.29	124.69	88.34
28	32.72	23.12	129.30	91.62
29	33.89	23.95	133.92	94.89
30	35.06	24.77	138.54	98.16
31	36.23	25.59	143.16	101.43
32	37.40	26.42	147.78	104.70
33	38.57	27.25	152.39	107.98
34	39.64	28.08	157.01	111.25
35	40.45	28.64	161.63	114.52
36	41.60	29.46	166.25	117.79
Continue by adding for each inch—				
....	1.15	0.82	4.62	3.27

NOTE.—To convert results into cubic feet, divide the number of gallons by 7.5, or, more accurately, by 7.48.

The flow in pipes of diameters not given in the table can easily be obtained in the following manner:

For ½-inch pipe, multiply discharge of 1-inch pipe by 0.25
For ¾-inch pipe, multiply discharge of 1-inch pipe by .... .56
For 1¼-inch pipe, multiply discharge of 1-inch pipe by 1.56
For 1½-inch pipe, multiply discharge of 1-inch pipe by 2.25
For 3-inch pipe, multiply discharge of 2-inch pipe by 2.25

For 4-inch pipe, multiply discharge of 2-inch pipe by 4.00
For 4½-inch pipe, multiply discharge of 2-inch pipe by 5.06
For 5-inch pipe, multiply discharge of 2-inch pipe by 6.25
For 6-inch pipe, multiply discharge of 2-inch pipe by 9.00
For 8-inch pipe, multiply discharge of 2-inch pipe by 16.00

LIST OF TYPICAL WELLS.

Wells in Jordan River and Utah Lake valleys.

[Height of water above surface indicated by plus +; below surface indicated by minus −.]

Name of owner.	Location.	Diameter.	Depth.	Height of water.	Yield per minute.
		Inches.	*Feet.*	*Feet.*	*Gallons.*
B. Young	T. 1 N., R. 1 E., sec. 31		75	−	
J. L. Haywood	do		61	−	
R. R. Anderson	do		48	−	
C. R. Savage	T. 1 N., R. 1 E., sec. 32		35	−	
G. A. Hatch	T. 1 N., R. 1 W., sec. 1		18	−14	
J. Howard	do	2	312	+	½
Stockyards	T. 1 N., R. 1 W., sec. 3	2		+	5
T. German	T. 1 N., R. 1 W., sec. 4	2½		+	1½
F. S. Rudy	T. 1 N., R. 1 W., sec. 5	6	1,002	+	Many.
J. E. Peterson	T. 1 N., R. 1 W., sec. 9	2	497	+	6
J. Minegar	T. 1 N., R. 1 W., sec. 10	1½	150	+	1½
Do	do	1½	250	+	5
R. A. Bosley	T. 1 N., R. 1 W., sec. 11	1½	50	−20-50	
J. C. Hansen	T. 1 N., R. 1 W., sec. 15	2	479	+	
W. S. McDonald	T. 1 N., R. 1 W., sec. 17	2	400	+	40
Gun Club	T. 1 N., R. 1 W., sec. 21	2	450	+	30
J. Herridge	T. 1 N., R. 1 W., sec. 22	1½	160	+	3-7
G. Baldwin	do	2	330	+	3
C. A. Anderson	T. 1 N., R. 1 W., sec. 23		28	−	
P. Olene	do		26	−	
S. Bamberger	T. 1 N., R. 1 W., sec. 25	2	60-70	+	
G. Fritt	do	1½	80	+	2
J. Withers	do	1½	70	−	
I. Langton	T. 1 N., R. 1 W., sec. 26	2	400	+	3
G. Martin	do		140	+	1-2
A. J. Davis	T. 1 N., R. 1 W., sec. 27	2	154	+	1
F. W. Kettle	do	2	208	+	
A. M. Davis	T. 1 N., R. 1 W., sec. 34	2	408	+	25
Do	do	1½	250	+	1
E. King	do	2	320	+	1½
Wantland	do	2	350	+	1
J. J. Sears	T. 1 N., R. 1 W., sec. 35	1¼	140	+	
Do	do	2	210	+	5
Do	do	2	350	+ 1	15
P. Cline	do	1½	135	+	2
R. Weisner	do	2	130	+	3
J. W. Evans	do	1½	68	+	2
W. Pearson	T. 1 N., R. 1 W., sec. 36	1¼	93	+	15
J. W. Haddock	do	2	95	+	35
A. Elkins	do	2	123	+	30
A. J. Ridges	do	1½	100	+	25
W. Spicer	do	1½	75	+	5-20
J. Sandborg	do		75	−	
H. Price	do	1½	75	−	
Mrs. Winters	do	2	96	−	
R. Griffith	do	2	200	+	20

Wells in Jordan River and Utah Lake valleys—Continued.

Name of owner.	Location.	Diameter.	Depth.	Height of water.	Yield per minute.
		Inches.	*Feet.*	*Feet.*	*Gallons.*
S. A. Gibbs	T. 1 N., R. 1 W., sec. 36	2–3	75–80	+	40
F. Auerbach	T. 1 N., R. 2 W., sec. 25		400		
J. Bond	T. 1 N., R. 2 W., sec. 29		401	+	4
Do	do		465	+	9
Cullen Dairy	T. 1 N, R. 2.W., sec. 35	2		+	
J. Walker	T. 1 S., R. 1 E., sec. 5	1½	80	+	20
P. J. Stone	do		16	− 6	
J. Lunn	do		73	−	
W. J. Kelson	do		45	−	
S. McKay	do		29	−	
Speirs	do		40	−12	
Do	do		12	− 6	
J. E. Wesley	T. 1 S., R. 1 E., sec. 6		75	−	
J. Warburton	do	2	82	+	7
H. S. Sampson	do	2	387	+	8
W. Wheeler	do		10	−	
T. Golightly	do	1½	100	+	
S. K. Hansen	do	2	162	+	6–8
W. N. Sheets	T. 1 S., R. 1 E., sec. 7	2	100	+	30
F. Sproul	do	2	125	+	1/7
G. Baiber	do		170	+	12
F. Rogansky	do		150	+	1
City, about 16 wells	do	2–9	100–600	+35	(?) 600
E. O. Butterfield	do	2	178	+	2–3
J. S. Wooley and others	do		150–200	+	20–50
T. Berg	do	2	155	+	50
Do	do	2	160	+	50
W. Colton	do	2	60	+	6
L. Badger	do	2	165	+	30
J. W. Hicks	do	2	110	+	35
A. Duncan	T. 1 S., R. 1 E., sec. 8	1½	50	− 1	
T. Antisill	do	2	50	+	3
S. M. Alley	do	3	26	−	
S. H. Calder	do	2	246	+	40
S. Sudbury	do	1½	390	+	8
J. R. Miller	do	2	207	+12	50
P. Rosmason	do		41	−	
Mrs. M. Larsen	do		28	− 5–6	
W. Pickens	do		42	− 7	
A. Ames	T. 1 S., R. 1 E., sec. 9		100	−	
A. S. Martin	T. 1 S., R. 1 E., sec. 10		130	−	
J. A. Shelter	T. 1 S., R. 1 E., sec. 15		85	−65	
L. Hunt	do		51	−30–50	
A. Hord	T. 1 S., R. 1 E., sec. 16		54	−	
A. Martin	do		56	−46	
H. E. Thorp	do		18	−	
J. S. Southern	T. 1 S., R. 1 E., sec. 17		32	−	
A. Buggs	do		22	− 4–16	
J. E. Nailor	do		20	− 5–14	
T. Y. Taylor	do	2	100	−	
(*a*)	do	2	200	+	6
W. H. Miller	do	2	335	+	50
W. H. Burnett	do		15	− 3–11	
M. C. Sandford	do		33	− 3	

a Owner's name unknown.

