KWICT 4477

DEPARTMENT OF THE INTERIOR
HUBERT WORK, Secretary

UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, Director

WATER-SUPPLY PAPER 517

WATER POWERS
OF THE
GREAT SALT LAKE BASIN

BY

RALF R. WOOLLEY

WITH AN INTRODUCTION
BY
NATHAN C. GROVER

WASHINGTON
GOVERNMENT PRINTING OFFICE
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GEOGRAPHY, GEOLOGY, AND PHYSIOGRAPHY OF THE GREAT SALT LAKE BASIN.

The Great Salt Lake basin comprises that part of the Great Basin that drains into Great Salt Lake, Utah. It is about 27,000 square miles in area and includes the northern part of Utah, a small part of eastern Nevada, the southeast corner of Idaho, and the southwest corner of Wyoming.

The eastern part of the area consists of mountainous highlands; the western part chiefly of low-lying plains. The lowest portion of the plain is occupied by Great Salt Lake and minor parts by low mountain ranges. The area has no outlet to the sea.

The geologic features of the basin are important in a study of its water supply and power possibilities in at least three ways, pertaining to the composition and physical condition of the rocks, to their structure, and to the conditions resulting from dynamic processes. The rocks of the Wasatch Mountains, the principal mountain system in the basin, range in age from pre-Cambrian to Pleistocene. Most of the Paleozoic and older rocks are hard and either crystalline or metamorphosed. They are too nearly impervious to hold large quantities of water, and the run-off from their barren surfaces is extremely rapid. However, in some places they are so faulted or broken that much water is held in the cracks and gradually released at springs. The younger rocks that occupy the surface in the eastern part of the basin and the slightly consolidated Pleistocene deposits that occur in the mountains are more porous and absorb much of the precipitation that falls on them. Unconsolidated beds of talus or fragmental rock along the mountain slopes serve to retard the flow of the water derived from rain and from melting snow, so that the flow of the streams is somewhat regulated.

The two general types of stream courses in the basin are those established before the last great rise of the mountains and those dependent on the present mountain slopes. Weber River is the best example of the first-mentioned type, and the short torrential streams, like Cottonwood Creek, are included in the other type. Bear and Ogden rivers represent modifications of the first type. Bear River was probably deflected from its former course by a rise of the mountains, and Ogden River has its source in a basin that was once partly filled with water but was eventually drained when the river cut its outlet low enough.

CLIMATE.

The general climate is of the arid or semiarid type. The maximum of precipitation occurs in the winter and spring. The precipitation increases rapidly with altitude.

The mean monthly and annual temperatures decrease with increase in altitude, uniformly in all months. The highest temperatures of record in the basin range from 101° to 110° over the lower areas, and from 90° to 100° at the mountain stations. The lowest temperatures range from 10° to 20° below zero near Great Salt Lake and Utah Lake to 35° or 50° below zero at Thistle, Laketown, Heber, Henefer, and East Portal. The average daily ranges of temperature are generally greatest during the warm, dry season from June to October, and least from December to February. The growing season in the agricultural areas is four to six months.

The average annual precipitation ranges from less than 5 inches on the Great Salt Lake Desert to more than 20 inches along the western slope of the Wasatch Mountains and to at least 30 inches on the higher westerly parts of this range. Lands lying about 4,250 feet above sea level along the base of the Wasatch slopes receive about 15 inches of precipitation annually. The principal agricultural lands have an average annual precipitation of 15 to 18 inches. Approximately 70 to 75 per cent of the annual precipitation on the basin falls from November to May, and probably less than 13 per cent in June, July, and August. Droughts without rain of agricultural importance will last in some seasons from 30 to 50 days in regions having about 15 inches of annual precipitation and from 60 to 90 days in regions receiving from 8 to 12 inches.

The annual snowfall ranges from about 3 feet at the lower levels to about 12 feet at the higher points of observation.

The evaporation from a water surface during the summer appears to be 35 to 40 inches at Utah Lake and 40 to 45 inches at Nephi, as indicated by the short-time records available.

GENERAL FEATURES.

Bear River basin.—Bear River drains about 6,000 square miles of mountain and valley lands in the northeastern part of the Great Salt Lake basin. It rises on the north slopes of the Uinta Mountains, about 60 miles east of Salt Lake City, flows northward into Wyoming and Idaho, turns to the southwest, and empties into Great Salt Lake. The course of the river is more than 300 miles long, but the air-line distance from its source to its mouth is about 75 miles. The valley lands along the upper stretches of the river are chiefly suitable for raising hay, but those in Idaho and Utah are devoted to diversified farming. Dairying, farming, and cattle raising are the chief industries in the Bear River basin.

Weber River basin.—Weber River rises in a number of small giacial lakes on northwest slopes of the Uinta Mountains, 50 miles due east of Salt Lake City. It flows in a general northwesterly direction through a series of small mountain valleys and short rocky canyons in the Wasatch Range. Thence it winds across the floor of the Great Salt Lake valley and empties into Great Salt Lake west of Ogden. It is about 125 miles long and has a total fall of 4,000 feet. More than 40 tributaries empty into Weber River. The most important one in many respects is Ogden River, which drains about 400 square miles of mountainous lands in the Wasatch Range immediately north of the Weber River canyon. Ogden River flows westward through a rugged canyon cut into the Wasatch Range and joins the Weber a few miles west of Ogden, in the Great Salt Lake valley. Ogden Canyon is a picturesque scenic resort.

Jordan River and Utah Lake drainage basins.—Jordan River flows northward from Utah Lake to Great Salt Lake, passing through the Jordan Narrows, which consist of low spurs of rolling hills that join the Wasatch and Oquirrh ranges. These Narrows form a low divide between the valleys of Utah Lake and Great Salt Lake. All the southern part of the Great Salt Lake drainage basin, comprising some 3,600 square miles, drains into Utah Lake. The lake serves as a reservoir to some extent, but by agreement between the canal companies that take water from Jordan River and farmers who own land along the shore of the lake, the water surface can not be raised in the lake sufficiently high to store all the flood waters that run into it.

All the streams tributary to Jordan River are in the Great Salt Lake valley north of the Jordan Narrows, and the larger ones enter from the Wasatch Mountains, on the east. These streams are all short, derive their water from melting snow and springs, and flow through steep, narrow V-shaped canyons that have rough, rugged rock walls.

The principal streams flowing into Utah Lake also rise in the Wasatch Mountains, to the east and southeast of the lake. Most of them are similar to the tributaries of Jordan River, but a few are much larger and drain a greater area. Provo River is the largest one. It rises in several small glacial lakes in the Uinta Mountains just south of the source of Weber and Bear rivers and flows southwestward through a series of valleys and canyons. It passes through the Wasatch Range and enters Utah Lake valley near the town of Provo, finally emptying into Utah Lake.

Willard, Farmington, and Box Elder creeks and streams in Tooele and Rush valleys.—Willard, Farmington, and Box Elder creeks are small spring and snow fed mountain streams that flow from the west slopes of the Wasatch Range between Salt Lake City and Brigham. They are short and fall rapidly through their canyons. The canyon of Box Elder Creek is not so rugged nor so steep as those of Willard and Farmington creeks, and the stream is larger. These streams flow directly into the marshy areas along the east shore of Great Salt Lake.

Tooele and Rush valleys lie south of Great Salt Lake, between the Oquirrh and Onaqui ranges, and are separated by a low divide near the town of Stockton. Both valleys are comparatively flat in the center and slope gradually northward to Great Salt Lake. A number of streams flow into the valleys from the mountains on either side, but they are all small and many of them have intermittent flow, the channels being dry in the summer. All the flow is used for irrigation, and several hundred acres of land is reclaimed in and around the settlements of Tooele, Grantsville, Stockton, St. John, Clover, and Vernon.

STREAM FLOW.

In all studies of the utilization of stream flow it is imperative that records of stream discharge be available in order to determine with some degree of accuracy the possibilities of development. Such records have been kept on most of the principal streams of the Great Salt Lake basin and on many of the smaller ones where power plants have been built. More than 65 gaging stations have been established in the basin, and many valuable data have been obtained from them, but for many of the smaller streams no data are available.

RESERVOIRS AND RESERVOIR SITES.

The advance of irrigation and power development in the Great Salt Lake basin has completely utilized the entire low-water flow of most of the streams, and progress is already being made in conserving the flood flow by building reservoirs. The largest reservoir in the basin is Bear Lake, whose capacity is more than 1,400,000 acre-feet in the upper 23 feet. A pumping plant is situated at the north end of the lake, on a natural causeway that forms the impounding dam. Four smaller reservoirs have a combined storage capacity of 26,700 acre-feet. Considerable preliminary study has been made of 15 additional reservoir sites which, as planned, have a combined storage capacity of more than 300,000 acre-feet.

In the Weber River basin one reservoir has been constructed, with a capacity of 28,000 acre-feet, and 10 other reservoir sites having a proposed combined capacity of about 175,000 acre-feet have been investigated.

In the Jordan River and Utah Lake drainage basins Utah Lake is used as a reservoir, and it has an estimated capacity of 300,000 acre-feet at "compromise level," a point a little more than 3 feet higher than the bed of Jordan River at the outlet of the lake.

The Strawberry Valley reservoir has a capacity of 250,000 acre-feet. Although it is not in the Great Salt Lake basin, it is a part of the Strawberry Valley reclamation project. The water is brought into the basin through a tunnel and is used on lands in Utah Lake valley.

A number of small lakes at the head of Cottonwood Creek and Provo River have been developed as reservoirs, but the amount of storage is relatively small. In addition to the Utah Lake and Strawberry Valley reservoir storage the other reservoirs in the Jordan River and Utah Lake area have a combined capacity of about 29,000 acre-feet. Nine possible reservoir sites and several small lakes at the head of Provo River have been investigated to some extent, and the estimated storage possibilities as shown by these studies amount to about 176,000 acre-feet.

The gross undeveloped storage capacity in the Great Salt Lake basin is estimated to be between 600,000 and 700,000 acre-feet, or approximately half of the storage capacity of Bear Lake.

DEVELOPED WATER POWER.

The development of hydroelectric power is one of the most important industries in the Great Salt Lake basin, and the water-power resources are rather intensively developed, especially in that part of the basin in Utah, where the settlement and industrial growth are concentrated. On practically every stream that is large enough for an economical development of power there is one or more hydroelectric power plants, and in view of the many advantages of large-unit installation that have been acquired in the development of the industry in the last 10 years, the possibility of increasing the number of small isolated plants is extremely remote. There are 50 plants in the basin having an installed water-wheel capacity of 225,149 horsepower at the end of 1923. Most of them are small.

UNDEVELOPED WATER POWER.

The amount of potential power at any power site ranges from the minimum to the maximum stream-flow capacity and can not be indicated by a definite figure unless qualified by the time factor. Accordingly, the power capacities considered in this report are based somewhat arbitrarily on two time elements—(*a*) the capacity available 90 per cent of the time, or that available during ordinary low flow and for so great a part of the time that comparatively little pondage will render it thoroughly reliable; and (*b*) the capacity available 50 per cent of the time, or that available when conditions of flow are such that though development is ordinarily warranted substantial storage regulation or auxiliary steam power must be provided to render the capacity thoroughly reliable. Only those streams that show a power capacity of at least 100 horsepower for 90 per cent of the time have been considered in this report. The 65 sites that were investigated are estimated to be capable of furnishing about 56,000 horsepower for 90 per cent of the time or 81,000 horsepower for 50 per cent of the time, with the existing stream flow. With regulated flow these figures would be increased to 80,000 and 115,000 respectively.

WATER RIGHTS AND APPROPRIATIONS.

In the arid States irrigation is necessary to grow good crops, and the available land is usually far more than can be properly irrigated by the available water supply. It is therefore essential to the proper utilization of the streams that the different water rights are defined and protected.

The Great Salt Lake basin has streams in Wyoming, Idaho, and Utah, and in these States the streams are public property, the use of the waters of which must be acquired through application, and beneficial use is the measure of the right. In order that water rights may be properly recorded and the unappropriated waters properly disposed of, each State has a State engineer or commissioner of reclamation, whose duty it is to protect the rights and interests in the streams and take action on all new applications for water rights. The method of acquiring these rights is, in general, the same in each State. The applicant must first file an application, and upon approval of it he is permitted to proceed with construction. When the water has been put to beneficial use in compliance with the State law and the rules and regulations of the State engineer a license is issued for the amount of water upon which proof of beneficial use has been made.

IRRIGATION AND ITS RELATION TO THE DEVELOPMENT OF WATER POWER.

All the streams in the Great Salt Lake basin are used for irrigation, and more than 800,000 acres of land is irrigated. Most of the power plants do not interfere with irrigation, because the streams in general are short and flow in their upper stretches through steep, narrow canyons. The power plants are in the canyons, most of them above all irrigation diversions. Some plants are built as adjuncts to irrigation enterprises, and there are irrigation diversions both above and below a few plants. However, the use of water for irrigation has a preference right over its use for power, and the development of power has been designed to avoid infringement on irrigation rights. On Bear River power and irrigation are so intimately associated that the greatest utilization of the stream requires both interests to be developed together, for the power furnishes the means of extending irrigation to the bench lands which otherwise would not be reclaimed by gravity systems.

MARKET.

In all water-power developments a market for the power is the factor that determines the economic feasibility of the project, and where the power is to be used for public service it is the force that compels the development. The Great Salt Lake basin and the surrounding territory are well provided with natural resources, and the development of these resources has furnished an increasing market for power. The first plants in the basin were built to supply a small local market near the plants, but in the last 12 years, since the advent of long-distance transmission, the interconnection of isolated plants, and the advance in reliability of service, the uses for power in the industrial world have increased greatly.

The total connected power load in the basin is more than 270,000 kilowatts. The average load is 70,000 kilowatts, and the average monthly output is 50,400,000 kilowatt-hours. The load comprises lighting, fuel, and power for more than 100 communities, power for mining, interurban railroads, sugar factories, canneries, manufacturing establishments of various kinds, and irrigation pumping enterprises. The diversity of uses permits a much greater connected load than the installed capacity of the plants and thus adjusts the total demand to such an extent that the load curve shows no excessive fluctuations.

With the extensive coal and iron fields to the south of the basin, the huge salt deposits near Great Salt Lake, and the manufacture of sulphuric acid as a by-product of the smelters, raw materials are easily accessible for extensive steel manufacture, for a colossal chemical industry, and for utilizing the by-products from a great coke industry. The railroads in the basin also offer a good possibility for the use of power and a betterment of service by electrification over the steep mountain grades.

RELATION OF THE FEDERAL GOVERNMENT TO THE DEVELOPMENT OF WATER POWER IN THE GREAT SALT LAKE BASIN.

Federal control of the development of water power rests on the constitutional prerogatives of the Congress "to regulate commerce with foreign nations, among the several States, and with the Indian tribes" and "to dispose of and make all needful rules and regulations respecting the territory or other property belonging to the United States." The Federal Government holds public lands both as sovereign and proprietor, and as such it may do with its lands everything that any other proprietor may do.

The chief relation that the public lands bear to the development of water power in the Great Salt Lake basin arises from the fact that it is necessary to utilize portions of them for the emplacement of structures and to overflow other portions as a result of the construction of dams. In both cases the consent of the United States is necessary. Several acts have been passed by Congress dealing with rights of way across public lands; the most recent one is the Federal water-power act, approved June 10, 1920 (41 Stat., 1063). This act created and established the Federal Power Commission, composed of the Secretary of War, the Secretary of the Interior, and the Secretary of Agriculture. The commission has general administrative control over all power sites on the navigable waters and the public lands and reservations of the United States except existing national parks and national monuments. Briefly, the commission is charged with the duty of issuing permits and licenses for the utilization of all power sites over which it has jurisdiction to all bona fide, financially responsible applicants whose plans for development conform to the prescribed rules and regulations issued by the commission and are not at variance with the full utilization of the stream to the best public interests.

WATER POWERS OF THE GREAT SALT LAKE BASIN.

By Ralf R. Woolley.

INTRODUCTION.

By Nathan C. Grover.

In this age of mechanical and electrical energy a country or region that has resources from which an abundant supply of cheap and reliable power may be developed holds a position of industrial and commercial advantage. The United States holds just such a position with respect to many other countries by reason of its fuel and water-power resources, and it has therefore led the world not only in the aggregate quantity of mechanical and electrical energy devoted to industrial use but, more strikingly, in the quantity of such energy entering into each unit of manufactured product. We have therefore been able to compete in the world's markets for manufactured products, although we have paid a relatively high rate for labor. If the established high standard of living is to be maintained by the American laborers employed in manufacturing materials for sale in competition with similar materials produced by the poorly paid laborers of other countries during the present period of readjustment, cheap energy must be used to increase the unit output of labor to an even greater extent than in the past. This country's immediate future prosperity therefore depends largely on its ability to increase its use of its enormous resources of coal and of water power. The present interest in available water-power sites, of which evidence is afforded by the great number of applications submitted to the Federal Power Commission, is significant of an appreciation of this fact by the engineer, business man, and capitalist.

In a somewhat lesser degree, perhaps, a region containing great resources in water power or in good coal that can be cheaply mined has an advantage over less favored regions in the same country, though of course other factors enter into the comparison. Climatic conditions may determine the location for certain manufacturing industries; a satisfactory supply of skilled or unskilled labor may control the choice of sites for other industries; and the cost of transporting raw materials and finished products to the place of use may be the deciding factor in fixing the sites for still others. A knowledge of the resources of a region, either in agriculture and minerals or in the essentials for producing cheap energy whereby other sources of wealth may be developed, will serve to promote the sound growth of the region.

In this report Mr. Woolley has presented concisely the principal available facts relating to water-power plants and undeveloped sites in the Great Salt Lake basin, together with such information relative to the use of water in irrigation and to the market for power as will enable the reader to form a correct estimate of the present and future importance of the water-power resources of the basin and will serve as a safe basis for water-power development.

The classification of the public lands with respect to their value for various possible uses is necessary in order that the lands may be administered or alienated in accordance with the public-land laws. The classification must therefore include a definition of existing developments and of projects for development with respect to cadastral surveys. Mr. Woolley has satisfied this need in discussing the water-power value of the public lands included in developments or projects that involve the construction of water-power plants in the Great Salt Lake basin.

The report is based on examinations of power plants and power sites made by Mr. Woolley in parts of three or more field seasons for the United States Geological Survey; on field and office work done by him prior to his employment by the Geological Survey; on information furnished to him by individuals and by officials of power companies; and on long records of stream flow in the basin collected by the Geological Survey in cooperation with the States of Utah and Idaho, which have served as a basis for the existing developments and for estimates for future developments of both water power and irrigation. It shows for the entire basin not only the capacity of water wheels installed but also the total potential capacity of undeveloped sites with both regulated and unregulated flow. The capacities of existing power plants and of undeveloped sites are not directly comparable, because much greater wheel installations are demanded for widely varying loads than would be required to utilize continuously the full capacities of the sites. It appears probable, however, that the water-power resources of the basin are not yet more than half developed.

The sites already utilized have of course been those that would supply the available market for energy at the least cost. The feasibility of future developments must be judged by the same criterion. In planning to supply the future increase in demand for power in this region consideration must be given to the cost and service of power developed from Utah coal in competition with that developed at the water-power sites of Snake River and its tributaries on the north and of Green and Colorado rivers and their tributaries on the east, as well as at the power sites in the Great Salt Lake basin. The early use of undeveloped sites in that basin therefore depends on the cost of development and transmission of their energy as compared with the similar cost for power sites outside the basin and for coal-burning power plants.

Projects for the use of water for power in this region must be considered with respect to the present or probable future demand for the same water for irrigation. The highest agricultural development is possible only on lands that can be irrigated, and irrigation is rated as a higher use than the development of power. A policy that would limit or prevent the maximum agricultural development of the region would certainly be shortsighted. An attempt should therefore be made to harmonize the uses of the available water for irrigation and power in such a way as to provide for the maximum ultimate development of the region and the maximum benefit to the community. Any development that would conflict with this program would not conform to good public policy.

ACKNOWLEDGMENTS.

The writer wishes to express his appreciation of the helpful services of the engineers and others who have rendered assistance in collecting the basic data for this report. Special acknowledgments are due to Mr. W. G. Swendsen, commissioner of reclamation in Idaho, for data regarding the acquisition of water rights in that State; to Mr. J. Cecil Alter, of the United States Weather Bureau, for the report on climatic conditions in the Great Salt Lake basin; to officials of the Utah Power & Light Co., who gave the writer many data on power plants, market conditions, and irrigation enterprises closely associated with the power developments; and to Mr. W. L. Whittemore, project manager of the Strawberry Valley project, United States Bureau of Reclamation, Provo, Utah, who furnished data regarding the power possibilities on Sixth Water and Diamond Fork creeks. The writer is also especially indebted to Mr. H. N. Sulliger, consulting engineer, Los Angeles, Calif., for valuable data obtained through association with him in an earlier study of the water-power possibilities in this region.

GEOGRAPHY, GEOLOGY, AND PHYSIOGRAPHY OF THE GREAT SALT LAKE BASIN.

By W. T. Lee.

LOCATION.

The Great Salt Lake basin comprises that part of the Great Basin that drains into Great Salt Lake. It includes the northern part of Utah, a small part of eastern Nevada, the southeast corner of Idaho, and the southwest corner of Wyoming. This basin, which extends east and west, is about 180 miles long and 150 miles wide and has an approximate area of 27,000 square miles (Pl. I).

Great Salt Lake is a remnant of Lake Bonneville.[1] It rests upon the surface of a broad plain and has a mean depth of about 15 feet.

The principal tributaries to Great Salt Lake are Bear, Weber, and Provo rivers. They all rise to the east, in the Wasatch Mountains and associated uplands, which afford the chief and almost exclusive water supply of the basin.

PROBLEM OUTLINES.

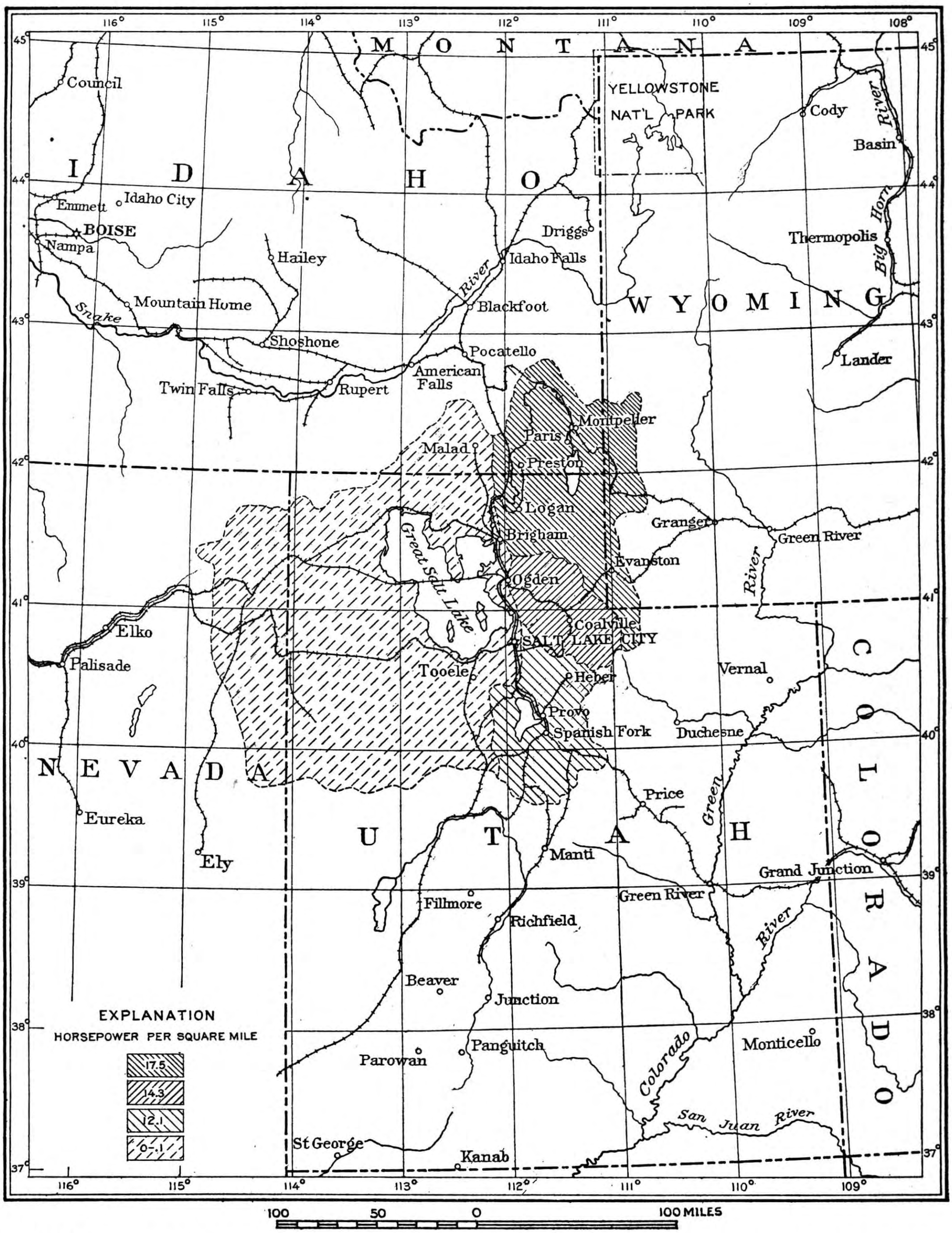
This area is in a region of complicated geographic, geologic, and physiographic relations, which it would be difficult to describe fully. As this report deals chiefly with water power, it is not the place to describe features whose connection with water power is only remote, but certain features that are intimately connected with the development of water power are discussed in general.

The eastern part of the area consists of mountainous highlands; the western part chiefly of low-lying sandy plains. The lowest portion of the plain is occupied by Great Salt Lake, and minor parts by low mountain ranges. This area includes parts of two of the major physiographic divisions of the United States—the Rocky Mountain region and the Intermontane Plateaus. The eastern mountainous area is the southern extremity of the Northern Rocky Mountain province and extends southward and eastward to the high plateaus of Utah, which constitute a part of the Colorado Plateaus province. The western lowland area is a part of the Basin and Range province and is the eastern extremity of the Great Basin. The relations of these provinces to one another are important in solving the water-power problems, for they explain the peculiar physical characteristics that make power sites possible, such as steep gradients, persistent flow, narrow rock-walled gorges, and solid rock in stream beds.

GEOGRAPHY.

Geographically the Great Salt Lake drainage area is a borderland between the Great Basin and the mountainous highlands to the east and includes some of both. Continental surfaces are usually drained by streams that flow to the ocean, but the Great Salt Lake basin has no outward drainage. The streams all flow into the Great Basin, an area of diversified surface features, including flat desert valleys and rugged mountain ranges. The Great Basin is not, as its name might suggest, a single pan-shaped depression gathering its waters

[1] Gilbert, G. K., Contributions to the history of Lake Bonneville: U. S. Geol. Survey Second Ann Rept., pp. 167-200, 1882.



KEY MAP SHOWING LOCATION OF GREAT SALT LAKE BASIN AND POTENTIAL POWER PER SQUARE MILE.

to a common center but is divided into a large number of independent drainage areas, of which the Great Salt Lake basin is the best known. Both the mountains and the valleys are of types more or less peculiar to this region.

The mountains are long, narrow ridges, most of which extend from north to south and rise abruptly from the plains, there being a notable absence of foothills. Many of the ridges terminate at the ends as abruptly as their side slopes join the surrounding plains.

Arid plains are abundant in this region, and some are so extensive that they appear almost boundless. They present many of the features that characterize a desert, such as deep, drifting sands and broad stretches of barren mud plains, and in the heat of the midday sun they exhibit all the tricks of the mirage.

The climate of the lowlands is very dry. In the spring the barren-looking soil produces a surprising variety of beautiful and delicate flowers, most of which disappear as the parching heat of summer approaches. Trees are exceedingly scarce. Cottonwoods and willows grow in patches or border some of the more permanent watercourses, and a scattered growth of more or less scrubby pines and cedars is found on some of the higher mountain slopes. Agriculture is almost wholly restricted to areas that can be irrigated, though dry farming is being tried in some localities.

The climate of the highlands is quite different. The mountains in the basin and near its border have desert slopes, but in the Wasatch Mountains the greater part of the surface is so high that rain falls on it frequently. Here the slopes are covered with forests and the bottom lands with turf. These are the highlands that make possible the best-developed parts of Utah. Without them Salt Lake City and the other prosperous communities along the foot of the mountains would not exist.

The line between the highlands and lowlands, separating the two great provinces, is here sharply defined at the steep western face of the Wasatch Mountains. This range of mountains has a north-south trend, like the basin ranges farther west, and in this sense it is the easternmost of these ranges.

The Uinta Range, immediately east of the Wasatch Mountains, extends nearly east and west, or practically at right angles to the Wasatch Range. The Uinta Range is regarded as a continuation of the Rocky Mountain ranges in Colorado, most of which have a northwest trend, the deflection toward the west becoming conspicuous in some of the westernmost ridges. Thus the boundary between two great tectonic subdivisions, as well as the boundary between geographic and physiographic subdivisions, passes through the Salt Lake drainage area; for in the contact of the Uinta Range with the Wasatch Mountains is found the separation of the Rocky Mountain type of mountain structure, consisting of modified arches that reach their maximum development farther east in central Colorado, and the basin-range type, consisting of tilted blocks whose axes have a regular northerly trend.

One of the results of the relation of these two ranges appears in the stream courses. A large part of the drainage north of the Uinta Range finds its way northward and westward in Bear River around the end of the Wasatch Mountains, thence southward to Great Salt Lake. That south of the Uinta Range goes in the opposite direction and finally reaches Colorado River.

GEOLOGY.

CHARACTER OF THE ROCKS.

The character of the rocks is important in a study of water-supply and power sites in at least three ways—one pertaining to their composition and physical condition, one to their structure, and one to the conditions that have been forced upon them by dynamic processes

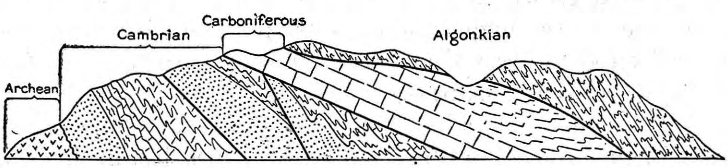


FIGURE 1.—Diagrammatic section showing the structure of the Wasatch Range in Ogden Canyon.

or by the forces that fractured the rocks and lifted the mountains to their present position.

The rocks of the Wasatch Mountains range in age from the pre-Cambrian, or oldest, at the base to the Pleistocene, or youngest, at the top. Exceptions to this general rule are found where the older rocks have been pushed by overthrust faulting up over younger rocks, as in Ogden Canyon (fig. 1). As old rocks are likely to be harder than young rocks and therefore make better dam sites, the presence of old rocks at the surface pushed up by overthrust faulting might be a controlling factor in selecting a power site. Those rocks that occupy the floor of the Great Basin are Pleistocene and abut against the pre-Cambrian rocks of the main mountains and against the Paleozoic rocks of the basin ranges. Most of the Paleozoic and older rocks are hard and either crystalline or metamorphosed. They are too nearly impervious to hold large quantities of water or to allow water to pass readily through them, but they are so faulted and broken that a large amount of water is held in the cracks and is gradually released at springs. Furthermore, because of their hardness, they constitute the high mountains, where the rainfall is greatest; hence they are important in maintaining a constant flow of water in the streams.

The Mesozoic, Tertiary, and younger rocks, which occupy the surface in the eastern part of the drainage basin, are more porous and therefore capable of absorbing more of the water which falls on them as rain. This characteristic is offset in a measure by their occurrence at lower altitudes, where there is less rainfall than in the high mountains. Moreover, as they are not fractured to the same extent as the older rocks, they are of less use in maintaining constant stream flow.

The youngest or Pleistocene deposits are slightly consolidated, and where considerable volumes of the porous material occur in the mountains they serve an important purpose in the conservation of water. The loose material that forms the floor of the Great Basin is of relatively little importance in reference to water power, for although capable of holding much water it lies too low to be of use in conserving water for the streams.

The unconsolidated beds of talus or fragmental rock that occur on all mountain slopes are probably more effective than all the older rocks combined in conserving the rainfall and regulating the stream flow. In some places the beds of talus are thick; in others they form only a thin veneer over the solid rock; and in still others the angular fragments of rocks are embedded in soil. The loose material retards the flow of the water derived from rain and from melting snow. Ice forms in the beds of coarse material in winter and melts out slowly during the summer, thus distributing the flow through a long period of time.

STRUCTURE AND DYNAMICS.

For present purposes the structure of the rocks and the forces within the earth that produced that structure may be considered together. The mountainous area consists in general of old crystalline rocks at the base, and these are covered with successive layers of sedimentary rocks, all sloping eastward. When the rocks are examined in detail, however, the structural relations are found to be extremely complicated. There are faults and folds and slips and overthrusts. (See fig. 1.) Furthermore, the structure is complicated by the effects of movements of different character which have occurred at different times.

In general the highland area consists of a huge block of the earth's crust lifted bodily, tilted slightly toward the east, and later deeply dissected by erosion. The break in the earth's crust that made this tilting possible extends from north to south along what is now the western base of the range. The rocks that lie east of this line of fracture were pushed up thousands of feet higher than those west of the line, thus producing a great fault. Later the elevated part of the block was so deeply eroded that now its surface is a complicated mass of rugged mountains, separated from one another by valleys, canyons, and gorges. The western face of the range, which was originally nearly vertical and might have been a single cliff if it had not been eroded, is still very precipitous and forms what is known as a fault scarp. It is this western face that is so impressive as seen from Salt Lake City, Ogden, and other points in Great Salt Lake valley.

The structure is much more intricate than it appears to be at first glance. Broad folds of ancient origin have been complicated by accessory deformation, intrusion by masses of igneous rock, and erosion of ancient surfaces, which later were covered by sediments. Some of these old surfaces were formed in Paleozoic time. Then the Paleozoic rocks were buried under thick deposits of Mesozoic sediments, which in turn were raised at the end of the Mesozoic era, eroded, and in their turn covered with sedimentary rocks of Cenozoic age. Finally these also were lifted and tilted, and the whole complicated mass has been carved by recent erosion into the present mountains. It would be impossible to describe the details of the structure of the Wasatch Range without years of investigation.

PHYSIOGRAPHY.

The important physiographic features considered in this report are those pertaining to the character of the mountain streams. There are two general types of stream courses—those established before the last great rise of the mountains and those dependent on the present mountain slopes. Weber River is probably the best representative of the first type, and the short torrential streams like Emigration Creek are included in the second.

Weber River must have been flowing in a course essentially the same as at present before the beginning of the great crustal uplift that resulted in the present Wasatch Mountains. This stream rises east of the high mountain ranges, cuts a canyon 4,000 feet or more in depth through the Bear River Range, crosses a parklike opening, and once more enters a narrow rock gorge, within which it passes through the main range of the Wasatch Mountains. This alternation of open basins and narrow rock-walled gorges can be explained only by assuming that the mountains were uplifted across a course already established by the stream.

Bear River may have had a more eventful history. Its course suggests that the uplift of the mountains may have deflected it from its former course, so that now it takes a circuitous route influenced to some extent by the relation to one another of the separate mountain ridges. At some places it cuts through ridges of hard rock, like the Weber, but in general it seems to have followed an easier course.

As the crust block was raised and the rocks broken, some parts were pushed up higher than others, making inclosed basins, such as that occupied by Bear Lake. Some of the streams draining these basins were able to lower their beds as fast as the block was pushed up, thus keeping the basins fully drained. Others, such as Ogden River, sometimes fell behind and temporary lakes were formed in which lake deposits accumulated, but eventually the rivers cut the outlets low enough to drain the basins. Still others, such as Bear River, have not yet succeeded in draining all the basins tributary to them.

The life history of the shorter streams which constitute the second general type is much simpler. They are young and correspondingly vigorous. They originated on the slopes formed by the last great uplift of the mountains, and their life has been one of uninterrupted erosion. This erosion, however, has varied somewhat in rate and character, for the upper parts of the gorges were filled with ice at least twice during the ice age. Although these gorges are probably due chiefly to stream erosion, they were shaped to some extent by the ice.

CLIMATE.

GENERAL CONDITIONS.

The general climate of the Great Salt Lake drainage basin, as shown by the records of the United States Weather Bureau, is of the arid or semiarid type, with a definite seasonal march of temperatures typical of the mid-temperate zone. There is a maximum of precipitation in the winter and spring seasons, and the summer and autumn seasons are comparatively dry. The annual precipitation in this basin increases rapidly with the altitude. The principal agricultural areas at the lower levels receive about half as much precipitation annually as Iowa, or one-third as much as the Coastal Plain of Georgia or the Carolinas.

The four temperature seasons and the monthly and annual mean temperatures in the more thickly populated areas of the basin are very nearly like those of an area of similar extent at the same latitude in central Indiana, though the daily ranges of temperature from average maximum to average minimum are somewhat greater than in Indiana, as is usual in regions of greater altitude and aridity.

Meteorologic data for Great Salt Lake basin, Utah.

[By United States Weather Bureau.]

Station.	County.	Altitude (feet).	Length of record (years).	Date of average killing frost.		Average time between killing frosts (days).
				Latest in spring.	Earliest in autumn.	
Alpine	Utah	4,900	22			
Brigham City	Box Elder	4,305	11	May 2	Oct. 15	166
Castle Rock	Summit	6,240	15			
Clarkston	Cache	5,930	9			
Corinne	Box Elder	4,240	40	May 18	Sept. 30	135
East Portal	Wasatch	7,606	7			
Elberta	Utah	4,650	15	May 18	Sept. 30	135
Farmington	Davis	4,267	19	May 7	Oct. 1	147
Garland	Box Elder	4,248	7	May 29	Sept. 28	140
Grantsville	Tooele	4,328	13			
Heber	Wasatch	5,593	26	June 16	Sept. 6	82
Henefer	Summit	5,301	19	June 16	Aug. 31	76
Huntsville	Weber	5,100	17	June 8	Sept. 8	92
Laketown	Rich	6,200	19	June 14	Sept. 6	84
Logan	Cache	4,507	28	May 14	Oct. 8	147
Marion	Summit	6,750	8			
Midlake	Box Elder	4,235	8	Apr. 2	Nov. 15	227
Midvale	Salt Lake	4,365	7	May 21	Sept. 20	122
Millville	Cache	4,848	24			
Morgan	Morgan	5,080	12	June 10	Sept. 3	85
Mosida	Utah	4,510	7	May 19	Sept. 29	133
Ogden No. 1	Weber	4,310	18	Apr. 22	Oct. 15	176
Ogden No. 2	do	4,310	50	May 1	Oct. 7	159
Park City	Summit	7,000	20	June 13	Sept. 18	97
Payson	Utah	4,637	15			
Pine View	Summit	6,335	6			
Provo	Utah	4,532	29	May 24	Sept. 24	123
Randolph	Rich	6,442	17			
Richmond	Cache	4,529	7			
Saltair	Salt Lake	4,200	16	Apr. 11	Oct. 22	198
Salt Lake City	do	4,408	45	Apr. 20	Oct. 19	182
Silver Lake	do	8,700	7			
Spanish Fork	Utah	4,585	9	May 5	Oct. 8	155
Thistle	do	5,033	26	June 9	Sept. 9	91
Tooele	Tooele	4,900	23	May 13	Oct. 12	152

TEMPERATURE.

The mean monthly and annual temperatures, which are the mean of the maxima and minima shown in the accompanying table, decrease with increase in altitude in all months pretty uniformly, owing principally to the relatively lower minimum or early morning temperatures. The decrease in the maximum or mid-afternoon temperatures with increase in altitude is comparatively small at stations in the partly inclosed mountain valleys, as compared with those at the base of the mountains or in the Great Salt Lake basin proper, owing to the collection of the sun's rays and to the diminished wind velocities, which usually favor higher daytime temperatures in the higher valleys; though on the more exposed mountain plateaus, slopes, and ridges the afternoon temperature curve is very much flatter, particularly during the summer, than the curve at the lower levels, presumably because of the increased wind movement and the dispersion of the sun's rays from these exposed areas.

The average minimum temperatures decrease rapidly as the altitude increases, the decrease being greatest in winter, somewhat less in midsummer, and least in spring and autumn. This variation with the season is probably due, at least in part, to the increased storm frequency and cloudiness, especially in the spring, which interrupt the normal cooling by radiation at night. However, when a general snow cover is present, the sky is clear, and there is little or no wind movement, the mountain minimum temperatures fall very low in comparison with temperatures when it is generally cloudy or windy, for, under those conditions the mountain and valley temperatures, both day and night, will be much the same irrespective of topography and altitude.

The absolute highest temperatures recorded in the Great Salt Lake basin are 101° to 110° at the stations in the lower areas, and 90° to 100° at the mountain stations, which, however, are limited to the more permanently populated places. The absolute lowest temperatures recorded range from 10° to 20° below zero near the Great Salt and Utah lakes to 35° or 50° below zero at Thistle, Laketown, Heber, Henefer, and East Portal, named in the order of magnitude of the minimum temperatures observed.

The average daily ranges of temperature from maximum to minimum are generally greatest during the warm dry season, from June to October, at practically all altitudes, owing to the diminished obstruction offered by clouds or high atmospheric humidity to the receipt of heat from the sun and its subsequent radiation into space. The least daily ranges of temperature occur usually from December to February. The ranges are greater in winter and less in summer at the higher and more exposed stations than at the lower and more sheltered stations.

The favorable temperature conditions for preserving the snow that falls on the mountains through a much longer period than at the lower levels are augmented by the high winds, usually of brief duration, that accompany many of the snowstorms and sweep the loose snow from the exposed ridges and crests into the ravines for greater solidification and preservation.

The growing season for agricultural crops on the floors of the Great Salt Lake and Utah Lake valleys, as shown by the averages of the dates of killing frost and by the average maximum and minimum temperatures in the tables herewith, is from four to six months in length. The length depends on the local topography and the sensitiveness of the crop to low temperatures for brief periods each day in early spring and late autumn. On the mountain slopes the native vegetation has a growing season that diminishes rapidly to only a few weeks in the higher parts of the Wasatch Mountains.

Average monthly maximum and minimum temperatures in Great Salt Lake basin, Utah.

Station.	Jan.	Feb.	Mar.	Apr.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Corinne	35.7	40.0	51.4	63.6	72.2	84.0	92.8	91.1	80.4	65.8	50.8	37.1
	14.3	19.2	26.9	34.0	40.7	48.9	56.0	55.2	44.6	34.0	25.4	16.1
East Portal	25.3	29.0	36.6	46.0	55.9	68.0	73.5	72.7	64.2	54.1	42.1	28.9
	−2.6	.3	7.3	18.1	27.9	33.4	40.7	37.1	31.2	24.8	12.3	1.2
Elberta	37.5	42.1	53.6	63.8	72.2	83.7	90.3	89.6	79.1	66.0	51.6	38.8
	17.9	20.8	28.5	35.4	41.6	50.9	58.3	57.2	46.8	35.2	25.4	17.1
Farmington	37.8	41.6	51.2	61.4	71.1	81.8	90.1	87.0	75.6	63.2	50.8	38.8
	21.2	24.3	31.1	36.3	41.3	48.9	56.0	54.5	44.6	36.2	28.9	22.1
Heber	33.1	36.8	47.3	60.1	68.4	79.4	86.5	85.3	75.5	63.5	50.2	34.6
	9.1	11.5	21.2	28.4	34.7	39.8	45.0	43.7	35.4	27.3	20.2	10.8
Henefer	36.2	39.6	49.3	59.6	68.2	78.4	85.7	84.6	75.5	64.3	51.2	37.1
	8.4	11.7	21.2	28.4	33.5	38.8	44.6	42.8	34.2	26.5	18.4	10.1
Laketown	31.4	32.1	39.6	53.4	62.7	73.4	82.0	80.4	69.6	57.3	44.5	33.6
	12.5	11.2	18.9	28.6	35.2	41.0	47.2	46.2	38.3	30.2	22.1	15.4
Logan	32.5	35.9	46.6	59.1	66.0	77.0	85.8	84.5	74.6	61.6	46.7	33.0
	16.6	19.4	27.0	35.7	42.5	50.4	58.9	57.3	48.3	38.0	28.3	17.7
Ogden No. 1	35.9	40.4	50.7	62.1	69.2	80.3	87.7	86.2	74.6	63.1	49.7	37.3
	18.0	22.8	30.6	38.2	44.6	52.5	59.3	57.7	48.7	33.0	29.1	20.4
Provo	39.1	44.1	54.4	65.5	72.2	83.5	90.8	89.8	80.0	66.8	54.2	39.6
	16.4	21.2	28.3	34.2	39.4	45.9	52.4	50.9	42.3	32.9	26.5	17.5
Salt Lake City	36.1	41.0	50.7	60.0	68.4	79.2	88.0	86.6	76.2	62.6	49.6	39.0
	21.3	25.8	32.7	39.7	46.7	55.3	63.3	62.5	52.7	42.0	32.1	24.8
Thistle	38.8	42.8	52.8	63.4	71.3	82.9	91.1	90.5	80.5	68.3	53.7	40.6
	10.3	17.1	22.8	30.7	35.0	41.2	47.4	45.1	36.0	28.1	20.5	12.4

PRECIPITATION.