Wells in Jordan River and Utah Lake valleys—Continued.

Name of owner.	Location.	Diameter.	Depth.	Height of water.	Yield per minute.
		Inches.	*Feet.*	*Feet.*	*Gallons.*
J. A. James	T. 1 S. R. 1 E., sec. 17		33	−28	
(*a*)	do		10	−	
G. Hemsley	do		14	−	
J. Hemsley	do		48	−43	
J. J. Hurtt	T. 1 S., R. 1 E., sec. 18	2	325		4–5
T. Furgeson	do	2	300	+	30–40
W. N. Sheets	do	2	100	+	30
M. Gray	do	2	164	+	10
F. H. Woodbury	do		160	+	18
M. P. Holmes	do		20	−	
E. H. Stout	do	2	72–82	+	30–40
J. H. Cochran	do	2	500	+	5
F. Prittish	do	2	600	+	12–14
Salt Lake Co	do	2	636	+	(?) 150
E. Jepson	do	2	150	+	10
F. Wittich	do	2	40	+	18
L. A. Kelsh	do	2	325–350	+	30–40
D. Evans	do		501	+	80
Erickson	do	3	382	+	(?) 100
I. Riches	do		17	−	
M. Chophussen	do	2	250–300	+	1–13
E. S. Pierce	do	2	322	+	55
(*a*)	do		560	+	20–30
W. H. Wolstezhoh	do	3	40	−	
C. B. Stock	do	2	298	+	10–12
J. I. Freeman	do	2	100	+	5–6
H. Best	do	1½	50	+	8
A. Best	do		160–170	−	
J. A. Bush	T. 1 S., R. 1 E., sec. 19	3	323		
J. H. Tipton	do	2	296	+	50–60
L. W. Burton	do	2	285	+	60
Do	do	2	150	+	25
Do	do	2	437	+	10–30
Do	do		100		
J. Riley	do	2	94	+	17–20
G. Hall	do	2	60	+	1
J. C. Hogan	do	2	176	+	18
J. O. Young	do	2	180	+	20–25
R. B. Young	do		90	+	20–25
M. W. Taylor	do	2	181	+	(?) 100
L. H. Kimball	do	1¾	84	+	10
Do	do	2	212	+	1
W. C. Winder	do	2	75	+	
Do	do	2	240	+	
A. Walker	do			+	30
(*a*)	do		150		40
E. P. Parrot	do	2	150–160		46
H. Behling	T. 1 S., R. 1 E., sec. 20		23	−20	
H. Eldridge	do		26		
T. R. Cutler	do	3	65		
S. Love	do		40	+	5–6
M. C. Morris	do		162	+	½
N. J. Hansen	do	2	156	+	28
A. Hoskinson	do		21	−14–15	

a Owner's name unknown.

Wells in Jordan River and Utah Lake valleys—Continued.

Name of owner.	Location.	Diameter.	Depth.	Height of water.	Yield per minute.
		Inches.	*Feet.*	*Feet.*	*Gallons.*
C. Hansen	T. 1 S., R. 1 E., sec. 20		22	− 18	
P. R. Ryon	do		158	+	80
G. Cusiman	do		18	− 15	
W. C. Smoot	do		22	− 19	
J. Neff	T. 1 S., R. 1 E., sec. 26		23	−	
C. Banford	do		100	−	
J. Fisher	T. 1 S., R. 1 E., sec. 27		33	− 20	
J. Young	do		184	−104	
F. Ereickson	T. 1 S., R. 1 E., sec. 28		27	− 25	
J. Childs	T. 1 S., R. 1 E., sec. 29		55	−	
W. M. Tillman	do		68	−	
F. Degenhart	do	2	68	− 37	
J. P. Cahoon	do		26	−	
W. S. Timmons	do	2	194	+	9
J. T. Guest	do	2	187	−	
R. Pike	do		40	− 34	
J. Madsen	do		260	− 16	
J. S. Gustavensen	do	2	190	+	2
H. Hizzard	do		200	+	2
Mrs. C. Green	do		184	−	
Do	do		215	+	11
S. F. Evans	do	2	208	−	
O. Reece	do		209	+	30
Do	do		245	+	30
Do	do		245	+	13
L. Stutts	do	2	141–143	+	40
S. Hicks	do	2	100	+	30
E. E. Keithley	do	3	120	+	(?) 100
H. Burnett	do		202	+	27
Do	do		24	−	
W. J. Miller	do	2	200	+	20
G. Fairbourne	do	2	128	+	20
J. Tremayave	T. 1 S., R. 1 E., sec. 30	2	251	+	20
G. Taylor	do		104	+	
W. Chantron	do	2	235	+	30
J. J. Spencer	do	2	240	+	17
M. M. Listen	do	2	110	+	5
J. Cobert	do		216	+	24
School	do	2	218	+	12
G. Calder	do	2	130	+	45
R. Norman	do	1½	100	+ 6	
Mrs. A. S. Berg	do	2		+	28
A. Johansen	do	2	175	+	8
(a)	do	2		+	30
Murray Live Stock Co.	do	2		+	40–60
M. Knudsen	do		300	+	20
L. White	do		185–230	+	60
E. J. Williams	do	2	82–83	+	25
Do	do	2	50	+	1
C. Halford	do	1¼	160	+	10
A. M. Rymarson	T. 1 S., R. 1 E., sec. 31	2	202	+	35
Do	do	2	72	+	6
L. Parks	do	2	237		
J. Hulse	do	2	160	+	20

a Owner's name unknown.

Wells in Jordan River and Utah Lake valleys—Continued.