In studying the utilization of irrigation waters by agricultural crops and the production and value of mountain foliage as a cover for absorbing moisture and retarding run-off, the usually abundant supply of soil moisture in the spring and the current precipitation, available for all vegetation, as reviewed in the following paragraphs and in the accompanying tables, should be examined.

The average annual precipitation for this part of Utah ranges from less than 5 inches on the desert west of Great Salt Lake to more than 20 inches along the western slope of the Wasatch Mountains and to 30 inches or more on the higher westerly exposures of this range, which intercepts the average storm tracks from the Pacific Ocean about at right angles.

Along the base of the Wasatch Mountains the lands that lie about 4,250 feet above sea level, or only a few feet above the level of Great Salt Lake, receive about 15 inches of precipitation annually, and the comparatively small area of mountain surface around 9,000 feet in altitude receives about 35 inches. The principal agricultural lands have an average annual precipitation of 15 to 18 inches. The extreme difference in annual precipitation at different localities in this general region probably occurred in 1918, when 46.06 inches fell at Silver Lake and only 3.94 inches at Midlake, 70 miles to the northwest.

The precipitation begins to increase with altitude at a considerable distance west of the base of the Wasatch Mountains and continues to increase most of the way up the long, gradual slopes. Near the summit it decreases, but the area receiving this diminished precipitation is small. The relation between increase in altitude and increase in precipitation is generally rather irregular, varying with local topography, especially where high ridges intercept the rain-bearing winds before they reach the principal Wasatch crest.

Comparisons of all data available for the entire western Wasatch slope and a particular study of precipitation records during identical periods at adjacent stations [2] show that the average uninterrupted increase in precipitation with altitude on this slope is comparatively uniform at about the rate of 4 inches annually to 1,000 feet.

A similar review of meager but reliable data for the eastern slope of the Wasatch Range reveals an increase of approximately 5.5 inches to 1,000 feet, the plains areas immediately east of the Wasatch Range being drier than similar areas at the western base of the range. The average precipitation for the major eastern slope of the Wasatch is roughly about 55 per cent of that for the western slope as a whole, but the difference is greater toward the base.

The diminished precipitation shown east of the principal topographic barriers is usually more or less manifest also in the valleys and on their slopes that lie within the western part of the Wasatch Range; and the same variations are seen where the initial crest or section of the range is high and large enough to wrest a considerable share of the moisture from passing clouds before they reach the principal crest.

Periodic variations in the annual amounts of precipitation appear somewhat irregularly in practically all records covering 20 years or more. These variations are not indications of a permanent climatic change, however, and do not form a trustworthy basis for forecasting. The occurrence of these periods of deficient or excessive precipitation necessitates the adjustment of all records of precipitation for a short period with those for the longest periods at the nearest stations. Averages of records for even ten consecutive years may be discrepant from the true normal as much as 15 per cent or even more.

The longest records of precipitation in Utah were obtained in this basin, at Corinne, Ogden, and Salt Lake City; and in the combined averages of these stations the consecutive 10-year means fluctuate about the 49-year mean from 90 to 119 per cent. An important fact about this periodicity or variation, as given more fully in the paper on normal precipitation in Utah, already cited, is that it does not appear uniformly in all months. The precipitation from March to May, inclusive, presents swings of the cycle that are opposite to those appearing in all other months, and the averages for November show almost no variation during the so-called wet and dry cycles indicated in the annual records.

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[2] Normal precipitation in Utah: Monthly Weather Review, September, 1919.

Approximately 70 or 75 per cent of the annual precipitation in this basin falls from November to May, inclusive, and probably less than 13 per cent in June, July, and August. A comparatively large part of the precipitation represented in the monthly means is often due to a few isolated heavy rains, and therefore in a long record the number of years in which any particular month is abnormally dry is likely to exceed the number in which the same month is abnormally wet. This tendency is particularly well shown in this basin at a number of stations in the records for January, March, June, and July.

Droughts without rain of agricultural importance will last in occasional seasons from 30 to 50 days in the regions receiving about 15 inches of annual precipitation, and from 60 to 90 days in the regions receiving 8 to 12 inches.

Most of the precipitation from early in November to the end of March is in the form of snow, the greater amount occurring in January and February, though normally heavy snows may be expected also in December and March. A comparatively small amount of snow generally falls at the moderate and higher altitudes early in May and late in October.

The seasonal or annual snowfall ranges from 3 feet at stations at the lower levels and in the higher easterly areas to 10 or 12 feet at stations in the higher westerly areas. These totals, like those shown in the following table, are the sums of the separate falls, measured each day, but the accumulated depth on the ground seldom exceeds a foot over the agricultural areas, or 6 to 8 feet over any extensive areas of the higher mountains during the time of greatest accumulations, toward early spring. At the lower or agricultural levels the snow seldom lasts more than a few weeks at a time.

The average number of stormy days, having 0.01 inch or more of precipitation, is about 4 a month in summer, 8 in winter, and 10 in spring over the settled part of the drainage basin, but storms occur more frequently at the higher stations. There is an average of about 190 clear days a year, 90 partly cloudy days, and 85 cloudy days in the basin as a whole, though the number of clear days increases somewhat in the more arid regions to the west and decreases in the mountain areas. At Salt Lake City 63 per cent of the possible amount of sunshine occurs in an average year, and the relative humidity is 60 per cent at 6 a. m. and 45 per cent at 6 p. m. for the year as a whole.

The evaporation from a water surface during the open or summer season at Provo, as shown by a short record, is 35 or 40 inches, and at Nephi, where the wind velocity is somewhat greater, 40 or 45 inches. Adding to these figures the evaporation from snow and ice surfaces and from water surfaces in winter and on early spring and late autumn days after freezing has been general, we find that the average annual evaporation for the agricultural regions of this basin, as determined by an examination of all existing records, and published in detail in the Utah climatologic data for the last few years, is between 45 and 55 inches, distributed in average years as follows:

	Per cent.		Per cent.
January	0. 6	July	18. 7
February	. 8	August	16. 5
March	2. 4	September	11. 6
April	8. 9	October	6. 9
May	13. 0	November	2. 0
June	17. 6	December	1. 0

Average monthly and annual precipitation in the Great Salt Lake basin, in inches.

Station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
Alpine	1. 70	1. 80	2. 12	1. 90	2. 26	0. 81	0. 69	0. 96	1. 22	1. 60	1. 27	1. 41	17. 74
Brigham City	2. 13	1. 64	2. 11	1. 49	2. 20	1. 08	. 83	. 40	1. 14	1. 64	1. 47	1. 19	17. 32
Castle Rock	1. 82	1. 80	1. 76	1. 28	1. 72	1. 24	1. 09	1. 15	1. 39	1. 46	. 96	. 96	16. 63
Clarkston	1. 74	1. 84	1. 70	1. 61	1. 88	1. 53	. 97	. 50	1. 19	1. 79	1. 69	. 92	17. 36
Corinne	1. 41	1. 22	1. 31	1. 11	1. 48	. 67	. 49	. 54	. 73	1. 11	. 99	1. 40	12. 46
East Portal	3. 05	2. 09	2. 30	1. 22	1. 44	1. 24	1. 77	. 94	1. 96	2. 22	1. 52	1. 52	21. 27
Elberta	1. 09	1. 21	1. 30	. 92	1. 19	. 50	. 63	. 57	. 96	1. 01	. 70	. 72	10. 80
Farmington	2. 29	2. 23	2. 63	2. 07	2. 07	2. 39	. 65	. 73	1. 19	1. 74	1. 47	2. 04	20. 41
Garland	1. 03	1. 61	1. 34	1. 31	1. 89	1. 12	1. 16	. 39	1. 79	1. 10	1. 06	1. 17	14. 97
Grantsville	1. 06	. 91	1. 21	1. 14	1. 34	. 88	. 79	. 81	1. 02	. 99	. 86	. 56	11. 57
Heber	2. 49	2. 04	2. 15	1. 28	1. 47	. 66	. 80	. 91	1. 18	1. 35	1. 26	1. 61	17. 20
Henefer	2. 45	2. 19	2. 33	1. 64	1. 69	1. 01	. 89	. 95	1. 38	1. 31	1. 61	1. 59	19. 04
Huntsville	2. 98	2. 53	2. 65	1. 55	2. 07	. 77	. 67	. 87	. 99	1. 59	2. 05	1. 86	20. 58
Laketown	1. 95	1. 69	1. 56	1. 56	1. 61	. 95	. 69	. 75	1. 27	1. 27	1. 07	. 82	15. 19
Logan	1. 80	1. 57	1. 97	1. 69	2. 28	. 90	. 63	. 63	1. 21	1. 46	1. 23	1. 03	16. 40
Marion	2. 28	1. 81	2. 66	1. 72	2. 21	1. 06	. 74	1. 63	1. 54	1. 26	1. 61	1. 75	20. 27
Midlake	. 69	. 70	. 86	. 48	. 42	. 62	. 36	. 09	. 30	. 71	. 16	. 49	5. 88
Midvale	1. 59	1. 51	1. 92	1. 77	1. 54	1. 05	. 97	. 40	1. 03	1. 48	1. 06	1. 05	15. 37
Millville	1. 89	1. 53	2. 10	1. 70	2. 20	. 95	. 54	. 73	1. 24	1. 59	1. 60	1. 16	17. 23
Morgan	3. 00	2. 11	2. 21	1. 27	2. 16	. 98	. 88	1. 37	1. 09	1. 80	1. 62	1. 73	20. 22
Mosida	1. 10	1. 34	. 89	1. 12	1. 40	. 55	. 90	. 32	. 59	1. 36	. 55	. 77	10. 89
Ogden No. 1	2. 32	2. 26	2. 49	1. 74	2. 38	1. 09	. 34	. 83	1. 05	1. 34	1. 19	1. 89	18. 92
Ogden No. 2	1. 70	1. 61	1. 82	1. 45	1. 74	. 74	. 37	. 61	. 86	1. 36	1. 18	1. 58	15. 02
Park City	3. 09	2. 84	3. 04	1. 42	1. 22	. 68	1. 20	1. 14	1. 11	1. 20	1. 28	2. 02	20. 24
Payson	2. 11	1. 80	2. 33	1. 92	2. 20	. 93	. 87	. 68	1. 23	1. 66	1. 46	1. 43	18. 62
Pine View	2. 43	1. 07	1. 06	1. 11	. 99	1. 55	. 89	. 74	2. 16	1. 66	1. 04	. 89	15. 59
Provo	1. 72	1. 64	1. 68	1. 36	1. 60	. 78	. 57	. 65	1. 02	1. 31	1. 11	1. 43	14. 87
Randolph	. 90	. 74	. 88	. 96	1. 11	1. 00	1. 05	. 91	1. 19	. 79	. 47	. 54	10. 54
Saltair	1. 41	1. 26	1. 89	1. 49	1. 54	1. 21	. 63	. 74	1. 08	1. 33	1. 21	. 86	14. 65
Salt Lake City	1. 35	1. 47	2. 07	2. 01	2. 00	. 81	. 52	. 77	. 97	1. 54	1. 37	1. 35	16. 23
Silver Lake	5. 29	6. 45	6. 35	4. 36	2. 54	. 48	. 96	1. 93	3. 48	3. 34	2. 93	3. 81	34. 94
Spanish Fork	2. 26	1. 47	1. 80	1. 75	1. 77	. 94	. 78	. 51	1. 18	1. 90	1. 47	1. 57	17. 40
Thistle	2. 19	1. 75	1. 85	1. 32	1. 22	. 70	. 83	. 81	1. 08	. 95	1. 19	1. 68	15. 57
Tooele	1. 53	1. 45	2. 09	1. 83	2. 23	. 86	. 74	. 83	1. 04	1. 44	1. 46	1. 02	16. 52

Average monthly and annual snowfall in the Great Salt Lake basin, in inches.

Station.	Jan.	Feb.	Mar.	Apr.	May.	Sept.	Oct.	Nov.	Dec.	Annual.
Alpine	15.3	12.8	9.3	3.3	T.	0	0.2	3.7	10.7	55.3
Brigham City	14.9	11.1	6.8	.4	.6	0	0	1.2	10.5	45.5
Castle Rock	23.8	25.1	22.3	9.6	5.5	1.0	4.8	8.3	12.0	112.4
Clarkston	14.2	15.5	0	0	0	0	0	4.0	2.7	36.2
Corinne	10.7	7.5	4.5	2.2	.5	0	.1	2.3	5.7	33.5
East Portal	30.5	26.1	22.2	7.7	5.9	1.1	4.2	13.5	22.3	133.5
Elberta	10.3	7.3	5.3	.6	T.	0	.7	2.8	6.6	33.6
Farmington	20.9	15.3	14.7	4.5	.4	T.	.7	6.6	15.3	78.5
Garland	13.0	13.2	4.5	1.3	.2	T.	.3	1.7	16.5	62.7
Grantsville	12.2	8.5	4.9	1.0	.1	0	.8	2.4	3.8	33.7
Heber	21.3	20.0	13.4	2.4	1.3	T.	.5	7.4	16.1	82.4
Henefer	19.0	15.0	12.5	3.8	1.5	.3	2.0	7.5	12.0	73.6
Huntsville	19.9	14.0	13.5	1.9	.5	.1	1.7	5.8	13.3	70.7
Laketown	14.1	13.3	12.6	4.7	1.3	.6	1.9	4.3	5.5	58.5
Logan	13.9	11.1	9.4	4.2	.5	T.	T.	3.7	7.9	50.7
Marion	18.0	18.3	18.8	9.5	5.6	.2	4.8	9.2	13.0	97.4
Midlake	7.0	3.8	1.7	T.	0	0	T.	.3	4.9	17.7
Midvale	13.9	8.8	6.8	1.8	T.	0	.1	4.1	10.7	46.2
Millville	19.4	26.2	10.3	7.0	T.	0	T.	3.8	12.0	78.7
Morgan	20.0	14.4	13.5	3.4	0	T.	2.4	6.6	12.7	73.0
Mosida	9.5	7.4	6.6	0	0	0	T.	1.0	7.0	31.5
Ogden No. 1	16.4	10.6	9.2	1.0	0	0	.8	3.4	10.5	51.9
Ogden No. 2	11.8	8.9	9.3	2.0	.1	.2	.3	5.1	10.3	48.0
Park City	34.3	34.5	28.9	11.7	6.6	1.3	3.2	14.4	19.0	155.1
Payson	18.4	10.2	12.1	3.6	.5	0	1.4	5.5	13.0	64.7
Pine View	36.0	13.1	6.9	8.5	0	0	0	9.5	12.3	86.3
Provo	14.7	10.2	10.9	2.7	.1	0	.4	3.6	11.4	54.0
Randolph	9.2	5.1	8.5	3.8	.5	0	1.8	2.1	3.8	34.8
Richmond	22.3	15.8	13.9	4.7	T.	.1	.3	4.8	11.7	73.6
Saltair	10.4	9.1	7.4	1.6	T.	0	.2	3.3	7.4	39.4
Salt Lake City	11.3	10.4	10.9	2.6	.4	T.	1.2	5.3	10.2	52.4
Spanish Fork	30.0	13.4	7.2	.2	.7	T.	.8	4.3	18.8	75.4
Thistle	22.1	14.6	15.0	4.3	1.0	0	.6	7.5	15.6	80.7

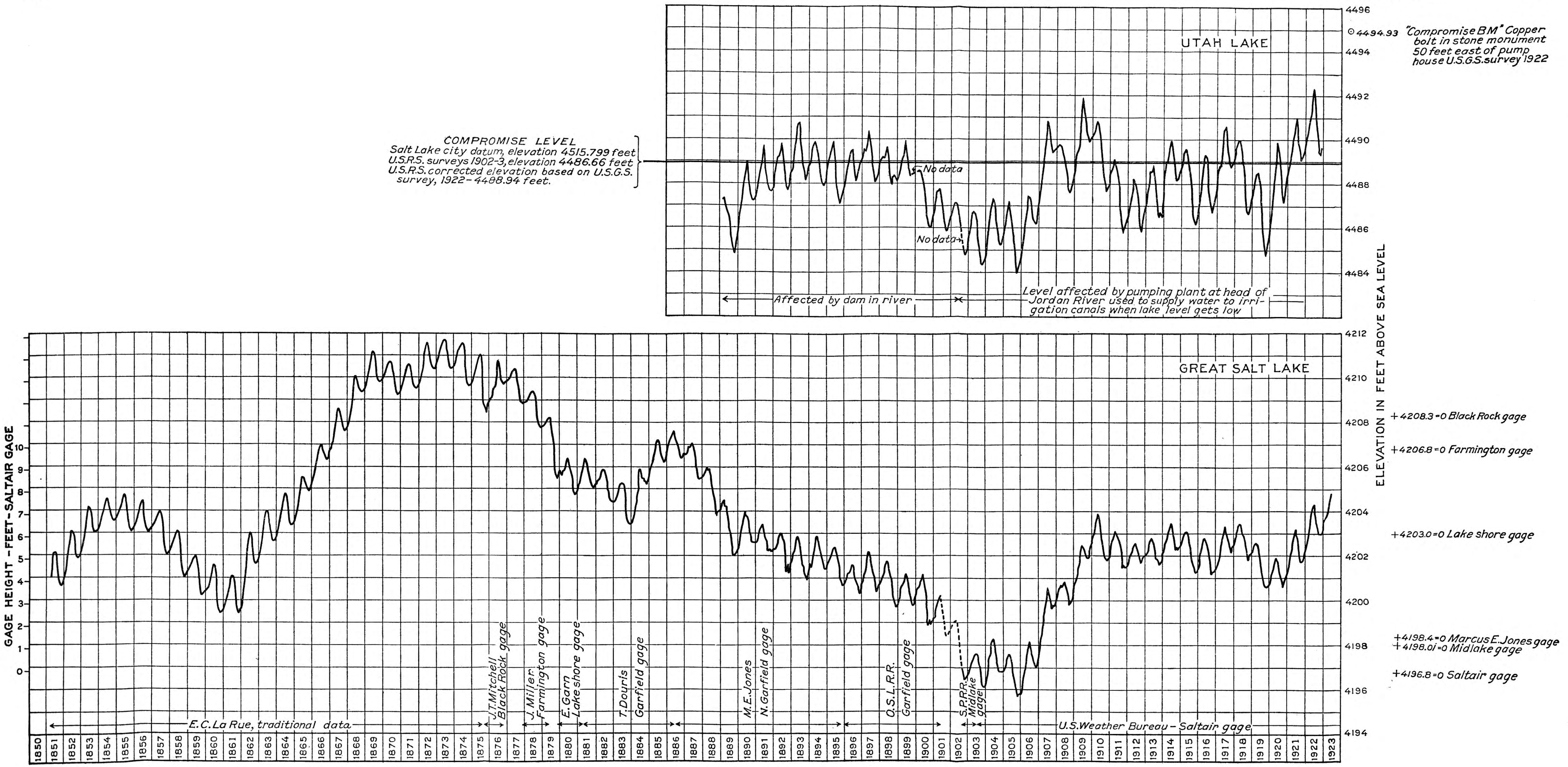
LAKE LEVELS.

Three comparatively large lakes lie in the Great Salt Lake basin. Bear Lake, at the north end of the basin, and Utah Lake, at the south end, are fresh-water lakes that drain into Bear and Jordan rivers respectively. In these lakes the fluctuations in surface level are modified from the natural conditions by dams and pumping plants designed to control the outflow for irrigation or power use.

Great Salt Lake, in the central part of the basin, has no outlet. Its waters are salty, the percentage of dissolved solids varying inversely with the changes in lake level. For example, an analysis made in 1877 gave 13.79 per cent of dissolved solids, and another one made in 1904, when the lake level was much lower, gave 27.72 per cent.[3]

The fluctuations in level of Great Salt Lake result from the balance of the two factors precipitation and evaporation. Both of these factors are variable, and the complexity of the problem of determining their relation to the different lake levels becomes very apparent when it is considered that the precipitation on the basin ranges from 90 to 119 per cent of the mean and the evaporation probably ranges from 45 to 55 inches annually. Furthermore, it is reasonable to expect that during periods of abnormally low precipitation the

[3] U. S. Geol. Survey Bull. 695, p. 153, 1920.



DIAGRAMS SHOWING FLUCTUATIONS OF UTAH LAKE, 1889–1922, AND GREAT SALT LAKE, 1851–1923.

evaporation may be above normal and accordingly the two factors combine to accelerate the rate of fall of the lake level; likewise the converse of these conditions may be expected to raise the lake level. It must be remembered, however, that the fluctuations in the lake levels will lag by several months, to the extent that they are affected by the precipitation factor, because of the time necessary for the run-off from the drainage basin to find its way into the lake. This condition adds materially to the difficulty of correlating the precipitation and evaporation factors, and with the meager data available on the many other conditions which are involved in these two factors, such as run-off, irrigation, wind, and temperature, it is quite impossible to make a complete analysis of the problem or even to discriminate between the consequences of natural and human influences.

One fact, however, stands out clearly when the lake levels are plotted as on Plate II and considered in connection with the precipitation data at all the rainfall stations throughout the basin. Such of these station records as are long enough to include the period of lowest lake levels from 1900 to 1906 show almost without exception an accumulated deficiency of annual precipitation below the mean until about 1906 and an accumulated excess above the mean from that year to date. The effect of this condition on the level of Great Salt Lake is no doubt indicated by the chart, with the very striking downward trend of the lake graph from 1900 to 1906 and the continuous rise from that time on.

The fluctuations in the level of Utah Lake are shown by the graph in Plate II. Though the tendency of the level to follow the variations in precipitation is obscured by the effects of the dam in the river and the pumping plant at the outlet of the lake, the characteristics of the graph for the years 1900 to 1906 are very similar to those of the Great Salt Lake graph.

GENERAL FEATURES.

BEAR RIVER BASIN.

The Bear River basin comprises about 6,000 square miles of mountain and valley lands in the northern part of Utah, the southeast corner of Idaho, and the southwest corner of Wyoming. Bear River rises in the northeastern part of Utah, flows northward into the southwest corner of Wyoming, turns west and reenters Utah, returns to Wyoming, flows northwestward to a point near Soda Springs, in the southeast corner of Idaho, turns abruptly to the southwest, and finally empties into Bear River Bay of Great Salt Lake. This circuitous course is more than 300 miles long, but the air-line distance from the source of the river to its mouth is only 75 miles.

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The headwaters of Bear River are in the high peaks and north slopes of the Uinta Mountains, about 60 miles east of Salt Lake City. The main stream is formed by the union of several small torrential streams which, after rushing through deep, rugged canyons, unite in small, narrow valleys at the foot of the peaks. Among these high peaks, at altitudes of 9,000 to 13,000 feet, are many small glacial lakes and basins that serve as excellent catchment areas for the precipitation, the greater part of which falls in the form of snow. This precipitation and the numerous small springs scattered over the basins forms the direct source of supply for the small headwater streams.

For the first 20 miles of its course the river flows down the north slopes of the Uinta Mountains, descending at the rate of about 100 feet to a mile. These slopes are covered with a heavy growth of timber and in summer are used as grazing lands for sheep. At the Wyoming boundary the river valley broadens to nearly 2 miles in width and is skirted on both sides by rolling hills that are used extensively for grazing and in some places for dry farming. The valley does not maintain a uniform width but narrows in places. A number of ditches divert water from the river for irrigating the bottom lands; but the ditches are small, except near Evanston, Wyo., where several large canals supply the town and adjacent hay ranches.

At 16 miles north of Evanston the river enters the Narrows, a rocky gorge 3 miles long, turns abruptly to the west, and enters Utah near the town of Woodruff. Immediately above the Narrows is a suitable site for a reservoir. Below it the valley broadens and continues open to and below Woodruff, where the open land is about 1½ miles in width.

For more than 25 miles below this point the valley ranges from 1½ to 5 miles in width, and the border lines are well defined by abrupt hill slopes on each side. The valley floor is nearly level, having a slope to the northeast of only 100 feet in 23 miles. The river meanders sluggishly along the east side of the valley. Several small tributaries enter it from the south and west, and their waters are diverted into an extensive system of canals for irrigating the lands west of the river.

About 14 miles northeast of Randolph, Utah, the stream reenters Wyoming. Here it turns gradually to the northwest, and at the Wyoming-Idaho boundary it makes an abrupt turn to the southwest and enters Idaho. Along this stretch of the stream the valley is from 1 mile to 3 miles wide and has rich bottom lands along the river and bench lands on each side. At intervals ditches divert water onto large tracts of ranch land on which hay and other forage crops are raised. Smith Fork, the principal tributary to Bear River in Wyoming, enters it from the east near Cokeville, Wyo. Its waters are used largely for irrigating bench lands adjacent to the town.

In Idaho the river crosses the south end of Thomas Fork valley and following a circuitous and tortuous course passes through a narrow canyon cut in the Preuss Range and enters the Bear Lake valley near Dingle. The south end of this valley is occupied by Bear Lake, which is 20 miles long and 7 miles wide and is surrounded on all sides except the north by steep hills from which many small streams flow into the lake. Prior to 1915 the outlet of the lake was a meandering channel that extended north through several miles of swamp lands and joined Bear River near the north end of the valley, where the rolling hills gradually close in and form a narrow canyon.

Before the present power developments on Bear River it did not flow directly into Bear Lake but skirted along the east edge of the valley, flooding the marsh lands north of the lake in times of high water. From these flooded lands the water backed into the lake and after the flood season it flowed back through the marsh and into the river several miles below. The lake thus had a modifying effect upon the regimen of the river, dividing it naturally into two portions, one above Bear Lake valley and the other below. Private enterprises have improved these natural conditions. An inlet canal was built from the river near Dingle, Idaho, to the lake, the natural causeway at the north end of the lake was improved, the outlet channel was dredged and straightened, and a pumping plant was installed at the outlet for maintaining a uniform flow during time of drought. The flow of lower Bear River is thus regulated as may be desired.

The bench land on each side of Bear Lake valley north of Bear Lake has an average altitude of 5,950 feet above sea level. It is well adapted for raising hay, grain, and potatoes if irrigated, and as much of it as can be served from the natural flow of the many small streams that enter the valley from both sides is being utilized.

Leaving Bear Lake valley at the north end the river flows northwestward in a well-defined channel through hilly and broken grazing lands and vast stretches of lava plain. Near Soda Springs, Idaho, it turns west, passes through a deep, narrow channel cut through the lava sheet, bends around the north end of the Bear River Range, and flows south into Gentile Valley.

Gentile Valley is a prosperous agricultural region. Most of the land is held in large tracts, and each owner lives on his farm and not in a village, as is customary in many agricultural districts. The houses are generally well kept and substantially built. On each side of the valley bottom rolling lands recede to the foothills. These rolling lands are used for raising wheat and forage plants and are irrigated wherever possible from ditches diverting water from the small mountain streams that enter the valley from both sides. Dry farming is practiced successfully in the foothills and on those lands that can not be reached by irrigation ditches.

The course of the river through the valley is tortuous, the fall is slight, and the flow of the stream is sluggish. As these conditions form obstacles to the diversion of water in canals the low lands along the river are devoted to meadows. At the south end of the valley the hills on the two sides converge and the river enters a narrow canyon about 4 miles in length, within which it falls rapidly. This canyon, known as the Oneida Narrows, has several possible dam sites at which hydroelectric power developments are proposed by the Utah Power & Light Co.

Upon leaving Oneida Narrows the river enters Cache Valley, the greater part of which lies in Utah, the north end extending into Idaho. This is one of the largest and finest valleys in the Bear River basin. It is about 30 miles long and 10 miles wide, and smooth fertile hills on both sides slope gently toward the river. The extensive agricultural development supports many small enterprising towns and has earned for it the significant name "the granary of Utah." Several good-sized streams enter the valley from the east and are diverted by a network of canals onto the uplands, most of which are less than 5,000 feet above sea level and yield abundant crops of fruits, grains, and vegetables. The bottom lands of the valley support a prolific growth of grasses and forage plants and are used for pasturing. Dairying is also a notable industry here.

Owing to the flatness of the valley floor the river flows sluggishly through many miles of winding channel to a point in the lower part of the valley where it turns abruptly to the northwest and rushes through a short, precipitous canyon, known as "The Gates." This canyon is about 2 miles long and connects Cache Valley with the Great Salt Lake valley. On emerging from "The Gates" the river turns southward and flows through the Salt Lake Plains in a more and more tortuous course until it finally enters Bear River Bay near the town of Corinne. No ditches are taken out of the river below "The Gates," but the lands along this portion of the stream are irrigated from two large canals that divert water at the head of the canyon. These canals, one on each side of the river, consist of tunnels, flumes, and rock sections. They are built along the sides of the canyon and extend for several miles beyond its mouth, to lands on each side of the river.

More than fifty tributaries enter Bear River, and most of them are short mountain streams that drain small areas composed principally of steep, rugged slopes. In general, the water supply is almost wholly dependent on the precipitation, and as a consequence the stream flow is flashy, being in flood stage during the spring and very little or nothing in the late summer and winter. As exceptions to this general rule, however, some of the streams, such as Swan, Soda, Whiskey, and Mink creeks, are almost entirely spring-fed.

Among the larger tributary streams that have relatively large drainage basins and receive their water supply both from springs and from precipitation are Smith Fork, near Cokeville, Wyo.; Thomas Fork, along the Idaho-Wyoming boundary to the north; Little Bear River, comprising Logan River and Blacksmith Fork, in Cache Valley, Utah; and Malad River, entering Bear River from the north near Corinne, Utah.

WEBER RIVER BASIN.

Principal features.—Weber River has its source in a number of small glacial lakes that lie among the lofty peaks on the northwest slopes of the Uinta Range 50 miles due east of Salt Lake City. In this vicinity, clustered about the base of Bald Mountain, which rises to an altitude of 11,970 feet above sea level, are many such lakes, in which the three largest rivers of the Great Salt Lake basin, the Bear, Weber, and Provo, have their source.

Weber River is 125 miles long. It traverses Summit and Morgan counties, forms the boundary for 7 miles between Davis and Weber counties, and empties into Great Salt Lake in Weber County, about 11 miles southwest of Ogden. Above the mouth of Weber Canyon, where the river emerges into the Great Salt Lake valley, the drainage basin comprises 1,600 square miles of rough mountainous country interspersed with small fertile valleys along the streams.

From its source Weber River flows in a steep, rugged canyon, at first northwestward and gradually swinging around to the southwest and entering the north end of Rhodes Valley, 2 miles northeast of Oakley. The fall is more than 600 feet to the mile in the upper part of the course and in this distance of 25 miles averages 160 feet to the mile, the total fall being 4,000 feet.

Rhodes Valley comprises about 20 square miles of bench and bottom land, most of which is suitable for agriculture and is irrigated from Weber River and its tributaries. The valley, which is about 7 miles long, extends north and south. It slopes to the northwest, from an altitude of 6,600 feet above sea level at the south end to 6,200 feet at the outlet.

Weber River traverses the north end of the valley and at the outlet makes a nearly right-angle turn to the northwest. At this bend Beaver Creek enters from the southeast, carrying the water from the southern part of the valley. A singular physical feature exists in connection with this little valley. Provo River crosses the south end of it, and without any difficulties in construction water could be diverted from the Weber River basin to the Provo River basin or from the Provo to the Weber.

From Peoa, a small settlement at the outlet of Rhodes Valley, down to Echo, a distance of 20 miles, the Weber River canyon trends slightly west of north and is sufficiently wide, except at a few places, to allow the cultivation and irrigation of a considerable area of land on each side of the river. Accordingly, there are many farm houses along this stretch of the stream, also several small villages, which are shown on the United States Geological Survey's map of the Coalville quadrangle.

At Echo the main transcontinental line of the Union Pacific Railroad enters Weber Canyon, having crossed the divide between the Weber River basin and the Bear River basin near the head of Echo Creek. It follows down Echo Canyon to its junction with the Weber River canyon and thence down Weber River to Ogden. The geologic features of these canyons and many interesting historical data concerning the settlements along the railroad are given in Bulletin 612 of the United States Geological Survey.

For a distance of 8 miles below Echo Weber River flows northwestward through a beautiful little valley about 2 miles wide, much of which is irrigated by ditches taken out of the river. Then the river swings around to the west and flows through a narrow rugged canyon, about 6 miles long, cut through the Bear River Range, into Round Valley, a relatively small circular basin that forms an arm of the largest and most important valley on the river in respect to the extent of the area irrigated and the value of agricultural products. The city of Morgan, having a population of about 1,000 inhabitants, is at the upper end of this valley, from which an arm of the valley extends south and includes the lower valley of East Canyon Creek. The outlet of the valley is at Devils Gate, nearly 12 miles from Morgan. Here the river flows almost due west, passing abruptly from the open valley into the narrow V-shaped gorge cut through the Wasatch Range; thence it emerges into the Great Salt Lake valley and finally empties into Great Salt Lake west of Ogden.

More than 40 tributaries flow into Weber River before it enters the Great Salt Lake valley, but most of them are small and have flashy discharges, usually carrying a flood flow in the spring or a season of heavy rainfall and little or no flow during the dry season. Accordingly, only the largest tributaries are here considered, and these are mentioned in downstream order of their confluence with Weber River.

Beaver Creek.—Beaver Creek joins Weber River 2 miles southwest of Oakley. It drains a rough mountainous area and is confined to a steep, narrow canyon until it reaches the Kamas Prairie or Rhodes Valley, where it is largely used for irrigation.

Silver Creek.—Silver Creek enters Weber River from the southwest 4 miles below Rockport. It rises near Park City, and the branch line of the Union Pacific Railroad that runs between Echo and Park City follows up its canyon. The flow is small, and the creek carries considerable slime owing to the fact that its waters are used in the Park City mining district for sluicing and mining.

Chalk Creek.—At Coalville Chalk Creek enters Weber River from the east. It has a well-sustained low-water flow from numerous small springs scattered over its basin, which covers approximately 250 square miles. Its general course is westerly through a steep, narrow canyon, which broadens into a small fertile valley that extends from a point 4 miles above Coalville down to the Weber River valley. Here a number of ditches on each side of the stream divert water for irrigation.

Echo Creek.—Half a mile above the town of Echo Weber River is joined by Echo Creek from the northeast. This stream flows through a very narrow canyon for the greater part of its course. Its waters are used to irrigate a few acres along the lower part of its canyon and in the Weber River canyon, but its discharge is small.

Lost Creek.—Lost Creek also enters Weber River from the northeast 4 miles below Henefer, but its discharge is somewhat greater than that of Echo Creek and is used to irrigate several hundred acres in a small valley just above its mouth.

East Canyon Creek.—The largest tributary of Weber River above Devils Gate is East Canyon Creek, which rises in the rugged mountainous plateaus southwest of Park City and enters the Weber 3 miles below Morgan. A reservoir having a capacity of 28,000 acre-feet has been built in its course by the Davis & Weber Counties Canal Co. in order to regulate the flow and insure a late summer supply for the irrigation of 49,200 acres under the canals owned by this company in the Great Salt Lake valley. All the natural low-water flow of the stream, however, is used for irrigating land in the valley along the lower portion of its course.

Ogden River.—Although Ogden River is tributary to Weber River it has its confluence in the lowlands of Great Salt Lake valley, 2 miles west of Ogden. Its drainage basin is separate from that of the Weber, and it has cut an independent canyon into the Great Salt Lake valley through the Wasatch Range. It is, therefore, generally considered an independent stream in all power or irrigation studies.

The drainage basin lies wholly within Weber County, Utah, and comprises about 400 square miles of mountainous territory, including parts of the Wasatch and Bear River ranges. The principal water supply comes from the west slopes of the Bear River Range.

Ogden River is formed by the junction of the North, South, and Middle forks at the head of Ogden Canyon or the outlet of Ogden

Valley, earlier known as Ogden Hole, 10 miles east of Ogden. It then flows westward for 6 miles through Ogden Canyon, a deep rugged gorge cut through the Wasatch Range, and enters the Great Salt Lake valley about 2 miles northeast of Ogden.

Ogden Valley is a well-defined mountain basin comprising several thousand acres of good agricultural land having an average altitude of 4,900 feet above sea level and sustaining a population of more than 1,500.

The North and Middle forks of Ogden River enter the main stream from the north and drain a relatively small barren area as compared with that drained by the South Fork, which is the main tributary. South Fork is formed by the junction of Right and Left forks, which rise on the slopes of Monte Cristo, in the Bear River Range, flow through steep V-shaped canyons, and unite at a point 9 miles slightly northeast of Huntsville. Downstream from this point the canyon assumes a V-shape, with rolling hills along the north side, and finally opens into Ogden Valley 4 miles east of Huntsville.

Much of the stream flow that enters Ogden Valley is diverted for irrigation, and the lower part of the valley near the outlet is a natural artesian basin, which has been developed to a considerable extent by the city of Ogden for a municipal water supply.

Ogden Canyon is a local scenic resort that offers an excellent opportunity to see the geologic structure of the Wasatch Mountains, and a detailed description of this and other interesting features is given in Bulletin 612 of the United States Geological Survey.

JORDAN RIVER AND UTAH LAKE BASINS.

UTAH LAKE.[4]

Principal features.—Utah Lake is a body of fresh water 22 miles long and 10 miles wide, situated about in the center of a drainage basin having an area of 3,600 square miles, nearly nine-tenths of which is rough mountainous country lying east and southeast of the lake.

All the southern part of the Great Salt Lake drainage basin is included in this area, and it embraces Utah County and parts of Wasatch, Summit, and Juab counties. More than 30 streams supply water to the lake. The territory to the west and southwest, however, consists of dry rolling hills and low mountains from which no perennial streams emerge. The area of the lake at "compromise level"[5] is 93,000 acres, and the maximum depth is 13 feet (fig. 2).

[4] U. S. Dept. Agr. Bull. 124; U. S. Recl. Service First, Second, and Third Ann. Repts.; U. S. Geol. Survey Eleventh and Twelfth Ann. Repts.

[5] An agreement made in 1885 between the canal owners on Jordan River and the owners of land along the shores of the lake provides that the water surface of the lake can be raised by means of a dam in Jordan River "not to exceed 3 feet 3½ inches above the point heretofore established and recognized as low-water mark." This point is known as "compromise point" and is 4,488.94 feet above sea level.

The drainage system tributary to and including Utah Lake valley is unique in its physical features, the characteristic one of which is the occurrence of a large lake in the valley at a place where the inflowing streams would naturally unite to form the trunk stream. In this position the lake has a modifying effect on the regimen of the drainage system, allowing the force of the heavy floods of the streams to become disseminated over a large area, with a gradual outflow through Jordan River.

All the larger tributaries flow into the lake from the Wasatch Mountains, east and southeast of the valley. Named in order beginning at the north end, Dry Creek enters the lake near Lehi, American Fork 2½ miles south of the town of American Fork, Battle Creek near Pleasant Grove, Provo River 2 miles west of Provo,

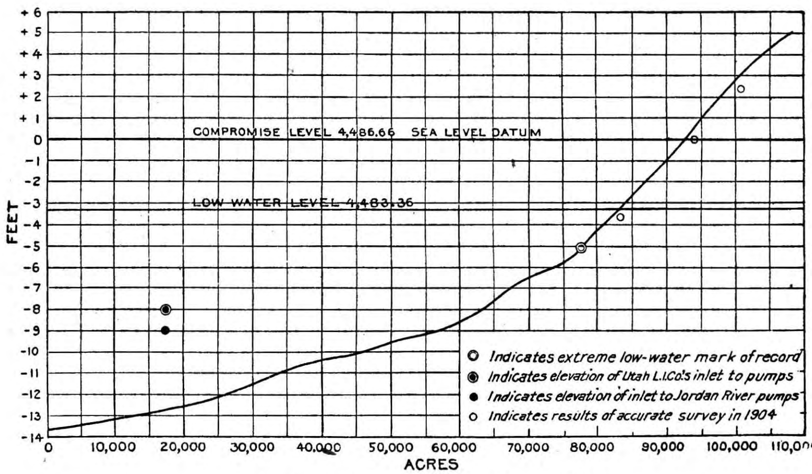

FIGURE 2.—Area of Utah Lake at different levels.

Hobble Creek near Springville, Spanish Fork northwest of Spanish Fork, Payson or Peteetneet Creek northwest of Payson, Santaquin Creek 11 miles north of Santaquin, and Currant Creek at the extreme south end of the lake, about 6 miles north of Goshen. Many smaller streams and numerous springs are also tributary to Utah Lake, but these have very little if any value for power and so are not considered in this report.

Dry Creek.—Dry Creek, a small spring-fed stream, rises on Lone Peak and flows in a general southwesterly direction. It drains a small part of the Wasatch Mountains lying just south of the boundary line between Salt Lake and Utah counties, immediately south of the Little Cottonwood Creek basin. Dry Creek is 12 miles long and flows for about 3 miles in a deeply cut canyon. It enters Utah Lake valley at Alpine, where the low-water flow is entirely diverted for canyon, which broadens at the mouth into a small valley devoted to ranching. The discharge from this creek is small except during the spring and early summer.

Lake Creek is fed by lakes and springs on the west slopes of the Uinta Mountains 12 miles east of Charleston. It flows westward through a steep, rugged canyon into Provo Valley, through the city of Heber, and empties into Provo River. It is about 15 miles long, and several small tributaries enter in the upper part. The flow is flashy and, like that of the other tributaries, is very low during the greater part of the year.

Center Creek is a small spring-fed stream that enters Provo River in Provo Valley 2½ miles from Charleston. It rises on the west slopes of the Uinta Mountains about 10 miles southeast of Charleston and flows through a broad, steep canyon in which all the waters of the stream are diverted for irrigation.

Round Valley, lying directly south of Provo Valley and separated from it by a low range of hills, is drained by Round Valley Creek, which joins Provo River 5 miles below Charleston. The stream rises in the Uinta Mountains, to the southeast. The main water supply comes from Hobble and Main creeks, both of which enter the valley at its south end. Several tributaries flow into the main stream, but they are all short, with relatively small discharge, and during the irrigation season their entire flow is diverted. A number of springs that rise in Round Valley are also used for irrigation in the summer.

Snake Creek is the largest tributary of Provo River in Provo Valley, and its flow is the most constant. It enters the valley from the west and joins the river 2 miles below Midway. It rises near the top of the mountain range that separates Provo Valley from the northern extremity of Utah Lake valley and flows southeastward. The water supply is derived chiefly from Mahogany Springs, on Pine Creek, a tributary, and the Snake Creek drainage tunnel, which was constructed to drain certain mines. The entire flow of the stream below the Snake Creek power plant is controlled by irrigation interests and is used in Provo Valley for irrigation.

A short distance below the outlet of Provo Valley Deer Creek enters Provo River from the north, flowing through a rather steep U-shaped canyon skirted on each side by earthen hill slopes. Its discharge is small and is derived principally from springs about 5 miles up its canyon.

North Fork joins Provo River 3½ miles below its confluence with Deer Creek. It rises on the east slope of Timpanogos Peak and is formed by the union of two branches that join in a small mountain basin about 2 miles from the junction with the river. The stream flows southeastward in a steep, rugged canyon that opens into Provo River canyon 5 miles above its mouth. The stream flow is fairly constant, as practically all the low flow is derived from springs. The creek has a fall of about 800 feet to the mile, and its length below the forks is slightly more than 2 miles.

The last tributary of Provo River before it reaches Utah Lake valley is South Fork, which enters the main canyon from the south at a point 4 miles above its mouth. It is 6 miles long and is formed by the union of several small spring-fed streams. Its flows through a broad U-shaped canyon which has relatively smooth slopes of earth and rock on each side. The State of Utah has built a fish hatchery on South Fork 1 mile above its confluence with Provo River and controls the use of the waters of the stream above that point.

Hobble Creek.—Hobble Creek is a small stream that rises in the Wasatch Mountains 18 or 20 miles east of Provo. It is about 25 miles long and flows for 15 miles or more through a rather shallow canyon, enters Utah Lake valley near Springville, and flows northwestward through the town into Utah Lake. The main stream is formed by two tributaries which join at a point 6 miles up the canyon, and each of these forks flows through a broad, flat canyon. The greater part of the flow of Hobble Creek is controlled by the municipal corporation of Springville, and the water is used for generating power in the canyon and irrigating several hundred acres on Mapleton Bench, 2 miles south of the city.

Spanish Fork and tributaries.—Spanish Fork is the second largest stream that empties into Utah Lake. It has three large tributaries, which unite to form the main stream near Thistle. The total length of the main stream is not more than 45 miles, and in this distance it falls nearly 3,000 feet. It flows northwestward, enters Utah Lake valley 2 miles south of Mapleton, and empties into the lake 6 miles southeast of Provo. The drainage basin comprises more than 600 square miles of mountainous country ranging in altitude from 4,800 to 10,500 feet above sea level. The greater part of it consists of smooth rolling hills. The main canyon is cut through the front range of the Wasatch Mountains and is followed by the main line of the Denver & Rio Grande Western Railroad between Denver and Salt Lake City. The low-water flow of the river is derived largely from springs scattered over the drainage basin and is all diverted at the mouth of the canyon to irrigate the lands around Spanish Fork, but the flood flow is the result of precipitation on the drainage basin. Owing to the barren slopes of the basin the run-off is very rapid, and one of the characteristic features of the stream is the torrential flood flow in spring, or after heavy local rains, and the great amount of silt carried during these freshets.

The three main tributaries of Spanish Fork, named in order from north to south, are Diamond Fork, Soldier Creek, and Thistle Creek. Diamond Fork, which drains the northern part of the Spanish Fork basin, is the largest of the three. It rises on the west slope of that part of the Wasatch Range which forms the divide between the Spanish Fork basin and the Strawberry River basin of the Duchesne River system. Several small tributaries enter Diamond Fork from each side in the 20-mile stretch between the headwaters and its confluence with Spanish Fork, at a point 2 miles above Castilla. The largest of these is Sixth Water Creek, 8 miles long, which receives the water from the Strawberry reservoir for the Strawberry Valley project of the United States Bureau of Reclamation.

The general course of Diamond Fork is southwest, and the total fall is approximately 5,000 feet; Sixth Water Creek falls 2,000 feet.

Soldier Creek rises on the north and west slopes of the divide between the Spanish Fork basin and the Price River basin of the Colorado River system. It flows through an irregular canyon bordered by smooth rolling hills for a distance of 24 miles and joins Thistle Creek at Thistle to form the main stream. It has a total fall of about 2,500 feet, and consequently several loops and heavy construction work were necessary in building the railroad up the canyon to Soldier Summit. The flow of Soldier Creek is normally small but is subject to torrential floods.

Thistle Creek is formed by several small streams that drain a large plateau area north of the divide between this stream and San Pete Valley. It flows northward, passes through a narrow canyon in the lower 6 miles of its course, and joins Soldier Creek at Thistle. The total length of the stream is about 20 miles, and it has a fall of 3,000 feet. The discharge is flashy, the stream being usually very low during the dry summer and in flood during the spring. A branch line of the Denver & Rio Grande Western Railroad from Thistle parallels the creek and passes over the divide to the towns in San Pete Valley, to the south.

Payson or Peteetneet Creek.—Payson Creek, often called Peteetneet Creek, is a small spring-fed stream that rises in the Wasatch Mountains 10 miles southeast of Payson. Its drainage basin consists largely of rolling hills having smooth slopes. From its source this stream flows for 10 miles through a comparatively shallow canyon, which opens into Utah Lake valley just south of Payson. The direction of flow is northerly, and during some periods of high water the stream reaches Utah Lake 6 miles northwest of the town, but all the low-water flow is diverted into irrigation canals at the mouth of the canyon. This stream is controlled by the city of Payson, and a number of small storage reservoirs have been constructed by the city on the headwaters of the creek. A municipal hydroelectric power plant was also constructed at the mouth of the canyon, but it was destroyed by fire.

Santaquin Creek.—Santaquin Creek, sometimes called Summit Creek, is also a small spring-fed stream, which rises in the Wasatch Mountains west of Payson Creek and about 8 miles southwest of Santaquin. It flows northward through an exceedingly rough, rocky canyon for 10 miles, enters Utah Lake valley immediately south of Santaquin, and empties into Utah Lake 10 miles farther north. Like the other small streams flowing into Utah Lake, Santaquin Creek has a flashy discharge. The town of Santaquin controls its entire flow.

Salt or Currant Creek.—The stream usually called Salt Creek in its upper part and Currant Creek below rises near the east slope of the Mount Nebo Range, south of Santaquin Creek. From its source it flows south 8 miles and thence west about the same distance, passing through a shallow canyon which opens into Juab Valley near Nephi. From Nephi it flows northward, and at the north end of Juab Valley the stream has cut a canyon through the Juab Range into Goshen Valley, through which it flows and empties into the extreme south end of Utah Lake, 5 miles north of Goshen. Hop and Rock Springs creeks, the principal tributaries of Salt Creek, unite about 6 miles east of Nephi to form the main stream. The entire low-water flow of the stream is diverted at the mouth of Salt Creek canyon for irrigation near Nephi, but through Juab Valley the flow is materially increased from springs and by seepage from the irrigated lands. At the outlet of Juab Valley a dam [6] has been built which makes a reservoir of the lower part of the valley, and water is stored here for supplying a late summer flow in Goshen Valley. In Goshen Valley, where the stream is known as Currant Creek, it has been used for irrigating land near Goshen since 1858.

JORDAN RIVER.

Principal features.—Jordan River heads at the north end of Utah Lake, flows northward through Jordan Narrows into the Great Salt Lake valley, and empties into Great Salt Lake 10 miles northwest of Salt Lake City. From the Narrows to its mouth, a distance of 35 miles, the river has a fall of 250 feet, much of which occurs in the first few miles, and in this stretch several large irrigation canals are taken out on each side of the stream. Only a comparatively narrow strip of land can be reached by these canals, because the bench lands rise abruptly back of the bottom lands that border the stream. At the Narrows Utah Lake valley and Great Salt Lake valley are separated by low spurs of rolling hills that extend westward from the Wasatch Range and eastward from the Oquirrh Range.

[6] Hardesty, W. P., The Mount Nebo reservoir and canal system, Utah: Eng. News, vol. 36, No. 23, p. 354, 1896.

All the tributaries of Jordan River are in the Great Salt Lake valley, and the largest ones enter the valley from the Wasatch Mountains, on the east. Only one stream, Bingham Creek, reaches the river from the Oquirrh Range, on the west. This stream flows through the famous copper-mining camp in Bingham Canyon, and the water is used in the camp for mining, milling, and other purposes and when it reaches the Jordan River valley is so polluted and impregnated with mineral matter that it is not fit for irrigation or domestic uses. Accordingly, all the land on the west side of Jordan River that is reclaimed must depend on the river itself for a water supply.

The chief tributaries from the east, named in downstream order, are Little Cottonwood Creek, Cottonwood Creek, Mill Creek, Parleys Creek, and City Creek. These streams enter the river below most of the irrigation canal headings, but they are used extensively for irrigating the bench lands that lie along the foot of the Wasatch Range below their canyons.

Little Cottonwood Creek.—Little Cottonwood Creek is a swift mountain stream that flows for 10 miles through one of the most rugged and deepest canyons in the front range of the Wasatch Mountains. The entire drainage area consists of about 28 square miles of crags and peaks with short deep ravines leading into the main canyon. From its headwaters, above Alta, to the mouth of its canyon the creek has a total fall of 5,000 feet, and more than 3,000 feet of it occurs in the first 8 miles. The stream flow is flashy, being at flood stage during the spring, when the snows melt rapidly, and low in the dry seasons of the year, when the principal source of supply consists of small springs scattered over the basin. Little Cottonwood Creek flows westward until it reaches the valley, where it turns and flowing northwestward empties into Jordan River just west of Murray.

Cottonwood Creek.—Cottonwood Creek is the largest tributary of Jordan River. It rises in several small lakes among the highest plateaus and peaks of the Wasatch Range, 20 miles southeast of Salt Lake City, flows westward through a deep rugged canyon similar to that of Little Cottonwood Creek, and empties into Jordan River about 2 miles northeast of Murray. Its drainage basin comprises nearly 50 square miles of very rough, mountainous country broken by deep canyons, through several of which tributaries enter the main canyon. Cottonwood Canyon has a steep grade; in the lower part it is cut through the front of the Wasatch Range and has almost sheer rock walls rising several hundred feet above the stream bed. Brighton, a popular summer resort, lies among the lakes at the headwaters of Cottonwood Creek, and from this point to the mouth of the canyon, a distance of 16 miles, the stream has a fall of nearly 5,000 feet, more than 3,500 feet of which occurs in the first 14 miles of its course. At Mill D, about 14 miles downstream from Brighton, the canyon broadens and forms a small basin, known as Reynolds Flat. Salt Lake City has made a survey of this flat to determine its value as a reservoir site in connection with the city's water supply.

Mill Creek.—Mill Creek drains a rather long, narrow mountainous area comprising about 21 square miles immediately north of Cottonwood Creek. The topography of the Mill Creek basin is not so rough and rugged as that of the basins to the south, as the mountains that extend northward change from barren crags and peaks to smooth rolling slopes directly east of Salt Lake City. Mill Creek, however, is a swift mountain stream that flows through a narrow canyon about 12 miles long before it reaches the Great Salt Lake valley. Its course is westward, and it empties into Jordan River 3 miles south of Salt Lake City. The main stream receives a large part of its flow near its head, as it has only a few small, short tributaries.

Parleys Creek.—Parleys Creek flows through the front range of the Wasatch Mountains in a rather flat canyon, which is rugged and deep near its mouth but broadens between low rolling hills about 6 miles upstream. The main stream is supplied from many small tributaries, which drain an area composed of brush-covered hills and rugged barren slopes. At the confluence of Parleys and Mountain Dell creeks, where the canyon broadens to form a basin, Salt Lake City has built a concrete multiple-arch dam, forming a reservoir for the city's water system. The Park City branch of the Denver & Rio Grande Western Railroad follows up Parleys Canyon to a point about half a mile below this dam and then climbs up the south side of the canyon, passing above the reservoir.

Emigration Creek, a tributary of Parleys Creek, drains an area of smooth rolling hills lying due east of Salt Lake City. Its flow is very small—less than 10 second-feet—except during the flood season each year, and the water is used principally for municipal purposes in Salt Lake City.

City Creek.—City Creek rises in the Wasatch Range northeast of Salt Lake City. It flows southwestward through a deep canyon in the upper part of its course and a long, rather shallow canyon through the rolling foothills adjacent to the city in the lower part, and finally empties into Jordan River in the northwestern part of the city, at a point where the flow is too large to be properly handled in the city's water system. The entire flow of the creek is owned by the city and is used for municipal purposes.

Red Butte Creek is a small spring-fed tributary of City Creek directly north of Emigration Creek and northwest of Fort Douglas. It is controlled by the United States War Department and is used as a source of water supply for Fort Douglas.

WILLARD, FARMINGTON, AND BOX ELDER CREEKS AND STREAMS IN TOOELE AND RUSH VALLEYS.

Many small independent streams enter the Great Salt Lake valley from canyons along the west face of the Wasatch Range. All of them are used for irrigating bench lands adjacent to the mouths of the canyons, but with the exception of Box Elder, Willard, and Farmington creeks none of them have any value for power, and in the summer and winter the stream flow is almost negligible.

Box Elder Creek is a small stream that receives the greater part of its flow from numerous springs in Mantua Valley, just back of the front range of the Wasatch Mountains, east of Brigham, in Box Elder County. This valley has an area of about 10 square miles, much of which is good agricultural land, and supports a thriving farming community. It serves as an excellent catchment basin for the precipitation on the surrounding hill slopes, and the run-off from this source and that from the large springs rising along the edge of the valley join near Mantua to form Box Elder Creek, which flows northwestward through the Wasatch Range into the Great Salt Lake valley. The water that is not there diverted for irrigation finds its way into Box Elder Lake, 2 miles northwest of Brigham. South Fork, the principal tributary of Box Elder Creek, drains a rough mountainous area lying just south of Mantua Valley. It flows northward through a long canyon and joins the main stream a short distance below the head of Brigham Canyon.

Willard Creek is a small but very swift mountain stream that has its source on the steep barren slopes of the front range of the Wasatch Mountains, east of Willard and 6 miles south of Brigham Canyon. The front of the Wasatch Range south of Brigham changes, a short distance north of Willard, from a fairly smooth grassy slope to bare crags, through which Willard Creek has cut a sharp, precipitous canyon. The main stream is formed by the junction of two small tributaries at a point 1½ miles up the canyon. One fork, from the south, drains the highest peaks of this section of the range, and the other, from the northeast, rises near the South Fork of Box Elder Creek and the North Fork of Ogden River. From a small basin at the junction of these forks the stream rushes through the canyon into the Great Salt Lake valley, having a fall of more than 1,600 feet in a distance of 1½ miles. The entire flow of the creek, after passing through a power plant, is used for irrigation and domestic purposes in and around Willard.

Farmington Creek rises in the Wasatch Range a few miles east of Farmington, in Davis County. It flows westward through a sharp, rugged canyon cutting the front of the range, enters the Great Salt Lake valley 1 mile above Farmington, and flows southwestward for 3½ miles to Great Salt Lake. It is a perennial stream receiving its water supply from small springs, as well as from the natural precipitation on its drainage basin. After the high-water season during the spring the flow becomes small and, like that of all other small streams entering the Great Salt Lake valley, is all diverted into irrigation ditches after leaving the canyon.

Tooele Valley occupies the north end of the structural trough between the Oquirrh and Onaqui ranges. It extends from the south shore of Great Salt Lake to the town of Stockton, where a low divide separates it from Rush Valley, which occupies the south end of the trough. The Oquirrh Range trends in a north-south direction, between Tooele and Rush valleys on the west, and the south end of Great Salt Lake valley and the north end of Utah Lake valley on the east. The Onaqui Range, also known as the Stansbury Range, parallels the Oquirrh Range on the west side of Tooele and Rush valleys, joins the Tintic Mountains on the south, and culminates in Booneville Peak, nearly 11,000 feet above sea level.

The central part of Tooele Valley is comparatively flat and slopes gently northward to Great Salt Lake. Near the lake the land is marshy. The sides of the valley beyond the flat, however, are rolling alluvial slopes.

The physical features of Rush Valley resemble those of Tooele Valley except at the north end, where the flood waters from the small streams that flow into the valley collect in Rush Lake, a small shallow body of water which seldom, if ever, exceeds 3 square miles in area.

A number of streams enter these two valleys from the mountains on the east and the west, but they are all small, and the flow is intermittent, the channels usually being dry in the summer. At several places enough water can be obtained to irrigate a few hundred acres, and the settlements of Tooele, Grantsville, Stockton, St. John, Clover, and Vernon owe their existence to this possibility.

North Willow and South Willow creeks, the largest streams in Tooele Valley, rise in the Onaqui Mountains 10 miles southwest of Grantsville. They flow through short, steep canyons into the valley and are there used for irrigation and domestic supplies in and near Grantsville.

There is a hydroelectric power plant on South Willow Creek having its point of diversion just below some tributary springs in the canyon. This plant has done much to conserve the flow of the creek by preventing the excessive seepage losses that were sustained when the water flowed down the natural channel. Before the power plant was built only a small part of the flow of the creek in the canyon reached the irrigation canals in the valley, but now the water is carried in a pipe line to the power house and thence in a concrete conduit for 4 miles down the valley slope, to the point where it joins the flow from North Willow Creek and is diverted into the canal system.

At the opposite side of the valley Pine, Dry, and Settlement creeks issue from the Oquirrh Range and furnish domestic, irrigation, and smelting water for the smelters, the town of Tooele, and the outlying agricultural lands.

Soldier and Ophir creeks enter Rush Valley from the Oquirrh Mountains on the east. The water of Soldier Creek is used for domestic and irrigation supplies at Stockton, and that of Ophir Creek, which has a flow of about 3 second-feet, is used on the Johnson ranch, at the mouth of its canyon. On the west side of the valley Clover Creek supplies water to a few hundred acres in the Clover and St. John settlements. Issuing from the Tintic Mountains on the south and flowing northward into the valley, Vernon Creek supplies water to several hundred acres near Vernon. All these streams emerge from short, steep canyons, and have comparatively small drainage basins. The low-water flow is supplied by springs and at the most is not more than a few second-feet.

STREAM FLOW.

VALUE OF STREAM-FLOW RECORDS.

In all problems concerning the utilization of water, such as irrigation projects, hydroelectric power developments, municipal water supply, manufacturing or mining and milling enterprises, the primary factor that limits the extension of the project is the available water supply, and usually this is equivalent to all or a part of the local stream flow. The value of accurate stream-flow data is therefore inestimable, and an abundance of such data on all sources of water supply under consideration is always to be desired. The need for records of stream flow becomes much more intensified with increase in the number of users along the stream, owing to the growing necessity of properly apportioning the flow to the several claimants. Especially is this true when the appropriations nearly or quite equal the total run-off of the stream.

Although a great mass of stream-flow data has been collected in all parts of the United States, the data cover only a small percentage of the streams for which records would be valuable. This condition is general but is perhaps more marked throughout the arid region—not, however, because of a lack of realization of the necessity and value of such information but from lack of funds to carry on the work.

If no records are available it often becomes necessary for the engineer, in making a study of the possible developments on a stream, to estimate the flow of the stream from records of precipitation or by comparison with existing records of streams whose drainage basins are similar. As these methods are subject to many uncertainties the results are at best only approximate and should be used with caution. It should also be borne in mind that the records for each succeeding year may shed new light on data already available, and for this reason the engineer who uses the records here given should verify all ratings and carefully consider any adjustments that may seem necessary in the earlier records.

GAGING STATIONS.

A list of gaging stations that have been maintained in the Great Salt Lake basin by the United States Geological Survey and cooperating organizations or persons is given below. Records have been kept on most of the principal streams of the basin and on many of the smaller ones where power plants have been built, but for making a study of the undeveloped power sites, especially on the smaller streams, no data on stream flow are available. In the list the stations are arranged in downstream order. All stations from the source to the mouth of the main stem of the river are presented first, and those on the tributaries in order from source to mouth follow, the stations in each tributary basin being listed before those of the next basin below. The relation of the tributaries to the main stream is shown by indention. A dash after the last date in a line indicates that the station is still being maintained. The positions of the gaging stations are indicated on Plate III.

Bear River near Evanston, Wyo., Oct. 26, 1913–
Bear River at Harer, Idaho, June 21, 1913, to Sept. 30, 1916; May 31, 1919–
Bear River at Dingle, Idaho, May 9, 1903, to Dec. 31, 1914.
Bear River at Soda Springs, Idaho, May, 1896, to July, 1898.
Bear River at Alexander, Idaho, Mar. 27, 1911, to Sept. 30, 1916; Apr. 17, 1919–
Bear River near Preston, Idaho, Oct. 11, 1889, to Jan. 15, 1917.
Bear River near Collinston, Utah, July 1, 1889–
- Bear (Mud) Lake inlet canal near Dingle, Idaho, June 21, 1911, to Sept. 30, 1913.
- Bear Lake at Fish Haven, Idaho, Oct. 5, 1903, to June 30, 1906.
- Georgetown Creek near Georgetown, Idaho, Oct. 23, 1911, to Sept. 30, 1914.
- Soda Creek near Soda Springs, Idaho, Mar. 5, 1913–
- Cub Creek near Franklin, Idaho, July 23, 1900, to Jan. 21, 1901.
- Logan River above State dam, near Logan, Utah, May 7, 1913–
- Logan River near Logan, Utah, June 1, 1896, to July 17, 1903; Apr. 14 to Dec. 31, 1912.
- Logan River below State dam, near Logan, Utah, Apr. 29, 1913, to Oct. 31, 1914.
- Logan River below Logan Northern canal, near Logan, Utah, July 26, 1915, to June 13, 1917.
    - Utah Power & Light Co.'s tailrace near Logan, Utah, May 7, 1913–
    - Logan, Hyde Park & Smithfield canal near Logan, Utah, 1904–1912 (fragmentary); Apr. 22, 1912–
    - Logan Northern canal near Logan, Utah, June 6, 1913, to Sept. 30, 1914; May 13, 1915, to Oct. 2, 1916.

Bear River—Continued.

Blacksmith Fork above Utah Power & Light Co.'s dam near Hyrum, Utah, July 19, 1900, to Dec. 31, 1902; Nov. 28, 1913–

Blacksmith Fork at Utah Power & Light Co.'s plant near Hyrum, Utah, Apr. 15, 1914–

Blacksmith Fork below Utah Power & Light Co.'s plant near Hyrum, Utah, May 16, 1904, to Dec. 31, 1910; Apr. 15, 1914 to Dec. 13, 1916.

Hyrum City power canal near Hyrum, Utah, 1904–1910; Apr. 15, 1914–

West Side canal near Collinston, Utah, June 1, 1912–

Hammond (East Side) canal near Collinston, Utah, June 1, 1912–

Little Malad River near Malad, Idaho, Aug. 2, 1911, to Aug. 16, 1913.

Box Elder Creek at Brigham, Utah, May 20, 1909, to Dec. 31, 1912; Aug. 5, 1918–

Brigham City power-plant tailrace at Brigham, Utah, Aug. 5, 1918–

Weber River near Oakley, Utah, Oct. 22, 1904–

Weber River at Devils Slide (Croyden), Utah, Feb. 1, 1905–

Weber River near Uinta, Utah, October, 1889, to July 11, 1903.

Weber River near Plain City, Utah, May 14, 1905–

Chalk Creek at Coalville, Utah, October, 1904, to Dec. 31, 1905.

Lost Creek near Croyden, Utah, Feb. 3, 1905, to Dec. 31, 1905.

Ogden River at Upper end of Canyon near Ogden, Utah, June 14, 1895, to Dec. 31, 1896.

Ogden River at Utah Power & Light Co.'s dam near Ogden, Utah, January, 1904, to Oct. 29, 1912.

Ogden River at power mill near Ogden, Utah, 1889–1890; 1897 to Aug. 26, 1899.

Mill Creek near Bountiful, Utah, Dec. 4, 1913, to Sept. 30, 1914.

Jordan River near Lehi, Utah, May 30 to Dec. 31, 1904; July 22, 1913–

City Creek near Salt Lake City, Utah, 1898, to Sept. 30, 1913.[7]

Emigration Creek near Salt Lake City, Utah, 1898, to Sept. 30, 1913.[7]

Parleys Creek near Salt Lake City, Utah, 1898, to Sept. 30, 1913.[7]

Mill Creek near Salt Lake City, Utah, 1898, to Sept. 30, 1913.[7]

Cottonwood Creek near Salt Lake City, Utah, 1898, to Sept. 30, 1913.[7]

Little Cottonwood Creek near Salt Lake City, Utah, 1898, to Sept. 30, 1913.[7]

Great Salt Lake at Saltair, Utah, 1904; 1912–

Great Salt Lake at Midlake, Utah, 1912–

Great Salt Lake at Garfield Beach, Utah, 1875–1899.

Utah Lake near Spanish Fork, Utah, 1889–1896.

Utah Lake at Geneva, near outlet, Utah, 1896–1900.

American Fork above South Fork, near American Fork, Utah, Feb. 15, 1912, to Sept. 30, 1915.

American Fork near American Fork, Utah, May 21, 1900, to June 15, 1901; Apr. 6, 1903, to Dec. 31, 1915.

South Fork of American Fork near American Fork, Utah, Feb. 15, 1912, to Sept. 30, 1915.

Provo River at Forks, Utah, Nov. 17, 1911–

Provo River above Utah Power & Light Co.'s dam near Provo, Utah, Feb. 1, 1905, to Dec. 31, 1911.

Provo River at mouth of canyon, near Provo, Utah, July 27, 1889–1906.

Provo River at Denver & Rio Grande Railroad bridge, near Provo, Utah, 1905.

Provo River at San Pedro, Los Angeles & Salt Lake Railroad bridge near Provo, Utah, May 24, 1903, to Dec. 31, 1904.

South Fork of Provo River at Forks, Utah, Nov. 17, 1911–

Hobble Creek near Springville, Utah, Mar. 23, 1904, to Dec. 31, 1916.

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[7] Records subsequent to Sept. 30, 1913, published in Salt Lake City engineer's reports.

Maple Creek near Springville, Utah, Nov. 10, 1910, to Sept. 30, 1912.
Spanish Fork at Thistle, Utah, Dec. 3, 1907–
Spanish Fork near Spanish Fork, Utah, May 23, 1900, to Nov. 30, 1901; Mar. 26, 1903, to Sept. 30, 1917.
Spanish Fork at Lake Shore, Utah, Dec. 10, 1903, to July 10, 1907; Mar. 10, 1909–
Diamond Fork near Thistle, Utah, Dec. 2, 1907, to Sept. 30, 1917.
United States Reclamation Service power canal near Spanish Fork, Utah, Jan. 1, 1909, to Sept. 30, 1917.
Peteetneet Creek near Payson, Utah, Aug. 1, 1910, to Sept. 30, 1917.
Summit Creek near Santaquin, Utah, Mar. 8, 1910, to Sept. 30, 1916.

The monthly maximum, minimum, and mean discharge in second-feet and the run-off in acre-feet of the streams in the Great Salt Lake basin at the gaging stations listed above are tabulated in the appendix (pp. 173–265).

PUBLICATIONS.

The results of stream-flow measurements made in the Great Salt Lake basin by the United States Geological Survey and cooperating organizations or persons have been published in the reports tabulated below. Many independent data have been collected and appear in the annual reports of the State engineer and the city engineer of Salt Lake City.

Stream-flow data in reports of the United States Geological Survey.

[A=Annual report; B=Bulletin; W=Water-Supply Paper.]

Year.	Report.	Character of data.
1884 to Sept., 1890	11th A, pt. 2	Monthly discharge and descriptive information.
1884 to June 30, 1891	12th A, pt. 2	Do.
1884 to Dec. 31, 1892	13th A, pt. 3	Mean discharge in second-feet.
1888 to Dec. 31, 1893	14th A, pt. 2	Monthly discharge (long-time records, 1871 to 1893).
1893 to 1894	B 131	Descriptions, measurements, gage heights, and ratings.
1895	B 140	Descriptions, measurements, gage heights, and ratings, and monthly discharge; also many data for earlier years.
1896	W 11	Gage heights; also gage heights for earlier years.
1895 and 1896	18th A, pt. 4	Descriptions, measurements, ratings, and monthly discharge.
1897	W 16	Gage heights.
	19th A, pt. 4	Descriptions, measurements, ratings, and monthly discharge; also some long-time records.
1898	W 28	Measurements, ratings, and gage heights.
	20th A, pt. 4	Monthly discharge; also for many earlier years.
1899	W 38	Descriptions, measurements, gage heights, and ratings.
	21st A, pt. 4	Monthly discharge.
1900	W 51	Descriptions, measurements, gage heights, and ratings.
	22d A, pt. 4	Monthly discharge.
1901	W 66	Descriptions, measurements, gage heights, and ratings.
	W 75	Monthly discharge.
1902	W 85	Complete data.
1903	W 100	Do.
1904	W 133	Do.
1905	W 176	Do.
1906	W 212	Do.
1907–8	W 250	Do.
1909	W 270	Do.
1910	W 290	Do.
1911	W 310	Do.
1912	W 330	Do.
1913	W 360	Do
1914	W 390	Do.
1915	W 410	Do.
1916	W 440	Do.
1917	W 460	Do.
1918	W 480	Do.

RESERVOIRS AND RESERVOIR SITES.

BEAR RIVER BASIN.

Several engineers have made a careful study of the reservoir sites of upper Bear River in connection with both hydroelectric power and irrigation developments. The results of these investigations indicate that three reservoir sites above Bear Lake may be worth developing. One, known as the Narrows reservoir site, is on the main stream about 15 miles below Evanston; and the other two, known as the Yellow Creek and Coyote Creek reservoir sites, are in the Yellow Creek basin, 10 miles southwest of Evanston.

In addition to these proposed reservoirs, the Neponset Land & Live Stock Co. has built a small reservoir (10HB 1[8]) in Tps. 7 and 8 N., R. 7 E., Salt Lake base and meridian, about 9 miles south of Woodruff, and is using it to furnish water for irrigating about 6,100 acres southeast of Woodruff. Several miles farther downstream, on Twin Creek near the mouth, in T. 21 N., R. 120 W. sixth principal meridian, is a small reservoir site (10HB 4) owned by Beckwith, Quinn & Co., who propose to use it for irrigation. These reservoir sites are small and have no material effect on the regimen of Bear River, as they are situated on minor tributaries.

WOODRUFF NARROWS SITE.

The Woodruff Narrows reservoir site (10HB 3) is the largest and by far the best reservoir site above Bear Lake. The dam site is in sec. 32, T. 19 N., R. 120 W. sixth principal meridian, at the Narrows, about 18 miles north of Evanston, Wyo. The Narrows is formed by a contraction of Bear River valley from an open valley 1 mile in width to a narrow canyon whose entrance is only 200 feet wide at the bottom and about 850 feet wide at 100 feet above the river.

About a quarter of a mile west of this dam site is a low earth ridge separating two small valleys, one of which lies in Wyoming and the other in Utah. The lowest point on this ridge is about 80 feet above the river. Consequently, a dam at the Narrows more than 80 feet in height would necessitate a dike at this point in the ridge. At a height of 100 feet above the river the distance between the hill slopes at the sides of this lowest point is 1,700 feet.

At the entrance of the Narrows the hills on both sides approach close to the river banks, and some engineering work has been done to determine the depth to bedrock.

The land that would be inundated by building an 80-foot dam at this site is a flat valley floor of approximately 3,600 acres. It

[8] Index numbers refer to corresponding numbers on the map.

averages 1 mile in width and lies between steep hills. The greater part of it is irrigated and is devoted to growing hay. The capacity of the reservoir with a dam 80 feet high would be nearly 147,000 acre-feet. (See fig. 3.)

Area and volume for Woodruff Narrows reservoir.

Depth of water at dam site.	Area.	Capacity.
Feet.	*Acres.*	*Acre-feet.*
5	250	1,000
20	800	8,000
35	1,490	28,195
50	2,320	56,770
65	3,015	96,775
80	3,630	146,605
100	4,995	232,845

YELLOW CREEK AND COYOTE CREEK SITES.

The sites on Yellow Creek and its tributary Coyote Creek (10HB 1 and 2) are in the southwest corner of Wyoming. The Wyuta Development Co. at one time contemplated the development of these sites. The project was primarily one of storage to utilize the flood waters of upper Bear River in reclaiming about 54,000 acres in Yellow Creek valley and the upper Woodruff Flats, with the development of hydroelectric power as a secondary consideration.

At a point in Utah about 1 mile south of the Utah-Wyoming boundary the water may be diverted by a low crib diversion dam into a canal leading along the hill slope west of the river, across a low divide, and into the Yellow Creek drainage basin; thence it passes down the natural channel of Yellow Creek

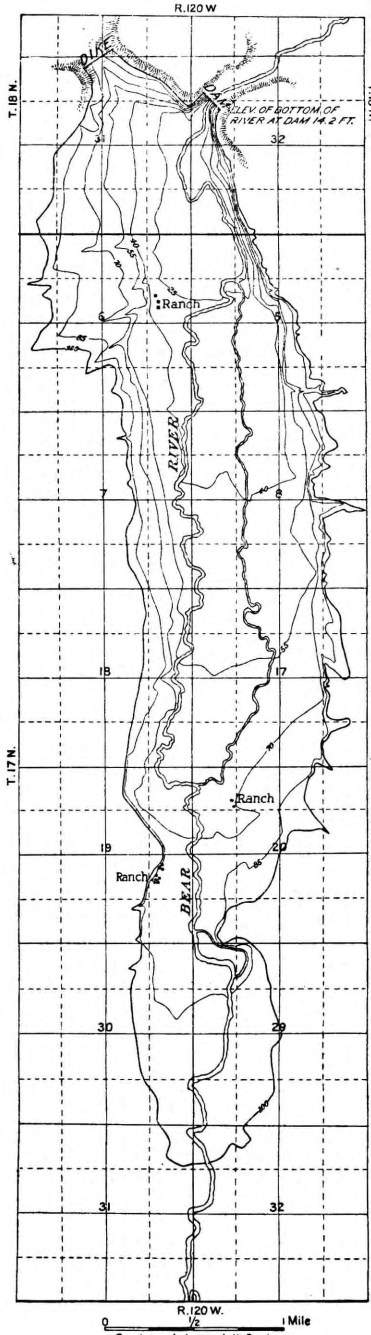


FIGURE 3.—Plan of Woodruff Narrows reservoir site.

into the proposed Yellow Creek reservoir, and thence into the proposed Coyote Creek reservoir through a canal connecting the two.

The dam site for the Yellow Creek reservoir (10HB 1) is at a narrows on that creek near its intersection with the western boundary of Wyoming, in T. 13 N., R. 121 W. sixth principal meridian. A dam 130 feet high at this place would have a crest length of 1,300 feet, and the reservoir would have a surface area of approximately 1,200 acres and a capacity of 44,700 acre-feet.

The dam site for the Coyote Creek reservoir (10HB 2) is at the "Needles," about half a mile above the mouth of the creek. A dam 120 feet high at this site would have a crest length of 660 feet, and the reservoir would have a surface area of 1,985 acres and a capacity of 39,200 acre-feet.

Area and volume for Yellow Creek and Coyote Creek reservoirs.

Yellow Creek.			Coyote Creek.		
Depth of water at dam site.	Area.	Capacity.	Depth of water at dam site.	Area.	Capacity.
Feet.	*Acres.*	*Acre-feet.*	*Feet.*	*Acres.*	*Acre-feet.*
10	180	1,370	10	15	90
20	265	3,595	20	45	390
30	375	6,975	30	107	1,150
40	500	11,170	40	222	2,795
50	640	16,870	50	331	5,560
60	780	23,970	60	460	9,515
70	995	32,845	70	586	14,745
80	1,180	44,720	80	732	21,333
			90	886	29,425
			100	1,085	39,280

BEAR LAKE RESERVOIR.

Most of the storage sites in the lower part of Bear River basin have been utilized in connection with hydroelectric power and irrigation developments. The largest and best reservoir is Bear Lake (10HB 3), and by means of the present development of this lake the entire flow of Bear River below it is regulated as desired. This lake lies half in Rich County, Utah, and half in Bear Lake County, Idaho. It covers about 21 by 8 miles, besides a large swamp or shallow lake at its north end called Mud Lake. The immediate drainage area tributary to Bear Lake is about 250 square miles, but by means of a canal from Bear River about 3,000 square miles more is made tributary to it.

As early as 1889 [9] a reconnaissance of Bear Lake was made, and later about 6,000 acres of land adjacent to it was recommended [10] for a reservoir site and for reservation from sale or settlement. Since

[9] U. S. Recl. Service Third Ann. Rept., p. 110, 1904.
[10] U. S. Geol. Survey Thirteenth Ann. Rept., pt. 3, p. 451, 1893.

that time private interests and the United States Reclamation Service[11] have made many detailed surveys of the lake to determine its real value as a storage reservoir. In 1901 the Telluride Power Co. initiated a plan to use the lake as a reservoir and constructed a canal to divert the flood waters from Bear River to the lake for use both in developing power and in irrigation. The inlet canal built by the power company was about 4½ miles long and had a drop of about 60 feet. It was designed to carry 2,000 second-feet but was found to be unsafe for more than 1,000 second-feet on account of its steep grade.

At about the same time the Utah Sugar Co. undertook to build another canal from Mud Lake to Bear River, contemplating the utilization of the water in its irrigation system and power plant in the northern part of Utah.

The outlet of Bear Lake passes north through Mud Lake and through 14 miles of bottom land to Bear River. Although considerable work was done in 1902 to construct the inlet canals the carrying capacity of the outlet was not improved until 1909. In that year the Telluride Power Co. started to dredge this channel and to increase its capacity, but it was not completed until 1914, by the Utah Power & Light Co., successor to the Telluride Power Co. The new company also built another inlet canal from Bear River, increasing the capacity of the inflow from that source to about 4,500 second-feet, and installed a pumping plant on the "causeway" at the north end of the lake for drawing down the water in the lake. The capacity of the outlet canal was increased to 1,200 second-feet or more, and the pumping plant has a capacity of 1,500 second-feet under a 13-foot lift.

The capacity of Bear Lake as a reservoir is approximately 1,375,000 acre-feet in a drawdown of 21 feet, and the pumping plant will make available all water in the lake to that depth, although during a year of average flow in Bear River the maximum variation in the lake level to equalize the flow would not exceed 3½ feet.

CONDITIONS BELOW BEAR LAKE.

Along the course of Bear River below Bear Lake the only feasible dam sites appear to be in the 50-mile stretch between Soda Point and Cache Valley. These dam sites, however, are better suited for power developments than for storage reservoirs, because they are in comparatively narrow canyons where the storage capacity is small. The fall in this section is approximately 1,035 feet, of which 765 feet is already utilized in three hydroelectric power plants of the Utah Power & Light Co.—525 feet at the Grace plant, 95 feet at the Cove plant, and 142 feet at the Oneida plant. From Soda Point down-

[11] U. S. Recl. Service Second Ann. Rept., p. 475, 1903.

stream for a distance of about 4 miles the river flows through a deep, narrow lava gorge having nearly vertical sides, which in many places rise more than 100 feet above the water surface. In places the superficial conditions in this canyon indicate good dam sites for the development of power. Immediately below this canyon is the Grace power plant, which utilizes the fall of the stream in Black Canyon, and below it is the Cove plant. Below the Cove power plant the river valley broadens and the grade is much flatter, thus precluding any further power plant above the narrow canyon that connects Cache and Gentile valleys. This canyon is about 9 miles long and has a total fall of 280 feet, 142 feet of which has been utilized at the Oneida power plant, where a gravity-section concrete dam 116 feet high has been built. The reservoir at this plant has an area of 450 acres and a working storage capacity of about 14,000 acre-feet.

There are apparently two or three feasible dam sites in the Oneida Narrows, the part of Bear River canyon below the Oneida power plant. These sites and those above Grace power plant will probably be developed as power sites, and the reservoirs formed by the dams will act as regulating ponds for the power plants.

The tributaries that enter Bear River between Bear Lake and Cache Valley are short mountain streams that flow in steep, narrow canyons. The stream flow is usually torrential in the spring but very low during the rest of the year. None of these streams except Cottonwood Creek have any large reservoirs or reservoir sites.

COTTONWOOD CREEK SITE.

Cottonwood Creek empties into Bear River at the head of Oneida Narrows. It drains a rolling plateau area west of Gentile Valley and is used to irrigate about 2,000 acres in the vicinity of Cleveland, Idaho. The topography shown on the Preston topographic map indicates a dam site (10HC 1) near the center of sec. 25, T. 12 S., R. 39 E. Boise meridian. This site has been studied on one or two occasions to determine the feasibility of storing water here and in Stock Valley, to the south, for use on lands that might be reached by diversions from Battle Creek, the stored water to be led by a short tunnel from Stock Valley southward into the Battle Creek drainage basin. A dam 50 feet high at this site would create a reservoir having a surface area of about 120 acres and a storage capacity of 1,800 acre-feet. By raising the dam to a height of 100 feet Stock Valley would become an arm of the reservoir, and the total surface area would be increased to 994 acres and the storage capacity to about 28,800 acre-feet.

RESERVOIRS IN CACHE VALLEY.

On the small tributary streams that enter Bear River in Cache Valley several small reservoirs have been built by the neighboring communities for irrigation and domestic purposes. Most of them have a capacity of less than 500 acre-feet and are therefore not described in detail. Among the larger ones are the Oneida reservoir, near Clifton; the Newton reservoir, on Newton Creek near Newton; and the Strong Arm Reservoir Co.'s reservoirs, on Battle Creek near Treasureton. All these reservoirs have been built because late in summer the flow of these streams gets so low that it yields too little water to produce successful crops, and therefore a conservation of some of the spring floods is necessary to supplement it.

STRONG ARM RESERVOIRS.

The Strong Arm Reservoir Co. has two small reservoirs (10HC 1) on Battle Creek, the combined capacity of which is about 1,100 acre-feet. The dam for reservoir No. 1 is in sec. 2, T. 14 S., R. 39 E., Idaho, and the dam for No. 2 is in sec. 9 of the same township. Both of these reservoirs are used for supplemental irrigation and furnish water to about 900 acres.

ONEIDA RESERVOIR.[12]

The Oneida reservoir (10HC 2) is 2 miles northeast of Clifton, Idaho, in T. 14 S., R. 38 E., in the north end of Cache Valley. It is shown on the United States Geological Survey's topographic map of the Preston quadrangle. The basin is a small depression among low rolling hills on the bench lands 5 miles northwest of the nearest point on Bear River. It is fed by a canal more than 20 miles long, which diverts water from Mink Creek, on the opposite side of Bear River, and crosses the river canyon by means of an inverted siphon. The project is owned by the Oneida Irrigation District and is used entirely to supply water for irrigation and domestic purposes. The capacity of the reservoir is about 14,000 acre-feet.

NEWTON RESERVOIR.

The Newton reservoir (10HC 3) is on Newton Creek in T. 14 N., R. 1 W., 3 miles north of Newton, Utah. (See map of Logan quadrangle.) The reservoir is in a basin cut by Clarkston Creek in a somewhat rolling and broken plain. Its area at full stage is 246 acres, and the capacity is given as 1,566 acre-feet. The water is confined by two dams, one on each side of a hill at the north end of the reservoir. The smaller dam is used as a waste weir. The main dam is about 300 feet long and 30 feet high and is constructed of earth. This dam was first built about 1872 to conserve the flood waters of Clarkston Creek for irrigating about 1,000 acres around Newton, as

[12] This is a separate project from the Oneida power development on Bear River.

the entire flow of the creek is used by the farmers of Clarkston during the irrigation season. After April 1 all the waters of the creek flow into the reservoir for 5 days, then for 15 days the Clarkston farmers use it, and so on alternately throughout the season.

WORM CREEK SITE.

There is an undeveloped reservoir site (10HC 2) in T. 15 S., R. 40 E. Boise meridian, on Worm Creek 3 miles northeast of Preston, Idaho. Its development has been proposed in connection with an irrigation project that involves the diversion of part of the flood waters of Cub River through a 5-mile canal extending across the divide between Worm Creek and Cub River and emptying into the proposed reservoir. The construction of an 80-foot dam at this site would give a storage capacity of about 11,000 acre-feet, and the water could be used advantageously as a supplemental supply in the present canal systems along Worm Creek.

CUB RIVER SITE.

Another undeveloped site (10HC 3) is on the left fork of Cub River in T. 15 S., R. 41 E. Boise meridian, Idaho, near the head of the river, in a small mountain basin known as Willow Flat. The utilization of this site to its full capacity of 3,500 acre-feet would require a dam 85 feet high having a crest length of 410 feet. As the site is above the confluence of the right and left forks the water from the right fork, if stored in the reservoir, must be conveyed through a pipe line 4,500 feet long.

LOGAN RIVER SITES.

Owing to the steep slope and the narrowness of Logan Canyon there are no large reservoir sites on Logan River. There is a dam site (10HC 4) in T. 12 N., R. 2 E., Utah, about 5 miles above the mouth of the canyon, at which the city of Logan at one time considered building a dam. The reservoir thus formed would extend 3 miles up the canyon and would have a surface area of about 291 acres and a capacity of 9,000 acre-feet. The crest length of a dam 100 feet high at this place would be about 800 feet. The city expected to build this reservoir to furnish additional water supply for its hydroelectric plant, which is a short distance below, and also for additional municipal supply.