Name of owner.	Location.	Diameter.	Depth.	Height of water.	Yield per minute.
		Inches.	*Feet.*	*Feet.*	*Gallons.*
J. Hulse	T. 1 S., R. 1 E., sec. 31	2	130	+	20
Do	do	2	255	+	30
J. Pearson	do		83	+	
C. Bell	do	2	209	+	40
Do	do		211	+	20
J. Bert	do	2	203	+	12
C. Cramer	do		150	+	(?) 110
Do	do		90	+	
N. White	do		130	+	15
J. Anderson	do		80	+	⅓
S. Haslam	do	2	244	+	8
E. Huish	T. 1 S., R. 1 E., sec. 32	2	210	+	28
Do	do		70	+	35
S. W. Moyle	do		196	+	6
J. Cornwell	do		235	+	20
Do	do		160	+	
Do	do		160	+	1-12
Do	do		165	+	
S. A. Cornwell	do	2	193	+	1
Do	do	2	55	+	
A. Young	do		33	− 24	
E. Bailey	do		25	− 22	
L. E. Sowers	do		54-56	−	
J. W. Murphy	do		70-150	−	
C. A. North	T. 1 S., R. 1 E., sec. 33		25	−	
W. H. Thuers	do	3	520	−419	
P. C. Brizen	do	3	350	+	25
Mrs. M. Cold	T. 1 S., R. 1 W., sec. 1	1½	317	+	1
J. R. Morgan	do	2	300	+	20
Mrs. E. R. Wadsen	do	1½	202	+	2
(*a*)	T. 1 S., R. 1 W., sec. 2	2	120	+	
J. Harrison	do	3	1,100	+	30
F. J. Guth	do	2	114	+	1½
Mrs. C. Bickson	do	2	318	+	6
J. H. Haward	do	2	335	+	4
J. Taylow	do	1	95	+	2½
Rio Grande Rwy	do	4	1,072	+ 30	80
H. L. Eyler	T. 1 S., R. 1 W., sec. 3	2½	381	+	16
Mortensen	T. 1 S., R 1 W., sec. 4	2	280	+	3
R. Boss	T. 1 S., R. 1 W., sec. 5	2	360	+ 4¼	7
E. B Swan	do	2	385	+	6
J. Rodgers	T. 1 S., R. 1 W., sec. 7	1¼	154	−	
Do	do	2	405	+	10
Do	do	1½	154	+	
F. Schonfeld	T. 1 S., R 1 W., sec. 8	2	325	+ 1	1
Brighton School	T. 1 S., R. 1 W., sec. 9	2	320	+	5-6
H. J. Walk	do	1¼	98	+ 1	1
H. E. Evans	T. 1 S., R. 1 W., sec. 10	3	624	+	30-40
W. Baden	T. 1 S., R. 1 W., sec. 11	2	377	+	9
W. J. Kinsman	do	2	130	+	20-30
Cannon	do		165	+	6-7
Sudbury	do	2		+	25
A. Bailey	do	2	367-387	+	5-6
J. Cleveland	do	2	456	+	60-70

a Owner's name unknown.

Wells in Jordan River and Utah Lake valleys—Continued.

Name of owner.	Location.	Diameter.	Depth.	Height of water.	Yield per minute.
		Inches.	*Feet.*	*Feet.*	*Gallons.*
E. Kidd	T. 1 S., R. 1 W., sec. 12	2	475	+	25
A. H. White	do		300	+	5–15
J. Anderson	T. 1 S., R. 1 W., sec. 13		400		60
J. H. Shaffer	do		18		
Lambert Paper Co	do	2	177		10
R. Cutler	do	2	315	+	45
J. Gabbot	do	2	380	+	10–15
(a)	do	2	275	+	16
J. S. McCallan	T. 1 S., R. 1 W., sec. 14		355	+	25
J. G. Gumman	T. 1 S., R. 1 W., sec. 16	2	330	+	25
Schoolhouse	T. 1 S., R. 1 W., sec. 17	2	400	+	12
S. C. Sudbury	T. 1 S., R. 1 W., sec. 18	2	412	+12	25
L. S. Hansen	T. 1 S., R. 1 W., sec. 21	1¼		+	15
N. Hansen	T. 1 S., R. 1 W., sec. 24		145	—	
S. Sorensen	do	2	385	—	
Gilchrist	T. 1 S., R. 1 W., sec. 25	1¼	130	—	
Rockhill	do	2	120	+	5
P. Austin	do	2	145	—	
G. H. Walton	do	2	350	+30	
B. Harmon	T. 1 S., R. 1 W., sec. 26	2	350	+30	
(a)	T. 1 S., R. 1 W., sec. 28	1¼	290	—	
Murray	do			+	6
C. J. Lambert	T. 1 S., R. 1 W., sec. 29		182	+	1
L. Burden	do		70	—	
N. P. Peterson	T. 1 S., R. 1 W., sec. 31		50	−30	
J. C. Poulton	do		60	−51	
(a)	T. 1 S., R. 1 W., sec. 32	1¼	290	—	
T. R. Jones	T. 1 S., R. 1 W., sec. 35	2	345	—	
Do	do	1¼	75	—	
(a)	T. 1 S., R. 1 W., sec. 36	1¼	140	+	2
J. P. Anderson	T. 1 S., R. 2 W., sec. 1		160	—	
(a)	do	2	260	+	5
(a)	T. 1 S., R. 2 W., sec. 14	2	150	+	3
Wolstenholm	T. 1 S., R. 2 W., sec. 21	1¼	30	+	10
Spencer	do		68	+	2
Oslen	do	3	150	+	
Butterworth	do	1½	175	+	15
T. West	T. 1 S., R. 2 W., sec. 22	2	40	+	6
N. T. West	do	1½	40	+ 3	12
J. Michaels	T. 1 S., R. 2 W., sec. 23	1½	90	+ 6	25
J. Hayhoe	T. 1 S., R. 2 W., sec. 26	1¼	177	+	5
Goodwin	T. 1 S., R. 2 W., sec. 27		27	−21	
A. Cockerill	T. 1 S., R. 2 W., sec. 29	1½	118	−14	
Speirs	T. 1 S., R. 2 W., sec. 33		84	—	
J. Kersey	T. 1 S., R. 2 W., sec. 34	42	166	−66	
Inland Crystal Salt Co.	T. 1 S., R. 3 W., sec. 2	4	720	+ 9	8
Salt Lake and Los Angeles Rwy. Co.	do		330	+12	20
P. J. Reid	T. 1 S., R. 3 W., sec. 24		134	+	9
J. Bertock	do	1½	73	+	3
J. Neilson	T. 2 S., R. 1 E., sec. 3	4	540	—	
G. Coleman	do		62	—	
T. Newman	do		65	—	
T. Gundesser, jr	T. 2 S., R. 1 E., sec. 4		18	—	Dry.

a Owner's name unknown.

Wells in Jordan River and Utah Lake valleys—Continued.