Two other dam sites have been investigated to some extent by the water users on Logan River and the United States Bureau of Reclamation. The upper or Twin Bridge site, as it is called, is about three-fourths of a mile down the river from the mouth of Spawn Creek, near the southeast corner of sec. 28, T. 13 N., R. 3 E., Salt Lake base and meridian, and the lower site is in the eastern part of sec. 24, T. 12 N.,

R. 2 E. The lower site would be inundated if the proposed city reservoir were built.

Data on dam sites on Logan River.

Twin Bridge site.			Lower site.		
Contour.	Area (acres).	Capacity (acre-feet).	Contour.	Area (acres).	Capacity (acre-feet).
25	3	40	50	25	625
75	15	490	100	75	3, 125
125	56	2, 240	150	125	8, 125
175	109	6, 390	200	195	16, 125
225	196	14, 000	250	280	28, 000
275	285	26, 000			
Crest length of dam 275 feet high, about 1,800 feet.			Crest length of dam 250 feet high, about 1,200 feet.		

BLACKSMITH FORK SITE.

For a distance of 14 miles above the mouth of Blacksmith Fork the canyon is rather narrow, and above this stretch it broadens into a small basin, part of which is occupied by the Hardware ranch. A proposed dam site (10HC 5) is in T. 10 N., R. 3 E., just below the mouth of Rock Creek, where the canyon narrows to about 500 feet in width. A reconnaissance of this site indicates that a dam 100 feet high would give a storage capacity of approximately 8,000 acre-feet. The water from such a reservoir could be used advantageously by the present power plant near the mouth of the canyon and also in the irrigation systems that now divert water from Blacksmith Fork.

LITTLE BEAR RIVER SITE.

Some of the farmers irrigating lands in the valley below Avon have had an investigation made of a proposed reservoir site (10HC 6) on the east fork of Little Bear River 3 miles above Avon, at the mouth of Pole Creek, in sec. 17, T. 9 N., R. 2 E., Salt Lake base and meridian. (See map of Logan quadrangle.) A dam 100 feet high at this site would form a reservoir having an area of about 160 acres and an estimated storage capacity of 7,000 acre-feet. The water is to be used on some 4,000 acres in the valley of Little Bear River near the towns of Hyrum, Paradise, and Avon.

MALAD RIVER SITES.

There are apparently no feasible sites on the main course of Malad River, but the Malad Reservoir Co. has a developed site (10HD 1) on Little Malad River, a tributary stream. This company is constructing a 60-foot dam in the northwest quarter of T. 13 S., R. 35 E. Boise meridian, and expects to have a storage capacity of about

11,000 acre-feet. The flood water will be stored and used for irrigating lands in Little Malad Valley. Some of the water is intended for new lands and the remainder for supplementing the present late summer supply, which is insufficient for the lands under the present canal systems.

WEBER RIVER BASIN.

Weber River is one of the chief streams in the Great Salt Lake basin and furnishes water to a large area of agricultural land in Weber, Morgan, and Davis counties. As this land adjoins the industrial centers of Salt Lake City and Ogden, several attempts have been made at different times to extend the irrigated areas by conserving the flood waters of the stream. No detailed survey of the feasible storage sites was made, however, until 1919, when the Utah Water Storage Association, composed of and financed by the several counties interested, made a rather extensive investigation. The data thus obtained were supplemented during the summer of 1920 by the United States Geological Survey and during 1922–23 by the United States Bureau of Reclamation.

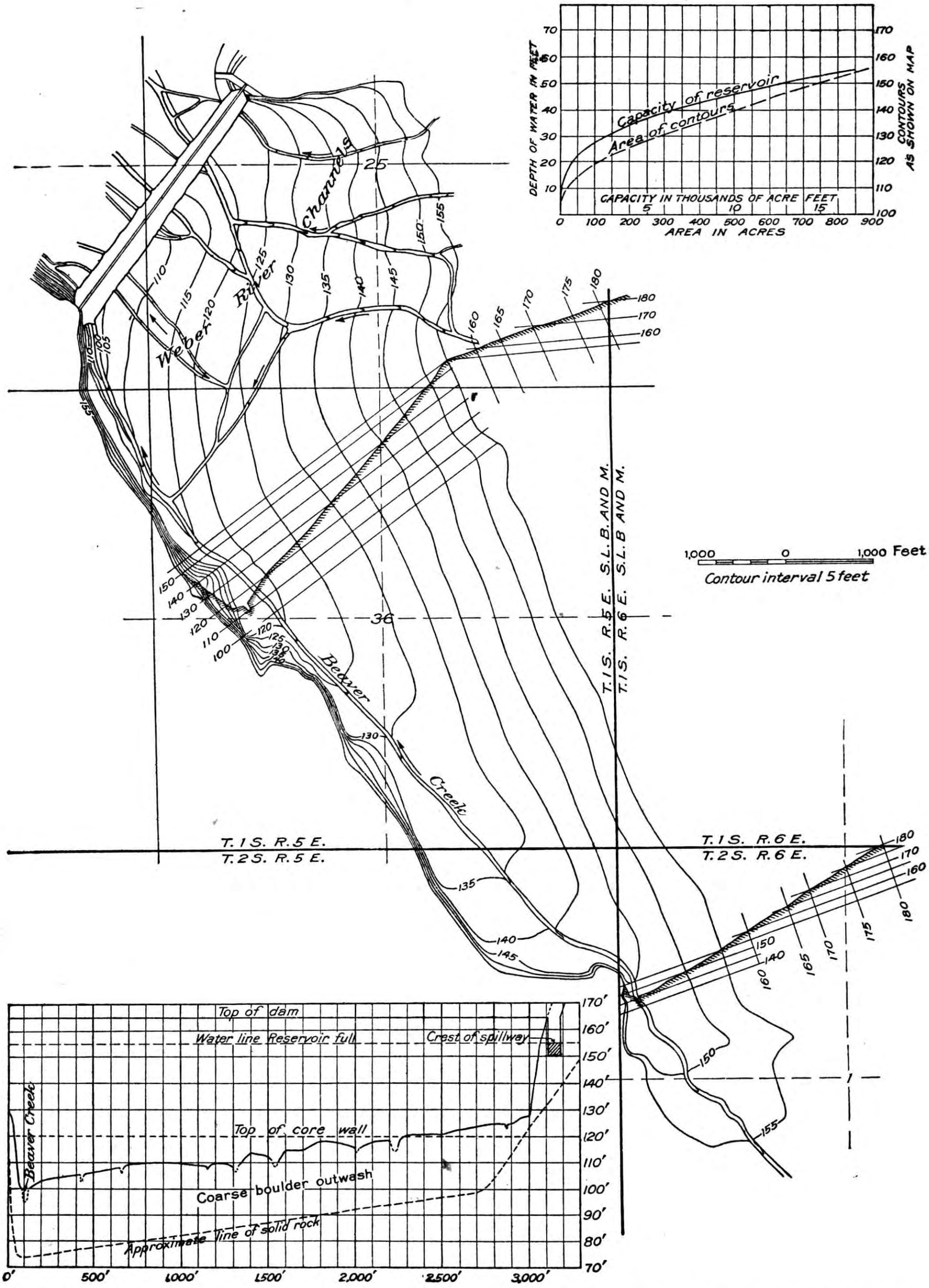
Applications for a number of reservoir sites on Weber River and its tributaries have been filed at the State engineer's office, but most of the sites are small.

LARABEE FLAT SITE.

In 1910 a water filing was made in T. 1 N., R. 8 E. (10HE 1), for right to store the flood waters of the upper Weber for developing power in the stretch of the river above Oakley and for irrigation in the valley areas below. The surface area of the reservoir at full stage was given as 520 acres with a 50-foot dam, and the storage capacity was estimated to be 12,000 acre-feet. Such a reservoir is greatly needed for the further utilization of upper Weber River, but the feasibility of building it is a moot question. The engineer's report to the Utah Water Storage Association contains the following statement: "The site just below Holiday Park, known as the Larabee site, has been surveyed and investigated, but the dam required is of excessive length and the foundation is very unpromising, being a heavy river wash of coarse gravel with indications of deep-lying bedrock."

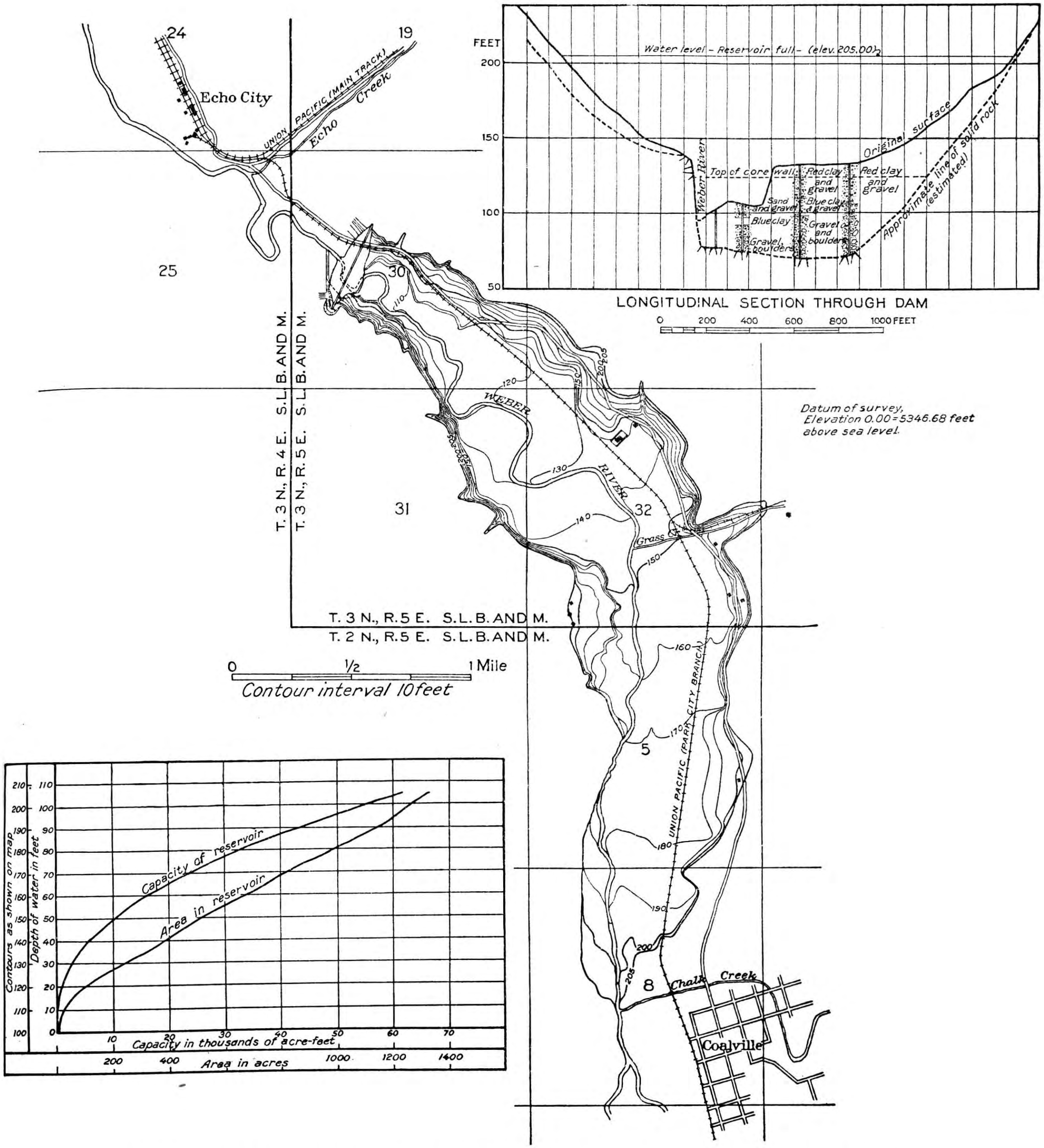
BEAVER CREEK SITE.

On Beaver Creek, which empties into Weber River a little more than 1 mile above the settlement of Peoa, a survey in the southeast quarter of T. 1 S., R. 8 E. Salt Lake meridian (10HE 2), was made by the Utah Water Storage Association to determine the reservoir possibilities. The basin above the proposed dam site is a broad, flat meadow, and by raising the water surface 55 feet at the dam site the surface



CONTOUR MAP OF BEAVER CREEK RESERVOIR SITE, WEBER RIVER BASIN, AND SECTION OF DAM.

From preliminary plans by Utah Water Storage Association, 1919.



CONTOUR MAP OF ECHO RESERVOIR SITE, WEBER RIVER BASIN, AND SECTION OF DAM.

From preliminary plans by Utah Water Storage Association, 1919.

area of the reservoir would be about 872 acres. The capacity at this depth would be 16,900 acre-feet. The dam site, however, is wide and is cut by several river channels and springs, and bedrock is probably deep-seated. The dam would be 3,100 feet long, and a large area of improved farm land would be inundated (Pl. IV).

ROCKPORT SITE.

The Rockport site (10HE 3) on Weber River is often mentioned as a reservoir possibility, but the results of the work done by the Utah Water Storage Association at this site indicate that "the river bottom is too wide for an economical dam, and prospect holes reveal the existence of coal seams." This site is in the north half of T. 1 S., R. 5 E., Salt Lake base and meridian, about 1 mile below Rockport, and an application was at one time filed on it to store water for irrigation. The reservoir with a 35-foot dam would have a surface area of about 805 acres. The capacity would be about 10,000 acre-feet, and part of the water would be diverted from Silver Creek into the reservoir through a canal about 27,000 feet long. Much valuable farm and ranch land would be inundated.

ECHO SITE.

The Echo reservoir site (10HE 4) extends from Coalville down Weber River to the proposed dam site in sec. 30, T. 3 N., R. 5 E., which is about three-quarters of a mile above the mouth of Echo Creek. It is the largest feasible reservoir site on the river, having an estimated capacity of 62,000 acre-feet, a surface area of 1,333 acres, and a maximum depth of 105 feet (Pl. V).

This reservoir site has been considered several times in connection with irrigation enterprises, but the high cost of construction is a serious handicap. The Park City branch of the Union Pacific Railroad parallels the river, and several miles of track would have to be taken up with no alternative but to rebuild it east of the proposed reservoir, along a rough broken hillside which is cut by numerous transverse washes. The wagon road would also have to be relocated. The crest length of the proposed dam would be about 2,150 feet, and bedrock is at least 65 feet below the surface. Practically all the lands to be inundated are now in private ownership, and much of the area is good farm land. A recent estimate made by the engineers for the Utah Water Storage Association places the cost of developing this site at $2,500,000, and plans are being made to build the dam through the cooperative efforts of all the water users and landowners who will benefit from the stored water.

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SMITH AND MOOREHOUSE SITE.

On Smith and Moorehouse Creek in sec. 1, T. 1 S., R. 7 E. Salt Lake meridian (10HE 5), about 4½ miles above its confluence with Weber River, is a small basin which was investigated and filed on in 1909 as a reservoir site to be used in connection with a proposed water-power development just above the town of Oakley. The site was surveyed, and it was found that at full stage a 75-foot dam would create a reservoir having a surface area of about 225 acres and a capacity of 8,000 acre-feet. A very long dam would be required, and as there is no evidence of bedrock the feasibility of the project depends on a more detailed study of the conditions governing the foundation of the dam.

CHALK CREEK SITE.

About 5½ miles from Coalville Chalk Creek enters The Narrows, where in sec. 7, T. 2 N., R. 6 E. (10HE 6), a dam 120 feet high would have a crest length of about 1,050 feet. The surface area of the reservoir at this site would be about 672 acres, and the storage capacity would be about 26,000 acre-feet. Practically all the area to be inundated is improved ranch land.

LOST CREEK SITE.

Construction was started at one time at a dam site on the Left or Blue Fork of Lost Creek about 12 miles above Devils Slide, but the project was abandoned. It was decided by the Utah Water Storage Association that a more favorable dam site exists on the stream in T. 5 N., R. 5 E. Salt Lake meridian (10HE 7), about half a mile below the junction of the Right and Left forks. The storage capacity at this site would be greater, and both forks of the stream would supply water. The data obtained by a survey of this reservoir site indicate that with a dam 120 feet in height the storage capacity would be about 8,000 acre-feet. The area is about 190 acres. (See fig. 4.)

YELLOW CREEK AND COYOTE CREEK SITES.

It would be physically possible, without encountering any difficult engineering problems, to divert water from Bear River into reservoirs on Yellow Creek (10HB 1) and Coyote Creek (10HB 2), in the Bear River basin, and thence carry it through a canal to the head of Echo Creek, in the Weber River basin. This would add materially to the available water supply in Weber River, but the plan involves interstate water rights and would no doubt meet with strong opposition from water users along Bear River unless means were provided to maintain the full amount of water in that stream from other sources.

OGDEN RIVER SITES.

Ogden Canyon is a narrow rock gorge that connects Ogden and Great Salt Lake valleys, and on this stretch of Ogden River there are no feasible reservoir sites. Above the canyon on the tributaries of

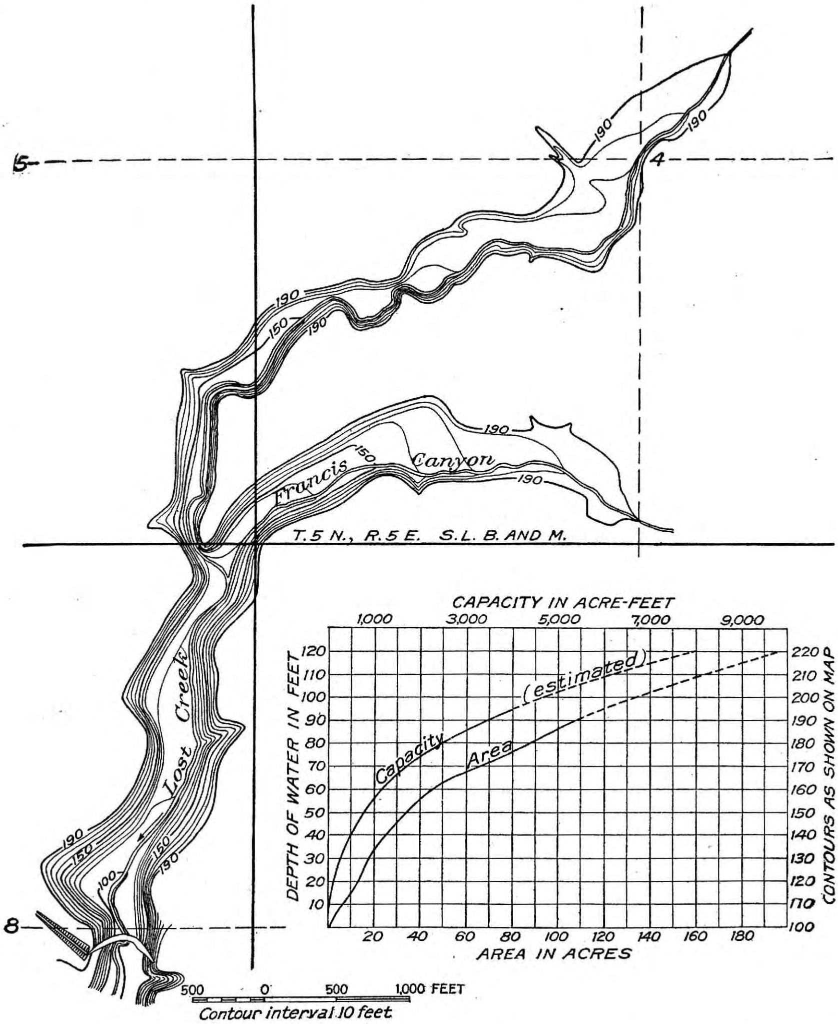


FIGURE 4.—Contour map of Lost Creek reservoir site, Weber River basin. From preliminary plans by Utah Water Storage Association, 1920.

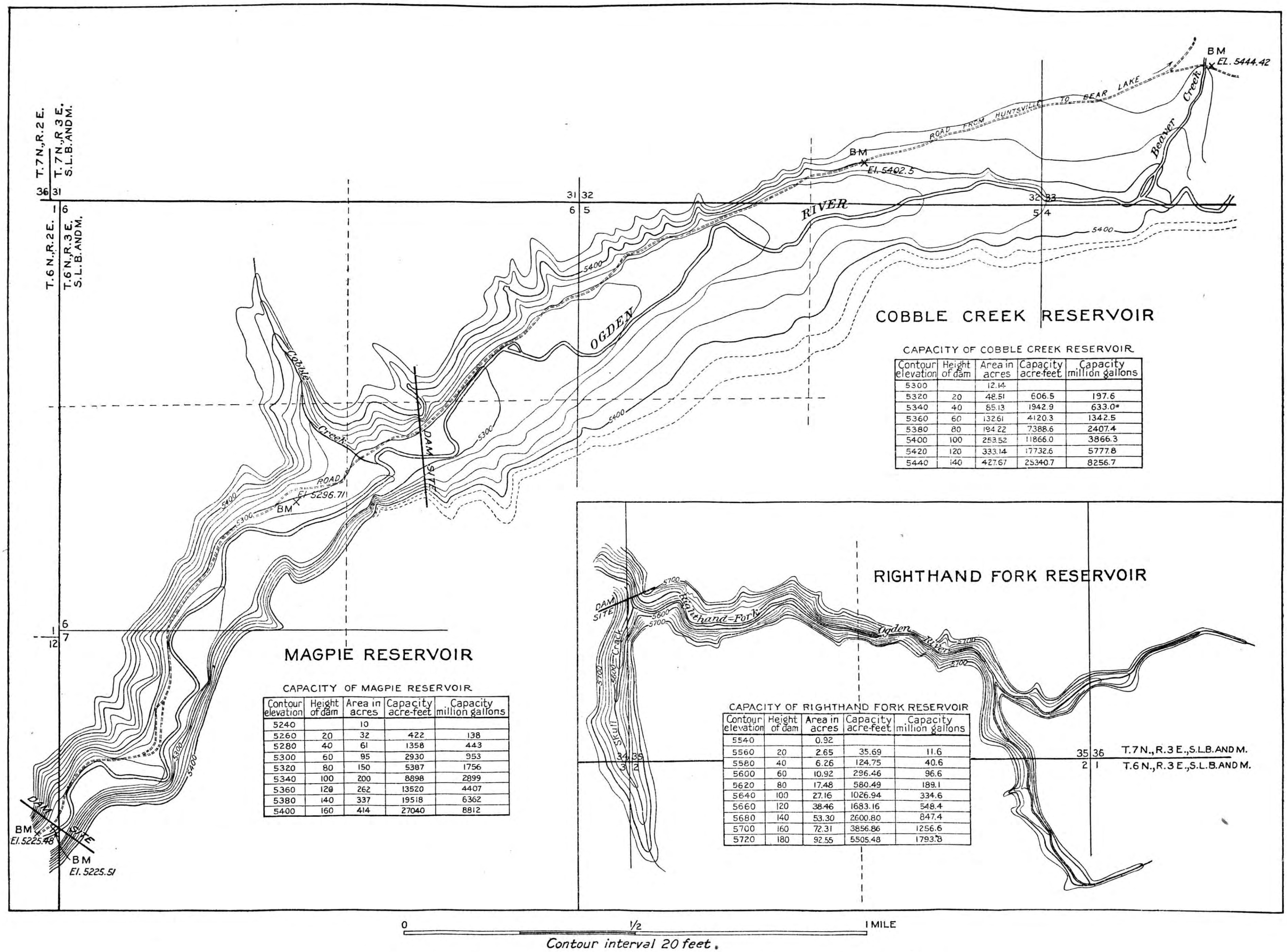
Ogden River, however, some investigative work has been done by the city of Ogden, by private interests, and by the United States Bureau of Reclamation to locate possible storage sites. The best reservoir sites appear to be along the South Fork, the largest tributary of Ogden River.

In 1908 the city of Ogden authorized the city engineer to make surveys of the reservoir sites on South Fork in order to provide water for the increasing demands of the city's growing population. The surveys were made, and the Magpie, Cobble Creek, and Right Fork reservoir sites were pronounced the most feasible. The lands included in the reservoir sites in the Ogden River basin are not improved and are not valuable for agriculture.

Righthand Fork site.—A little more than 3 miles above Cobble Creek South Fork is divided into the Righthand and Lefthand forks. Righthand Fork is the larger of the two, and its course from a short distance above the junction is through a narrow rock gorge whose walls are almost vertical for about 60 feet above the stream and rather steep above that height. A dam in sec. 34, T. 7 N., R. 3 E. Salt Lake meridian (10HE 8), raising the water surface 180 feet above the stream bed, would form a reservoir having a surface area of 92 acres and a storage capacity of 5,500 acre-feet (Pl. VI). This site is now controlled by the city of Ogden and is being considered as a possible source of additional water supply.

Cobble Creek site.—The Cobble Creek dam site is in sec. 6, T. 6 N., R. 3 E. (10HE 9), just above the mouth of Cobble Creek, about 1 mile upstream from the Magpie dam site. It has been examined several times by different interests, and in 1913 the South Fork Reservoir Co. and the city of Ogden attempted to construct a dam there. The city's object was to get additional water for city use, and that of the reservoir company was to get additional water for the irrigated and irrigable lands around Ogden. A contract was let for the construction work, and more than $40,000 was spent digging a core-wall trench across the canyon. Certain difficulties then arose between the contracting parties, and the work was abandoned. The dam as planned would have a crest length of 1,300 feet and a height of 150 feet. This would form a reservoir having a surface area of 427 acres and a capacity of 25,340 acre-feet (Pl. VI).

Magpie site.—The Magpie dam site is about 5 miles east of Huntsville, Utah, just above the confluence of Magpie Creek and South Fork (10HE 10). It is estimated that a dam on the line between T. 6 N., R. 2 E., and T. 6 N., R. 3 E., raising the water surface 160 feet and having a crest length of about 550 feet, would form a reservoir having a surface area of 414 acres and a storage capacity of 27,040 acre-feet. This reservoir would almost inundate the Cobble Creek dam site and would preclude its development (Pl. VI).



CAPACITY OF COBBLE CREEK RESERVOIR

Contour elevation	Height of dam	Area in acres	Capacity acre-feet	Capacity million gallons
5300		12.14		
5320	20	48.51	606.5	197.6
5340	40	85.13	1942.9	633.0*
5360	60	132.61	4120.3	1342.5
5380	80	194.22	7388.6	2407.4
5400	100	253.52	11866.0	3866.3
5420	120	333.14	17732.6	5777.8
5440	140	427.67	25340.7	8256.7

CAPACITY OF MAGPIE RESERVOIR

Contour elevation	Height of dam	Area in acres	Capacity acre-feet	Capacity million gallons
5240		10		
5260	20	32	422	138
5280	40	61	1358	443
5300	60	95	2930	953
5320	80	150	5387	1756
5340	100	200	8898	2899
5360	120	262	13520	4407
5380	140	337	19518	6362
5400	160	414	27040	8812

CAPACITY OF RIGHTHAND FORK RESERVOIR

Contour elevation	Height of dam	Area in acres	Capacity acre-feet	Capacity million gallons
5540		0.92		
5560	20	2.65	35.69	11.6
5580	40	6.26	124.75	40.6
5600	60	10.92	296.46	96.6
5620	80	17.48	580.49	189.1
5640	100	27.16	1026.94	334.6
5660	120	38.46	1683.16	548.4
5680	140	53.30	2600.80	847.4
5700	160	72.31	3856.86	1256.6
5720	180	92.55	5505.48	1793.8

CONTOUR MAP OF RIGHTHAND FORK, MAGPIE, AND COBBLE CREEK RESERVOIR SITES.

Survey by city engineering department, Ogden, 1908.

EAST CANYON CREEK RESERVOIR.[13]

The Davis & Weber Counties Canal Co., composed of the early settlers in Davis and Weber counties, is one of the oldest irrigation companies in Utah. It built the East Canyon Creek reservoir, in T. 2 N., R. 3 E. (10HE 1), to insure an adequate water supply to its lands during the later part of the growing season, when the natural flow of the river is low. This reservoir is the only one that has been built in the Weber River basin. The first dam was built in 1896 to a height of 58 feet above the outlet. After four years' use it was raised 30 feet, and two years later it was raised 12 feet more. The capacity of the reservoir was originally 3,850 acre-feet, and this was increased by the additions first to 9,000 and then to 14,000 acre-feet. The demand for stored water soon taxed this capacity, and after some study as to the best method of enlarging the reservoir the company on the recommendation of its engineer built a new dam immediately below the old one. The new structure is a concrete arch 128 feet long, 190 feet high above bedrock, and 145 feet above the outlet. The reservoir capacity was thus increased to 28,000 acre-feet.

The water from this reservoir is not only used for irrigation, but all of it is available for use through the Devils Gate power plant, at the mouth of Weber Canyon, at a time when the natural flow of the river is low.

JORDAN RIVER AND UTAH LAKE BASINS.

UTAH LAKE.[14]

The eastern shore of Utah Lake has figured prominently in all projects affecting the water-surface level of the lake. The lands that border this shore slope gently and were among the first lands to be taken up during the early settlement of Utah Lake valley.

In 1872 the irrigation canal companies using water from Jordan River in Salt Lake County built a dam (10HF 1) in the river for the purpose of retaining the high-water run-off in the lake. The resultant rise in the lake level flooded the lowland farms on the eastern border, and the difficulties that arose culminated in a lawsuit in 1884. The suit ended in 1885 in a compromise by which the lake level could be raised "not to exceed 3 feet 3½ inches above the point heretofore established and recognized as low-water mark." This elevation is known as the "compromise level" and is 4,488.94 feet above sea level.

[13] Am. Soc. Civil Eng. Proc., March, 1919; Eng. News, Jan. 2, 1902; Eng. Rec., Sept. 2, 1899.

[14] U. S. Recl. Service First, Second, and Third Ann. Reports; U. S. Dept. Agr. Office Exper. Sta. Bull. 124.

Though Utah Lake is in effect a large storage reservoir and serves that purpose within the limitations imposed by the "compromise level," it is too large and shallow for more effective use. The losses by evaporation are far in excess of the amount put to beneficial use, and the utilization of the lake for extending the irrigated areas within reach of it will depend largely on the ability to reduce these losses and to handle the lake water more effectively. The surface area of Utah Lake at "compromise level" is 93,000 acres, but its usable capacity is more or less uncertain because of the numerous springs that rise in the bottom of the lake, in addition to the many surface streams that empty into it. It has been estimated by the United States Bureau of Reclamation, however, that the lake could be so utilized as to deliver 300,000 acre-feet of water annually.

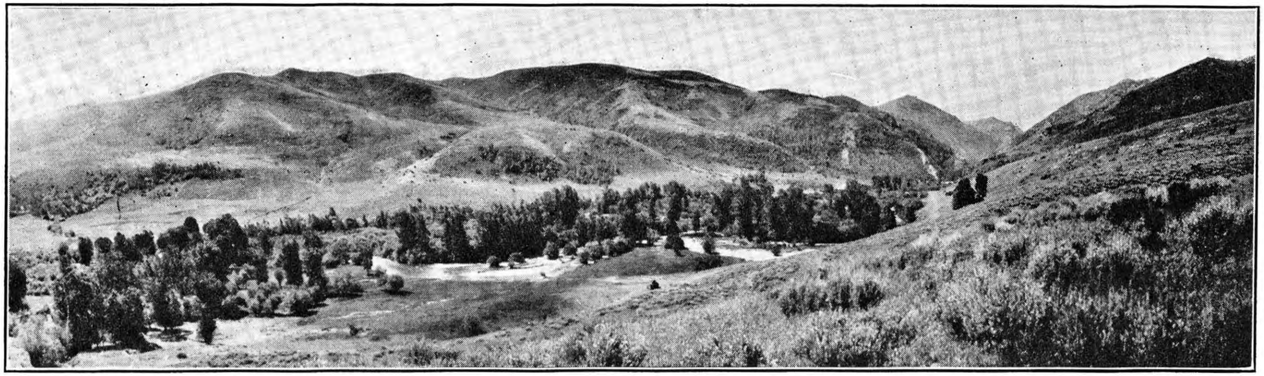
With the exception of Provo River and Spanish Fork, all the streams that empty into Utah Lake are relatively short and flow through steep, narrow canyons. Accordingly, the only places where a reconnaissance indicates reservoir possibilities are on American Fork near its confluence with Deer Creek and on Hobble Creek about 3½ miles above Springville, Utah.

AMERICAN FORK SITE.

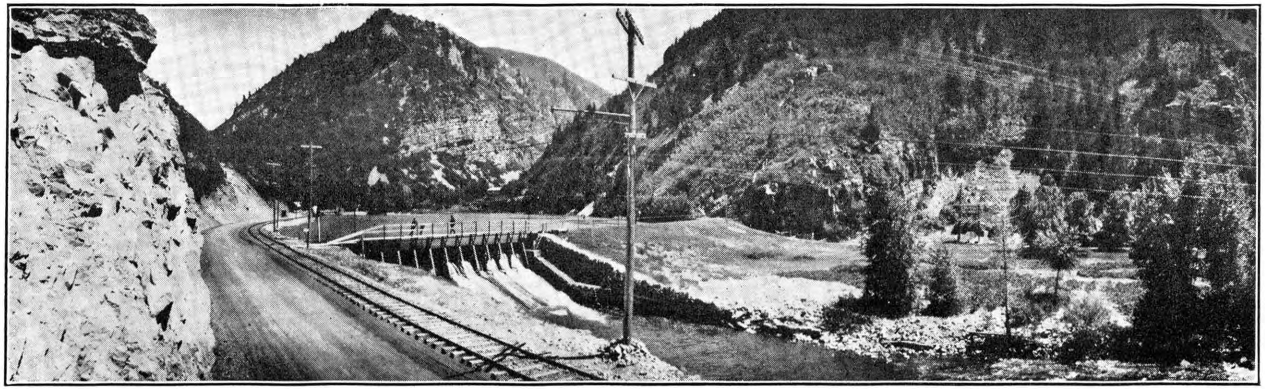
Applications for the site on American Fork have been filed at different times, but no construction work has been done on it and no detailed study of the conditions governing the foundation has been made at the dam site. Data obtained in the course of the topographic survey of American Fork canyon made by the United States Geological Survey in the summer of 1920 indicate a possible dam site in T. 4 S., R. 3 E. (not yet surveyed), about a quarter of a mile below the mouth of Deer Creek (10HF 1). At this place the canyon is about 660 feet wide at a height of 160 feet above the creek bed. A dam of the height indicated would form a reservoir having a surface area of 140 acres and an estimated capacity of 7,000 acre-feet. All water stored in this reservoir could be used very advantageously for the development of power through the two power plants already built in the canyon and would also be very beneficial to the irrigation projects that divert water from the creek below the canyon.

HOBBLE CREEK SITE.

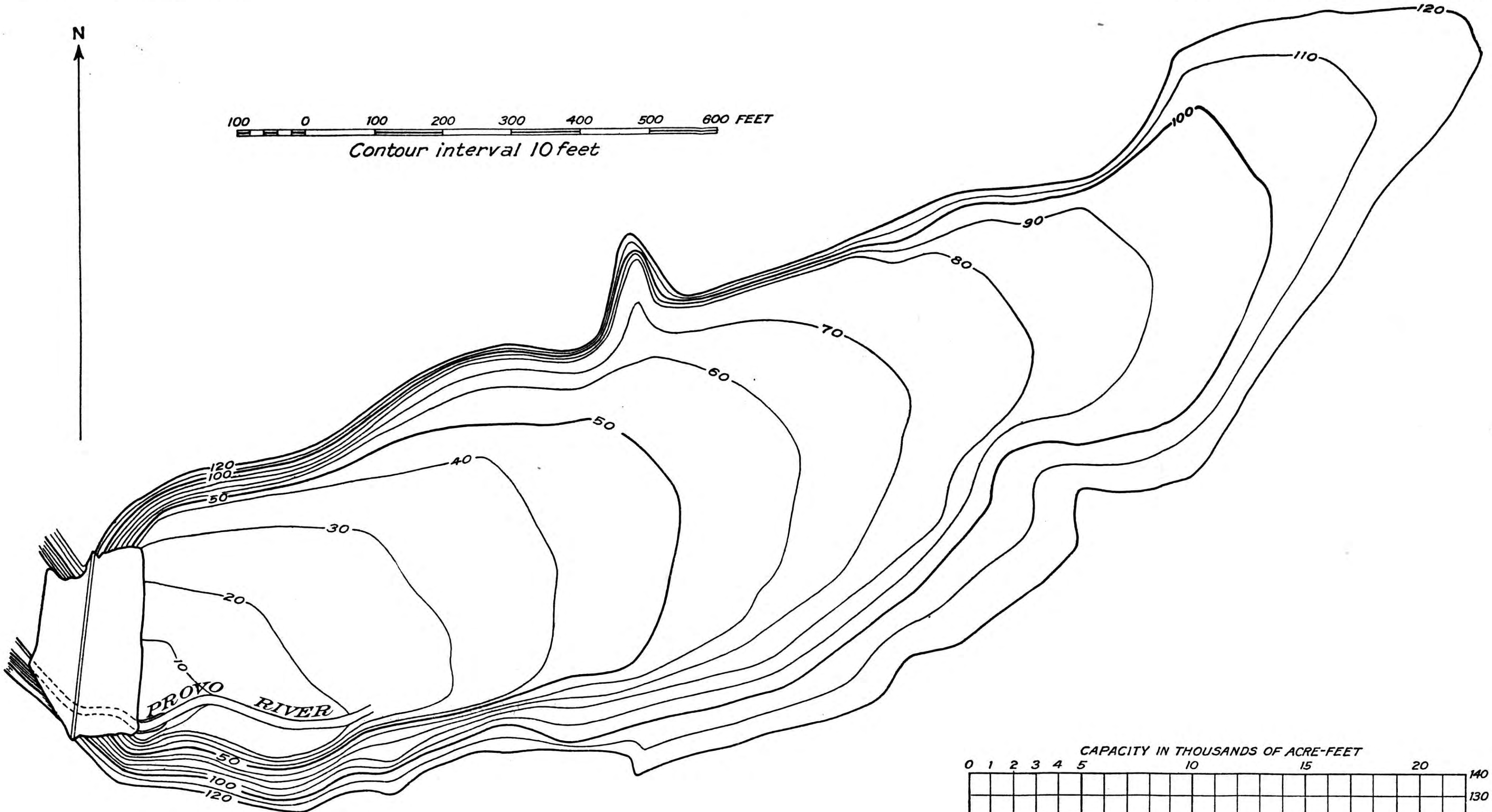
Data from the topographic survey of Hobble Creek indicate that perhaps the most feasible place along that stream for a storage dam is in sec. 32, T. 7 S., R. 4 E. Salt Lake meridian (10HF 2), about one-tenth of a mile above the power plant of the city of Springville. At this point a dam 130 feet high would have a crest length of about 800 feet. The surface area of the reservoir would be about 180 acres and the estimated capacity would be 7,200 acre-feet, all of which could be used for both power and irrigation.

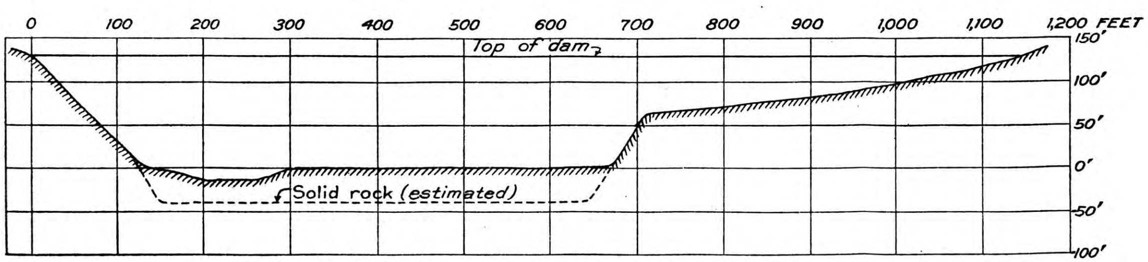


A. VIEW DOWN SOUTH FORK OF OGDEN RIVER TOWARD COBBLE CREEK DAM SITE.

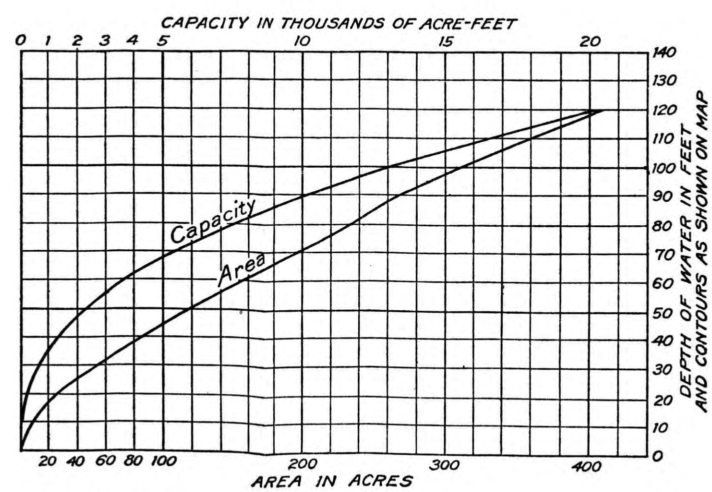


B. DIVERSION DAM OF PIONEER PLANT IN OGDEN CANYON, NEAR OGDEN.



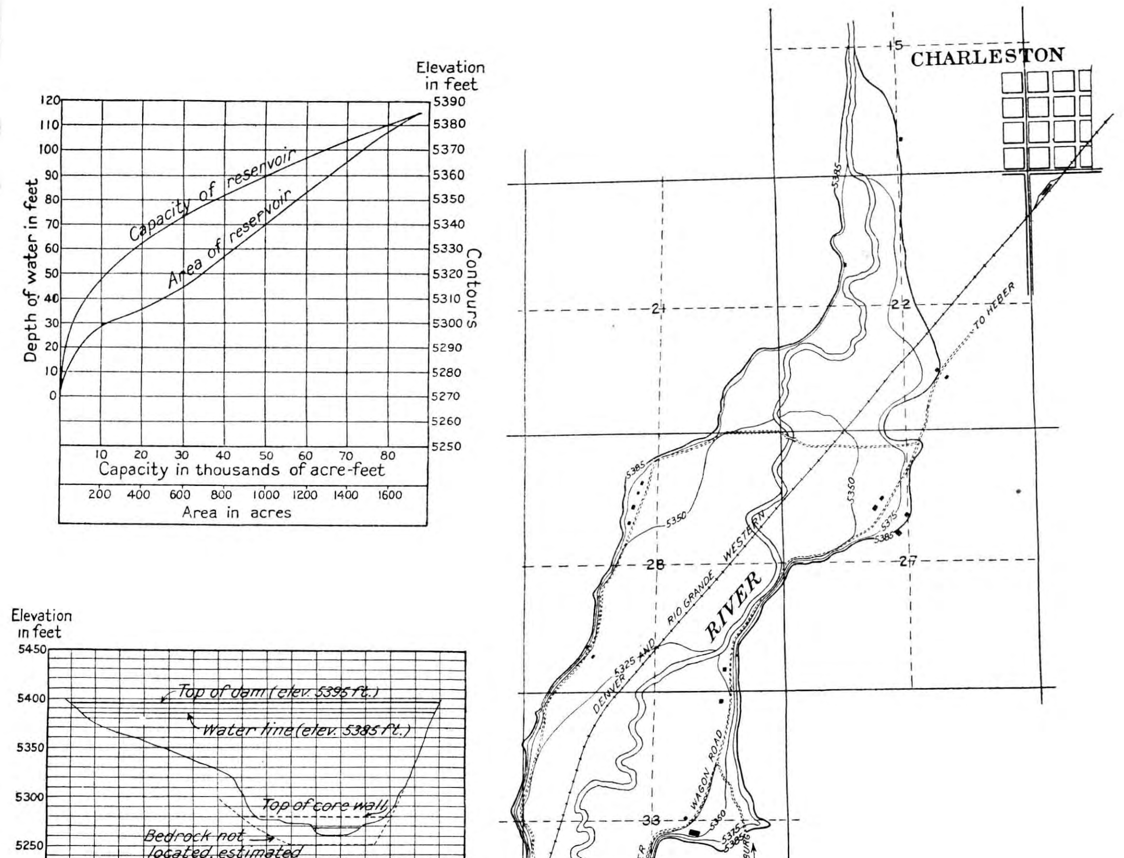


LONGITUDINAL SECTION THROUGH DAM



CONTOUR MAP OF BATES RESERVOIR SITE, ON PROVO RIVER, AND SECTION OF DAM.