Name of owner.	Location.	Diameter.	Depth.	Height of water.	Yield per minute.
		Inches.	*Feet.*	*Feet.*	*Gallons.*
T. R. Brockbank	T. 2 S., R. 1 E., sec. 4		104	+	46
Do	do		102	+	25
J. Southerland	do	2	76	+	15
Do	do	2	78	+	24
Do	do	2	99	+	4
Do	do	3	232	−	
W. Templeman	do	2	225	−	
F. Hopp	do	2	70–100	+	20–34
A. Fuller	do	2	65	+	4
Do	do		335	+	20
P. C. Brizen	do	3	122	−70	
J. Wright	T. 2 S., R. 1 E., sec. 5		200	+	1½
E. Pugh	do	2	108	+	25
S. A. Williams	do	2	180	+	3–5
Mrs. A. D. Park	do		90	+	2
O. Lemon	do		384	+	5
H. J. Bullock	T. 2 S., R. 1 E., sec. 6	2	100	+	10
T. Powell	do	2	194	+	10
H. Park	do	2	90	+	32
W. Hill, sr	do	2	255	+	28
Do	do	2	80	+	4
W. Hill, jr	do	2	255	+	40
G. E. Christensen	do	2	210	+	20
J. Godfrey	T. 2 S., R. 1 E., sec. 7	2	150	+	40
I. Hackley	do	3	115	+	1
Mrs. B. Erickson	do	2	80	+	30
J. S. Williams	do	2	315	+	15
A. E. Williams	do	2	100	+	4
L. Williams	do		190	+	10
T. Martin	do	2	189	+	38
E. Warenski	do		230	+	
C. E. Warenski	do		300	+	2
J. R. Miller	T. 2 S., R. 1 E., sec. 8		215	+	10
W. Noble	do		230	+	7
M. M. Miller	do	5	85	+	(?)160
Do	do	2	82	+	22
T. H. Pierce	do		80	+	20
C. West	do		172	+	10
J. Walker	do	1½	80	+	20
State fish hatchery	do	4		+	(?)130
Do	do	4		+	(?)100
Do	do	2	80	+	40
A. Gillard	do		310	+	17
H. Brinton	do	2		+	30
J. R. Hansen	T. 2 S., R. 1 E., sec. 9		120	+	6
L. B. Howard	do	2	148	+	18
A. Scott	do	2	96	+	20
H. Bagley	do	2	275–250	+	
Do	do	3	60	+	(?)100
W. Reynolds	do	2	100–103	+	43
F. Brinton	do		92–96	+	25
C. Bagley	do	1½	100	+	20
Do	do	2		+	30
R. Anderson	T. 2 S., R. 1 E., sec. 10		14	−	([a])

[a] Dry 9 months in year.

Wells in Jordan River and Utah Lake valleys—Continued.

Name of owner.	Location.	Diameter.	Depth.	Height of water.	Yield per minute.
		Inches.	*Feet.*	*Feet.*	*Gallons.*
A. Olander	T. 2 S., R. 1 E., sec. 15		18	− 16	
J. Spilet	do		15	− 10–11	
J. Smith	T. 2 S., R. 1 E., sec. 16		20	− 4–17	
J. Hemmert	do	2	78	− 40	
S. Neilson	do		18–20	− 8–10	
S. F. Smith	do		20	− 10	
A. L. Hansen	do		22	− 11	
J. W. McHenry	do		18	− 12	
J. Hobbs	do		113	− 9	
J. Furgeson	do		60	+	17
I. Furgeson	do		60	+	
O. Headman	do		92	−	
J. Brighouse	T. 2 S., R. 1 E., sec. 17	1½	58	+ 16	30
H. V. Ballard	do	2	83	+ 8	50
G. Peterson	do		14	− 9	
District school	do		250	− 12	
R. Brown	do		40	+ 8	
R. M. Ballard	do	1¼	46	+	35
Mrs. Shumann	do	2	50–60	+	20
H. E. Howe	do		60	+	22
D. A. Rauser	do		45	+	60
J. T. Erickson	do	2	175	+	2
F. C. Howe	do	2	90	+	35
Do	do	2	190	+	35
J. B. Thompson	do	1½	75	+	45
Do	do	2	80	+	60
E. Taylor	T 2 S., R. 1 E., sec. 18		125	−117	
E. Gillen	do	2	20–30	−	
H. Berger	do	3	90	− 10	
C. Turner	do		70–80	− 4–13	
H. Chambers	do	2	200	− 10	
J. Jones	do	2	22	−	
J. H. Wheeler	do	2	75–100	+	20
South Cottonwood Ward.	do	2	75–100	+	40
Do	do	3	110	+	60
Mrs. J. Clark	do		18	− 4	
M. Sibbs	T. 2 S., R. 1 E., sec. 19	2	50	−	
N. Nelson	do		22	− 8	
C. Atkinson	T. 2 S., R. 1 E., sec. 20		10	−	
H. Wheeler	do		12	−	
C. B. Walder	do		22	−	
C. J. Wright	do		10	−	
W. Barrett	T. 2 S., R. 1 E., sec. 21		16	−	
J. E. Brown	do		13	−	
H. C. L. Russell	do		50	− 30	
J. W. Fawlke	T. 2 S., R. 1 E., sec. 22		6	−	
A. Fawlke	do		12	−	
S. Jones	T. 2 S., R. 1 E., sec. 26		80	− 55	
A. D. Brown	T. 2 S., R. 1 E., sec. 27		96	− 93	
(a)	T. 2 S., R. 1 E., sec. 28		125	−	
W. Baggas	T. 2 S., R. 1 E., sec. 29		18	−	
D. M. Griffin	do		22	−	
J. A. Wagstaff	do		35	−	

a Owner's name unknown.

Wells in Jordan River and Utah Lake valleys—Continued.

Name of owner.	Location.	Diameter.	Depth.	Height of water.	Yield per minute.
		Inches.	*Feet.*	*Feet.*	*Gallons.*
N. Morquist	T. 2 S., R. 1 E., sec. 29		30	— 26–27	
M. Holmes	T. 2 S., R. 1 E., sec. 30		35		
H. Chambers	do	2	200	— 7–10	
J. Jones	do	2	22	—	
O. G. Nelson	T. 2 S., R. 1 E., sec. 31		40–50	— 25–34	
C. G. Johnson	do		29–30	— 26	
G. L. Rosengren	do		51	— 41	
H. M. Pearson	do		90	— 60	
A. Neilson	do		53	—	
H. Larsen	do		26	—	
L. Jacobson	do		15	—	
W. Dugger	T. 2 S., R. 1 E., sec. 32		100	— 75	
A. Hansen	do		14	—	
E. E. Osbund	do		200	—200	
H. C. Monten	T. 2 S., R. 1 E., sec. 33		22	—	([a])
J. F. Proctor	T. 2 S., R. 1 E., sec. 34		40	—	
W. Rasmanson	T. 2 S., R. 1 E., sec. 35		50	—	Dry.
H. Covert	do		40	— 26	
Clark	T. 2 S., R. 1 W., sec. 1	2	40	+	20–35
J. M. Wood	do		100	+	40
E. Erickson	do		287	+	2
Lumston	do	2	140	+	22
([b])	do	2	90	+	25
Gleason	do		65	+	8
J. Hays	do		280	—	
J. Harper	T. 2 S., R. 1 W., sec. 2		372	— 18	
J. M. Mantell	do		240	+	6
J. Mackey	T. 2 S., R. 1 W., sec. 3		212	— 10	
Barker	do		260	— 25	
([b])	T. 2 S., R. 1 W., sec. 6		56	—	
Parker	T. 2 S., R. 1 W., sec. 8	3	157	— 37	
School	do		120	— 60	
Snider	do	3	150	— 50	
McAllister	T. 2 S., R. 1 W., sec. 9	3	110	—	
H. McKay	T. 2 S., R. 1 W., sec. 10	3	141	— 40	
H. Harker	T. 2 S., R. 1 W., sec. 11	3	315	+	35
W. H. Hague	do		222	— 15	
P. Swendsen	do	2	323	+	5
B. Williams	do	3	85	—	
G. Bueger	T. 2 S., R. 1 W., sec. 12	3	77	— 36	
Western Pickling Co	do		100	+	40
S. Benson	do	2	350	+	15
D. Adamson	do	2	249	+	20
Creamery	do	2	117	+	20
A. E. Erickson	do	2	345	— 8	
J. C. Cahoon	T. 2 S., R. 1 W., sec. 13	3	180	—	
Mrs. A. J. Plummer	do	3	60	— 30	
([b])	do		9½	— 6½	
M. Bishop	do	2	50	— 10	
E. B. Tripp	T. 2 S., R. 1 W., sec. 14	3	80	— 40	
A. S. White	do		22	— 12	
R. P. Binghurst	do	2½	175	— 6	
Jones	do	2	180	+	12