From preliminary plans by Utah Water Storage Association, 1919.



CONTOUR MAP OF DEER CREEK RESERVOIR SITE, ON PROVO RIVER, AND SECTION OF DAM.

From preliminary plans by Utah Water Storage Association, 1919.

PROVO RIVER SITES.

Much time has been devoted to the study of storage possibilities along Provo River. The most recent work was done in 1922–23 by the United States Bureau of Reclamation, in cooperation with the State.

Bates site.—At a point on Provo River between the settlements of Hailstone and Woodland, about 11 miles above the city of Heber, in sec. 26, T. 2 S., R. 5 E. Salt Lake meridian (10HG 1), the walls of the canyon form a narrows where a dam 120 feet high would have a crest length of perhaps 1,000 feet. The reservoir created by such a dam would have a surface area of 380 acres and a capacity of about 20,000 acre-feet. An application has been filed on the river at this place, and a reconnaissance was made of the reservoir site about 1911, but sufficient detailed investigations have not been made at the dam site to determine whether or not the project is feasible (Pl. VIII).

Four miles below the Bates dam site and half a mile above the Murdock power plant the topographic conditions appear to be favorable for a dam 135 feet high. Such a dam would have a crest length of about 1,050 feet, and the surface area of the reservoir would be 330 acres. The capacity of such a reservoir would be about 17,000 acre-feet, but its development would interfere to some extent with the pipe line of the Murdock power plant.

Deer Creek site.—The engineer for the Utah Water Storage Association, after making an investigation of the entire length of Provo River, reached the conclusion that the Deer Creek reservoir site (10HG 2), below Charleston and Wallsburg, is probably the best one available. The results of the two independent surveys of this site indicate that a dam 125 feet high in sec. 7, T. 1 S., R. 4 E. Salt Lake meridian, would form a reservoir having a surface area of about 1,735 acres and a capacity of about 88,000 acre-feet. Two dam sites have thus far been mentioned, one immediately above and the other immediately below the mouth of Deer Creek, but no detailed investigations of them have yet been made. At the upper site a dam 120 feet high would have a crest length of about 900 feet, and at the lower site a dam 135 feet high would have a crest length of 1,200 feet. The expense of moving the Heber branch of the Denver & Rio Grande Western Railroad and the wagon road through almost the entire length of this reservoir site may preclude its development. (See Pl. IX.)

Other sites and reservoirs.—Provo River rises in a number of small lakes, many of which could be made into small reservoirs. Washington, Wall, and Trial lakes (10HG 1), three of the largest ones, have already been utilized by the Provo Reservoir Co. The storage capacity of these lakes has been increased by dams, which raise the old water level as much as 40 feet when the reservoir is full, and by outlet pipes, which lower it 10 to 14 feet below the natural low-water point when the stored water is drawn out. The dam at Trial Lake has a crest length of 600 feet and is 45 feet high. It is a rock fill and earth structure, through which a steel pipe passes for the outlet. The other dams are of the same general type. The rated storage capacity of the three lakes is 8,500 acre-feet. All the water stored in these lakes is used on lands in Utah Lake valley. If Lost, Haystack, and North Fork lakes were utilized in a similar manner, their total estimated storage capacity would be 4,700 acre-feet.

Several other small reservoirs have been built on the headwaters of Lake, Center, and Daniels creeks, tributaries of Provo River, for irrigating the lands adjacent to Heber and Charleston.

STRAWBERRY RESERVOIR.[15]

No reservoir sites are available on Spanish Fork or its tributaries, but the United States Reclamation Service developed the Strawberry reservoir by building a dam in sec. 3, T. 4 S., R. 11 W. Uinta meridian, on Strawberry River, in the Colorado River basin, and by means of a tunnel 19,900 feet long brings the stored water into Sixth Water Creek, a tributary of Diamond Fork. From Diamond Fork the water flows into Spanish Fork and is used on lands in the southern part of Utah Lake valley. The capacity of this reservoir is about 250,000 acre-feet, and during the irrigation season all the stored water could be used above the irrigation diversions to develop power. (See fig. 5.)

MOUNT NEBO RESERVOIR.[16]

Salt or Currant Creek, after emerging from its canyon near Nephi, flows northward through two small valleys separated by a low range of hills through which the stream has cut a short narrow canyon, making a good dam site at the outlet of the upper valley. In 1895 the Mount Nebo Irrigation Co. constructed a 30-foot dam in sec. 6, T. 11 S., R. 1 E. (10HF 2), to store the surplus waters of the creek for use on lands in Goshen Valley, at the south end of Utah Lake. The reservoir thus formed is about 5 miles long and three-quarters of a mile in average width. It has a capacity of at least 19,000 acre-feet, but the full capacity has never been utilized.

JORDAN RIVER.

The flat grade and tortuous course of Jordan River through the low valley lands that lie between Utah Lake and Great Salt Lake preclude any storage on the stream. It is chiefly valuable for irriga-

[15] Annual reports of U. S. Reclamation Service.

[16] Eng. News, Dec. 3, 1896.

tion, although a small power plant has been built in Jordan Narrows, a short canyon cut through the foothills that separate Utah Lake

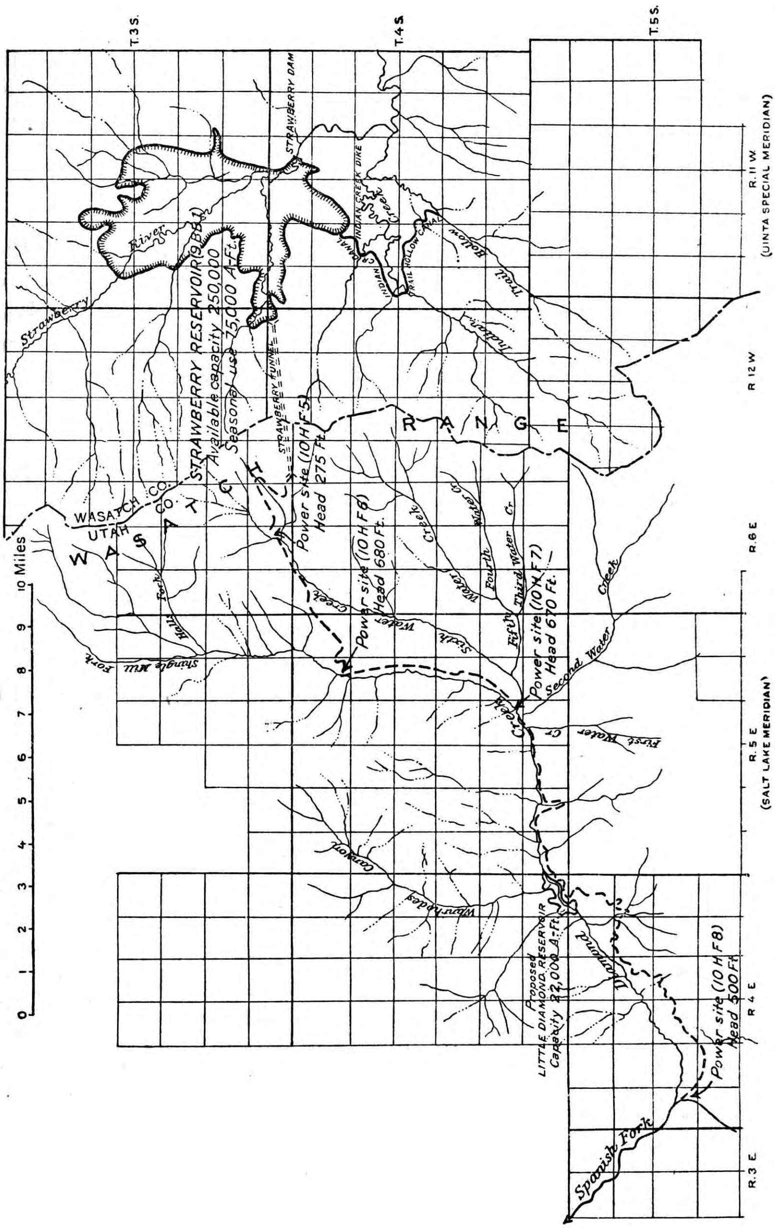


FIGURE 5.—Sketch map showing Diamond Creek power sites and Strawberry reservoir.

and Great Salt Lake valleys. Several large irrigation canals divert water from Jordan River in this canyon and carry it to lands in Great Salt Lake valley south and west of Salt Lake City. The flow of the river is regulated within certain limits by a dam at the head of the Narrows, which makes use of Utah Lake as a reservoir.

The principal tributaries of Jordan River drain the west slopes of the Wasatch Range east and southeast of Salt Lake City. Named in downstream order they are Little Cottonwood, Cottonwood, Mill, Parleys, and City creeks. All these streams are comparatively short and flow through steep, narrow, rugged canyons that are not suitable for storage reservoirs.

LITTLE COTTONWOOD CREEK SITES.

White Pine Lake, the source of White Pine Fork, and Red Pine Lake, the source of Red Pine Fork, both tributaries of Little Cottonwood Creek, have at times been considered for reservoirs by private irrigation interests. The lakes are very small, however, and would furnish at most a storage capacity of only a few hundred acre-feet.

COTTONWOOD CREEK SITES.

Cottonwood Creek rises in a number of small lakes, and as early as 1889, in anticipation of the use of the largest of these lakes for a possible water supply for Salt Lake City, three of them were withdrawn by the Federal Government from all forms of disposal for reservoir purposes. Salt Lake City has recently developed two storage sites on these lakes—the Twin Lakes site (10HH 1) and the Phoebe and Mary lakes site (10HH 2). The reservoirs at both of these sites are more than 5,000 feet higher than the city. Each one has a concrete dam about 70 feet high, and their combined storage capacity is 1,680 acre-feet.

At Reynolds Flat, on Cottonwood Creek just above the mouth of Mill D South Fork, the canyon broadens and the grade of the stream flattens. A dam (10HH 1) built across the canyon at the lower end of this flat and having sufficient height to raise the water surface 160 feet at the dam would have a crest length of approximately 650 feet. The resulting reservoir would have a surface area of about 197 acres and a possible capacity of 12,000 acre-feet. A natural spillway could be provided from the south side of the reservoir about half a mile above the dam over a low pass into Mill D South Fork. The road now following the creek could easily be changed to avoid the dam by extending it up Mill D South Fork across this pass and along the south side of the reservoir.

Near the Argenta mine, 1½ miles below the Reynolds Flat dam site, is another possible dam site (10HH 2), where a dam high enough to raise the water 250 feet would have a crest length of about 1,050 feet. The resulting reservoir would have an area of 180 acres and an estimated capacity of 15,300 acre-feet. Both of these reservoirs would be expensive to build, but they could be used advantageously by Salt Lake City for additional water supply and also for the generation of power through the two power plants farther down the canyon and in the stretch of the canyon between the upper power plant and the reservoir sites.

MILL CREEK SITE.

The narrowness and steep grade of Mill Creek canyon preclude the existence of any large reservoir sites in it. Salt Lake City in planning for additional water supply has considered to some extent the building of a dam at the lower end of Taylors Flat, on Mill Creek (10HH 3). A dam 115 feet high at this place would have a crest length of approximately 555 feet. The resulting reservoir would be comparatively small, having an area of only about 30 acres and a storage capacity of about 1,100 acre-feet. The cost of the dam would be excessive for the amount of water stored, but the project may be feasible to provide water for municipal use, as for that purpose the item of cost has a somewhat greater range than for an irrigation or a water-power project.

PARLEYS CREEK RESERVOIR.

The Park City branch of the Denver & Rio Grande Western Railroad from Salt Lake City passes through Parleys Canyon, and as the expense of moving this stretch of track would have to be added to the cost of building a reservoir in the canyon there are no reservoir sites here large enough to warrant the cost of development. However, a reservoir has been formed at the mouth of Mountain Dell Creek, above the canyon, where the railroad bears away from the stream for some distance. The dam (10HH 3) is a multiple-arch reinforced-concrete structure 100 feet high and 400 feet long. The surface area of the reservoir is 36 acres, and the storage capacity is about 850 acre-feet. The dam was built in 1916–17 by Salt Lake City at a total cost of $116,258.86, or $138 an acre-foot of storage capacity. The city now contemplates raising the height of the dam 40 feet, thus increasing the reservoir capacity to about 3,000 acre-feet.

CITY CREEK SITES.

City Creek is the smallest of the important tributaries of Jordan River, and the entire flow of the stream is controlled by Salt Lake City. However, the entire flow can not be utilized for municipal purposes, because there are on the creek no available reservoir sites large enough to control the spring freshets. At present the city has in the canyon a small concrete distributing reservoir with a capacity of about 16 acre-feet (10HH 4).

WILLARD, FARMINGTON, AND BOX ELDER CREEKS AND STREAMS IN TOOELE AND RUSH VALLEYS.

Owing to the steep, narrow canyon through which Willard Creek flows there are no reservoir sites along its course. Similar conditions exist on Farmington Creek, but this stream has a larger drainage basin and rises in a small lake that might be used for a small amount of storage.

Mantua Valley, which lies at the head of Box Elder Creek canyon, serves as a catchment basin for much of the water that flows in the creek. It could be used in part as a reservoir site by building a dam across the head of the canyon, but the storage capacity of the reservoir thus formed would be much larger than the amount of water available, and as all the land is productive farming land it is doubtful whether the value of the amount of water that could be stored would even compensate for the damage to present improvements.

In 1912 a filing was made in the State engineer's office to build a reservoir at this site (10HA 1), but no construction work has been done. The filing indicates that a dam 400 feet long and 20 feet high would form a reservoir having a capacity of 4,000 acre-feet.

On the South Fork of Box Elder Creek, about 4 miles from Mantua, the stream passes through a narrows locally known as Devils Gate. A 65-foot dam having a crest length of 181 feet has been built at this point (10HA 1), and the resulting reservoir has a surface area of 165 acres. This site was developed for supplementing the flow of the creek during the late summer irrigation season, and all the water, about 2,800 acre-feet, is to be used on lands adjacent to Brigham. The water may also be used for developing power before it reaches the irrigation diversion gates.

All the streams of Tooele and Rush valleys are very small and flow through short, steep canyons which are topographically not suitable for storage reservoirs.

SUMMARY.

Reservoirs in Great Salt Lake basin.

Name.	Designation.	Drainage basin.	Source of supply.	Location.	Height of dam (feet).	Approximate area (acres).	Capacity (acre-feet).	Use.
Strawberry	9BB 1	Colorado River [a]	Strawberry Creek	Tps. 3 and 4 S., R. 11 W., Uinta meridian.	71	8,200	250,000	Power and irrigation.
Devils Gate	10HA 1	Box Elder Creek	South fork of Box Elder Creek.	T. 8 N., R. 1 W., Utah	65	165	2,800	Irrigation.
Neponset	10HB 1	Bear River	Bear River	T. 8 N., R. 7 E., Utah	26	1,043	8,701	Do.[b]
Bear Lake	10HB 3	do	do	Utah and Idaho	Natural causeway.	107,500	1,400,000	Power and irrigation.
Strong Arm	10HC 1	do	Battle Creek	T. 14 S., R. 39 E., Idaho	34, 20		1,100	Do.[b]
Oneida district	10HC 2	do	Mink Creek	T. 14 S., R. 38 E., Idaho	35		4,000	Irrigation.
Newton	10HC 3	do	Clarkston Creek	T. 14 N., R. 1 W., Utah	30	246	1,566	Irrigation and domestic supply.
Oneida	10HC 4	do	Bear River	T. 13 S., R. 40 E., Idaho	145	450	14,000	Power and irrigation.
Malad	10HD 1	do	Little Malad River	T. 13 S., R. 35 E., Idaho	50	325	7,600	Do.
East Canyon	10HE 1	Weber River	East Canyon Creek	T. 2 N., R. 3 E., Utah	190	400	28,000	Do.
Utah Lake	10HF 1	Jordan River	Streams in Utah Lake valley.	Tps. 6, 7, 8, and 9 S., R. 1 E., Utah.	([c])	93,000	300,000	Irrigation.
Mount Nebo	10HF 2	Utah Lake	Salt Creek	T. 11 S., R. 1 E., Utah	30	1,620	19,000	Do.
Small lakes	10HG 1	do	Provo River	Unsurveyed			8,500	Do.
Small lakes	10HH 1, 2	Jordan River	Cottonwood Creek	Tps. 2 and 3 S., R. 3 E., Utah			1,680	City.
Mountain Dell	10HH 3	do	Parleys Creek	T. 2 S., R. 3 E., Utah	100	36	850	Do.

[a] Although the reservoir is in the Colorado River basin the water is used in Utah Lake valley.
[b] Project not completed.
[c] Lake level must not be raised above "compromise level," which is a little more than 3 feet higher than the bed of Jordan River.

NOTE.—Small reservoirs of only a few acre-feet capacity built in connection with small irrigation projects and municipal water systems are not included in this table.

Reservoir sites in Great Salt Lake basin.

Name.	Designation.	River basin.	Source of supply.	Location.	Approximate height of dam (feet).	Approximate area (acres).	Capacity (acre-feet).
Mantua	10HA 1	Box Elder Creek	Box Elder Creek	T. 9 N., R. 1 W., Utah	20	[a]400	4,000
Yellow Creek	10HB 1	Bear River	Bear River	T. 13 N., R. 121 W., Wyoming	130	1,200	44,700
Coyote Creek	10HB 2	do	do	T. 14 N., Rs. 120 and 121 W., Wyoming	120	1,985	39,200
Narrows (Woodruff)	10HB 3	do	do	Tps. 17 and 18 N., R. 120 W., Wyoming.	100	3,600	147,000
Twin Creek	10HB 4	do	Twin Creek	T. 21 N., R. 120 W., Wyoming	25	853	5,850
Cottonwood Creek	10HC 1	do	Cottonwood Creek	T. 12 S., R., 39 E., Idaho	100	994	28,800
Worm Creek	10HC 2	do	Worm Creek	T. 15 S., R. 40 E., Idaho	80	215	11,000
Willow Flat	10HC 3	do	Cub River	T. 15 S., R. 41 E., Idaho	85	75	3,500
Logan River (Twin) Bridge.	10HC 4	do	Logan River	T 13 N., R. 3 E., Utah	275	285	26,000
Logan River	10HC 4	do	do	T. 12 N., R. 2 E., Utah	100	291	9,000
Do	10HC 4	do	do	do	250	280	28,000
Blacksmith Fork	10HC 5	do	Blacksmith Fork	T. 10 N., R. 3 E., Utah	100	170	8,000
Little Bear River	10HC 6	do	East Fork of Little Bear River	T. 9 N., R. 2 E., Utah	100	160	7,000
							349,050
Larabee Flat	10HE 1	Weber River	Weber River	T. 1 N., R. 8 E., Utah	50	520	12,000
Beaver Creek	10HE 2	do	Beaver Creek	Tps. 1 and 2 S., Rs. 5 and 6 E., Utah	60	872	16,870
Rockport	10HE 3	do	Weber River	T. 1 N., R. 5 E., Utah	35	805	10,000
Echo	10HE 4	do	do	Tps. 2 and 3 N., R. 5 E., Utah	115	1,333	62,000
Smith and Moorehouse	10HE 5	do	Smith and Moorehouse Creek	T. 1 S., R. 7 E., Utah	75	225	8,000
Chalk Creek	10HE 6	do	Chalk Creek	T. 2 N., R. 6 E., Utah	120	672	26,000
Lost Creek	10HE 7	do	Lost Creek	T. 5 N., R. 5 E., Utah	120	190	8,000
Right Fork	10HE 8	do	Ogden River	Tps. 6 and 7 N., R. 3 E., Utah	190	92	5,500
Cobble Creek	10HE 9	do	do	do	150	427	[b]25,340
Magpie	10HE 10	do	do	do	170	414	27,040
							175,410
Deer Creek	10HF 1	Utah Lake	American Fork	T. 4 S., R. 3 R., Utah	160	140	7,000
Hobble Creek	10HF 2	do	Hobble Creek	T. 3 S., R. 4 E., Utah	130	180	7,200
Bates	10HG 1	do	Provo River	T. 2 S., R. 5 E., Utah	120	380	20,000
Deer Creek	10HG 2	do	do	T. 4 S., R. 4 E., Utah	125	1730-1740	88,000
Reynolds Flat	10HH 1	Jordan River	Cottonwood Creek	T. 2 S., R. 3 E., Utah	160	197	12,000
Argenta	10HH 2	do	do	T. 2 S., R. 2 E., Utah	250	180	15,300
Taylor's Flat	10HH 3	do	Mill Creek	T. 1 S., R. 2 E., Utah	120	30	1,100

Small lakes		Utah Lake	Provo River	Headwaters			4,700
Murdock plant [c]		do	do	T. 2 S., R. 5 E., Utah	135	330	17,000
							143,200
Grand total							671,660

[a] Estimated; no data on survey available.
[b] Not included in total. Development precluded by building at other sites.
[c] See description of power plant 10HG 1 (pp. 92–93).

NOTE.—In addition to the above sites there are several possible dam sites in Bear River canyon between Soda Springs and Cache Valley. Applications for four of these sites have now been filed for power development, and the storage behind the proposed dams will probably total 15,000 acre-feet or more, which will be used for power-plant regulation and for irrigation below.

DEVELOPED WATER POWER.

GENERAL FEATURES.

The hydroelectric sites in the Great Salt Lake basin are rather intensively developed, especially in that part of the basin lying in Utah, where the settlement and industrial growth are greatest. On practically every stream flowing from the west slope of the Wasatch Range that is large enough to permit the economical development of power there is one or more hydroelectric power plants. The basin contains 50 of these plants, which at the end of 1923 had a total installed water-wheel capacity of 225,149 horsepower. Most of these plants are small, as it has only been within the last 12 years that the larger plants, on lower Bear River, have been built.

Summary of developed power sites in Great Salt Lake basin at end of 1923.

Drainage basin.	Number of plants.	Installed water-wheel capacity (horse-power).
Bear River	16	147, 278
Weber River	4	21, 450
Jordan River and Utah Lake	24	52, 134
Willard, Farmington, and Box Elder creeks and streams in Tooele and Rush valleys	6	4, 287
	50	225, 149

In the upper part of the Bear River basin the settlement and industrial growth have not been great and the market for electrical power is small. The largest town above Bear Lake is Evanston, Wyo., which has a population of 3,479 (1920). Its electrical energy is supplied from a municipal steam-generating plant. At Cokeville, Wyo., the next largest town, which has a population of 430, a small hydroelectric power plant has been built on Pine Creek. This is the only hydroelectric plant in the upper Bear River basin above Bear Lake.

In Bear Lake valley numerous small mountain streams enter Bear Lake from the west, south, and east, and others enter the lower end of the valley north of the lake from the east and from the west. All these streams are short, and except on a few their run-off is wholly dependent on the natural precipitation on their small drainage areas. They usually have a high-water period in the spring, when the snow is melting rapidly, and a very low flow late in the summer and through the remainder of the year. For this reason these streams as a whole are not suitable for any comprehensive power development.

There are several small towns along the south and west shores of Bear Lake, some of which were founded as early as 1864, but they were without electrical energy until about 1910. Laketown, Utah, on the south shore of the lake, has a population of about 300. It is a farming and ranching community, and its small demand for power was originally supplied by a generator installed in a flour mill on Laketown Creek. The waterway for this flour mill is an irrigation ditch that extends up the creek to a point about half a mile above the mill and divides into three irrigation laterals below the mill. The diversion is effected by a low timber dam, and the main ditch is about 4 by 2 feet. This service was discontinued in 1914, and the town has since been supplied with energy by an extension of the transmission system of the Swan Creek Electric Co. from its hydroelectric plant on Swan Creek, about 12 miles northwest.

The first hydroelectric plant in Bear Lake valley was built on Georgetown Creek by the Montpelier Electric Light Co. to supply power to the towns of Montpelier, Bennington, and Georgetown, Idaho, which have populations of 2,984, 221, and 456, respectively. In 1908 this company sold its interests to the Bear Lake Power Co., which in 1910 built a hydroelectric plant on Paris Creek to serve the towns of Paris, Bloomington, and St. Charles, having populations of 1,333, 475, and 569, respectively.

The Swan Creek Electric Co. was organized in 1913 and took over a small hydroelectric plant on Swan Creek that was built to supply the towns of Garden City, Fish Haven, and Laketown.

The holdings of the Bear Lake Power Co. were absorbed in 1914 by the Utah Power & Light Co., and the Georgetown and Paris plants were tied into the general system of that company. The Swan Creek Electric Co. remained as an independent company. (See Pl. III.)

Descriptions of the hydroelectric plants in the basin follow. The index numbers refer to the map (Pl. III) showing the location of the plants. No attempt is made to describe all the "special use" plants in the basin, such as flour mills and sawmills, which do not generate hydroelectric power except for lighting their plants or some other use incident to their business. Plants of this class that are in conflict with a proposed power site are mentioned in the description of the power site in the section "Undeveloped water powers." The following abbreviations, with others that are easily understood, are used in the descriptions:

a., amperes.
d. c., direct current.
e. m. f., electric motor force.
hp., horsepower.
kv., kilovolts.
kva., kilovolt-amperes.
kw., kilowatt.
Q50, flow available 50 per cent of the time.

Q90, flow available 90 per cent of the time.
r. p. m., revolutions per minute.
sec.-ft., second-feet.
v., volts.
w. hp., water horsepower.

BEAR RIVER BASIN.

McNEICE PLANT (10HB 1).

Location and plan of development.—On Pine Creek about 8 miles from Cokeville, Wyo. Entire development in SW. ¼ sec. 35, T. 25 N., R. 118 W. sixth principal meridian. Small diversion dam turns water into ditch along left bank of creek. Steel penstock leads to power house.

Ownership and market.—Owner, Cokeville Light & Power Co. Market, town of Cokeville.

Chronologic summary.—Built in 1917 by Irwin McNeice. Put in operation in October, 1917. Sold to Cokeville Light & Power Co. in 1918. Substation built in 1918 by Cokeville Light & Power Co.

Water supply.—Source of water, Pine Creek. Rights acquired through State engineer of Wyoming. Permit issued for 38 sec.-ft. Developed capacity of plant about 11 sec.-ft. No regulation of stream flow. Estimated Q90 flow 11 sec.-ft., corresponding power capacity 90 hp. Estimated Q50 flow 16 sec.-ft., corresponding power capacity 130 hp.

Hydraulic features.—Dam, timber crib; crest length, 75 ft.; height, 4 ft. Conduit, ditch 855 ft. long on hillside, connects with steel penstock extending down hillside to power house. Tailrace, open channel.

Power house and transmission system.—Power house, lumber; built to furnish quarters for operator as well as to house machinery. Installation, one 100-hp. Hydraulic Turbine Co.'s turbine direct-connected to one 90-kva. 1,200 r. p. m. Allis-Chalmers generator with exciter generator on opposite end of shaft. One Woodward 1,200-ft.-pound oil-pressure governor. Three 25-kva. oil-filled self-cooled single-phase Allis-Chalmers transformers. Static head at plant 103 ft. Water capacity of turbine approximately 11 sec.-ft. Current generated at 2,300 v., stepped up to 13,000 v. and transmitted to Cokeville. Transmission line 25-ft. cedar poles 300 ft. apart with No. 10 galvanized-iron wire. Voltage stepped down to 2,300 v. at substation for distribution.

SWAN CREEK PLANT (10HB 2).

Location and plan of development.—In Rich County, Utah, near Garden City, about 1 mile from west shore of Bear Lake, in sec. 6, T. 14 N., R. 5 E. Salt Lake meridian, near mouth of Swan Creek canyon, above the irrigation ditches. Diversion dam in Swan Creek; canal leads along north side of creek to power house.

Ownership and market.—Owner, Swan Creek Electric Co. Market, small towns and summer resorts on south and west sides of Bear Lake.

Chronologic summary.—Present plant built about 1915 by Swan Creek Electric Co.

Water supply.—Source of water, Swan Creek. Rights acquired through application to State engineer of Utah. Stream largely spring-fed and has uniform flow. Estimated Q90 and Q50 flows 45 sec.-ft.; corresponding power capacity 540 hp.

Hydraulic features.—Dam, crude timber structure. Conduit, canal 2,600 ft. long on north side of creek. Wooden-stave pipe penstock extends to power house.

Power house and transmission system.—Power house, small rough lumber building at head of main irrigation canal. Installation, one 24-in. 140-hp. Victor turbine and one 75-kw. generator. Static head at plant 150 ft.

PARIS PLANT (10HB 3).

Location and plan of development.—In Bear Lake County, Idaho, near the mouth of Paris Canyon, 3 miles from Paris. Diversion dam in sec. 13, T. 14 S., R. 42 E. Boise meridian. Open canal along south side of canyon to power house in NW. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 9, T. 14 S., R. 43 E. (Pl. III).

Ownership and market.—Owner, Utah Power & Light Co. Market, territory served by Utah Power & Light Co. (See old Grace plant, below.)

Chronologic summary.—Plant built about 1910–11 by Bear Lake Co. Sold to Utah Power & Light Co. in 1914.

Water supply.—Source of water, Paris Creek. Rights acquired through State engineer of Idaho. Estimated Q90 flow 17 sec.-ft.; corresponding power capacity 480 hp. Estimated Q50 flow 23 sec.-ft.; corresponding power capacity 640 hp.

Hydraulic features.—Dam, low crude structure of logs laid across stream. Intake, 2-in. lumber head gates set in cement. Two gates, each $2\frac{1}{2}$ ft. wide by 4 ft. high. Conduit, open canal about 3.5 miles long, 4 ft. wide at bottom, with side slopes 1 to 1. Much trouble in winter in keeping it free from ice. Small reservoir, built in earth at head of penstock, serves as equalizing basin. Water spills into it from canal through a 50-ft. concrete spillway in canal bank. Canal extends around brow of hill and is used as irrigation ditch. All water not used for power and irrigation spills into wasteway just below reservoir and returns to creek. Penstock of riveted steel pipe connects reservoir and power plant; length 1,370 ft.; diameter 30 in. at top, 22 in. at bottom. Tailrace is a stone masonry archway opening into open concrete channel leading to the creek.

Power house and transmission system.—Power house, very substantial building of rough stone masonry on concrete foundation, shingle roof, half of floor area covered with concrete. Small frame cottage for operator just east of power house. Installation, one 1,180-hp. Allis-Chalmers water turbine direct connected to one 650-kva. 6,600-v. 3-phase 600 r. p. m. Allis-Chalmers generator. Exciter unit one 15-kw. 116–120-v. d. c. generator. Water wheel designed for 350-ft. head and delivers 650 kw. with 38 sec.-ft. of water. Operating head at plant, 346 ft. Current generated at 6,000 v. Outgoing line connected with Georgetown plant. Branch line leads to Montpelier substation, where connection is made with general system of Utah Power & Light Co.

OLD GRACE PLANT (10HC 1).[17]

Location and plan of development.—In Bannock County, southeastern Idaho, at upper end of Gentile Valley, 135 miles north of Salt Lake City, near Grace, on Oregon Short Line Railroad (Pls. III and X). Diversion dam on Bear River in NE. $\frac{1}{4}$ sec. 1, T. 10 S., R. 40 E. Boise meridian. Pipe line on the south and east side of the stream, approximately 5 miles long, leads to a power house in SW. $\frac{1}{4}$ sec. 21, same township.

Ownership and market.—Owner, Utah Power & Light Co. Market, more than 100 towns and communities in the Great Salt Lake basin, including mining and agricultural industries. Company owns more than 1,700 miles of primary transmission lines and 30 hydroelectric power plants in the basin and serves more than 84,000 customers. System serves also considerable additional territory outside of the basin, including parts of Idaho and Utah.

Chronologic summary.—Construction started in 1906 and completed in 1908. Plant built by Telluride Power Co. Sold to Utah Power & Light Co. in later part of 1913.

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[17] Eng. News Rec., Mar. 26, 1910; Min. and Eng. World, Aug. 24 and Oct. 12, 1912.

Water supply.—Source of water, Bear River. Right acquired by appropriation and use and through permits issued by the State engineer of Idaho. Stream flow is regulated by storage in Bear Lake, also a small amount of regulation from the pond above diversion dam. Estimated Q90 flow 900 sec.-ft.; corresponding power capacity about 38,000 hp. Q50 flow practically same as Q90 flow.

Hydraulic features.—Dam, overflow timber crib; crest length, 160 ft.; height 38 ft. above stream bed, with 6 ft. additional by use of flashboards. Intake, center line 10 ft. below crest of dam; 11 ft. 5 in. in diameter, tapering to 8½ ft. in first 40 ft. Protected from ice and débris by stop-log rack and heavy screen. Conduit, upper 4,187 ft. Oregon fir wooden-stave pipe 8½ ft. in diameter; remainder riveted steel pipe ¼-inch thick, made in three sections—upper, 6,542 ft. long and 8½ ft. in diameter; middle, 6,542 ft. long and 8 ft. in diameter; and lower, 6,544 ft. long and 7½ ft. in diameter. Pipe line follows natural ground surface with exception of few slight cuts. Most of it uncovered. Seven high points in line equipped with 10-in. air valves; four low points with drain valves. Placed in wooden saddles spaced 8 ft. apart. Full carrying capacity 450 sec.-ft. Steel surge tank on concrete foundation connects pipe line with penstocks. Tank 71 ft. high and 50 ft. in diameter. Penstock, riveted steel pipe about 2,700 ft. long laid in shallow trench in lava rock. Diameter 7½ ft. at top and 6 ft. at bottom; ⅜ in. thick at top, 1$\frac{1}{16}$ in. thick at bottom. Penstock terminates in a Y, each branch of which leads to a hydraulic turbine controlled by a 48-in. hydraulically operated gate valve. Tailrace is a concrete tunnel emptying into the river immediately below the power house.

Power house and transmission system.—Power house, concrete on masonry foundations to bedrock; inside dimensions 60 by 140 ft.; floors, machinery footings, and interior division walls all concrete. Eastern part used for hydraulic turbines, generators, and low-tension apparatus; western part for transformers, switching and high-tension apparatus. A 25-ton hand-operated Whiting crane serves the entire interior. Installation, two 8,500-hp. 300-r. p. m. Allis-Chalmers horizontal reaction turbines each designed to operate under a head of 440 ft. and to use 204 sec.-ft. of water. Direct connected to two 5,500-kva. 2,300-v. 3-phase 60-cycle 300 r. p. m. Westinghouse revolving-field generators. Each turbine runner has two draft tubes which form a Y and discharge horizontally into the tailrace 20 ft. below the center of the shaft. Effective operating head is 440 ft. Static head 484 ft. Two 100-kw. 125-v. Westinghouse d. c. generators are used as exciters, each direct-connected to a 37-in. Pelton water wheel served with water through a 10-in. pipe tapped into the Y of the penstock. Current is generated at 2,300 v., stepped up to 44 kv., and carried over 134 miles of transmission line to the terminal station at Salt Lake City, where it is fed into the distribution system of the Utah Power & Light Co.

Remarks.—Several relatively large hydroelectric power plants were built in the Great Salt Lake basin before the old Grace plant, but as none were so large and so remote from market, this plant marked a decided advance in the utilization of the hydroelectric sites in this region. The plant was built to deliver a constant amount of energy, and all regulation required on the system of the Telluride Power Co. at that time was provided for in other stations. With a flow of 450 sec.-ft. the plant can develop 11,000 kva.

NEW GRACE PLANT (10HC 2).[18]

Location and plan of development.—In Bannock County, southeastern Idaho, at the upper end of Gentile Valley, 135 miles north of Salt Lake City, near Grace, on the Oregon Short Line Railroad (Pls. III and X). Diversion dam in Bear

[18] Jour. Electricity, Power, and Gas, May 8, 1915.

River in NE. ¼ sec. 1, T. 10 S., R. 40 E. Boise meridian. Pipe line leads from the north end of the dam southwestward across the river to the power house, which adjoins the old Grace power house, in the SW. ¼ sec. 21.

Ownership and market.—Owner, Utah Power & Light Co. Market, Great Salt Lake basin and surrounding territory served by the system of the Utah Power & Light Co.

Chronologic summary.—Construction started in February, 1913, and completed in September, 1914. Plant built by Utah Power & Light Co.

Water supply.—Source of water, Bear River. Rights acquired by permit issued by the State engineer of Idaho. Stream flow is regulated by storage in Bear Lake, also small amount of regulation from pond above diversion dam. Estimated Q90 flow 900 sec.-ft.; corresponding power capacity about 38,000 hp.

Hydraulic features.—Dam, same dam as used for old Grace plant. Intake, concrete wall in solid rock at north end of dam. Walls 12 ft. higher than top of dam, giving 6 ft. freeboard above maximum flashboard height of dam. Water enters through two 10 by 10 ft. openings, passes through two sets of screens, and enters the pipe line through a steel nipple 11 ft. in diameter. Conduit, continuous wooden-stave pipe of Douglas fir; 77 staves in circumference and 11 ft. in diameter; total length 22,959 ft., laid to grade and carried on reinforced-concrete saddles spaced 8 ft. apart. Pipe crosses Bear River on a reinforced-concrete bridge 576 ft. long and having 12 twin arches on skew; each span is 48 ft. Surge tank is riveted steel, 30 ft. in diameter and 132 ft. high. Two steel penstocks 2,530 ft. long extend from surge tank to power house. Each is 90 in. in diameter at the top and tapers to 72 in. at the outlet end, and each is connected with a hydraulic turbine. Tailrace is an open channel emptying into the river immediately below the power house.

Power house and transmission system.—Power house, "hyrib" and plaster walls with structural-steel frame and reinforced-concrete substructure. Dimensions, 115½ by 53½ ft. by 65 ft. high. Roof is covered with asbestos shingles; window sashes all metal; equipped with 80-ton motor-operated crane. Installation, three 17,000-w. hp. I. P. Morris vertical-shaft turbines with double motor-driven triple pumps and oil fillers. Water wheels designed to operate under 482-ft. head and deliver 11,000 kw. each, when using 320 sec.-ft. of water. Effective head is 480 ft.; static head, 524 ft. Electrical equipment is all made by General Electric Co. and consists of three type AIB 12,222-kva. 514-r. p. m. 11,000-kw. 6,600-v. generators; three type MPC 6–55-kw. 514-r. p. m. 250-v. compound-wound vertical exciters; one 250-v. 55-kw. motor-driven exciter; three-section bench board and 12-panel vertical switchboard controlling generators and station equipment. One 44,000-v. and two 130,000-v. 3-phase outgoing transmission lines. All transformer equipment is outdoor type.

Current is generated at 6,600 v.; part is stepped up to 44,000 v. and the rest to 130,000 v. It is sent to the terminal station at Salt Lake City, a distance of 134 miles, for distribution over the company's system.

COVE PLANT (10HC 3).

Location and plan of development.—In Bannock County, southeastern Idaho, at the upper end of Gentile Valley, about 132 miles north of Salt Lake City (Pls. III and X). A diversion dam in Bear River less than half a mile below the Grace power house turns the water into a flume along the east bank of the river. This flume leads to the power house, which is 1¼ miles below the dam. Dam in NW. ¼ sec. 28, and power house in NW. ¼ sec. 33; all in T. 10 S., R. 40 E. Boise meridian.

Ownership and market.—Owner, Utah Power & Light Co. Market, all territory served by Utah Power & Light Co. (See old Grace plant, p. 67.)

Chronologic summary.—Construction started in May, 1916, and completed October 15, 1917. Plant built by Utah Power & Light Co.

Water supply.—Source of water, Bear River. Rights acquired for 1,500 sec.-ft. and 4,000 acre-ft. of storage through permits issued by the State engineer of Idaho in March, 1916. Stream flow is regulated by storage in Bear Lake, also small amount of regulation from the pond above diversion dam. Estimated Q90 flow 900 sec.-ft.; corresponding power capacity about 7,100 hp.

Hydraulic features.—Dam, ogee section, reinforced concrete, crest length 141 ft., height 21½ ft., with 5 ft. additional by use of flashboards, designed for flood capacity of 9,000 sec.-ft. At west end and extending 175 ft. beyond is a rock and gravel embankment having a concrete core wall and 18 in. of riprap on the upstream face. The crest of this embankment is 10 ft. higher than the dam. An ice chute at the east end of the dam next to the intake is provided for disposing of ice that collects at the screens. Intake, reinforced-concrete well 20 ft. deep, with five 15-ft. bays opening into it. Each bay has a 12 by 19 ft. opening equipped with structural-steel screens. Outlet is 20 ft. wide and opens into a concrete-lined canal, equipped with a Taintor gate. Conduit, first 424 ft. beyond intake basin is concrete-lined canal section with reinforced-concrete spillway section 244 ft. long over west bank to the river; crest of this spillway is 11 ft. higher than bottom of canal and same elevation as top of flashboards on dam. Remaining 5,700 ft. of conduit is flume built of reinforced-concrete saddles at 6-ft. centers and lined with lumber. Floor of flume for tangent sections is 5-in. lumber, for curved sections reinforced concrete 7½ in. thick. Sides of 3-in. lumber at top, increasing to 5 in. at the bottom; outside width of flume 21 ft. 7 in. A freeboard of 3 in. is maintained by increasing the depth of flume, providing a water depth of 12 ft. ½ in. at the upper end and 13 ft. 10⅝ in. at the lower end. Last 300 ft. of flume passes through a reinforced-concrete spill basin with floor sloping to the center of west side, where a 50-ft. wasteway channel leads to the river. The flume section through this basin has lower sides, and if the turbine gates are closed the surplus water spills over the edge of the flume. The elevation of these sides is 1 ft. below the top of the flashboards of the dam. A steel-pipe penstock 12½ ft. in diameter and 557 ft. long extends from the end of the flume to the power house. The tailrace beyond the power house changes from a concrete canal section 21½ ft. wide to an earth section 190 ft. wide, leading to the river. The floor of the concrete section is 16½ ft. lower than the rest of the stream bed. This forms a pond, which serves as the draft-tube seal.

Power house and transmission system.—The power house differs in many respects from the usual power house. The substructure is concrete, and the third floor might be called the ground floor. In general, plan of the structure is L-shaped. The main building is the longer leg of the L, and a tower extends above the second floor at the end of the shorter leg. The inside dimensions of the main building are 26½ ft. by 44 ft. 7 in. by 12½ ft. high, and the lower tower is 13 by 17 ft., extending to a height of about 30 feet above the third floor. The walls are 12-in. hollow tile below the fourth floor and 10-in. tile above, with stucco finish. The window sills are concrete with steel sash. The roof is clay tile. At least 30 ft. above the ground over the main part of the building is a 60-ton motor-driven outdoor traveling crane with a 10-ton auxiliary. It is mounted on a structural-steel framework with a 29-ft. 2½-in. span and serves the entire length of the main building. The roof of this part of the building is made in halves, which are built on rollers. A structural-steel transfer track extends out from the north end of the building a sufficient distance to permit this roof to be rolled out free from the walls, thus allowing easy access to the heavy machinery for the crane. On the third floor is nothing but the generator. The part of the second floor below the generator contains substructures, and the part extending into the other leg of the L contains operator's quarters, switchboards, pumps, and the exciter unit. On the fourth floor, in the tower, are 6,600-v. bus bars, and on the fifth floor is a large lubricating-oil head tank.

Installation, one special design General Electric 7,000-v. 3-phase 60-cycle 7,500-kw. vertical generator unit. It is 18 ft. in diameter and can carry a very heavy overload. Water wheel on same vertical shaft below is 10,500-hp. 171.3-r. p. m. I. P. Morris Co. turbine. Static head at plant is 98 ft.; operating head, 95 ft. when flow is 1,260 sec.-ft. Exciter unit, one 75-kw. 250-v. motor generator set. Current is generated at 6,600 v. and transmitted direct to the Grace plant, where it is stepped up and connected into the main distribution system.

Remarks.—The flume and the construction details of the power house of this plant are unique. The system of operation is also noteworthy. The plant is completely controlled from the Grace station.

ONEIDA PLANT (10HC 4).[19]

Location and plan of development.—In secs. 23 and 26, T. 13 S., R. 40 E. Boise meridian, Idaho, about 29 miles downstream from the Grace plant and 110 miles north of Salt Lake City. The Bear River channel is forced against the high mountain on the west side of its canyon by Little Mountain, a prominent pyramidal hill connected to the east wall of the canyon by a low ridge. This ridge forms a natural dam across the canyon, and the river has cut a narrow channel around the end of it. In this narrow channel the Oneida dam was built, and the natural dike was also raised to serve as a dam. (See fig. 6 and Pl. X.)

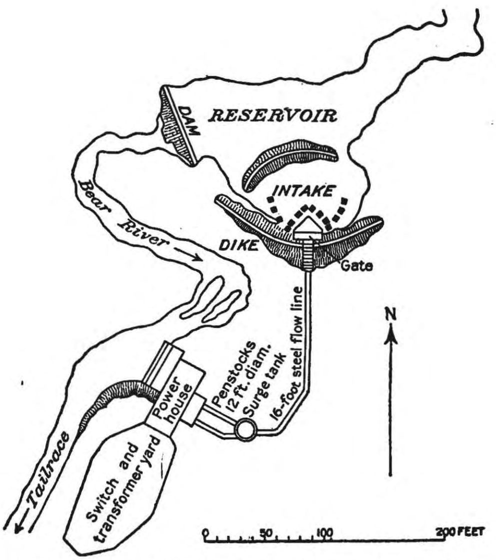


FIGURE 6.—Plan of Oneida power development, Bear River, Idaho.

Ownership and market.—Owner, Utah Power & Light Co. Market, Great Salt Lake basin and surrounding territory. (See old Grace plant, p. 67.)

Chronologic summary.—Construction started in December, 1912. Dam built to height of 85 ft. in 1913. Power house and conduit built in 1914–15. First unit began operating in August, 1915. Second unit began operating in August, 1916. Dam and dike raised 25 ft., to present level, in 1917. Third unit installed later part of 1920. Plant designed for four units. It was necessary to reconstruct one large irrigation canal and more than 20 miles of county highway. Permanent improvements to grounds are water-supply, sewage, and lighting systems and six frame dwelling houses on concrete foundations. Plant built by Utah Power & Light Co.

[19] Jour. Electricity, Power, and Gas, May 8, 1915.

Water supply.—Source of water, Bear River. Rights acquired by appropriation and use and through permits issued by the State engineer of Idaho. Stream flow is regulated by storage in Bear Lake, also by storage above the Oneida dam. Estimated Q90 flow 1,000 second-feet; corresponding power capacity about 11,600 hp.

Hydraulic features.—Dam, gravity section concrete, crest length 420 ft., height 116 ft., spillway 112 ft. long with five 15-ft. Taintor gates. Auxiliary spillway 176 ft. long forms part of crest. Two 6 by 6 ft. gates near middle and bottom for sluicing. Dike east of Little Mountain about 1,100 ft. long, rolled earth fill with upstream face riprapped. Intake, reinforced concrete, 80 ft. square; capacity, 4,400 sec.-ft. Two structural-steel gates 19 ft. 2 in. by 16 ft. 7 in. control the flow into the intake; openings equipped with structural-steel screens. Conduit, two 16-ft. steel pipes 220 ft. long extend from intake through the dike, providing for two lines. One 16-ft. steel pipe 2,022 ft. long is installed. Pipe line is laid in reinforced-concrete saddles and covered with earth. Plate-steel surge tank 40 ft. in diameter, 117 ft. high, on reinforced-concrete foundation, connects with pipe line. Plate material ⅜ in. thick at top, 1 in. at bottom. Two 12-ft. steel penstocks 116 ft. and 124 ft. long, lead from surge tank to power house and one from a T in the pipe line just above the surge tank. Johnson type motor-operated valves control the flow. Tailrace is about 1,000 ft. long and 118 ft. wide at power house. Sides and bottom are reinforced concrete.

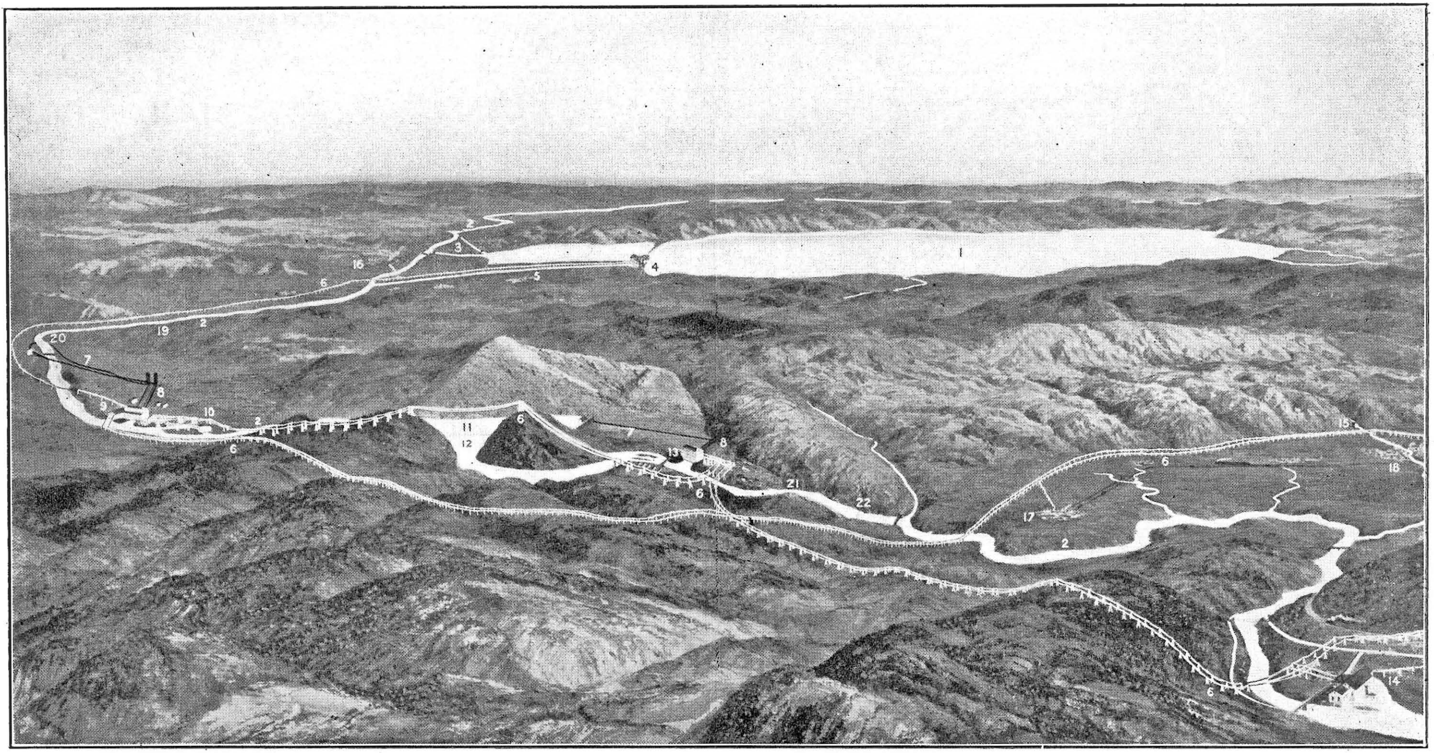
Power house and transmission system.—Power house (Pl. XI, *A*), structural-steel frame on reinforced-concrete foundation, supported partly on piles. Dimensions, 165 by 55 ft. by 46 ft. high. Walls, metal lath and plaster. Roof, interlocking reinforced-concrete tile. Window sash and doors metal. Windows, ribbed glass mechanically operated. All floors covered with ½-in. marbleoid composition. An 80-ton motor-operated crane serves part of the building containing heavy machinery. Installation, three 15,000-hp. I. P. Morris Co. vertical water turbines with oil-pressure governors. Each designed for 145-ft. head with 1,100 sec.-ft. of water. Operating head at plant 142 to 146 ft. Mounted on same shaft with each turbine is one 11,170-kva. 180-r. p. m. 6,600-v. 3-phase 60-cycle 10,000-kw. General Electric generator and one 100-kw. 250-v. compound-wound exciter generator. Seven outdoor-type 4,000-kva. 6,600-v. 130-kv. single-phase water-cooled transformers are installed; one is held in reserve. Current is generated at 6,600 v., stepped up to 130 kv., and transmitted to the terminal station at Salt Lake City for distribution.

Remarks.—This plant is used as the controlling plant of the system. Pondage above the dam is sufficient to carry any excessive peak-load demands long enough to allow the water stored in Bear Lake to reach the plant. All heavy fluctuations in load are readily handled owing to the increased efficiency of utilizing the water stored in Bear Lake.

WHEELON PLANT (10HC 5).[20]

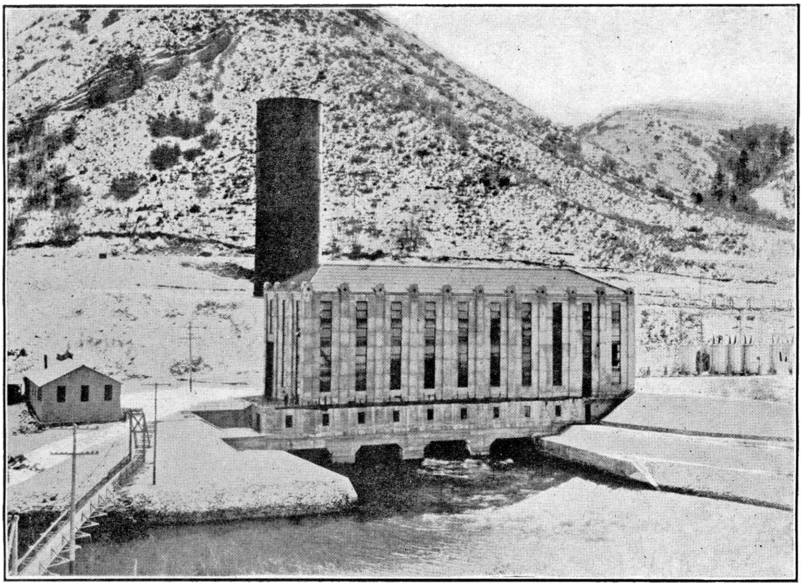
Location and plan of development.—In northern Utah, at the Gates, a short, steep canyon connecting Cache and Great Salt Lake valleys about 80 miles north of Salt Lake City, on Oregon Short Line Railroad. Dam at head of the canyon; power house near mouth of canyon, about 7 miles downstream, in sec. 27, T. 13 N., R. 2 W. Salt Lake meridian. Dam diverts water into a canal on each side of river. Canals parallel river 893 feet apart at power house. Power house on east side of river supplied through inverted-siphon penstock connecting the canals. (See Pls. X and XI, *B*.)

[20] Eng. News, Apr. 13, 1905: Elec. World and Eng., June 8, 1904; Jour. Electricity, Power, and Gas, May 8, 1915.

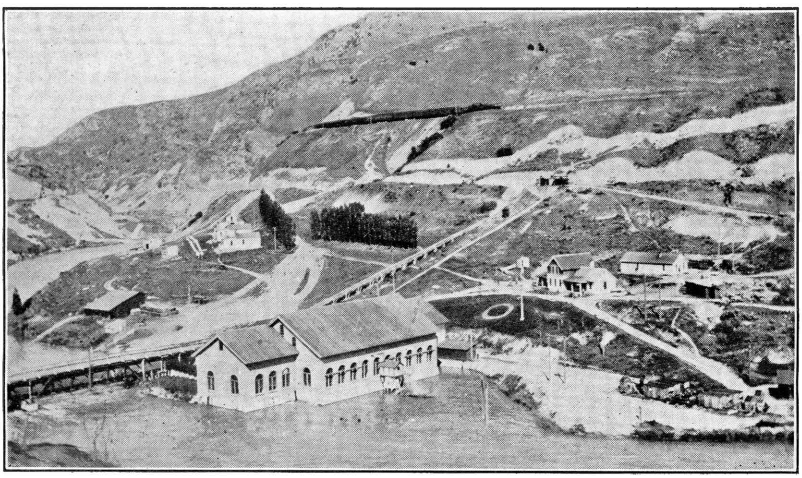


PANORAMIC SKETCH OF BEAR LAKE AND BEAR RIVER DEVELOPMENT.

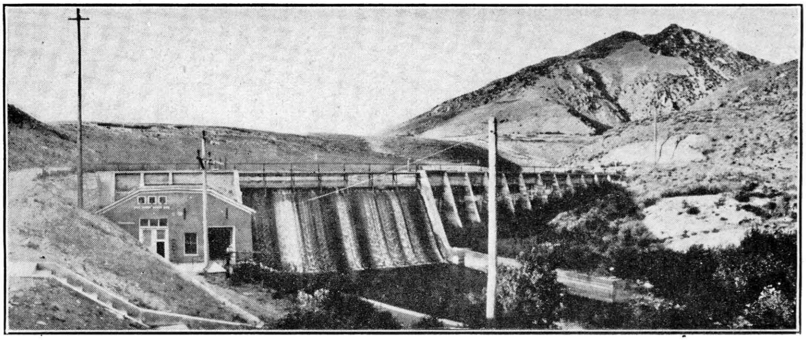
1, Bear Lake; 2, Bear River; 3, inlet canals to Bear Lake; 4, Lifton pumping plant; 5, outlet canal from Bear Lake; 6, transmission lines; 7, pipe lines; 8, surge tanks and penstocks; 9, Grace electric generating station; 10, Cove electric generating station; 11, storage pond at Oneida development; 12, dam at Oneida development; 13, Oneida electric generating station; 14, Wheelon electric generating station; 15, Logan electric generating station; 16, Montpelier, Idaho; 17, Preston, Idaho; 18, Logan, Utah; 19, Soda Point dam site; 20, Lava dam site; 21, Narrows dam site; 22, Mink Creek dam site.



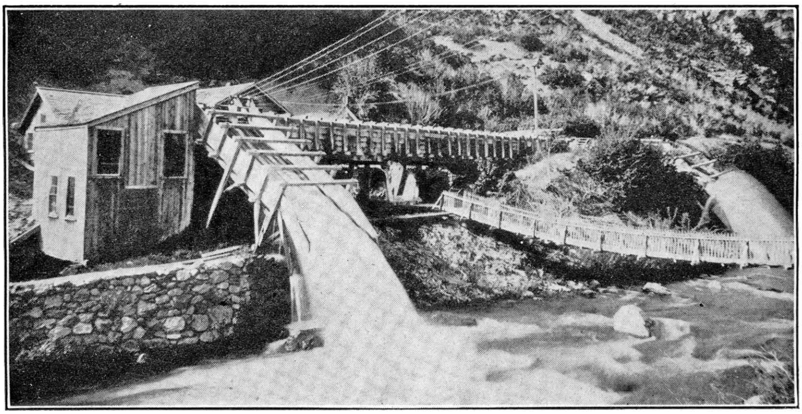
A. ONEIDA PLANT.



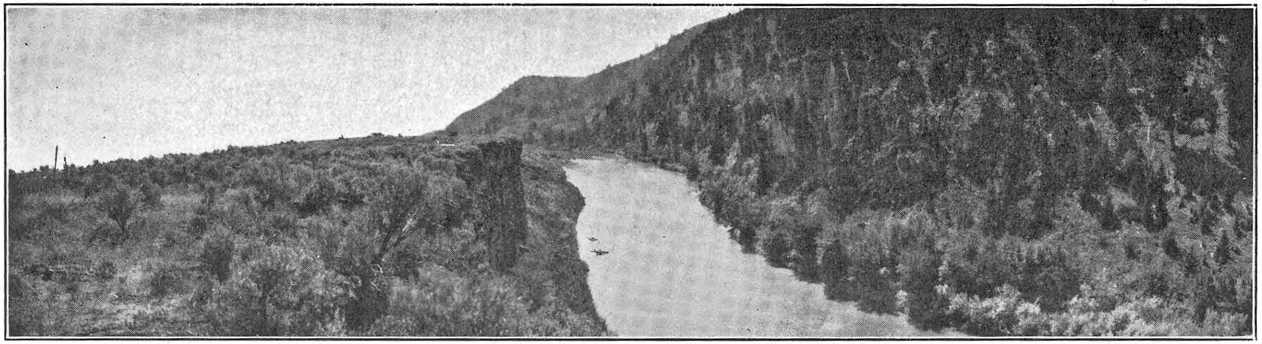
B. WHEELON PLANT, ON BEAR RIVER.



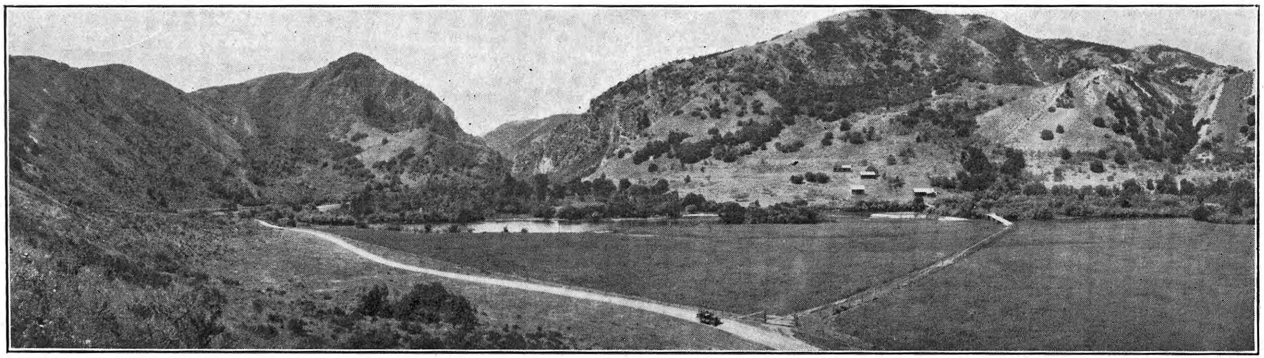
A. AGRICULTURAL COLLEGE POWER PLANT, AT MOUTH OF LOGAN CANYON, NEAR LOGAN.



B. HYDROELECTRIC PLANT BUILT IN OGDEN CANYON IN 1889.



A. VIEW UP BEAR RIVER AT SODA POINT DAM SITE, NEAR ALEXANDER, IDAHO.



B. VIEW DOWN BEAR RIVER CANYON TOWARD NARROWS DAM SITE, BELOW ONEIDA DEVELOPMENT.

Ownership and market.—Owner, Utah Power & Light Co. Market, Great Salt Lake basin and surrounding territory. (See old Grace plant, p. 67.)

Chronologic summary.—Dam and canals partly built by Bear Lake & River Waterworks & Irrigation Co.[21] in 1889–1891 as an irrigation enterprise. After many changes project passed into hands of Utah Sugar Co., which completed the development in 1903, finishing the work on the east canal and building the power plant. In 1904 frequent breaks on the east canal made it necessary to deepen the canal from the dam to the power house by 2 ft. Original installation in power house, two 750-kw. generators. Between December 1, 1904, and April 1, 1907, the power house was lengthened at both ends and two more units, each 750 kw., were installed. In 1907 top 5 ft. of dam was replaced with collapsible steel crest. Between April 1, 1907, and October 1, 1911, all four units were increased to 1,000 kw. each. In 1912 an annex was built on the rear of the building and another unit installed. In 1912 the Utah-Idaho Sugar Co., an outgrowth of the Utah Sugar Co., sold the power plant to the Utah Power & Light Co. The plant was originally operated by the Utah Light & Railway Co. in connection with the Pioneer plant, at Ogden.

Water supply.—Source of water, Bear River. Right acquired by appropriation and use. Stream flow regulated to some extent by stored water in Bear Lake. As use of water for power is subordinate to its use for irrigation, the plant is often shut down in the irrigation season. Estimated Q90 flow, 125 sec.-ft.; corresponding power capacity, 1,130 hp. Estimated Q50 flow, 590 sec.-ft.; corresponding power capacity, 5,330 hp.

Hydraulic features.—Dam,[22] rock-filled timber-crib weir, crest length 370 ft., maximum height 17½ ft., base width 38 ft. Foundation solid rock for nearly two-thirds width of river channel; remainder clay. Collapsible steel crest with flashboards to relieve flood strains and make easy disposition of accumulated dêbris.[23] Intake, iron gates in substantial masonry and concrete openings control flow into canals, one at each end of dam. Gates on west side hand operated, on east side electrically operated. Conduit, two canals, one on each side of river. First 2 miles of east canal in rock. Two tunnels have aggregate length of 623 ft. and many deep cuts, greatest being 97 ft. high on upper side. At many places bank near river is built up of rubble masonry cement. Next 5 miles of canal in steep earth hill slopes. West canal likewise in rock for 9,000 ft., with six tunnels from 57 to 279 ft. long and eleven intervening retaining walls. Each canal has capacity of 650 sec.-ft. Inverted siphon connects the two canals near mouth of canyon and forms penstock for power house. Canals continue and are used for irrigation. (See Pl. X.) Penstock, continuous wooden-stave pipe 8 ft. in diameter and 935 ft. long. Level part across bottom of canyon 418 ft. long, with its center 96 ft. below bottom of west canal and 93 ft. below bottom of east canal. Carried across river on a 3-span steel-truss bridge 150 ft. long on concrete piers. Inlets to penstock are concrete structures with two gates in canal line, one above and one below turnout, and a third gate in turnout leading into the siphon, all electrically operated. Water can be transferred from one canal to the other and closely regulated from both as desired. Four 66-in. and one 108-in. steel headers lead from the siphon to turbines in the power house, and one 24-in. header for exciter units. Tailrace is open channel.

Power house and transmission system.—Power house, brick building on concrete foundation in bedrock, originally 60 by 100 ft., enlarged to 60 by 136½ ft., inside

[21] Eng. News, Feb. 6 and 13, 1896.

[22] U. S. Dept. Agr. Office Exper. Sta. Bull. 249, pt. 2, 1912; U. S. Geol. Survey Thirteenth Ann. Rept., pt. 3, p. 226, 1893; U. S. Dept. Agr. Office Exper. Sta. Bull. 70,

[23] Eng. News, Oct. 3, 1907.

dimensions; later an annex 52 ft. square built on upstream side. (See Pl. X.) Installation, four Leffel (Samson) double-runner horizontal water turbines, each 1,700 hp. when operating at 400 r. p. m. under head of 116 ft.; one Wellman-Seaver-Morgan horizontal Francis type water turbine, 5,500 hp. when operating under above-stated conditions. Each Leffel turbine at full load requires 170 sec.-ft.; Wellman-Seaver-Morgan turbine requires 400 sec.-ft. Operating head at plant 110 ft.; static head 113 ft. All wheels designed for 116 ft. Direct-connected to each Leffel turbine is one 1,000-kva. 2,300-v. 60-cycle 3-phase Westinghouse generator. Similarly connected to the Wellman-Seaver-Morgan turbine is one 3,125-kva. 2,300-v. 60-cycle 3-phase Westinghouse generator. Exciter units for the four 1,000-kva. generator sets are two independent turbine-driven d. c. generators, 65 kw. each. For the 3,125-kva. unit also an independent unit, consisting of one 150-kw. Westinghouse d. c. generator connected to a 250-hp. Leffel water turbine. Total capacity of plant 7,125 kva. Current is generated at 2,300 v. Part is stepped up to 6,600 v. and transmitted to Fielding, Riverside, Garland, East Garland, and Tremonton, in Box Elder County, and Cache Junction, in Cache County, Utah. Remainder is transmitted to Ogden at 44,000 v. over wooden-pole line 45 miles long and there connected into the Utah Power & Light Co.'s general distribution system.

Remarks.—No thought was given to the development of power at this site until the Utah Sugar Co. discovered a surplus flow of water in Bear River during all except about two months in late summer and fall. The plant was built to utilize this flow and was named in honor of J. C. Wheelon, engineer for the company. The siphon penstock not only serves for power but is an advantageous adjunct of the irrigation system. If a break occurs in either canal between the plant and the dam, water for the plant may be carried around the break through the other canal and siphon. As a penstock, it affords a double conduit and insures more reliable water supply to the plant.

GEORGETOWN PLANT (10HC 6).

Location and plan of development.—In Bear Lake County, Idaho, about 2½ miles from Georgetown on the Oregon Short Line Railroad. Diversion dam in Georgetown Creek on unsurveyed land in what would be sec. 3, T. 11 S., R. 44 E. Boise meridian. Pipe line along south side of stream to power house, in sec. 4 of the same township (Pl. III).

Ownership and market.—Owner, Utah Power & Light Co. Market, territory served by Utah Power & Light Co. (See old Grace plant, p. 67.)

Chronologic summary.—Construction started in summer of 1904, completed in spring of 1905. Plant built by Montpelier Electric Light Co. Sold in July, 1908, to Bear Lake Power Co. Sold in 1914 to Utah Power & Light Co.

Water supply.—Source of water, Georgetown Creek. Rights acquired through State engineer of Idaho. Application made for 40 sec.-ft. Installed capacity of plant requires about 20 sec.-ft. Estimated Q90 flow 17 sec.-ft., corresponding power capacity about 190 hp. Estimated Q50 flow 25 sec.-ft., corresponding power capacity 260 hp. No regulation of stream flow.

Hydraulic features.—Dam, concrete core, which is remaining part of an earth-fill dam. About 15 ft. high. Surface area of small forebay reservoir about 12 acres. Conduit, intake at south end of dam opens into 33-in. wooden-stave pipe line laid in stream bed on a broken grade, length 4,900 ft.

Power house and transmission system.—Power house, small wooden building on south bank of creek. Installation, one 30-in. 300-hp. Leffel (Samson) turbine, direct connected to a 180-kw. 6,600-v. 3-phase 60-cycle Westinghouse generator. Exciter belt driven from generator shaft is a 10-kw. 126 e. m. f. 80-a. 513 r. p. m. Westinghouse generator. Operating head at plant 130 ft. Current generated at 6,600 v. and transmitted at that pressure over about 14 miles of 3-wire transmission line that connects into the general distribution system.

Remarks.—Before this plant was bought by the Utah Power & Light Co. it was used to supply a small local market, first to supply a few small towns on the east side of Bear Lake valley and later, in connection with the Paris plant, to supply a few additional small towns on the west side of the valley.

SODA SPRINGS PLANT (10HC 7).

Location and plan of development.—On Soda Creek, at north edge of town of Soda Springs. Diversion dam in Soda Creek near northwest corner of sec. 6, T. 9 S., R. 42 E. Boise meridian. Canal about 3,000 ft. long on west bank of creek leads to power house in same section (Pl. III).

Ownership and market.—Owner, Soda Springs Electric Co. Market, town of Soda Springs.

Chronologic summary.—Plant built by private individuals about 1908. Acquired by Soda Springs Electric Co. in 1908.

Water supply.—Source of water, Soda Creek. Rights acquired through State engineer of Idaho. Stream flow largely from springs, very uniform. Q90 and Q50 flows estimated to be 42 sec.-ft.; corresponding power capacity, approximately 170 hp.

Hydraulic features.—Dam, simple lumber structure 40 ft. long and 8 ft. high. Conduit, open canal, known as Horsley canal, built originally for irrigation, used for irrigation beyond power house. Length from dam to power house 3,000 ft. Penstock from canal to power house, 48-in. wooden-stave pipe. Tail water discharges directly into creek.

Power house and transmission system.—Power house, brick with concrete floor, one small room. Installation, one 250-hp. 20-in. Leffel horizontal turbine direct-connected to one 150-kw. 2,300-v. 37.7-a. 600-r. p. m. Allis-Chalmers generator. Exciter unit belt-driven from main generator shaft, 120-v. 83.3-a. 1,800-r. p. m. d. c. generator. Operating head at plant 50 ft. Current generated at 2,300 v.; all used in Soda Springs.

HIGH CREEK PLANT (10HC 8).

Location and plan of development.—In Franklin County, Idaho, 4 miles northeast of Franklin. Diversion dam in sec. 24, T. 15 S., R. 40 E. Boise meridian. Open canal along north side of stream; pipe penstock from canal to power house in sec. 34 of same township. (See Pl. III, also map of Preston quadrangle.)

Ownership and market.—Owner, Utah Power & Light Co. Market, territory served by Utah Power & Light Co. (See old Grace plant, p. 67.)

Chronologic summary.—Plant built about 1908 by High Creek Electric Co. Sold to Utah Power & Light Co. about 1913.

Water supply.—Source of water, Cub River. Rights acquired through State engineer of Idaho. No regulation of stream flow. Estimated Q90 flow 20 sec.-ft.; power capacity about 290 hp. Estimated Q50 flow 30 sec.-ft.; power capacity about 440 hp.

Hydraulic features—Dam, low timber-crib structure, crest length 45 ft., height 4 ft., timber wing walls. Intake, wooden flume, length 13 ft., width 7½ ft., controlled by three small wooden head gates. Conduit, open canal, 8 ft. wide at bottom, 5 ft. deep, mostly in earth. Two flume sections having aggregate length of 470 ft. Total length of canal from dam to intake to penstock 16,732 ft. Intake to penstock lumber pressure box with compartment for carrying water for irrigation into continued canal; spillway to creek for all surplus water. Penstock continuous wooden-stave pipe, length 827 ft. First 200 ft. 40 in. in diameter; remainder 36 in. in diameter. Branches into Y, each branch to a water wheel. Tailrace open channel to creek.

Power house and transmission system.—Power house, small frame building on north bank of creek. Installation, two 500-hp. 600-r. p. m. Platt Iron Works horizontal turbines, one direct-connected to an Allis-Chalmers 350-kva. 2,300-v. generator, the other similarly connected to a Warren Electric 200-kva. 2,300-v. generator. Both turbines together under full generator load (550 kva.) require 57 sec.-ft. of water under head of 177 ft. Operating head at plant 177 ft., static head 182 ft. Current generated at 2,300 v., stepped up to 11,000 v., and carried over wooden-pole transmission line to Franklin, where it is connected into the general distribution system of the Utah Power & Light Co.

LOGAN CITY PLANT (10HC 9).

Location and plan of development.—In Cache County, Utah, 5 miles east of Logan. Diversion dam in NE. ¼ sec. 28, T. 12 N., R. 2 E. Salt Lake meridian. Flume and pipe line leading from south end of dam across stream to power house on north bank in SE. ¼ sec. 29 of same township (Pl. III). Power house immediately above diversion for Logan plant of Utah Power & Light Co.

Ownership and market.—Owner, city of Logan. Market, city of Logan.

Chronologic summary.—Plant built by city in 1904. Pipe line collapsed 1923 and reconstruction started August, 1923. Development to be enlarged.

Water supply.—Source of water, Logan River. Rights acquired by appropriation and use and by purchase. No regulation of stream flow. Estimated Q90 flow 155 sec.-ft., Q50 flow 264 sec.-ft.; corresponding power capacities, 1,120 and 1,900 hp., respectively.

Hydraulic features.—Dam, overflow timber crib, crest length 68½ ft., height 15 ft., filled in with rock. Intake, rectangular flume section controlled by three wooden gates, each 4 ft. wide. Conduit, first 700 ft. rectangular flume with spillway about middle of the stretch into the river. End of flume through vertical section, forming one leg of an inverted siphon, connected with 60-in. wooden-stave pipe, which extends across river and follows natural ground surface to power house, tapers to 54 in. in diameter at power house. Total length of conduit 6,700 ft. Tailrace open channel to river.

Power house and transmission system.—Power house, small one-story brick building 38 by 44 ft. Installation, two 22-in. 250-hp. double-discharge Victor horizontal turbines, each direct-connected to one 250-kw. 6,600-v. 60-cycle 3-phase Allis-Chalmers generator. Operating head at plant 80 ft., output approximately 450-kw., static head approximately 90 ft. Current generated at 6,600 v., carried over 3-phase 3-wire transmission line to substation in center of Logan, distance 5 miles. Voltage reduced to 2,300 v. by six 100-kw. 6,600/2,300-v. transformers. Distribution system comprises about 40 miles of service lines.

Remarks.—Plant being enlarged. Plans contemplate higher dam, larger pipe line, and increased power capacity.

LOGAN OR HERCULES PLANT (10HC 10).[24]

Location and plan of development.—In Logan Canyon, 3 miles from Logan, Utah, and 72 miles from Salt Lake City. Diversion dam in sec. 29, T. 12 N., R. 2 E. Salt Lake meridian. Flume along north side of river to power house at mouth of canyon, in sec. 36, T. 12 N., R. 1 E. Salt Lake meridian (Pl. III).

Ownership and market.—Owner, Utah Power & Light Co. Market, territory served by Utah Power & Light Co. (See old Grace plant, p. 67.)

[24] Min. and Eng. World, Oct. 12, 1912.

Chronologic summary.—Water rights initiated by Hercules Electric Co. in 1893. Present plant built by Telluride Power Co. about 1903. Sold to Utah Power & Light Co. in 1912.

Water supply.—Source of water, Logan River. Rights established through appropriation and use. First appropriation made by Hercules Electric Co.; claimed "all water in Logan River except right of Logan, Hyde Park, and Smithfield canal." Capacity of flume approximately 200 sec.-ft. No regulation of stream flow. Estimated Q90 flow 100 sec.-ft., Q50 flow 150 sec.-ft.; corresponding power capacities 1,600 and 2,560 hp., respectively. Flow affected by irrigation diversion above power plant.

Hydraulic features.—Dam, timber crib, crest length 112 ft., with 72-ft. spillway section, height about 12 ft. Intake, at north end of dam, housed in small frame building, is wooden well and flume, equipped with four hand-operated control gates and a sand sluice gate. Conduit, wooden flume, rectangular section, sides 2-in. Douglas fir. All cracks battened with ⅜-in. by 3-in. strips. Vertical battens 16 ft. apart, beveled on upstream edge. Inside dimensions 6 ft. wide, 5¼ ft. deep. Hydraulic grade 0.00169.[25] Course of flume exceedingly tortuous, along steep, rocky hillside. Many sharp bends and long stretches of trestle work. Total length from dam to penstock intake 9,250 ft. One tunnel 230 ft. long. 70-ft. spillway at penstock intake. Concrete pressure box at head of penstocks serves as surge tank. Two riveted steel-pipe penstocks, 44 in. in diameter, length 331 and 358½ ft. Two exciter-unit penstocks 10 in. in diameter, 345 ft. long. Tailrace open channel with rubble masonry walls.

Power house and transmission system.—Power house, buff brick on masonry foundation. A 10-ton hand-operated crane serves entire interior. Surrounded by lawns, flowers, and shade trees. An attractive cottage for attendant. Installation, two 1,500-hp. 400-r. p. m. Leffel horizontal turbines. Two 1,000-kva. 1,150-v. 3-phase 60-cycle revolving-field General Electric generators direct-connected to turbines. Two exciter units, each consisting of one 11-in. Leffel turbine direct-connected to one 30-kw. 125-v. d. c. generator. Large turbines designed for 200-ft. head. Operating head at plant 208 ft.; static head 213 ft. Each unit uses 81.5 sec.-ft. of water with 1,000-kw. load.

Current stepped up to 44,000 v. and transmitted to terminal substation at Salt Lake City, thence distributed through Utah Power & Light Co.'s system.

Remarks.—Water from Logan River was used for developing power as early as 1866. Twelve individual plants use its water for power. Nine small industrial establishments use water power direct for their needs. The other three are hydroelectric plants, generating power for commercial, State, and municipal use.

AGRICULTURAL COLLEGE PLANT (10HC 11).

Location and plan of development.—In Cache County, Utah, 2½ miles east of Logan, at mouth of Logan Canyon. Dam and power house built together in sec. 36, T. 12 N., R. 2 E. Salt Lake meridian (Pl. III).

Ownership and market.—Owner, State of Utah. Market, State institutions—Agricultural College at Logan, Industrial School and Utah School for Deaf and Blind at Ogden, University of Utah and State Prison at Salt Lake City.

Chronologic summary.—Construction begun in October, 1911, completed in February, 1913.

Water supply.—Source of water, Logan River. Right acquired through State engineer of Utah, application filed in May, 1908. Certificate of water right issued for 150 sec.-ft. Very small amount of storage regulation above dam. Estimated Q90 flow 100 sec.-ft., Q50 flow 150 sec.-ft.; corresponding power capacities 240 and 360 hp., respectively. Flow affected by irrigation diversion above.

[25] U. S. Dept. Agr. Bull. 194, 1915.

Hydraulic features.—Dam, hollow, reinforced concrete, crest length 257 ft., including 70-ft. weir spillway provided with flashboards, maximum height above bedrock 51.3 ft., width 56 ft. Surface area of forebay pond 13 acres. Storage capacity 160 acre-feet. Penstock well 12 by 14 ft. by 25½ ft. deep, with three lumber control gates, each 4 by 8½ ft., operated by handwheels on screw stems. Trash rack, steel bars, 2-in. centers.

Power house and transmission system.—Power house (Pl. XII, *A*), reinforced concrete, 20 by 27½ ft. inside, built into west end of dam. Installation, one 40-in. Allis-Chalmers horizontal turbine direct-connected to one 400-kw. 6,600-v. 3-phase 60-cycle 200-r. p. m. Allis-Chalmers generator. Operating head fluctuates from 30 to 33 ft.

Remarks.—By special act of the Utah State legislature, approved March 9, 1911, an appropriation of $40,000 was made for a hydroelectric plant to be erected on Logan River, "in order to furnish light and power for the Agricultural College at Logan, Utah, including the Experiment Station, and for the Industrial School and the Utah School for the Deaf and Blind, at Ogden, Utah, for the University of Utah, including the State Normal School at Salt Lake City, Utah, and for the State Prison at Salt Lake City, Utah." The State did not build a transmission line to Ogden and Salt Lake City, and to get the power to these places the above-mentioned special act further states:

"The Board of Trustees of the Agricultural College is hereby authorized and empowered to make such contracts as shall be proper and reasonable, with individuals, with private or municipal corporations for the purpose of having transmitted such electric energy as may not be used at the Agricultural College and Experiment Station at Logan, Utah, to other State institutions."

An additional appropriation of $20,000 was made by the State legislature during the session of 1913, and still another one of $30,322.55 was made during the session of 1915 in order to complete the construction work. Maintenance of the plant during 1915–16 was included in the appropriation of 1915.

HYRUM PLANT (10HC 12).

Location and plan of development.—In Cache County, Utah, at the mouth of Blacksmith Fork canyon, 3 miles east of Hyrum. Diversion dam near the line between secs. 7 and 8, T. 10 N., R. 2 E. Salt Lake meridian. Pipe line along south side of stream to power house in NE. ¼ sec. 11, T. 10 N., R. 1 E. (Pl. III).

Ownership and market.—Owner, Utah Power & Light Co. Market, territory served by Utah Power & Light Co. (See old Grace plant, p. 67.)

Chronologic summary.—Construction started in May, 1912; completed in January, 1913. Plant built by Blacksmith Fork Light & Power Co. Sold to Utah Power & Light Co. in 1913.

Water supply.—Source of water, Blacksmith Fork. Rights acquired through State engineer of Utah. Filing made for 125 sec.-ft. in 1906, increased to 200 sec.-ft. in 1911. Small amount of stream-flow regulation in forebay pond. Estimated Q90 flow 74 sec.-ft., Q50 flow 120 sec.-ft.; corresponding power capacities 1,520 and 2,460 hp., respectively.

Hydraulic features.—Dam, ogee section, concrete, crest length 60 ft., maximum height above bedrock 34 ft. with provisions for flashboards to additional height of 5 ft. Forebay-pond area 23.1 acres, capacity 300 acre-ft. Intake, at south end of dam, concrete well 38 by 10 ft. by 34¼ ft. deep, equipped with trash racks. Iron gate 7⅙ ft. square on mechanically operated screw. Conduit, continuous wooden-stave pipe, inside diameter 6 ft., length 14,332 ft. from intake to penstock. On steep hillside laid on uniform grade 7.5 ft. to a mile, except one stretch of 900 ft. where inverted siphon is a 78-in. steel pipe 50 ft. long to surge tank, 18 ft. inside diameter and 36 ft. long. Bottom of tank is hemispherical in section and connects with upturned end of steel pipe. Tank riveted steel on structural-steel columns set on concrete foundation. Total height above foundation 54 ft. Penstock riveted-steel pipe, length 335 ft. Diameter at top 78 in., at bottom 60 in. Lower end connected with Venturi meter having 31-in. throat. Tailrace open channel to river.

Power house and transmission system.—Power house, brick on concrete foundation, inside dimensions 65 by 40 ft. Flat roof sloping from 29½ ft. above ground at front to 27½ ft. at rear. A 10-ton hand-operated crane 25-ft. span serves entire interior. Installation, two 2,150-hp. 30-in. 600-r. p. m. Allis-Chalmers horizontal turbines, direct-connected to two 1,250-kva. 4,000-v. 600-r. p. m. ATB General Electric generators. On same shafts, two 32-kw. 125-v. 256-a. d. c. General Electric exciter generators. Turbines rated for head of 235 ft. Operating head at plant 238 ft., static head 256 ft. Each turbine uses 86 sec.-ft. of water under 238-ft. head, to generate 1,250 kw. Two 1,350-kw. 3-phase transformers, 4,000/-45,000 v., raise voltage to 44 kv. for transmission to Salt Lake terminal station, from which it is distributed over the general system of the Utah Power & Light Co.

HYRUM CITY PLANT (10HC 13).

Location and plan of development.—In Cache County, Utah, near the mouth of Blacksmith Fork canyon, 3 miles east of Hyrum. Diversion dam immediately below the Hyrum plant of the Utah Power & Light Co.; small canal about half a mile long on south side of river leading to power house (Pl. III).

Ownership and market.—Owner, city of Hyrum. Market, city of Hyrum.

Chronologic summary.—Plant built about 1900. Operated as private enterprise until 1910. Purchased by city in 1910. All the original machinery has been replaced.

Water supply.—Source of water, Blacksmith Fork. Rights acquired by appropriation and use. Requirements for full load at plant about 100 sec.-ft., but this amount is not always available. Estimated Q90 flow 74 sec.-ft., Q50 flow 107 sec.-ft.; corresponding power capacities 100 and 150 hp., respectively. Power flow reduced by irrigation part of year.

Hydraulic features.—Dam, loose rock. Conduit, small canal used jointly for irrigation and power purposes. Canal extends beyond power house for irrigation. Power branch of canal terminates in a vertical timber penstock, which contains the water wheel.

Power house and transmission system.—Power house, small frame building about 25 by 35 ft. Installation, one 158-hp. 24-in. double-runner Platt turbine, belt-connected to one 100-kw. 4,000-v. 60-cycle 3-phase Western Electric Co. generator and to a 5-kw. d. c. exciter generator. Operating head at plant 18 ft. Current taken directly from generator over 3-phase 4-wire neutral transmission line to the city. All the current is used in the city, but the plant does not furnish enough to supply demands. The city distribution system is connected into the system of the Utah Power & Light Co., and some power is bought from that company.

SUMMARY.

Developed power sites in Bear River basin.

Index No.	Name of plant.	Stream.	Static head (H).	Rated capacity of installed water wheels.	With existing flow. Q90	With existing flow. Q50	With existing flow. Horsepower. 0.08HQ90	With existing flow. Horsepower. 0.08HQ50	With regulated flow. Q90	With regulated flow. Q50	With regulated flow. Horsepower. 0.08HQ90	With regulated flow. Horsepower. 0.08HQ50
			Feet.	*Horsepower.*	*Sec.-ft.*	*Sec.-ft.*			*Sec.-ft.*	*Sec.-ft.*		
10HB 1	McNeice	Pine Creek	103	100	11	16	90	130				
10HB 2	Swan Creek	Swan Creek	150	140	45	45	540	540				
10HB 3	Paris	Paris Creek	346	1,180	17	23	480	640				
10HC 1	Old Grace	Bear River	484	17,000					900	900	38,000	38,000
10HC 2	New Grace	do	524	51,000								
10HC 3	Cove	do	98	10,500					900	900	7,100	7,100
10HC 4	Oneida	do	145	45,000					1,000	1,000	11,600	11,600
10HC 5	Wheelon	do	113	12,300					125	590	1,130	5,330
10HC 6	Georgetown	Georgetown Creek	130	300	17	25	190	260				
10HC 7	Soda Springs	Soda Creek	50	250	42	42	170	170				
10HC 8	High Creek	Cub River	182	1,000	20	30	290	440				
10HC 9	Logan city	Logan River	90	500	155	264	1,120	1,900				
10HC 10	Logan	do	213	3,000	100	150	1,600	2,560				
10HC 11	Agricultural College	do	30	[a] 550	100	150	240	360				
10HC 12	Hyrum	Blacksmith Fork	256	4,300	74	120	1,520	2,460				
10HC 13	Hyrum city	do	18	158	74	107	100	150				
				147,278								

[a] Estimated.