[a] Dry in winter. [b] Owner's name unknown.

Wells in Jordan River and Utah Lake valleys—Continued.

Name of owner.	Location.	Diameter.	Depth.	Height of water.	Yield per minute.
		Inches.	*Feet.*	*Feet.*	*Gallons.*
J. Anderson	T. 2 S., R. 1 W., sec. 15		117	−50	
School	do		165	−50	
W. Diamond	T. 2 S., R. 1 W., sec. 22	3	345	−110	
M. Parker	do		225	−40	
M. Hansen	do		140	−90	
(a)	T. 2 S., R. 1 W., sec. 23		185	−24	
C. Erickson	T. 2 S., R. 1 W., sec. 24		30	−12	
E. Bateman	T. 2 S., R. 1 W., sec. 25	3	251	−	
(a)	do		20	−16	
Bingham School	do	3	325	−60	
J. B. Wright	T. 2 S., R. 1 W., sec. 26	3	230	−40	
E. Gardner	do		180	−20	
(a)	T. 2 S., R. 1 W., sec. 27		100	−30	
Cooper	do	3	254	+	2
W. D. Runsal	do		137	−33	
A. L. Cooley	T. 2 S., R. 1 W., sec. 30		28	−	
Olsen	T. 2 S., R. 1 W., sec. 33		178	−20–30	
Cannon Farm	T. 2 S., R. 1 W., sec. 34	3	1,000	−30	
R. Egbert	do	6	52	−24	
P. T. Rundquist	do	3	80	−18	
M. Pusler	T. 2 S., R. 1 W., sec. 35	3	217	−	
J. Peterson	do		127	−53	
N. L. Gardner	do	3	309	−25	
G. Hunt	T. 2 S., R. 1 W., sec. 36		21	−17	
S. M. Wilmore	do	3	225	−8	
N. Nelson	do		190	−75	
(a)	do		50	−	
P. Jansen	do		30	−17	
P. J. Wolff	T. 2 S., R. 2 W., sec. 11		174		
Olsen	T. 2 S., R. 2 W., sec. 27	3	150	+	
H. Brown	T. 3 S., R. 1 E., sec. 2		38–40	−	
W. L. Bateman	T. 3 S., R. 1 E., sec. 5		14–16	−6	
E. Johnson	T. 3 S., R. 1 E., sec. 6		40	−	
C. Peterson	do		28	−25	
A. Yelter	T. 3 S., R. 1 E., sec. 7		75	−70	
H. P. Hansen	T. 3 S., R. 1 E., sec. 8		56	−45–52	
P. Anderson	T. 3 S., R. 1 E., sec. 9		125		Dry.
R. Despain	T. 3 S., R. 1 E., sec. 11		16		Dry.
C. Williams	T. 3 S., R. 1 E., sec. 17		30	−28	
F. Olsen	T. 3 S., R. 1 E., sec. 18		40	−24	
P. A. Yastrop	T. 3 S., R. 1 E., sec. 19		80	−	
J. P. Jenson	do		95	−	
E. N. Fish	T. 3 S., R. 1 E., sec. 21		34		Dry.
J. L. Johnson	T. 3 S., R. 1 E., sec. 22		65	−	
J. W. Smith	T. 3 S., R. 1 E., sec. 28		10	−	
H. Pearson	T. 3 S., R. 1 E., sec. 29		18	−	
J. Tarry	do		18–20	−	
N. Brown	do		16	−	
J. R. Stocking	do		42	−	
A. J. Wilson	T. 3 S., R. 1 E., sec. 32	4	70	−62	
J. R. Allen	do		24	−18	
J. Ennis	do		41	−35	
J. Boulter	T. 3 S., R. 1 E., sec. 33		22	−17	
F. B. Ladler	do		66		(b)

a Owner's name unknown.

b Dry in winter.

Wells in Jordan River and Utah Lake valleys—Continued.

Name of owner.	Location.	Diameter.	Depth.	Height of water.	Yield per minute.
		Inches.	*Feet.*	*Feet.*	*Gallons.*
P. Swindsen	T. 3 S., R. 1 W., sec. 1	2	323	+	5
E. Densley	do	3	200	−40	
C. Densley	do		30		
D. Densley, jr	do	3	412	−58	
J. F. Palmer	T. 3 S., R. 1 W., sec. 2	3	236	−43	
H. Gardner	T. 3 S., R. 1 W., sec. 3		250	−20	
J. A. Egbert	do		212	−40	
J. Goff	T. 3 S., R. 1 W., sec. 12	3	137	−	
B. Wellington	T. 3 S., R. 1 W., sec. 13	3	156	−45	
A. J. Holt	T. 3 S., R. 1 W., sec. 15	3	255	−85	
School	do		500	−75	
B. W. Osborne	T. 3 S., R. 1 W., sec. 23	2	50		12–15
W. R. Wellington	do	1¼	28		12–15
C. Erickson	T. 3 S., R. 1 W., sec. 24		30	−12	
E. Atwood	do	3	127	−	
R. Carlson	do		28	−	
A. Yoblong	T. 3 S., R. 1 W., sec. 25		15	− 4	
J. O. Smith	do	3	133	−40	
Creamery	T. 3 S., R. 1 W., sec. 26	2	90	+12	
G. H. Donzy	T. 3 S., R. 1 W., sec. 27	3	225	−60	
C. H. Roberts	T. 3 S., R. 3 W., sec. 26	3	102	−	
I. Langton	T. 4 S., R. 1 E., sec. 5	2	400	+	3
G. Newbold	do		40	−	
G. Sproul	do	2	125	+	
L. Andrews	T. 4 S., R. 1 E., sec. 6		20	−10	
J. Ennis	T. 4 S., R. 1 E., sec. 32		41	−35	
H. J. Allen	do		15	−	
W. H. Garfield	T. 4 S., R. 1 E., sec. 33		42	−	
W. Crane	do		21	− 8	
Alpine	T. 4 S., R. 1 E .,sec. 24		25–80		
W. L. Parry	T. 4 S., R. 1 W., sec. 3		30		
M. Densley	do	3	99½	−40	
J. Stedman	do	3	130	−40	
J. Beveridge	T. 5 S., R. 1 E., sec. 4		32	−20	
Lehi Junction	T. 5 S., R. 1 E., sec. 5		15–50	−10–40	
I. Anderson	T. 5 S., R. 1 E., sec. 7	2	134	+25	
Thomas College	do	1¼	125	−	
J. Wanless	do	1½	125	−	
G. Jacobs	do	1¼	90–100	+	12
Do	do	2	193	−	
D. J. Thurman	do	2	90–100	+	55
H. T. Davis	T. 5 S., R. 1 E., sec. 8		12	−	
G. Gerney	do	1½	145	− 8–10	
T. R. Jones	do	1¼	75	−	
B. W. Brown	do		12	−	
J. Gough	do		20	−	
P. Austin	T. 5 S., R. 1 E., sec. 9	2	145	−22	
(a)	do	2	130	+	5
J. Brown	do	1¼	135	−	
(a)	do	2	300	+	4
San Pedro, Los Angeles and Salt Lake R. R.	do	2	330	+	23
Do	do	1¼	330	+	35
Do	do	3	300	− 8	
Do	do	1¼	140	−	