NOTE.—The computed power capacities shown in this table are based somewhat arbitrarily on the time elements and other specified conditions given on pp. 109–110. They serve for comparison of power sites considered as individual sites, but they bear no definite relation to the installed capacities or the energy output of plants in the Utah Power & Light Co.'s system, because of the Bear River regulation and interconnection of plants, which permits a maximum utilization of the smaller streams.

WEBER RIVER BASIN.

WEBER OR DEVILS GATE PLANT (10HE 1).[26]

Location and plan of development.—At mouth of Weber River canyon, 8 miles southeast of Ogden, Utah, on Union Pacific Railroad. Diversion dam 3 miles above mouth of canyon, in SW. ¼ sec. 28, T. 5 N., R. 1 E., Salt Lake base and meridian; pipe line along south side of stream to power house in E. ½ sec. 30 (Pl. III).

Ownership and market.—Owner, Utah Light & Traction Co. Leased to Utah Power & Light Co. Market, territory served by Utah Power & Light Co. (See old Grace plant, p. 67.)

Chronologic summary.—Plant built by Utah Light & Railway Co. in 1909. Sold to Utah Light & Traction Co. in 1914. Leased to Utah Power & Light Co. in January, 1915. Spillway section of dam reconstructed in 1915–1917.

Water supply.—Source of water, Weber River. Rights acquired through appropriation and use. Entire flow of river entering Salt Lake valley available for use at plant, and in addition to natural flow all water released by Davis & Weber Counties Canal Co. from its reservoir of 28,000 acre-feet capacity, on East Canyon Creek. Stored water released during irrigation season when natural river flow is low. Because of these conditions plant operates at full capacity continuously. Estimated Q90 flow 250 sec.-ft., Q50 flow 420 sec.-ft.; corresponding power capacities 3,960 and 6,650 hp., respectively.

Hydraulic features.—Dam, originally hollow concrete overflow type; crest length 139 ft.; height 14 ft.; spillway section 65½ ft. Eleven sluiceways 5 ft. in diameter through bottom controlled by butterfly gate valves, from within dam. With all sluiceways open, pipe line full, and 2 ft. of water passing over crest, works were designed to handle flood flow of 5,320 sec.-ft. Highest flood recorded was 4,530 sec.-ft. in May, 1890. These provisions necessary to insure safety of main line of Union Pacific Railroad, which passes through canyon. At dam site railroad bed is only 20 ft. above river bed. Present dam same height as before. Sluiceways are closed, end abutments reinforced, additional abutment pillar built in center, and top 7 ft. replaced by two hand-operated 29-ft. Taintor gates. Intake, at south end of dam. Screened concrete bay 20 ft. wide, opens into tapered-section concrete pipe 12 to 7 ft. in diameter. Controlled by hand-operated valve in small brick gatehouse. Conduit, first 2,000 ft. continuous reinforced-concrete pipe 7 ft. in diameter, walls 9 in. thick, built in place. Pipe line at edge of stream. Vertical cut-off wall built along side of stream to prevent scouring under pipe at exposed places. Concrete pipe connected to continuous wooden-stave pipe 74 in. in diameter, 7,075 ft. long. Wooden pipe laid in trench follows generally natural ground surface. Penstock, riveted steel pipe 74 in. in diameter, 75 ft. long to power house. Tailrace opens directly into river.

Power house and transmission system.—Power house, one-story brick building, dimensions 58 ft. 5 in. by 76 ft. 6 in., concrete foundations, flat roof. Hand-operated Whiting crane 32 ft. 3 in. span serves entire interior. Three-room brick cottage at dam for attendant in charge of dam and gates. Installation, one 5,000-hp. single-unit Francis turbine direct-connected to one 2,500-kw. 2,300-v. Western Electric generator. One 40-kw. 125-v. d. c. 1,155-r. p. m. belt-driven Western Electric exciter generator. Two exciter units unstalled, one held in reserve. Operating head at plant 147 ft., static head 198 ft. Generator output 3,200 kw. with stream flow of 332 sec.-ft. Mean annual output 3,000 kw. Machine rated

[26] Eng. Rec., Apr. 2, 1910.

at 2,500 kw. Current generated at 2,300 v., leaves plant at 44,000 v., and is distributed over system of Utah Power & Light Co.

RIVERDALE PLANT (10HE 2).[27]

Location and plan of development.—On Weber River below mouth of canyon. Power house 4 miles south of Ogden, Utah. Diversion dam at mouth of canyon, in sec. 30, T. 5 N., R. 1 E., Salt Lake base and meridian, canal along south side of river; penstock from canal to power house, in NW. ¼ sec. 19, T. 5 N., R. 1 W. (Pl. III).

Ownership and market.—Owner, Utah Power & Light Co. Market, territory served by company. (See old Grace plant, p. 67.)

Chranologic summary.—Construction work started in October, 1910; completed in November, 1912. Built by Davis & Weber Counties Canal Co. Acquired by Utah Power & Light Co. in January, 1913.

Water supply.—Source of water, Weber River. Rights acquired through State engineer of Utah in 1909 for 300 sec.-ft. Permission to use 18 sec.-ft. additional in irrigation season from Riverdale ditch, which passes power house. Borrowed water returned to ditch below plant by 100-hp. motor-driven centrifugal pump. Lift 30 ft., 325 hp. developed by use of water. Net gain in power 225 hp. Only natural flow of river below power house available for use at plant. Storage water in East Canyon Creek; reservoir used for irrigation on bench ands beyond penstock intake. Estimated Q90 flow 70 sec.-ft., Q50 flow 275 sec.-ft.; corresponding power capacities 1,120 and 4,400 hp., respectively.

Hydraulic features.—Dam, concrete, submerged type, crest length 78 ft.; height 6 ft. Intake at south end of dam. Forebay section with trash racks set nearly parallel with course of stream, about 80 ft. long, tapers into concrete flume section 39⅔ to 20 ft. wide. Short distance downstream from axis of dam 48-ft. spillway with flashboards built into river side of flume. Control of flow into canal effected by Taintor gate set in flume about 50 ft. beyond spillway. Conduit, open canal along hillside on south side of Weber River. Originally built in early eighties for irrigation. Reaches top of bench known as Sand Ridge, at point about 9.5 miles from dam. Maximum capacity originally 210 sec.-ft. with seepage loss of 11 per cent in first 10 miles. In fall of 1909 several sections of canal reconstructed to uniform grade and curvature, and entire canal lined with concrete. First 4,000 ft. below headgate, rectangular flume section in solid rock. Next 38,485 ft. to power house, trapezoidal section. Bottom 22 ft., top 34 ft., depth 6 ft., side slopes 1 to 1. Capacity from dam to power house 725 sec.-ft.; 300 sec.-ft. for power, 425 sec.-ft. for irrigation. Forebay, 3 acre-ft. capacity, made at head of penstocks by widening section of canal to 60 ft. Spillway 200 ft. long over north bank into chute leading to tailrace. Penstock intake, concrete, 50 by 60 ft. with four bays—three for separate penstocks for 3,750-hp. turbo-generator units, one for 2,000-hp. unit. Controlled by screw-stem gates in brick gate house. One 3,750-hp. penstock and the 2,000-hp. penstock installed. Both penstocks riveted-steel pipe 1,400 ft. long. Larger one tapers from $7\frac{1}{4}$ to $5\frac{5}{12}$ ft. in diameter; other from $5\frac{5}{12}$ to $3\frac{3}{4}$ ft. Fitted with automatically controlled relief valves designed to replace surge tanks. Penstocks drop 173 ft. in first 400 ft. Remainder of distance on comparatively level flood plain of river. Carried in steel saddles spaced about 20 ft. apart in concrete piers. Discharge channels under power house, concrete, 19 ft. wide at bottom, 23 ft. deep below power-house floor. Tailrace open channel to river, length about 400 ft.

Power house and transmission system.—Power house, buff brick, dimensions 74 ft. 2 in. square inside, on concrete foundations. A 15-ton hand-operated Whit-

[27] Eng. Rec., Dec. 14, 1921; Jour. Electricity, Power, and Gas, May 8, 1915; Elec. World, Dec. 7, 1921.

ing crane, 41 ft. 8½ in. span. Installation, two Allis-Chalmers horizontal turbines. One 3,750-hp. 450-r. p. m. turbine direct-connected to one 2,500-kva. 2,300-v. 628-a. General Electric generator. One 2,000-hp. 600-r. p. m. turbine direct-connected to one 1,250-kva. 2,300-v. 314-a. General Electric generator. Two 50-kw. d. c. exciter generators, one motor driven, other turbine driven by small water wheel supplied with water through pipe tapped into both penstocks. Water wheels designed for 200-ft. head. Operating head at plant 198 to 200 ft. Water required by wheels under 198-ft. head and full generator load, 213 and 107 sec.-ft., respectively. To avoid impact heads at sudden shutdowns, governors connected with synchronous relief valves on turbine gates which automatically open by-pass when turbine wickets close. Capacity of by-pass 15 per cent greater than that of turbine at full load. By-pass openings close slowly by mechanical water-saving device. Current leaves plant at 11,000 and 44,000 v. and is distributed through system of Utah Power & Light Co.

BUTLER PLANT (10HE 3).

Location and plan of development.—In Summit County, Utah, about 2 miles from Kamas. Diversion dam in NW. ¼ sec. 26, T. 2 S., R. 6 E., Salt Lake base and meridian; small canal terminating in penstock leads to power house in western part of sec. 22 (Pl. III).

Ownership and market.—Owner, G. W. Butler. Market, town of Kamas.

Chronologic summary.—Plant built by G. W. Butler in 1913.

Water supply.—Source of water, Beaver Creek, a tributary of Weber River. Rights acquired through State engineer of Utah. Estimated Q90 flow 15 sec.-ft., Q50 flow 20 sec.-ft.; corresponding power capacities 120 and 160 hp., respectively.

Hydraulic features.—Dam, low concrete structure. Conduit, small canal about 1 mile long. Wooden-stave pipe penstock 36 in. in diameter to power house. Static head about 100 ft.

Power house and transmission system.—Power house, small wooden building. Installation, one 20-in. Pelton water wheel direct-connected to one 150-kw. 4,000-v. 3-phase 600-r. p. m. General Electric generator; one Westinghouse d. c. 115-v. belt-driven exciter generator. Current transmitted to Kamas at 4,000 v. and there stepped down for use.

Remarks.—Plant operates only during night, about 12 hours daily; no day load.

PIONEER PLANT (10HE 4).[28]

Location and plan of development.—In lower part of Ogden Canyon, east of Ogden, Utah. Diversion dam across canyon in SW. ¼ sec. 16, T. 6 N., R. 1 E., Salt Lake base and meridian; pipe line from south end of dam across river and along north wall of canyon to power house below mouth of canyon in NW. ¼ sec. 22, T. 6 N., R. 1 W. (Pl. III).

Ownership and market.—Owner, Utah Light & Traction Co., leased to Utah Power & Light Co. Market, territory served by Utah Power & Light Co. (See old Grace plant, p. 67.)

Chronologic summary.—Preliminary surveys made in 1894–95. Definite locations made and construction work started in 1896. Construction completed and plant in operation in 1897. Plant built by Pioneer Electric Co. Merged into Union Light & Power Co. Later acquired by Utah Light & Railway Co. and finally by Utah Light & Traction Co.

Water supply.—Source of water, Ogden River. Rights acquired through appropriation and use. Small amount of storage regulation above dam. Esti-

[28] Am. Soc. Civil Eng. Trans., May, 1897; Elec. Eng., April, 1898; Min. and Sci. Press, July, 1897; Jour. Electricity, March, 1898; Elec. World, October, 1897.

mated Q90 flow 45 sec.-ft., Q50 flow 85 sec.-ft.; corresponding power capacities 1,690 and 3,200 hp., respectively.

Hydraulic features.—Dam, timber crib; crest length 260 ft.; spillway at north end 66 ft. long. Dam originally 12 ft. high; later raised to present height, 15.7 ft. (Pl. VII, *B*). Spillway provided with structural-steel framework for flashboards to point 12 ft. below top of dam. Also 4 by 4 ft. sluice gate operated by crank and bevel gears on screw stem. Intake, tunnel at south end of dam, controlled by two 72-inch valves in small brick house about 200 ft. downstream from dam. One valve for pipe line; the other for surplus pipe leading back into river, below spillway. Conduit, wooden-stave pipe, length 27,000 ft., diameter 6 ft. Riveted steel penstock 4,600 ft. long. Upper part of pipe line mainly in earth excavation. Timber bridge of 75-ft. span carries pipe across Ogden River near Hermitage. Toward mouth of canyon pipe in limestone and quartzite rock along almost sheer walls 200 to 500 ft. above stream. Eight tunnels, longest 667 ft. Eight steel bridges, total length 560 ft. All material carried across river on temporary bridges and raised to place on inclines. Steel penstock made in sections on ground from steel plates, coated with asphalt. Y in penstock 100 ft. above power house. Each branch connects with receiver extending along each side of power house. Supply pipes to turbines tap into receivers. Venturi meters in penstock. Tailrace, open channel connecting with irrigation canals and river.

Power house and transmission system.—Power house, brick; dimensions 135 by 50 ft. Concrete and rubble footings, roof trusses steel on steel posts, roofing sheet metal. A 15-ton hand-operated crane serves entire interior. Designed for ten turbo-generator units arranged symmetrically on long axis of building. Five units installed. Installation, one 1,300-hp. and one 1,700-hp. 300-r. p. m. Knight pattern impulse water wheels each direct-connected to a 750-kw. 2,300-v. 3-phase General Electric generator. Two 3,750-hp. S. Morgan Smith horizontal turbines direct-connected to two 2,500-kw. generators. Two small d. c. generators each direct-connected to a 135-hp. water wheel serve as exciters. Original installation was five 1,200-hp. Knight pattern water wheels; this was changed in 1914. Plant capacity was increased from 3,750 to 6,500 kw. Operating head at plant about 440 ft., static head 470 ft. Current generated at 2,300 v. Part leaves plant at 11,000 to 23,000 v. for use in vicinity of Ogden; remainder transmitted at 44,000 v. to terminal station at Salt Lake City.

Remarks.—At the time this plant began operations it was one of the largest hydroelectric plants in the country. Some of the first experiments in high-voltage transmission were tried here. Power was carried to Salt Lake City over about 36 miles of transmission lines at 30,000 v., with loss of only 9 per cent—an achievement so far in advance of anything previously undertaken that it became world renowned as an epoch-marking event in the electrical field. Original plan contemplated a 60-ft. dam in Ogden Canyon, making a reservoir covering 2,000 acres and having a capacity of 43,000 acre-ft. This would enable regulation for power and supply water for irrigating about 18,000 acres of new land. Company was unable to finance this plan and built lower dam.

SUMMARY.

Developed power sites in Weber River basin.

Index No.	Name of plant.	Stream.	Static head (H).	Rated capacity of installed water wheels.	With existing flow.				With regulated flow.			
					Q_{90}	Q_{50}	Horsepower.		Q_{90}	Q_{50}	Horsepower.	
							$0.08HQ_{90}$	$0.08HQ_{50}$			$0.08HQ_{90}$	$0.08HQ_{50}$
			Feet.	*Horsepower.*	*Sec.-ft.*	*Sec.-ft.*			*Sec.-ft.*	*Sec.-ft.*		
10HE 1	Weber	Weber River	198	5,000					250	420	3,960	6,650
10HE 2	Riverdale	do	200	5,750	70	275	1,120	4,400				
10HE 3	Butler	Beaver Creek	100	[a] 200	15	20	120	160				
10HE 4	Pioneer	Ogden River	470	10,500					45	85	1,690	3,200
				21,450								

[a] Approximate.

NOTE.—Regulation of stream flow at Weber plant depends upon irrigation requirements for water from reservoir on East Canyon Creek. Regulation limited at Pioneer plant to short-time peak loads. The computed power capacities shown in this table are based somewhat arbitrarily on the time elements and other specified conditions given on pp. 109–110. They serve for comparison of power sites considered as individual sites, but they bear no definite relation to the installed capacities or the energy output of plants in the Utah Power & Light Co.'s system, because of the Bear River regulation and the interconnection of plants, which permits a maximum utilization of the smaller streams.

JORDAN RIVER AND UTAH LAKE BASINS.

ALPINE PLANT (10HF 1).

Location and plan of development.—In Dry Creek canyon 6 miles northeast of Lehi, Utah County, Utah. Diversion dam in SE. ¼ sec. 4, T. 4 S., R. 2 E. Salt Lake base and meridian; pipe line along south side of creek to power house in SW. ¼ sec. 8. (Pl. III.)

Ownership and market.—Owner, Utah Power & Light Co. Market, territory in Utah and southeastern Idaho served by Utah Power & Light Co. (See old Grace plant, p. 67.)

Chronologic summary.—Filing made on water in 1907. Plant built in 1910 by Utah County Light & Power Co. Acquired in 1913 by Utah Power & Light Co.

Water supply.—Source of water, Dry Creek. Rights acquired through State engineer of Utah. License issued for 17.74 sec.-ft. No regulation of stream flow. Estimated Q90 flow 2 sec.-ft.; Q50 flow 4 sec.-ft.; corresponding power capacities 310 and 620 hp., respectively.

Hydraulic features.—Dam, wood and concrete; height, about 10 ft.; built of 6-in. plank laid up against 8 by 8 in. posts set in concrete; length of wooden section, 16 ft.; joins concrete wing wall on north end and intake on south end; concrete wing wall beyond intake. Intake, submerged orifice in concrete well 13 ft. long, 3⅙ ft. wide, and 6 ft. deep; connects with 30-in. wooden pipe line. Conduit, wooden-stave pipe; length, 7,955 ft.; diameter, 2½ ft. Penstock, steel pipe; length, 4,910 ft.; diameter, 2 ft. at top, 1½ ft. at bottom.

Power house and transmission system.—Power house, white brick on concrete foundations, dimensions 30 by 56 by 20.6 ft. with extension 18 by 24 by 19 ft., shingle roof, concrete porch and balcony across front. A 10-ton 30-ft. span Northern Engineering Works crane serves main part of building. Installation, two 1,500 hp. 60-in. 600-r.p.m. Doble impulse water wheels supplied with water through Y in penstock. Direct-connected to two 875-kva. 6,600-v. 60-cycle 3-phase Westinghouse generators. Two 40-kw. 125-v. d. c. Westinghouse exciter generators belt-driven from main shafts. Water wheels designed for 1,800-ft. head. Operating head at plant 1,900 ft., static head 1,924 ft. Each wheel requires 8 sec.-ft. under 1,905-ft. head and 875-kw. load.

Current leaves plant at 6,600 v. and is practically all used in vicinity of Midvale, a few miles northwest, through the distribution system of the Utah Power & Light Co.

Remarks.—When this plant was built much comment was made on the remarkably high head used. It may still be classed among the high-head plants of the world, although a few now range from 1,960 to 2,250 ft. and one, very likely the highest, at Vauvry, Switzerland, has a gross head of 3,115.7 ft.

UPPER AMERICAN FORK PLANT (10HF 2).[29]

Location and plan of development.—In lower part of American Fork canyon 6½ miles northeast of American Fork, Utah County, Utah. Diversion dam in sec. 25, T. 4 S., R. 2 E., Salt Lake base and meridian; pipe line along north side of canyon to power house in sec. 28 (Pl. III).

Ownership and market.—Owner, Utah Power & Light Co. Market, territory in Utah and southeastern Idaho served by Utah Power & Light Co. (See old Grace plant, p. 67.)

Chronologic summary.—Construction work started in May, 1906, and completed in November, 1907. Plant built by Utah County Light & Power Co. Acquired by Utah Power & Light Co. in 1913.

[29] Eng. Rec., May 9, 1908.

Water supply.—Source of water, American Fork. Rights acquired through State engineer of Utah. Amount claimed 50.04 sec.-ft. Estimated Q90 flow 17 sec.-ft., Q50 flow 29 sec.-ft.; corresponding power capacities 780 and 1,330 hp., respectively.

Hydraulic features.—Dam, originally small wooden structure, replaced in 1914 by concrete and steel dam. Earth dike extends 50 ft. beyond south end. Total crest length, including dikes, approximately 108 ft. Maximum height 12 ft.; 4-ft. fish ladder at south end; 29¾-ft. spillway with flashboards 6 ft. high; 6-ft. sluiceway controlled by hand-operated gate. Intake, concrete flume section 6 ft. wide with screens, controlled by Taintor gate operated by means of 2-ton Yale & Towne duplex chain block; length of intake flume 48 ft. Conduit, wooden-stave pipe, crossing from south side of creek to north side at point 1,250 ft. below dam. Length 11,750 ft., diameter 30 in. Course, rough and broken. Three inverted siphons in the line. Maximum head at one of them 175 ft. Two trestles; 11 tunnels through solid rock varying in length from 25 to 160 ft. Penstock, steel pipe, length 547 ft., diameter 36 in. at top and 33 in. at bottom. Steel Y, each leg 30 in. in diameter, at lower end of penstock.

Power house and transmission system.—Power house, brick with concrete floor and foundations, inside dimensions 35 by 68 by 20 ft., with extension 20 by 39 by 20 ft. A 12-ton 30-ft. span hand-operated Whiting crane serves main part of building. Installation, two 1,000-hp. 300-r.p.m. Pelton water wheels direct-connected to two 600-kva. 6,600-v. 3-phase 60-cycle Westinghouse generators. Two 35-kw. 125-v. 280-a. 725-r.p.m. Westinghouse exciter generators belt driven from main shafts. Water wheels designed for 520-ft. head. Operating head at plant 525 ft., static head 575 ft. With generator load of 600 kw. and operating head of 525 ft. each wheel uses 22.5 sec.-ft. of water. Current leaves plant at 44,000 and 6,600 v. and is distributed over general system of Utah Power & Light Co.

LOWER AMERICAN FORK PLANT (10HF 3).[30]

Location and plan of development.—Near the mouth of American Fork canyon, 5 miles northeast of the town of American Fork, in Utah County, Utah. Diversion dam in sec. 28, T. 4 S., R. 2 E., Salt Lake base and meridian; pipe line along bottom of canyon and north side of creek to power house in sec. 32 (Pl. III).

Ownership and market.—Owner, Utah Power & Light Co. Market, territory in Utah and southeastern Idaho served by Utah Power & Light Co. (See old Grace plant, p. 67.)

Chronologic summary.—Construction began in December, 1899, and was completed in December, 1900. A second penstock added later. In 1912 one of these replaced by 3-ft. penstock and larger generator unit installed. Plant built by Utah County Light & Power Co. Acquired by Utah Power & Light Co. in 1913.

Water supply.—Source of water, American Fork. Rights acquired by appropriation and use. Estimated Q90 flow 21 sec.-ft., Q50 flow 37 sec.-ft.; corresponding power capacities 490 and 860 hp., respectively.

Hydraulic features.—Dam, timber, 14 in. by 14 in. by 25 ft. 5 in., embedded in concrete; crest height adjustable with flashboards. Intake, screened wooden flume 150 ft. long controlled by two wooden head gates, spillway over portions of flume into creek. Conduit, wooden-stave pipe line, first 2,987 ft. laid along bottom of canyon in many places in creek bed. Remaining 5,146 ft. along north hill slope on uniform grade of 10 ft. to a mile; diameter 3 ft. Two penstocks, length 325 ft., one 3 ft. in diameter, the other 2 ft. in diameter.

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[30] Eng. News, Apr. 17, 1902

Power house and transmission system.—Power house, brick on concrete foundations; dimensions 25 by 50 by 16 ft. Two-ton chain block for handling machinery. Installation, one 400-hp. 3-ft. 450-r. p. m. Cazin impulse water wheel direct-connected to one 250-kva. 6,600-v. 60-cycle General Electric generator. One 1,050-hp. 720-r. p. m. Allis-Chalmers horizontal turbine direct-connected to one 700-kva. 6,600-v. 60-cycle General Electric generator. One 6.5-kw. 125-v. 950-r. p. m. belt-driven General Electric exciter generator and one 20-kw. 125-v. 720-r. p. m. General Electric generator direct-connected to main generator shaft. Impulse water wheel when operating with full generator load (250 kw.) under head of 275 ft. requires 20 sec.-ft. of water. Turbine designed for head of 252 ft. Operating head at plant 255 ft., static head 292 ft. Turbine requires 39 sec.-ft. of water under head of 287 ft. and 700-kw. generator head. Current leaves plant at 44,000 and 6,600 v. and is distributed over system of Utah Power & Light Co.

Remarks.—Plant built to furnish light and power to towns of Lehi, American Fork, and Pleasant Grove, in Utah County, Utah.

BATTLE CREEK PLANT (10HF 4).[31]

Location and plan of development.—About 2½ miles from Pleasant Grove, Utah County, Utah, at the mouth of Battle Creek canyon. Diversion dam in Battle Creek in sec. 24, T. 5 S., R. 2 E., Salt Lake base and meridian, with auxiliary dam in Grove Creek in SW. ¼ sec. 14; pipe line along south side of creek, with branch pipe line entering it from Grove Creek; power house at mouth of canyon in SE. ¼ sec. 22 (Pl. III).

Ownership and market.—Owner, Utah Power & Light Co. Market, territory in Utah and southeastern Idaho served by Utah Power & Light Co. (See old Grace plant, p. 67.)

Chronologic summary.—Construction started in April, 1906; completed in November, 1907, with exception of pipe line from Grove Creek, which was built in 1908–9. Plant built by Telluride Power Co. Acquired by Utah Power & Light Co. in 1912.

Water supply.—Source of water, Battle Creek and four springs near head of Grove Creek. Rights acquired through State engineer of Utah. License issued for 15 sec.-ft. from Battle Creek. Proof made on 10 sec.-ft. from Grove Creek springs. Stream carries 25 sec.-ft. only small part of year. Estimated Q90 flow 2 sec.-ft., Q50 flow 4 sec.-ft.; corresponding power capacities 280 and 560 hp., respectively.

Hydraulic features.—Dam in Battle Creek, concrete, crest length 60 ft., height 14 ft., width at bottom 6 ft., at top 2 ft. Intake, 24-in. wooden-stave pipe through dam 10 ft. below crest. Dam in Grove Creek, concrete, crest length 50 ft., height 18 ft. Conduit, main conduit wooden-stave pipe, length 9,640 ft., diameter 24 in., from Battle Creek dam along face of steep foothills to regulating and storage reservoir on crest of high hill at edge of valley. Pipe from Grove Creek, spiral steel, length 6,105 ft., diameter 12 in. at head and 6 in. at junction with main conduit, 4,158 ft. above reservoir. Topography along course of main conduit very rough. Steel pipe used in several sharp curves. Two inverted siphons across gulches.

Reservoir, capacity 276,000 cu. ft., built partly in excavation and partly in embankment, length 275 ft., width 125 ft. Water enters at one end and leaves through penstock at other end. Outlet is 30-in. pipe controlled by gate valve. Penstock, steel pipe 30 in. in diameter at top, 20 in. at bottom, length 4,963 ft. Total fall is 1,758 ft. Water from power house flows into circular regulating reser-

[31] Min. and Eng. World, Oct. 19, 1912; Eng. Rec., Mar. 14, 1908.

voir 180 ft. in diameter and 400,000 cu. ft. capacity. With the two reservoirs the plant can operate at full capacity 6 hours a day, and the creek flow is regulated without interfering with irrigation rights below. Water from regulating reservoir returned to creek through 5,041 ft. of 10 and 12 in. steel pipe. Water measured upon entering storage reservoir and again on leaving regulating reservoir.

Power house and transmission system.—Power house, unusually attractive brick building on concrete foundations; main building 37 by 84 by 20 ft. with extension 17.5 by 50 by 20 ft.; broad portico with six white Ionic columns across front of building. A 16-ton 32-ft. span hand-operated Whiting crane serves main part of building. Installation, one double Pelton water wheel with two 2,000-hp. 10-ft. diameter wheels mounted on same shaft and supplied with water through separate Pelton nozzles. Direct-connected to one 2,400-kva. 2,300-v. 60 cycle 3-phase 300-r. p. m. revolving-field General Electric generator. One 35-kw. belt-driven General Electric exciter generator. Water wheels designed for 300 r. p. m. under 1,725-ft. head. Operating head at plant 1,662 ft., static head 1,757 ft. With full generator load (2,400 kw.) water wheels require 27 sec.-ft. of water under 1,662-ft. head. Current leaves plant at 44,000 v. and is distributed through system of Utah Power & Light Co.

Remarks.—Plant built for peak-load demands, as being less expensive than storage-battery installation or auxiliary steam plant. Designed to be able to operate so as to float on the general system, at all times furnishing some power.

SPRINGVILLE PLANT (10HF 5).

Location and plan of development.—In Hobble Creek canyon 4 miles from Springville, Utah County, Utah. Diversion from two forks of stream in W. ½ sec. 33, T. 7 S., R. 4 E., Salt Lake base and meridian. Canal and pipe line run along north side of creek to power house in NE. ¼ sec. 6, T. 8 S., R. 4 E., Salt Lake base and meridian (Pl. III).

Ownership and market.—Owner, city of Springville. Market, city of Springville.

Chronologic summary.—Plant built by city of Springville in 1903. Operated as independent plant until 1917, when it was connected with United States Reclamation Service plant near Payson.

Water supply.—Source of water, Hobble Creek. Rights acquired by appropriation and use. Some water diverted from power canal above pipe line for irrigation. Water supply usually sufficient throughout year. Estimated Q90 flow 22 sec.-ft., Q50 flow 32 sec.-ft.; corresponding power capacities 240 and 340 hp., respectively.,

Hydraulic features.—Dams, two small low structures across forks of creek. Conduit, canal, 4,800 ft. Wooden-stave pipe line 4,500 ft., diameter of pipe 24 in. Penstock, steel pipe, 254 ft. long.

Power house and transmission system.—Power house, frame, 15 by 45 ft., with living quarters built on north side. Installation, one 150-hp. 52-in. Pelton water wheel; one 100-kw. 4,000-v. 3-phase 60-cycle 720-r. p. m. belt-driven Westinghouse generator. One 3-kw. 125-v. 1,000-r.p.m. Westinghouse d. c. exciter generator, belt-driven from shaft of water wheel. Operating head at plant 134 ft. Current leaves plant at 4,400 v. Transmission line 4½ miles to city of Springville.

Remarks.—Plant cost $30,000.

STRAWBERRY VALLEY PROJECT PLANT (10HF 6).

Location and plan of development.—At the mouth of Spanish Fork canyon, 4 miles southeast of Spanish Fork, Utah County, Utah. Diversion dam in sec. 11, T. 9 S., R. 3 E., Salt Lake base and meridian; canal along south side of Spanish Fork to power house in sec. 33, T. 8 S., R. 3 E., Salt Lake base and meridian (Pl. III).

Ownership and market.—Owner, United States Government. Market, towns of Payson, Salem, and Springville.

Chronologic summary.—Work started in May, 1908. Plant turned over to operating superintendent in January, 1909. Transmission line to Strawberry tunnel and pressure pipe constructed under contract. Other construction work and installation done by Government force. Preliminary plans contemplated installing two units of 60 sec.-ft. each. Provision was made for two additional units of 90 sec.-ft. each.

Water supply.—Strawberry reservoir through Spanish Fork. Available flow for power ranges from 35 to 1,500 sec.-ft. Monthly mean usually 120 sec.-ft. or more for 8 months each year. Water carries considerable amount of silt for comparatively long periods. Two water-right filings made with State engineer of Utah by United States Reclamation Service; both cover possible future extension of development. Certificate issued for 156.5 sec.-ft. by State engineer. Estimated Q90 flow 100 sec.-ft., Q50 flow 150 sec.-ft., corresponding power capacities 1,000 and 1,875 hp., respectively.

Hydraulic features.—Diversion dam, rubble, concrete; crest length 70 ft., height 16 ft. Weir section 40 ft. long, two 5 by 10 ft. sluice gates. Main section ogee. Rests on concrete bedplate 20 ft. wide, 5 ft. thick, and 2-ft. apron extending 50 ft. downstream. Canal intake at south end of dam. Six openings 4½ by 8 ft. with sills 2 ft. above top of sluice gates to prevent sediment entering canal. Further provision for handling sediment is double-compartment sand box with sluice valves. Conduit, canal; length to power house 3¼ miles; capacity 500 sec.-ft.; carries water for power and irrigation. 1,500 ft. of tunnel, 750 ft. of covered aqueduct, and 8,000 ft. of concrete-lined section. Enlarged section at power house forms forebay provided with regulating gates and spillway facilities. Penstock, riveted-steel pipe; length 346 ft.; diameter 5½ ft. Lower end of penstock parallel with northeast side of power house. Supply pipes for turbines tapped into it at right angles. Each turbine discharges into separate tailrace underneath building. Provision for 60 sec.-ft. of water to empty into Salem canal when necessary and remainder to return to Spanish Fork.

Power house and transmission system.—Power house, corrugated iron fastened to timber frame. Dimensions 35 by 65 ft. Walls, plaster on metallic lath. All substructures concrete. Installation, two 800-hp. 30-in. single-runner American horizontal turbines designed to operate at 400 r. p. m. under head of 120 ft. direct-connected to two 500-kva. 11,000-v. 3-phase 60-cycle General Electric generators. Two 75-hp. 13-in. American turbines designed to operate at 976 r. p. m. under 120-ft. head direct-connected to two 45-kw. 125-v. General Electric exciter generators. Operating head at plant 120 ft.; static head 125.49 ft. Current leaves plant at 11,000 and 22,000 v. When the plant was first used a 22,000-v. wooden-pole transmission line 26 miles long carried power to the west portal of Strawberry tunnel for use in construction. After the work was finished this line was abandoned and the plant was used to supply commercial load only. Transmission system consists of a single-circuit wooden-pole line from power house to substation at Spanish Fork, 3½ miles; a similar line to Payson, 9 miles, with tap line to Salem, ¾ mile; and a line from plant to Springville, 5.3 miles. Substations at terminals of lines owned by towns are small brick buildings with single transformer and switching apparatus.

Remarks.—Plant built by United States Reclamation Service to supply power needed in construction of Strawberry Valley reclamation project.

SANTAQUIN PLANT (10HF 7).

Location and plan of development.—At mouth of Santaquin Canyon, 1½ miles southeast of Santaquin, in Utah County, Utah. Diversion dam in sec. 30, T. 10 S., R. 2 E., Salt Lake base and meridian; pipe line along north side of creek to power house in NW. ¼ sec. 13, T. 10 S., R. 1 E. (Pl. III).

Ownership and market.—Owner, Utah Power & Light Co. Market, territory served by company in Utah and southeastern Idaho. (See old Grace plant, p. 67.)

Chronologic summary.—Plant built in 1909–10 by Knight Investment Co. Acquired by Utah Power & Light Co.

Water supply.—Source of water, Summit or Santaquin Creek. Rights acquired through State engineer of Utah. Certificate of right issued by State engineer for 25 sec.-ft. Stream flow less than 25 sec.-ft. greater part of year. Estimated Q90 flow 6 sec.-ft., Q50 flow 8 sec.-ft.; corresponding power capacities 300 and 410 hp., respectively.

Hydraulic features.—Dam, concrete, crest length 20 ft., height 5.5 ft. Spillway, 10 ft.; sluiceway, 3.5 ft. Intake opening 4 ft. wide. Wooden gates at sluiceway and intake operated by 30-in. hand wheels. Intake 21 ft. long. Conduit, wooden-stave pipe, length 11,120 ft.; diameter 26 in. Grade, 26.4 ft. to a mile. Four inverted siphons, maximum head of one 91 ft.; two trestles. Penstock, riveted-steel pipe, length 2,415 ft. Diameter 26 in. at top, 20 in. at bottom; connects with Y, each leg 14 in. in diameter.

Power house and transmission system.—Power house, brick on concrete foundations; dimensions 52 by 34 by 22 ft.; equipped with 10-ton hand-operated crane. Installation, two 850-hp. 360-r. p. m. Doble impulse water wheels direct-connected to two 440-kva. 2,300-v. 3-phase 60-cycle General Electric generators. Two 25-kw. 125-v. 700-r. p. m. General Electric belt-driven exciter generators. Water wheels designed for 600-ft. head. Each wheel under 570-ft. head and full generator load (440 kw.) requires 12 sec.-ft. of water. Operating head at plant 570 ft., static head 636 ft. Current leaves plant at 44,000 v. and is distributed through system of Utah Power & Light Co.

NEPHI PLANT (10HF 8).

Location and plan of development.—In Salt Creek canyon, 3½ miles east of Nephi, Juab County, Utah. Diversion dam in NW. ¼ sec. 6, T. 13 S., R. 2 E., Salt Lake base and meridian; flume and canal along north side of Salt Creek to power house in NW. ¼ sec. 1, T. 13 S., R. 1 E. (Pl. III).

Ownership and market.—Owner, city of Nephi. Market, city of Nephi.

Chronologic summary.—Plant built by city of Nephi in 1911.

Water supply.—Source of water, Salt Creek. Rights acquired through State engineer. Amount claimed 17 sec.-ft. Estimated Q90 flow 15 sec.-ft., Q50 flow 20 sec.-ft.; corresponding power capacities 170 and 230 hp., respectively.

Hydraulic features.—Dam, wooden; length 34 ft.; height 8½ ft. Wooden head gate into flume conduit. Conduit, flume 6,864 ft. long and canal remainder of distance to power house. Penstock, wooden-stave pipe, diameter 34 in. at top, 24 in. at bottom.

Power house and transmission system.—Power house, brick, on north side of creek, dimensions 16 by 20 ft. with a lean-to of sheet iron about 14 ft. square. Concrete-tunnel tailrace 52 ft. long to creek. Installation, one 17-in. French turbine, belted to countershaft, to which is belted one 150-kw. 3-phase 60-cycle

900-r. p. m. General Electric generator. One 5-kw. 125-v. 1,800-r. p. m. General Electric d. c. exciter generator belted to generator shaft. Current used in city of Nephi.

NEPHI PLASTER & MANUFACTURING CO.'S PLANT (10HF 9).

Location and plan of development.—At mouth of Salt Creek canyon, 1 mile east of Nephi, in Juab County, Utah. Diversion dam in SW. ¼ sec. 1, T. 13 S., R. 1 E., Salt Lake base and meridian; canal along south side of creek to power house in SW. ¼ sec. 3 (Pl. III).

Ownership and market.—Owner, Nephi Plaster & Manufacturing Co. Market, supplies power for company's mill.

Chronologic summary.—Plant built by Nephi Plaster & Manufacturing Co. in 1907.

Water supply.—Source of water, Salt Creek. Rights acquired through State engineer of Utah. Estimated Q90 flow 15 sec.-ft., Q50 flow 20 sec.-ft.; corresponding power capacities 220 and 300 hp., respectively.

Hydraulic features.—Dam, wooden. Conduit, canal, length 11,000 ft.; capacity, 15 sec.-ft. Penstock, steel pipe; length 400 ft.; diameter 24 in.

Power house and transmission system.—Power house, part of mill. Installation, one 200-hp. 48-in. double-nozzle Pelton water wheel, used to drive machinery of mill. Operating head on wheel 184 ft. One 3-kw. 115-v. d. c. Fairbanks-Morse belt-driven generator supplies lights for mill.

MURDOCK PLANT (10HG 1).

Location and plan of development.—In upper Provo River basin 6 miles north of Heber, Wasatch County, Utah. Diversion dam in sec. 35, T. 2 S., R. 5 E., Salt Lake base and meridian; pipe line along north side of stream to power house in sec. 32 (Pl. III).

Ownership and market.—Owner, Utah Power & Light Co. Market, territory served by that company in Utah and southeastern Idaho. (See old Grace plant, p. 67.)

Chronologic summary.—Construction work started in May, 1910; completed in March, 1911. Plant built by Knight Power Co. Acquired by Utah Power & Light Co. in 1913.

Water supply.—Source of water, Provo River. Rights acquired through State engineer of Utah. Certificate issued for 180 sec.-ft. In irrigation season and in winter stream flow 50 sec.-ft. or less. Estimated Q90 flow 54 sec.-ft., Q50 flow 89 sec.-ft.; corresponding power capacities 840 and 1,390 hp., respectively.

Hydraulic features.—Dam, reinforced concrete, crest length 80 ft., height 10.3 ft., wing walls extending about 100 ft. upstream at ends, fishway 8 ft. wide at south end, spillway 11⅓ ft. wide at north end, intake next to sluiceway, central part of dam two 30-ft. spillways of six flashboard panels each. Intake, concrete 16 ft. wide, 11⅓ ft. long, with two hand-operated gates. Conduit, wooden-stave pipe, length 16,348 ft., diameter 5 ft., follows natural ground surface. Course crowded with horizontal and vertical curves. Steel Y connects with wooden pipe short distance from power house; each leg 42 in. in diameter, connects with water turbine.

Power house and transmission system.—Power house, brick on concrete foundations, dimensions 25 by 50 by 16 ft., extension on one side 11 by 44 by 16 ft. A 10-ton hand-operated crane serves main part of building. Installation, two 1,650-hp. 514-r. p. m. Allis-Chalmers single runner Francis turbines, direct-connected to two 1,250-kva. 4,000-v. 3-phase 60-cycle General Electric generators. Two 30-kw. 125-v. d. c. General Electric exciter generators belt driven from main shafts. Water wheels designed for 170-ft. head. Operating head at plant 130 ft.; static head 195 ft. Each turbine under full load requires 90.5 sec.-ft. of water. Current leaves plant at 44,000 v. for distribution through system of Utah Power & Light Co.

HEBER LIGHT & POWER CO.'S PLANT (10HG 2).

Location and plan of development.—In upper Provo River valley, 5 miles north of Heber, Wasatch County, Utah. Diversion dam in SW. ¼ sec. 31, T. 2 S., R. 5 E., Salt Lake base and meridian; canal runs along east side of river to power house in SW. ¼ sec. 7, T. 3 S., R. 5 E. (Pl. III).

Ownership and market.—Owner, city of Heber. Market, Heber, Midway, and Charleston.

Chronologic summary.—Work begun in 1908, completed in December, 1909. Plant built by city of Heber. Plant practically abandoned in 1920, city being served by Utah Power & Light Co.

Water supply.—Source of water, Provo River. Rights acquired through State engineer of Utah. Amount claimed 150 sec.-ft. Estimated Q90 flow 50 sec.-ft., Q50 flow 75 sec.-ft.; corresponding power capacities 370 and 540 hp., respectively.

Hydraulic features.—Dam, loose rock and logs, crest length 100 ft., height 2 ft. Intake, concrete with two wooden head gates, each 7 by 6 ft. Conduit, canal owned by Timpanogos Irrigation Co. serves for power and irrigation; length from dam to power house 10,475 ft.; cross sections 24 ft. at top, 12 ft. at bottom, 6 ft. deep; grade approximately 5 ft. to a mile; capacity, 250 sec.-ft.; course through bench lands. Several flume sections necessary to cross gullies. Two steel penstocks from canal to power house; length 140 ft., diameter 20 in. Tailrace open channel into Wasatch canal, also into river. Water of Wasatch Irrigation Co. used through power plant and turned into company's canal about 500 ft. beyond power house.

Power house and transmission system.—Power house, rubble masonry. Installation, two 800-hp. 30-in. Trump turbines direct-connected to two 300-kw. 4,000-v. 3-phase General Electric generators. Two 35-hp. 12-in. Trump turbines direct-connected to two 21-kw. 125-v. General Electric exciter generators. Operating head at plant 92 ft.