a Owner's name unknown.

Wells in Jordan River and Utah Lake valleys—Continued.

Name of owner.	Location.	Diameter.	Depth.	Height of water.	Yield per minute.
		Inches.	*Feet.*	*Feet.*	*Gallons.*
W. Hunger	T. 5 S., R. 1 E., sec. 9	2	145	− 2	(?)25
Rhodes	do	1½	140	+	9
Wing	do	1½	158	−	
Anderson	do	2	132	+	20
Gilchrist	do	1¼	130	− 6	
Barney	T. 5 S., R. 1 E., sec. 10	1¼	145	+	20
D. Wagstaff	T. 5 S., R. 1 E., sec. 14	2	270	−	
A. L. Thornton	do	2	201	+	2
American Fork, city well.	do	3	460	−25	
A. Green	T. 5 S., R. 1 E., sec. 15		160	+	
J. B. Greene	do	2	160	+	40
J. Stewart	T. 5 S., R. 1 E., sec. 16	2	140	+	
Broadbent	do	2	150	+	10
A. K. Thornton	do	3	543	− 4½	
T. J. Chipman	do	2½	263	− 2	
J. Peters	do	6	33	−	
A. Field	do	1½	162	+	5
Mrs. K. Fox	do	2	130	+	10
(a)	do	2	90	+	10
(a)	do	2		+	15
(a)	do	2	90	+	20
(a)	T. 5 S., R. 1 E., sec. 17		147		
O. Ellington	do	1¼	150	+	
E. A. Bushman	do	2	350	−	
Anderson	do	2	132	+	20
D. J. Thurman	do	2	150	+	10
J. Donaldson	do	2	143	+	20
J. Stewart	do	2	140	+	
P. Jacobs	do	1¼	140	+	5
J. Woodhouse	do	1½	164	−	
M. Evans	do	2	200	+ 3	(?)100
Rio Grande Western Rwy.	do	3	165	+30	50
G. Webb	T. 5 S., R. 1 E., sec. 18	2	195	+ 3	40
S. R. Taylor	do	2	156	+10	
W. H. Chipman	T. 5 S., R. 1 E., sec. 23	2	147	+	(?)150
Do	T. 5 S., R. 2 E., sec. 11	2	135	+46	(?)200
B. Willis	T. 5 S., R. 2 E., sec. 18	2	160	+	
M. Evans	do	2		+	30
(a)	T. 5 S., R. 2 E., sec. 19	2		+	20
J. D. Godey	do	2	290	+	
S. E. Davis	do	2	150	+	80
W. Howe	T. 5 S., R. 2 E., sec. 20	2	200	+	20
Clarke	do	2	40	+	
Lott	T. 5 S., R. 2 E., sec. 21	2	100	+	60
(a)	T. 5 S., R. 2 E., sec. 23	2	264	+	10
Elgin creamery	do	3		+	
A. F. Adams	do	3	280	+	15
American Fork City	do	3	280	+	
W. Anderson	T. 5 S., R. 2 E., sec. 25	1¼		+	10
W. D. West	T. 5 S., R. 2 E., sec. 29	2	64	+	15
Do	do	2	70	+	
(a)	do	2	74	+	35-50
Wadley	do	2	200	−33	
W. D. West	do	2	70	+18	

a Owner's name unknown.

Wells in Jordan River and Utah Lake valleys—Continued.

Name of owner.	Location.	Diameter.	Depth.	Height of water.	Yield per minute.
		Inches.	*Feet.*	*Feet.*	*Gallons.*
D. M. Smith	T. 5 S., R. 2 E., sec. 29	2	115	+20	45
(a)	T. 5 S., R. 2 E., sec. 32	2	150	+	
(a)	do	2	80	+	40
L. Olsen	do	2	160	+	90
F. Newman	do	2	150	+15	
Do	T. 5 S., R. 2 E., sec. 35	2	90	+	25
Pastures	do		100	+	
P. H. Aldred	T. 5 S., R. 1 W., sec. 1		100	+	80
I. Fox	T. 5 S., R. 1 W., sec. 12	2	100	+ 7 ins.	
Salt Lake City (about 130 wells).	do	2-6	100	+30	(?)2,000
J. M. Roberts	T. 5 S., R. 1 W., sec. 13	2	258	+	32
(a)	do	2	112	+	
M. Norman	T. 5 S., R. 1 W., sec. 24	2	160	+14	
I. Cole	T. 6 S., R. 2 E., sec. 5	2	210	+	
J. S. Johnson	do	2	130	+	
H. Gammon	T. 6 S., R. 2 E., sec. 7	3	110	+	(?)260
H. Gillies	do	2	112	+11	
D. A. Gillis	T. 6 S., R. 2 E., sec. 8	2	110	+	(?)100
J. K. Parcell	T. 6 S., R. 2 E., sec. 10		72	−67	
N. Knight	T. 6 S., R. 2 E., sec. 14		110	−	
Colorado Fish Co	do	3	250	−80	
N. J. Knight	do		60	−40–55	
W. Knight	do	2	300	−	
J. S. Park	T. 6 S., R. 2 E., sec. 15		72	−62	
A. N. Holdaway	T. 6 S., R. 2 E., sec. 17	2-3	120-140	+ 1-10	(?)1-200
M. Holdway	do	2	100	+	30
B. Larsen	T. 6 S., R. 2 E., sec. 18	3	100	+12	
Wride & Allen	do	2	110	+	(?)100
G. A. Slumway	T. 6 S., R. 2 E., sec. 21	2	104	+	25
J. A. Loveless	T. 6 S., R. 2 E., sec. 23		52	−50	
A. L. Mechum	T. 6 S., R. 2 E., sec. 24		40	−36	
D. C. Daniels	T. 6 S., R. 2 E., sec. 26	48	65	−60	
H. C. Scott	T. 6 S., R. 2 E., sec. 28	2	110	+	10
J. H. Clinger	do	1½	98	+	10
Creamery	T. 6 S., R. 2 E., sec. 34		125	+	
J. W. Park	do		110	+	
W. G. Williams	do	1½	130	+	
S. L. Aldred	T. 6 S., R. 2 E., sec. 35	2	210	−25	
W. Gammon	do		24	−	
P. H. Cluff	T. 6 S., R. 3 E., sec. 31		50	−40–45	
T. W. Whisble	T. 7 S., R. 2 E., sec. 1	2	217	+	48
J. A. Johnson	do	2	145	+	6
N. Lydian	T. 7 S., R. 2 E., sec. 2	2	145	+	
S. McFee	do	2	145	+	8
A. Holliday	do	2½	150	+10	
W. Cox	do	2	130	+	85
P. C. Bumrell	T. 7 S., R. 2 E., sec. 3	1½	135	+	25
Utah Sugar Co	do		110	+	
W. L. Camp	do	2	128	+	
N. A. Nelson	do		35	−	
R. A. Hills	T. 7 S., R. 2 E., sec. 4		50	−	
Provo resort	T. 7 S., R. 2 E., sec. 9	2	342	+	80
G. Baum	T. 7 S., R. 2 E., sec. 10		12	− 4	
W. D. Roberts	T. 7 S., R. 2 E., sec. 11	2	184	+	92

[a] Owner's name unknown.

Wells in Jordan River and Utah Lake valleys—Continued.

Name of owner.	Location.	Diameter.	Depth.	Height of water.	Yield per minute.
		Inches.	*Feet.*	*Feet.*	*Gallons.*
Westron	T. 7 S., R. 2 E., sec. 11	2	180	+	
W. B. Johnson	do	1½	160	+	15
M. Christensen	do	2	168–178	+	10
B. Johnson	do	2	150	+	45
W. Carter	do	2	170	+	40
Rio Grande Western Rwy.	T. 7 S., R. 2 E., sec. 12	3	175	+	(?)120
San Pedro, Los Angeles and Salt Lake R. R.	do	3	192	+35	(?)150
W. R. Pike	do	1½	248	+12	40
Do	do	1¼	198		36
W. J. Woodhead	do	2	168	+	60
H. Manney	do		168	+	60
Hospital	do		180	+	
W. Scott	do	2	150	+	55
S. W. Sharp	do	2	197	+	30
Farris Bros	do		185	+	60
S. Copp	do	2	175	+	9
Watkins & Taylor	do		300	+	2
(a)	T. 7 S., R. 2 E., sec. 14	1½	145	+	20
A. B. Johnson	do		170		
G. T. Peay	T. 7 S., R. 2 E., sec. 16	2	137	+ 5	30
A. W. Hanrer	T. 7 S., R. 3 E., sec. 6	2	140	+ 2	40
T. E. Thurman	do	1½	333	+20	35
J. Anderson	T. 7 S., R. 3 E., sec. 8	2	150	+20	15
Utah Co. Infirmary	T. 7 S., R. 3 E., sec. 17	3	270	+	70
H. M. Dougal	T. 7 S., R. 3 E., sec. 29	2	180	+10	40
Do	T. 7 S., R. 3 E., sec. 30	2	220	+ 4	20
Clubhouse	do	1½	299	+	5
Do	do	2	128	+	10
P. Boyer	T. 7 S., R. 3 E., sec. 31	2	150	+	18
Rio Grande Western Rwy.	T. 7 S., R. 3 E., sec. 32	3	220	+30	80
(a)	do	1½	232	+	15
J. B. Stevenson	T. 7 S., R. 3 E., sec. 33	1½	101	+	12
D. Wheeler	do	2	131	+	25
D. Clark	do	2	240	+	
A. Cox	do	3	230	+18	(?)120
W. Findley	do	2	135	+	25
(a)	do	2	115	+	70
A. Oakley	do	2	128	+	30
(a)	do	2	105	+	30
J. McCurdey	do		22	−	
(a)	do	1½	120	+	20
T. L. Mendenhall	do	2	245	+	45
S. Fuller	do		25	−	
M. Dougal	do	1½	230	+	10
E. P. Brinton	do	2	130	+	20
McKenzie	do	1½	132	+	10
Daley	do	1½	145	+	9
F. W. Phillips	do	2	217	+	65
(a)	do	2	138	+	30
W. Brookes	T. 8 S., R. 1 E., sec. 11	1¼	160		10
(a)	do	1¼	100	− 4	
(a)	T. 8 S., R. 1 E., sec. 24	1½		+	7

a Owner's name unknown.

Wells in Jordan River and Utah Lake valleys—Continued.

Name of owner.	Location.	Diameter.	Depth.	Height of water.	Yield per minute.
		Inches.	*Feet.*	*Feet.*	*Gallons.*
J. D. Evans	T. 8 S., R. 2 E., sec. 2	2	438	+	25
E. L. Oltison	T. 8 S., R. 2 E., sec. 4	2	366	+	72
H. Otis	do	1½	380	+	20
C. Barney	do	2	175	+10	20
(a)	do	1¼	112	+	10
(a)	do	2	175	+	12
J. Hall	T. 8 S., R. 2 E., sec. 7	2	225	+	....
J. S. Bellows	T. 8 S., R. 2 E., sec. 8	1½	400	+12	8–25
W. J. Soloman	do	2	230	+10	35
R. Hunter	do	2	350	+	8
J. E. Creer	T. 8 S., R. 2 E., sec. 9	2	400	+	....
P. Poulsen	do	2	390	+10	40
P. Neilson	T. 8 S., R. 2 E., sec. 10	1½	142	+	....
E. P. Thomas	do	3	430	+	15
A. Green	T. 8 S., R. 2 E., sec. 12	2	280	+	10
Do	do	2	260	+	5
Creamery	T. 8 S., R. 2 E., sec. 13	2	220	– 4	....
San Pedro, Los Angeles and Salt Lake R. R	do	2	405	+	36
A. T. Money	T. 8 S., R. 2 E., sec. 14	2	380	+	16
R. W. Money	do	3	423	+	60
W. R. Simmons	T. 8 S., R. 2 E., sec. 15	2	374	+	1
A. M. Furgeson	do	6	380	+	60
P. E. Nelson	do	2	400	+	30
Irrigation Co	do	....	500	+	60
Lake Shore Canal	do	3	373	+	(?) 118
E. M. Robertson	T. 8 S., R. 2 E., sec. 16	1¼	160	–	....
N. P. Hansen	do	2	380	+	3
(a)	T. 8 S., R. 2 E., sec. 18	2	450	+	....
(a)	do	2	412	+	30
G. McClellan	T. 8 S., R. 2 E., sec. 19	2	387	+	15
Do	do	2	170	+	6
Do	do	1¼	130	+	2
Do	do	1½	45	+	3
N. Thompson	T. 8 S., R. 2 E., sec. 20	2	475	+	10
D. L. Hoff	T. 8 S., R. 2 E., sec. 21	2	333	+	16
E. Ludlow	do	1¼	250	+	8
C. Howe	do	2	560	+	20
T. Cahoon	do	2	400	+	10
(a)	T. 8 S., R. 2 E., sec. 22	1½	286	+	....
(a)	do	1¼	....	+	6
O. Christensen	T. 8 S., R. 2 E., sec. 23	2	385	+	8
D. C. Markham	do	2	360	+	35
G. Hales	do	3	250	– 6	....
(a)	T. 8 S., R. 2 E., sec. 25	2	137	+	35
N. P. Jensen	T. 8 S., R. 2 E., sec. 26	2	318–320	+	64
B. Isaac	do	2	390	+	14
(a)	T. 8 S., R. 2 E., sec. 27	2	....	+	60
P. Thomas	do	2	425	+	35
F. Malley	T. 8 S., R. 2 E., sec. 28	1¼	385	+	5
Howe	do	2	415	+	....
G. Howe	T. 8 S., R. 2 E., sec. 29	2	450	+	....
(a)	do	2	175	+	8
Stewart's ranch	do	1½	....	+	20
Do	do	1½	....	+	10

a Owner's name unknown.

Wells in Jordan River and Utah Lake valleys—Continued.

Name of owner.	Location.	Diameter.	Depth.	Height of water.	Yield per minute.
		Inches.	*Feet.*	*Feet.*	*Gallons.*
Stewart's ranch	T. 8 S., R. 2 E., sec 29	2		+	5
C. Hickman	do	2	172	+	15
S. P. Lorensen	do	2	163	+	25
P. J. Lundale	T. 8 S., R. 2 E., sec. 32	1½	175	+	1
J. Howe	T. 8 S., R. 2 E., sec. 33	2	200	+	1
J. J. Hansen	do	2	380	+	20
G. Staley	do	2	185	+	20
Do	do	2	380	+	35
W. O. Creer	T. 8 S., R. 2 E., sec. 35	1½	20	+	10–25
Creamery	T. 8 S., R. 3 E., sec. 4	2	144	+	30
J. Anderson	T. 8 S., R. 3 E., sec. 5	2	145	+	
M. C. King	T. 8 S., R. 3 E., sec. 7	2	170	+	30
Do	do	2	154	+	12
(a)	T. 8 S., R. 3 E., sec. 8	1½	30	+	2–3
Sugar factory	do	2	123	+	10
T. B. Jones	T. 8 S., R. 3 E., sec. 21		22	−15	
(a)	T. 8 S., R. 3 E., sec. 30	1¼	140	+	2
H. A. Harlan	do	1¼	30	+	1½
J. P. Holt	do	1¼	100	+	1½
J. G. Robertson	do			+	
G. LeBaron	T. 9 S., R. 1 E., sec. 7			+	
McBeath	T. 9 S., R. 1 E., sec. 12	2	360	+	27
J. Webb	T. 9 S., R. 1 E., sec. 13	1½	247	+	
F. Rouse	T. 9 S., R. 1 E., sec. 32	2	180		8
J. E. Gardner	T. 9 S., R. 2 E., sec. 1	1½	290	−	
(a)	do	1¼	155	+	
(a)	T. 9 S., R. 2 E., sec. 2	1¼	200	+	
(a)	do	2	200	+	
(a)	T. 9 S., R. 2 E., sec. 3	2	160	+	30
(a)	do		375	+	
(a)	do	2	228	+	(?) 125
S. Douglas	T. 9 S., R. 2 E., sec. 5	2	50	+ 15	
Do	do		130		30
Dixon Bros.	do	2	300	+	(?) 100
P. Windward	do	2	140	+ 1	55
T. E. Daniels	T. 9 S., R. 2 E., sec. 6	2	116	+ 20	
C. Long	do	2	160	+	37
D. LeBaron	T. 9 S., R. 2 E., sec. 7	2	217	−	
(a)	T. 9 S., R. 2 E., sec. 10		438		3
A. Bingham	T. 9 S., R. 2 E., sec. 11	1¼	196	+	15
Do	do	2	275	+	8
Creamery	do		225	+	
C. Hanks	do	2	175	+	10
A. Burke	do	2	296	+	25
J. Sheen	do	2	279		35
O. R. Thomas	T. 9 S., R. 2 E., sec. 29		20	−16½	
H. Boyle	T. 9 S., R. 2 E., sec. 30	2	90–126	+	15–30
J. Job	T. 9 S., R. 1 W., sec. 25	1¼	50– 60	+	12
Do	T. 9 S., R. 1 W., sec. 26	1¼	220	+	
W. M. Phillippi	T. 9 S., R. 1 W., sec. 33	2	165	−125	
(a)	T. 9 S., R. 1 W., sec. 35	2	200	+	⅓
Rudd estate	T. 9 S., R. 1 W., sec. 36	2	58	+	2
A. Steele	T. 10 S., R. 1 E., sec. 6		85	+	7–8
E. Hawkins	T. 10 S., R. 1 E., sec. 17	2	130	− 80	
H. Johnson	T. 10 S., R. 1 W., sec. 2		407	− 9	

a Owner's name unknown.

Wells in Jordan River and Utah Lake valleys—Continued.

Name of owner.	Location.	Diameter.	Depth.	Height of water.	Yield per minute.
		Inches.	*Feet.*	*Feet.*	*Gallons.*
W. M. Phillippi	T. 10 S., R. 1 W., sec. 4	2	168	—	
W. C. Albertson	T. 10 S., R. 1 W., sec. 9	2	178	—	
J. Riley	do	2	307	−100	
Do	do	2	300	—	
Baxter	do	2	420	—	
P. Okleberry	T. 10 S., R. 1 W., sec. 11	2	77	− 3	
(a)	T. 10 S., R. 1 W., sec. 12		412	—	
Creamery	do		70	− 4	
Rio Grande Western Rwy	do		334	− 4	
W. Finch	T. 10 S., R. 1 W., sec. 14	2	160	—	
L. E. Thomas	T. 10 S., R. 1 W., sec. 15		8	—	
Goshen Wells	do	$1\frac{1}{4}$	50	− 3	
Do	do	2	70	− 20	
A. Lewis	do	2	60	—	
H. L. Cook	do	2	53	− 7	
Allen	T. 10 S., R. 1 W., sec. 21	2	116	− 86	
Rowe	T. 10 S., R. 1 W., sec. 30	2	238	−222	
(a)	T. 10 S., R. 1 W., sec. 33	2	138	—	

[a] Owner's name unknown.

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W.

Y.

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[Water-Supply Paper No. 157.]

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Correspondence should be addressed to

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WASHINGTON, D. C.

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