Current generated at 4,000 v. and carried over 12 miles of transmission line to Heber, Midway, and Charleston.

OLMSTEAD PLANT (10HG 3).[32]

Location and plan of development.—In Provo Canyon 6 miles north of city of Provo. Diversion dam in NE. ¼ sec. 34, T. 5 S., R. 3 E., Salt Lake base and meridian; wooden flume along north side of river to power house at mouth of canyon, in NW. ¼ sec. 7, T. 6 S., R. 3 E. (Pl. III).

Ownership and market.—Owner, Utah Power & Light Co. Market, territory served by that company in Utah and southeastern Idaho. (See old Grace plant, p. 67.)

Chronologic summary.—Plant built by Telluride Power Co. in 1904. Original flume 8 ft. wide and 6 ft. deep. Part of flume rebuilt in 1917; remainder rebuilt in 1920. Plant acquired by Utah Power & Light Co. in 1912.

Water supply.—Source of water, Provo River. Rights acquired by appropriation and use and court decree. Flume designed for 400 sec.-ft., but stream flow not that large at times. Estimated Q90 flow 200 sec.-ft., Q50 flow 310 sec.-ft.; corresponding power capacities 5,440 and 8,430 hp., respectively.

Hydraulic features.—Dam, timber crib, crest length 125 ft., height 16 ft., spillway 77 ft. with 5 ft. of flashboards. Intake, concrete pipe, diameter 8½ ft.;

[32] Min. and Eng. World, Oct. 19, 1912.

length 924 ft. Opens into concrete screen box and gate chamber, equipped with one 18-ft. radius Taintor gate for controlling flow into flume. Conduit, wooden flume, length 21,770 ft.; width 10 ft., depth 7 ft. Laid on uniform grade along north hillside of canyon. Tunnel 1,005 ft. long. Concrete pressure box at end of flume. Four riveted-steel pipe penstocks from pressure box to power house, length 874 ft.; three 5 ft. in diameter at top, 4 ft. at bottom; one 6 ft. in diameter.

Power house and transmission system.—Power house, brick on concrete foundations. Concrete draft tubes and discharge tunnels. Plan 62 by 85 ft. Installation, three 3,600-hp. 300-r. p. m. reaction-type inward-flow Allis-Chalmers turbines, direct-connected to three 2,400-kva. 2,300-v. 3-phase 60-cycle revolving-field General Electric generators, and one vertical 7,700-hp. 514-r. p. m. reaction I. P. Morris Co. turbine direct-connected to a 5,500-kva. 2,300-v. General Electric generator. One 100-hp. Pelton water wheel direct-connected to a 75-kw. 125-v. General Electric exciter generator. Pelton wheel supplied with water through 8-in. branch pipe from separate 12-in. penstock. Turbines designed for 339-ft. head. Operating head at plant 338 ft., static head approximately 340 ft. Under full load (2,400 kw.) each of the 3,600-hp. turbines requires 102 sec.-ft. of water under 338-ft. head. Current for city of Provo taken from 2,300-v. bus and transmitted to city at 5,000 v. over line owned by Provo Electric Co. Remainder of output leaves plant at 44,000 v. and is distributed through system of Utah Power & Light Co.

Remarks.—First high voltage in commercial transmission service developed at this plant. At that time 40,000 v., nearly three times greater than anything previously used.

PARK CITY OR ONTARIO PLANT (10HG 4).

Location and plan of development.—Near the mouth of Ontario mine drain tunnel, in the Park City mining district, Utah. Water carried from mouth of tunnel in wooden flume to steel-pipe penstock leading to power house. All works in sec. 24, T. 2 S., R. 4 E., Salt Lake base and meridian (Pl. III).

Ownership and market.—Owner, Utah Power & Light Co. Market, mines and mills in Park City district of Utah Power & Light Co.'s system.

Chronologic summary.—Plant built in 1895 by Ontario Mining Co. Sold to Utah Power & Light Co. in 1913. Water right not sold, only leased.

Water supply.—Source of water, Ontario mine drain tunnel. Tunnel driven in early nineties to unwater Ontario mine and others adjoining it. Flow very constant; average 25 sec.-ft. Half of flow belongs to Ontario Mining Co. and half to Daly Mining Co. Plant usually operates from 4 p. m. until midnight each day. Q90 and Q50 flow practically same, 25 sec.-ft.; power capacity 240 hp.

Hydraulic features.—Water flows from tunnel through wooden flume into two small circular reservoirs 600 ft. in diameter and 10 and 12 ft. deep, thence in another wooden flume 130 ft. long, 6 ft. wide, and 3.5 ft. deep to wooden pressure box 12 by 15 by 10 ft. Penstock, riveted-steel pipe 466 ft. long from pressure box to power house, diameter 30 in. at top, 18 in. at bottom. Tailrace, wooden flume 75 ft. long, 6 ft. wide, and 2.5 ft. deep.

Power house and transmission system.—Power house, frame on stone foundations; dimensions, 31 by 39 by 23 ft.; one set 2-ton Yale & Towne chain blocks. Installation, two 18-in. old-type Pelton water wheels, 120 hp. and 225 r. p. m. under 120-ft. head. One 2,200–2,500-v. 25-a. 900-r. p. m. 3-phase 60-cycle belt-driven General Electric generator. One 2,200–2,500-v. 17-a. 900-r. p. m. 3-phase 60-cycle belt-driven General Electric generator. One 9-kw. 125-v. 780-r. p. m. belt-driven General Electric exciter generator and one 3-kw. 125-v.

1,900-r. p. m. belt-driven General Electric exciter generator. Current leaves plant at 2,300 v. and is used near Park City in the Utah Power & Light Co.'s system.

SNAKE CREEK PLANT (10HG 5).

Location and plan of development.—About 6 miles northwest of Heber, Wasatch County, Utah. Main diversion dam in Snake Creek in sec. 18, T. 3 S., R. 4 E., Salt Lake base and meridian; auxiliary dam in Lavina Creek in sec. 17; pipe line to power house in sec. 21 (Pl. III).

Ownership and market.—Owner, Utah Power & Light Co. Market, territory in Utah and southeastern Idaho served by Utah Power & Light Co. (See old Grace plant, p. 67.)

Chronologic summary.—Construction started in 1907 and completed in 1909. Plant built by Snake Creek Power Co. Sold to Knight Power Co. in 1910. Acquired by Utah Power & Light Co. in 1913.

Water supply.—Source of water, Snake Creek, Lavina Creek, and Snake Creek drain tunnel. Rights in water from creeks acquired through State engineer of Utah. Contract with Snake Creek Mining & Tunnel Co. for use of water of Snake Creek tunnel. Estimated Q90 flow 19 sec.-ft., Q50 flow 25 sec.-ft.; corresponding power capacities 1,140 and 1,500 hp., respectively.

Hydraulic features.—Dams, both dams concrete-weir type. Crest length of Snake Creek dam 26 ft., height 5 ft. Crest length of Lavina Creek dam 15 ft., height 8 ft. Intake, both dams, concrete. Steel trash screens and hand-operated gates. Conduit, wooden-stave pipe 18 in. in diameter from Snake Creek around hill into Lavina Creek. Wooden-stave pipe 28 in. in diameter from Lavina Creek along north side of Snake Creek to penstock, 5,655 ft. laid to grade. Penstock, riveted-steel pipe 4,101 ft. long, diameter 28 in. at top, 22 in. at bottom.

Power house and transmission system.—Power house, brick on concrete foundations, dimensions 30 by 24 by 21 ft., with extension 9 by 18 by 21 ft. A 10-ton hand-operated crane 24-ft. span serves building. Installation, two 1,000-hp. 360 r. p. m. Doble impulse water wheels, direct-connected to two 590-kva. 6,600-v. 3-phase 60-cycle Westinghouse generators. Two 25-kw. 125-v. Westinghouse d. c. exciter generators belt driven from main shafts. Water wheels require 12.5 sec.-ft. of water each, under 667-ft. head and 530-kw. generator load. Operating head 667 ft.; static head 752 ft. Current leaves plant at 12,000 v. and is used principally in vicinity of Park City through transmission system of Utah Power & Light Co.

JORDAN PLANT (10HH 1).[33]

Location and plan of development.—At Jordan Narrows, the natural topographic division between Utah Lake valley and Salt Lake valley, 22 miles south of Salt Lake City. Diversion dam near center of sec. 26, T. 4 S., R. 1 W., Salt Lake base and meridian; canal along west side of river to power house in SE. ¼ sec. 15 (Pl. III).

Ownership and market.—Owner, Utah Power & Light Co. Market, territory in Utah and southeastern Idaho served by Utah Power & Light Co. (See old Grace plant, p. 67.)

Chronologic summary.—Salt Lake City Water & Electrical Power Co. organized in 1897. Plant built by this company in 1898. Acquired by Telluride Power Co. about 1904. Acquired by Utah Power & Light Co. in 1913.

Water supply.—Source of water, Jordan River. Rights acquired by appropriation and use. Rights set forth in following statement referring to decreed water rights on Jordan River.[34]

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[33] Eng. News, Apr. 28, 1898; Min. and Eng. World, Oct. 12, 1921; Salt Lake Min. Rev., May, 1899.

[34] U. S. Dept. Agr. Office Exper. Sta. Bull. 124, 1903.

"Salt Lake City Water & Electrical Power Co. is awarded the right to use the water belonging to the canals heading below its plant and return the same to the river; also the right to use the water of South Jordan canal so long as its contract with that company shall remain unrevoked; also to use the city's water so long as the city continues to divert its water at its present point of diversion. 'provided, however, that the right of the said (power company) to so take and use the city's water shall be effective only after said power company establishes by judgment of the court in an action at law its right to make connections with its flume and the said city's canal and shall have paid to said city any sum which may be awarded to said city by way of damages therefor.'"

The same provision is made with regard to the South Jordan canal in case the contract is revoked. The power company is to deliver water from its tailrace to the canals in proper proportion, as shall be determined by those authorized to divide the water. Estimated Q90 flow 178 sec.-ft., Q50 flow 293 sec.-ft; corresponding power capacities 1,040 and 1,700 hp., respectively. Like the Wheelon, Riverdale, and some of the smaller plants the Jordan is very intimately associated with irrigation enterprises, and for that reason the available flow for power purposes is very uncertain.

Hydraulic features.—Dam, reinforced concrete across Jordan River at head of Utah and Salt Lake canal, crest length 90 ft., height $18\frac{1}{3}$ ft. Regulation of flow by two 4 by 6 ft. openings near center, controlled by rack and pinion gates, and two 6 by 24 ft. weir openings controlled by two 13-ft. winze-operated radial gates. Six 4 by 4 ft. openings with cast-iron gates for sluicing. Intake to Utah and Salt Lake canal through wing wall at west end of dam, controlled by rack and pinion hand-operated gates. Conduit, canal, length to power house $2\frac{1}{2}$ miles, capacity to power house 600 sec.-ft., grade 1 ft. to 1 mile. Concrete forebay at power house 45 by 55 by 13 ft. Two steel-pipe penstocks 6 ft. in diameter connect forebay with power house, length 260 ft.

Power house and transmission system.—Power house, brick with concrete foundation and roof, dimensions $25\frac{5}{8}$ by $81\frac{1}{2}$ by $25\frac{1}{4}$ ft. One 25-ft. span Morris Bros. 10-ton hand-operated crane serves interior. Frame cottage for attendant. Installation, two 672-hp. double-runner S. Morgan Smith horizontal turbines, direct-connected to two 500-kw. 500-v. 3-phase 300-r. p. m. Westinghouse generators. One runner on each turbine discharges through draft tube 28 ft. long into tunnel to river. Others discharge through draft tube 9 ft. long into irrigation canal. One runner under 73-ft. head, other under 55-ft. head. Each turbine under rated head and peak load requires 256 sec.-ft. of water. Two 40-hp. water wheels direct-connected to two 30-kw. Westinghouse d. c. generators are exciter units. These water wheels are supplied with water from branch pipe lines from 24-in. overhead main carried across room from penstocks. Plant designed for doubling present installation. Accordingly, generator sets occupy one end of building, and exciter units the center. Current leaves plant at 44,000 v. for distribution over system of Utah Power & Light Co.

Remarks.—Plant not in use.

BENNION PLANT (10HH 2).

Location and plan of development.—In the western part of Murray, on Jordan River. Diversion dam in SW. $\frac{1}{4}$ sec. 1, T. 2 S., R. 1 W., Salt Lake base and meridian; canal along west side of river to power house in SW. $\frac{1}{4}$ sec. 14 (Pl. III).

Ownership and market.—Owner, Hyrum Bennion & Sons, Taylorsville, Utah. Market, formerly the flour mill in day time and small household load in towns of Murray and Taylorsville evenings; now supplies flour mill only.

Chronologic summary.—Bennion canal built for irrigation by Hyrum Bennion & Sons in early eighties. Work started on power plant in 1909 and completed in 1911.

Water supply.—Source of water, Jordan River. Rights acquired through State engineer of Utah. License for 60 sec.-ft. Additional flow of 40 sec.-ft. supplies irrigation rights in canal. Estimated Q90 and Q50 flow each 60 sec.-ft.; corresponding power capacity 75 hp.

Hydraulic features.—Dam, loose rock and earth, crest length 85 ft., height 4.5 ft. Wooden headgate $10\frac{1}{6}$ ft. wide opens into canal. Conduit, canal built in earth, length 15,320 ft. Average cross sections 15 ft. at top, 12 ft. at bottom, 3.5 ft. deep. At power house river bank has abrupt drop of 16 ft. or more from canal level to river bed. Concrete wall built up from river bed to top of canal banks; is west side of power house as well as retaining wall. Penstock, concrete well 13 ft. wide, equipped with screens at entrance. Wasteway is wooden chute 7 ft. wide from canal above penstock to river bank

Power house and transmission system.—Power house, concrete floor and west wall, rest sheet metal fastened to wooden framework; dimensions 16 by 32 ft. Floor set on concrete piers above river bed and tail-water discharge directly into river. Installation, one 100-hp. 35-in. Allis-Chalmers horizontal turbine belt-connected to one 75-kva. 2,300-v. 900-r. p. m. Allis-Chalmers generator. One 120-v. 1,800-r. p. m. Allis-Chalmers exciter generator belt-driven from main generator shaft. Current taken from plant at 2,300 v. over wooden-pole line to flour mill, about half a mile distant. Mill operates only during day.

Remarks.—Small commercial load formerly carried by plant now supplied by Utah Power & Light Co.

COLUMBUS CONSOLIDATED PLANT (10HH 3).

Location and plan of development.—In Little Cottonwood Canyon, near the Alta mining camp and 16 miles southeast of Salt Lake City. Diversion dam in SW. ¼ NW. ¼ sec. 11, T. 3 S., R. 2 E., Salt Lake base and meridian, with auxiliary diversion from Mahogany Fork in unsurveyed SW. ¼ sec. 10; pipe line along bed of canyon to power house in sec. 10; branch pipe line from Mahogany Fork taps main pipe line (Pl. III).

Ownership and market.—Owner, Wasatch Power Co. Market, Alta mining camp, for lighting town of Alta and vicinity and general mining purposes.

Chronologic summary.—Plant built in 1903 by Columbus Consolidated Mining Co. One unit installed in winter of 1903, second unit installed in 1908. Plant sold to Wasatch Power Co. in March, 1913. Auxiliary pipe line from Mahogany Fork built in 1916.

Water supply.—Source of water, Little Cottonwood Creek and Mahogany Fork, a tributary. Rights acquired through State engineer of Utah. Estimated Q90 flow 20 sec.-ft., Q50 flow 30 sec.-ft.; corresponding power capacities 790 and 1,190 hp., respectively.

Hydraulic features.—Dams, one in Little Cottonwood Creek, one in Mahogany Fork, both rubble masonry. Little Cottonwood dam 160 ft. long and 15 ft. high. Two steel sluice gates and large spillway. Water may overflow dam in case of flood without injuring dam. Mahogany Fork dam 35 ft. long and 5 ft. high. Conduit, steel pipe, 4,550 ft. long, diameter 22 in. at dam, 20 in. at power house. Feeder line from Mahogany Fork, steel pipe, 2,310 ft. long, diameter 12 in.; joins main line 270 ft. from power house. Mahogany Fork conduit also comprises 100 ft. of canal and 450 ft. of natural channel.

Power house and transmission system.—Power house, rubble masonry, 26 by 40 ft., on south bank of creek. Installation, one 400-hp. 36-in. Pelton water wheel direct-connected to one 300-kw. 6,600-v. 3-phase 60-cycle 512-r. p. m. Westinghouse generator. One 400-hp. 40-in. Pelton water wheel direct-connected to one 300-kw. 6,600-v. 3-phase 60-cycle 450-r. p. m. General Electric generator. One 11.25-kw. 125-v. 1,100-r. p. m. d. c. exciter generator and one 14-kw. 125-v. 1,100-r. p. m. d. c. exciter generator, both belt driven from main shafts. Operating head 489 ft., static head 496 ft. Current taken directly from generators to transmission line, 4.78 miles long, up canyon to Alta. Line consists of one circuit of three No. 4 hard-drawn copper wires on wooden poles.

Remarks.—This plant was built to serve the mines in the Alta mining district.

MURRAY CITY PLANT (10HH 5).

Location and plan of development.—In Salt Lake County 5 miles southeast of Murray, Utah. Dam in unsurveyed sec. 7, T. 3 S., R. 2. E., Salt Lake base and meridian. Pipe line along north side of creek to power house in sec. 2, T. 3 S., R. 1 E. (Pl. III).

Ownership and market.—Owner, city of Murray. Market, city of Murray and small settlements in Salt Lake County. Maximum demand about 300 kw.

Chronologic summary.—Plant built by city of Murray in 1914.

Water supply.—Source of water, Little Cottonwood Creek. Rights acquired through State engineer of Utah for 15 sec.-ft. Estimated Q90 flow 25 sec.-ft., Q50 flow 37 sec.-ft.; corresponding power capacities 1,020 and 1,520 hp., respectively.

Hydraulic features.—Dam, concrete overflow. Conduit, wooden-stave pipe 30 to 24 in. in diameter along north side of creek. Penstock, steel pipe 22 in. in diameter, length 305 ft.

Power house and transmission system.—Power house, stone; dimensions, 24 by 39 ft. Installation, two 600-hp. 48-in. Pelton water wheels direct-connected to two 400-kva. 2,300-v. 3-phase Westinghouse generators. Two 15-kw. 125-v. 800-r. p. m. d. c. Westinghouse exciter generators. One 100-kva. 60-cycle 6,600/2,300/1,150-v. style transformer. Operating head 435 ft., static head 523 ft. Current generated at 2,300 v., transmitted over 7 miles of transmission lines, two 3-wire 3-phase circuits, at 6,600 v.

STAIRS PLANT (10HH 6).[35]

Location and plan of development.—In Cottonwood Canyon 15 miles southeast of Salt Lake City. At Stairs a steep ascent in canyon with rise of 200 ft. in little more than ¼ mile. Diversion dam in SE. ¼ sec. 20, T. 2 S., R. 2 E., Salt Lake base and meridian; pipe line on north side of stream to power house in SW. ¼ sec. 20 (Pl. III).

Ownership and market.—Owner, Utah Light & Traction Co., leased to Utah Power & Light Co. Market, territory served by Utah Power & Light Co. (See old Grace plant, p. 67.)

Chronologic summary.—Work started in September, 1891, carried along on small scale until November, 1893. Big Cottonwood Power Co. organized in 1893. Plant completed in 1896.

Water supply.—Source of water, Cottonwood Creek. Rights acquired by appropriation and use. Estimated Q90 flow 24 sec.-ft., Q50 flow 38 sec.-ft.; corresponding power capacities 720 and 1,140 hp., respectively.

Hydraulic features.—Dam, earth, length 535 ft., width at base 92 to 135 ft., height 31 ft. Placed across narrow outlet from small basin through which creek flows. Serves as regulating reservoir. Overflow wasteway at east end 35 ft. wide, cut through solid slate and quartzite with crest 5 ft. lower than

[35] Elec. World and Eng., Mar. 30, 1901; Eng. News, Oct. 1, 1896; Elec. Eng., Sept. 2, 1896; Min. and Sci. Press, Sept. 19, 1896.

top of dam. Drainage tunnel 180 ft. long through solid rock at east end of dam also serves for carrying part of surplus flow of creek. Tunnel timbered and planked to section 6.5 ft. square. Area of reservoir 8¼ acres, depth 10 to 35 ft., average depth 12 ft., storage capacity about 110 acre-ft. Conduit, tunnel 430 ft. long, 7 by 7½ ft., through divide at west end of dam 65 ft. below summit of divide; 1,500-ft. wooden-stave pipe 4½ ft. in diameter, and 1,800 ft. of lap-riveted steel pipe 4 ft. in diameter to power house. When plant was built pipe line was laid through reservoir to draw water from creek as well as from reservoir. Pipe was 1,420 ft. long, 50 in. in inside diameter, and anchored to bottom of reservoir by loops of wire fastened to deadmen. Water was formerly diverted into pipe line by low concrete dam with flashboards but is now taken directly from reservoir. Tailrace, open channel 100 ft. long, 7½ ft. wide, and 6 ft. deep; lined with concrete; leads from south side of building to creek.

Power house and transmission system.—Power house, two-story brick building, dimensions 34 by 100 ft., concrete foundations, steel framework, concrete floors, and asphalt-gravel roof. A 10-ton crane serves entire lower floor. First floor occupied by water wheels, generators, and switchboards; second floor occupied by transformers and attendant's living quarters. Installation, originally four special double-nozzle Pelton water wheels, 61 in. in diameter, 600-hp. capacity under effective head of 370 ft., direct-connected to four 400-kw. 525-v. 60-cycle 3-phase 300-r. p. m. General Electric generators. Two exciter units comprising one 50-hp. 13-in. Pelton water wheel direct-connected to one 25-kw. 125-v. 1,300-r. p. m. General Electric d. c. generators. In 1914 two of the 400-kw. units were replaced by one 1,500-hp. 600-r. p. m. S. Morgan Smith turbine, direct-connected to one 1,000-kw. 2,500-v. General Electric generator. Capacity of plant increased from 1,600 to 1,800-kw. Static head, 376 ft. Current leaves plant at 11,000 and 28,000 v. for distribution over system of Utah Power & Light Co.

Remarks.—Besides this plant, the company at this time proposed to develop another site, on the water rights and property once owned by the Granite Paper Mills Co., which had a paper mill equipped with water-power machinery at the mouth of the canyon. The power development consisted of an open ditch 8 ft. wide at bottom and 5 ft. deep, extending for 3,300 ft. along the north hillside of the canyon and connecting with an 8 by 4½ by 130-ft. flume leading to a wooden penstock intake 8 by 8 by 24 ft., from the bottom of which a 48 to 38 in. riveted-steel pipe extended 460 ft. down the hill slope to a 26½-in. horizontal Leffel turbine, under a head of 132 ft. This mill burned down in 1892. The properties which the Big Cottonwood Power Co. contemplated acquiring comprised 200 acres of patented land with water rights and five brick dwelling houses. Nothing has been done toward the development of this old site. The Stairs plant was included with the Granite plant in the merger which resulted in the organization of the Utah Light & Power Co., later the Utah Light & Railway Co., and finally the Utah Light & Traction Co.

GRANITE PLANT (10HH 7).[36]

Location and plan of development.—In Cottonwood Canyon about 14 miles southeast of Salt Lake City. Diversion dam in SW. ¼ sec. 20, T. 2 S., R. 2 E., Salt Lake base and meridian. Flume along north side of creek to power house in NE. ¼ sec. 25, T. 2 S., R. 1 E. (Pl. III).

Ownership and market.—Owner, Utah Light & Traction Co., leased to Utah Power & Light Co. Market, territory served by Utah Power & Light Co. in Utah and Idaho. (See old Grace plant, p. 67.)

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[36] Elec. World and Eng., Mar. 30, 1901.

Chronologic summary.—Plant built in 1895 by Utah Power Co. Sold to Utah Light & Power Co., then to Utah Light & Railway Co., and finally to Utah Light & Traction Co.

Water supply.—Source of water, Cottonwood Creek. Rights acquired by appropriation and use. Estimated Q90 flow 27 sec.-ft., Q50 flow 43 sec.-ft.; corresponding power capacities 1,020 and 1,620 hp., respectively.

Hydraulic features.—Dam, stop-log structure about 8 ft. high, concrete foundations and steel uprights, in creek just below tailrace of Stairs station. Intake, timber box at north end of dam. Conduit, wooden flume, length 10,000 ft., dimensions 40 by 60 ft. Wooden standpipe 8 ft. in diameter, 25 ft. high, connects flume with penstock. Penstock 1,200 ft. long, riveted-steel pipe 4 ft. in diameter. Wooden-chute wasteway from flume to creek, length 1,200 ft., width 12 ft., depth 8 ft.

Power house and transmission system.—Power house, buff brick, on concrete foundations, on north bank of creek. Installation, two 1,200-hp. Pelton water wheels direct-connected to two 750-kw. 500-v. 60-cycle 2-phase 300-r. p. m. Westinghouse generators. Two 50-hp. Pelton water wheels direct-connected to two 25-kw. 125-v. Westinghouse d. c. exciter generators. Static head at plant 470 ft. Current leaves plant at 11,000 and 28,000 v. for distribution over system of Utah Power & Light Co.

Remarks.—This plant was built to supply power to Salt Lake City Railroad through substation in center of the city. It was one of the first commercially successful hydroelectric plants in the Great Salt Lake basin.

KNUDSON PLANT (10HH 8).

Location and plan of development.—On Cottonwood Creek near mouth of canyon. Diversion dam, canal, and power house all in sec. 23, T. 2 S., R. 1 E., Salt Lake base and meridian, about 4 miles east of Murray, Utah (Pl. III).

Ownership and market.—Owner, Progress Co. Market, Murray, Magna, Midvale, Sandy, and small settlements in Salt Lake County.

Chronologic summary.—Plant built by the Progress Co. in 1906.

Water supply.—Source of water, Cottonwood Creek. Rights adjudicated. Company has decreed right for 75 sec.-ft., but this amount is available only in May and June. Average flow for rest of year about 28 sec.-ft. Some power purchased from Utah Power & Light Co. during low-water season. Estimated Q90 flow 28 sec.-ft., Q50 flow 40 sec.-ft.; corresponding power capacities 180 and 260 hp., respectively.

Hydraulic features.—Dam, rock and brush, only high enough to turn water into canal. Conduit, open canal, 12 ft. wide on top and 4 ft. deep; carrying capacity about 75 sec.-ft. Penstock, 3 ft. in diameter.

Power house and transmission system.—Power house, small frame building 18 by 30 ft. Installation, one 24-ft. 200-hp. Leffel turbine and one 150-kw. 2,300-v. 3-phase General Electric generator. Operating head at plant 82 ft. Current generated at 2,300 v. and placed directly on distributing system, which consists of about 100 miles of transmission and service lines in Salt Lake County.

GORDON PLANT (10HH 9).

Location and plan of development.—At north edge of city of Murray, Salt Lake County, Utah. Plant on an irrigation canal in sec. 6, T. 2 S., R. 1 E., Salt Lake base and meridian.

Ownership and market.—Owner, Progress Co. Market, Murray, Midvale, Sandy, Magna, and smaller settlements in Salt Lake County.

Chronologic summary.—Plant built by the Progress Co. about 1904. Not operating at present time. Company contemplates more extensive development in the Cottonwood Canyon and may abandon this plant.

Water supply.—Source of water, Cottonwood Creek. Rights decreed by court for 150 sec.-ft., but this amount is available only in May and June. Average flow rest of year about 44 sec.-ft. Estimated Q90 flow 30 sec.-ft., Q50 flow 50 sec.-ft.; corresponding power capacities 60 and 100 hp., respectively.

Hydraulic features.—Dam, low overflow dam, canal which serves for irrigation as well as power. Carrying capacity about 150 sec.-ft. Penstock, short steel pipe to power house.

Power house and transmission system.—Power house, small brick building. Installation, one 48-in. 200-hp. Leffel turbine and one 150-kw. 2,300-v. 3-phase General Electric generator. Operating head at plant 25 ft. Current taken directly from generator onto transmission line and used in the settlements above mentioned. Transmission and distribution system comprises about 100 miles of lines. Plant used in connection with Knudson plant.

LOWER MILL CREEK PLANT (10HH 1).[37]

Location and plan of development.—In Mill Creek canyon 10 miles southeast of Salt Lake City. Diversion dam in SE. ¼ sec. 28, T. 1 S., R. 2 E., Salt Lake base and meridian. Pipe line along north side of creek to power house at mouth of canyon in W. ½ sec. 36, T. 1 S., R. 1 E. Porter Creek, Church Creek, and several large springs flow into Mill Creek below dam. Branch pipe lines from Porter and Church creeks and pumping plant at springs bring water from those sources into main creek and pipe line.

Ownership and market.—Owner, Utah Power & Light Co. Market, territory served by Utah Power & Light Co. (See old Grace plant, p. 67.)

Chronologic summary.—Construction started in 1909, completed in 1910. Plant built by Knight Power Co. Sold to Utah Power & Light Co.

Water supply.—Source of water, Mill Creek, Church Creek, Porter Creek, and springs. Rights acquired through State engineer of Utah. Small regulating pond above dam, 300 by 100 ft., average depth 8 ft.; can store about half stream flow for 12 hours and permit use of more water during day peak load. To do this, however, and not interfere with irrigation rights below, an equalizing reservoir was built below plant. Estimated Q90 flow 7 sec.-ft., Q50 flow 12 sec.-ft.; corresponding power capacities 580 and 1,000 hp., respectively.

Hydraulic features.—Dam, concrete wall, crest length 83 ft., height 21 ft., spillway 15 ft. Intake, concrete channel 22 by 5 ft., at north end of dam, controlled by hand-operated screw-stem gate. Conduit, wooden-stave pipe; length 25,094 ft., diameter 30 in. Follows tortuous course, more than 50 per cent curved. Grade 0.2 per cent. In 22 places riveted-steel elbows used for sharp curves. Steel T connects lower end of grade pipe and penstock, and 30-in. surge pipe extends 450 ft. up hillside. Penstock, steel pipe; length 2,400 ft., diameter 30 in. at top 20 in. at bottom; Y at lower end, each branch connecting with turbine. Water from Porter Creek carried in wooden-stave pipe 1½ ft. in diameter, 374 ft. long, and emptied into Mill Creek above diversion dam. Water from Church Creek carried in wooden-stave pipe 1 ft. in diameter, 405 ft. long, tapped into main pipe line 8,118 ft. below Mill Creek diversion dam. Water from springs rises about ½ mile below dam; from 3 to 4.5 sec.-ft. collected in concrete basin and pumped by 6-in. Worthington single-stage centrifugal pump through 1-ft. wooden-stave pipe into main pipe line. Pump direct-connected to one 100-hp. 1,800-r.p.m. 2,200-v. General Electric motor installed

[37] Eng. Rec. Mar. 25, 1911; Eng. Rec. Mar. 15, 1913.

in small brick and concrete house. One end of house made into collecting well by concrete partitions across building. Plant designed for capacity of 38 sec.-ft. when pumping against total head of 138 ft. Unit is automatically controlled by float switch.

Power house and transmission system.—Power house, brick on concrete foundations, on north bank of creek, dimensions 73 by 34 by 18 ft. One 32-ft. span 10-ton hand-operated Whiting crane. Installation, two 1,300-hp. Doble impulse water wheels designed for 990-ft. head and 514 r. p. m. Wheels direct-connected to two 700-kva. 2,300-v. 60-cycle 3-phase General Electric generators. On same shaft of each unit is one 21-kw. 125-v. d. c. General Electric exciter generator. Each water wheel requires 10.5 sec.-ft. of water when generator load is 650 kw. and head 960 ft. Operating head at plant 960 ft., static head 1,037 ft. Current leaves plant at 44,000 v. and is distributed through system of Utah Power & Light Co.

UPPER MILL CREEK PLANT (10HH 11).

Location and plan of development.—In Mill Creek canyon 12 miles southeast of Salt Lake City, Utah. Diversion dam near center of sec. 26, T. 1. S, R. 1 E.; pipe line along north side of creek to power house in SW. ¼ sec. 27; power house about 5 miles from mouth of canyon (Pl. III).

Ownership and market.—Owner, Utah Power & Light Co. Market, Great Salt Lake basin and adjacent territory. (See old Grace plant, p. 67).

Chronologic summary.—Plant built in 1907 by Mill Creek Power Co. Acquired by Utah Power & Light Co. in March, 1913.

Water supply.—Source of water, Mill Creek. Rights acquired through State engineer of Utah in 1907. License issued for 13.3 sec.-ft. No regulation of stream. Estimated Q90 flow 5 sec.-ft., Q50 flow 9 sec.-ft.; corresponding power capacities 240 and 430 hp., respectively.

Hydraulic features.—Dam, rubble masonry, crest length about 25 ft., height 8 ft., spillway 8 ft., sluiceway 2⅔ ft. Intake, screened, controlled by hand-operated gate, opens into wooden-stave pipe line. Conduit, wooden-stave pipe, length 9,117 ft., diameter 22 in., located along north side of canyon, mostly in earth excavation. Capacity 13½ sec.-ft. Penstock, riveted-steel pipe, length 775 ft., diameter 22 in. at top, 12 in. at bottom.

Power house and transmission system.—Power house, brick on rock foundations, dimensions 25 by 38 ft. One 3-ton chain block for handling machinery. Installation, one 650-hp. 450-r. p. m. double overhung impulse water wheel, designed for 300-kw. generator load with 9 sec.-ft. of water and 587-ft. head, direct-connected to one 300-kva. 2,300-v. 60-cycle 3-phase General Electric generator. Exciter unit one 10-kw. 125-v. General Electric d. c. generator, belt driven from main shaft. Operating head at plant 577 ft., static head 600 ft. Current leaves plant at 44,000 v. and is distributed through general system of Utah Power & Light Co.

SUMMARY.

Power plants in Jordan River and Utah Lake drainage basins.

Index No.	Name of plant.	Stream.	Static head (H).	Rated capacity of installed water wheels.	With existing flow.				With regulated flow.			
					Q90	Q50	Horsepower.		Q90	Q50	Horsepower.	
							0.08HQ90	0.08HQ50			0.08HQ90	0.08HQ50
			Feet.	*Horsepower.*	*Sec.-ft.*	*Sec.-ft.*			*Sec.-ft.*	*Sec.-ft.*		
10HF 1	Alpine	Dry Creek	1,924	3,000	2	4	310	620				
10HF 2	Upper American Fork	American Fork	575	2,000	17	29	780	1,330				
10HF 3	Lower American Fork	do	292	1,450	21	37	490	860				
10HF 4	Battle Creek	Battle Creek	1,757	4,000	2	4	280	560				
10HF 5	Springville	Hobble Creek	134	150	22	32	240	340				
10HF 6	Strawberry	Spanish Fork	125	1,600					100	150	1,000	1,875
10HF 7	Santaquin	Santaquin Creek	636	1,700	6	8	300	410				
10HF 8	Nephi	Salt Creek	146	200	15	20	170	230				
10HF 9	Nephi Plaster	do	184	200	15	20	220	300				
10HG 1	Murdock	Provo River	195	3,300	54	89	840	1,390				
10HG 2	Heber	do	92	1,600	50	75	370	540				
10HG 3	Olmsted	do	340	18,500	200	310	5,440	8,430				
10HG 4	Park City	Ontario drain tunnel	120	240	25	25	240	240				
10HG 5	Snake Creek	Snake Creek	752	2,000	19	25	1,140	1,500				
10HH 1	Jordan	Jordan River	73 55	1,344	[a] 178	[a] 293	1,040	1,700	[a] 178	[a] 293	1,040	1,700
10HH 2	Bennion	do	16	100	60	60	75	75				
10HH 3	Columbus Consolidated	Little Cottonwood Creek	496	800	20	30	790	1,190				
10HH 5	Murray	do	523	1,200	25	37	1,020	1,520				
10HH 6	Stairs	Cottonwood Creek	376	2,700	24	38	720	1,140				
10HH 7	Granite	do	470	2,400	27	43	1,020	1,620				
10HH 8	Knudson	do	82	200	28	40	180	260				
10HH 9	Gordon	do	25	200	30	50	60	100				
10HH 10	Lower Mill Creek	Mill Creek	1,037	2,600	7	12	580	1,000				
10HH 11	Upper Mill Creek	do	600	650	5	9	240	430				
				52,134								

[a] Existing flow of Jordan River is regulated for irrigation, and power must conform to that condition.

NOTE.—The computed power capacities shown in this table are based somewhat arbitrarily on the time elements and other specified conditions given on pp. 109–110. They serve for comparison of power sites considered as individual sites, but they bear no definite relation to the installed capacities or the energy output of plants in the Utah Power & Light Co.'s system, because of the Bear River regulation and the interconnection of plants, which permits a maximum utilization of the smaller streams.

WILLARD, FARMINGTON, AND BOX ELDER CREEKS AND STREAMS IN TOOELE AND RUSH VALLEYS.

BRIGHAM CITY PLANT (10HA 1).

Location and plan of development.—On Box Elder Creek near the mouth of its canyon, 1 mile southeast of Brigham, in Box Elder County, Utah. Diversion dam in SE. ¼ sec. 21, T. 9 N., R. 1 W., Salt Lake base and meridian; pipe line along north side of creek to power house in SE. ¼ sec. 19 (Pl. III).

Ownership and market.—Owner, city of Brigham. Market, city of Brigham.

Chronologic summary.—This is the second plant built by the city. The first one, built about 1908 at a cost of $64,000, was outgrown by the city and replaced by the present plant, built in 1921 at a cost of about $184,000.

Water supply.—Source of water, Box Elder Creek. Rights acquired through State engineer of Utah and purchase. Entire flow of creek, except South Fork, is available for use by plant. Pipe line designed large enough to include flow of South Fork when such additional flow becomes necessary. Total estimated Q90 flow of creek 19 sec.-ft., Q50 flow 30 sec.-ft.; corresponding power capacities 850 and 1,340 hp., respectively.

Hydraulic features.—Dam, concrete wall about 18 ft. high and 68 ft. long on top, with spillway in middle section, 48-in. opening into steel reducer through dam into pipe line. Conduit, wooden-stave pipe, 30 in. in diameter, 10,934 ft. long, along north side of canyon to its mouth, thence about 2,400 ft. welded-steel penstock 30 to 28 in. in diameter, with Y at lower end. Tailrace, open channel.

Power and transmission system.—Power house, one-story brick, with concrete foundations, floor, and bottom 3 ft. of walls. Outside dimensions, 42 ft. 2 in. by 36 ft. 2 in. Installation, two 750-hp. double-nozzle 450-r.p.m. Pelton water wheels, 52 in. in diameter, designed for static head of 560 ft. and effective head of 500 ft. Direct-connected to water wheels are two 600-kw. 4,000-v. 60-cycle 3-phase 450-r.p.m. Westinghouse generators. Current for excitation furnished by one 26-kw. 1,200-r.p.m. d.c. Westinghouse generator direct-connected to one 20½-in. diameter Pelton water wheel supplied with water from 5-in. pipe tapped into penstock. Also one three-bearing motor-generator set, 30-kw. motor and 26-kw. d.c. exciter, as dual exciter set. Operating head 500 ft., static head 560 ft. Current generated at 4,000 v. and transmitted on 3-phase 4-wire system through city, being stepped down for service distribution.

Remarks.—This power house is below old plant and point of diversion above old dam. Head at old plant 287 ft. Old plant to be abandoned. City voted bond issue of $200,000 for building new plant.

WILLARD PLANT (10HA 3).

Location and plan of development.—In Box Elder County, Utah, just east of the town limits of Willard. Diversion dam in NE. ¼ sec. 24, T. 8 N., R. 2 W., Salt Lake base and meridian; pipe line about 1¼ miles long to power house in SE. ¼ sec. 23. From dam to mouth of canyon pipe lines laid in creek bed to avoid excessive costs of construction. Canyon is rock-bound gorge with sheer walls (Pl. III).

Ownership and market.—Owner, Utah Power & Light Co. Market, territory served by company. (See old Grace plant, p. 67.)

Chronologic summary.—Construction begun in November, 1908; completed in May, 1909. Plant built by M. S. Browning, of Ogden, Utah. Sold to Utah Power & Light Co. in 1913.

Water supply.—Source of water, Willard Creek. Rights acquired through State engineer of Utah. Stream small spring-fed mountain creek. Winter flow about 2 sec.-ft.; high-water flow about 11 sec.-ft. Domestic water supply for Willard taken from concrete cistern supplied from tailrace of power plant. Estimated Q90 flow 3 sec.-ft., Q50 flow 4 sec.-ft.; corresponding power capacities 290 and 390 hp., respectively.

Hydraulic features.—Dam, small concrete structure. Height 17 ft., crest length about 30 ft., with 20-ft. spillway and 50 ft. of concrete retaining wall extending upstream to form bank for forebay pond. Maximum depth of pond at dam 15 ft., average depth 6 ft., capacity 0.4 acre-ft. Conduit, first 774 ft., wire-wound wooden-stave pipe tapering from 24 to 18 in. in diameter. Inlet to pipe controlled by steel hand-operated gate. Remainder of pipe line, 5,854 ft., riveted-steel pressure pipe tapering from 16 to 11 in. in diameter. Tailrace is concrete inclosed channel leading to a hermetically sealed concrete cistern which serves as a reservoir for town water supply.

Power house and transmission system.—Power house, small buff-brick building on concrete foundations. Dimensions 32.5 by 36.5 by 17.75 ft. Half-ton chain block used for handling machinery. Installation, one 700-hp. 48-in. 600-r. p. m. Allis-Chalmers tangential water wheel, direct connected to one 350-kw. 2,300-v. 60-cycle 3-phase Allis-Chalmers generator. Exciter unit, belt-driven from main shaft, is one 75-kw. 120-v. 1,650-r. p. m. generator. Water wheel designed for 4.7 sec.-ft. of water under 1,170-ft. head and 350-kw. generator load. Operating head at plant 1,170 ft., static head 1,209 ft. Current generated at 2,300 v. Local needs for town supplied from 6,600-v. line. Remainder leaves plant at 11,000 v. and is used in immediate vicinity in the general system of the Utah Power & Light Co.

Remarks.—Electrical machinery first installed consisted of one Allis-Chalmers d. c. 300-kw. 500–600-v. generator on same shaft with one Allis-Chalmers 350-kva. 2,300-v. 60-cycle generator direct connected to the water wheel and one 9-kva. 116–120-v. 1,650-r. p. m. belt-driven exciter generator. Direct current was used by Ogden, Logan & Idaho Electric Railway until 1915, when the power was furnished from other sources and d. c. machine was removed.

DAVIS OR FARMINGTON PLANT (10HA 4).

Location and plan of development.—In Davis County, Utah, less than 2 miles northeast of Farmington. Diversion dam in NE. ¼ sec. 17, T. 3 N., R. 1 E., Salt Lake base and meridian; pipe line along south side of creek to power house in NE. ¼ sec. 18 (Pl. III).

Ownership and market.—Owner, Utah Power & Light Co. Market, territory served by company. (See old Grace plant, p. 67.)

Chronologic summary.—Construction begun in July, 1908; completed in January, 1910. Plant built by Davis County Light & Power Co. Sold to Utah Power & Light Co.

Water supply.—Source of water, Cottonwood Creek, locally known as Farmington Creek, and Accommodation Creek, a small tributary. Rights acquired through State engineer of Utah. Application made in 1910; proof made in 1911. Certificate issued for 10 sec.-ft. No storage regulation on stream. Estimated Q90 flow 4.4 sec.-ft., Q50 flow 5.7 sec.-ft.; corresponding power capacities 270 and 350 hp., respectively.

Hydraulic features.—Dam, weir section, concrete, crest length 10½ ft., height 6 ft. Wing walls. Intake, screened opening 6 by 2 ft. through south wing wall controlled by hand-operated gates. Conduit, wooden-stave pipe 2 ft. in diameter, on grade of 42.2 ft. to a mile. Crosses Accommodation Creek about one-quarter mile downstream from dam. Water from Accommodation Creek carried in 6-in. pipe tapped into main line. Length of pipe line 6,200 ft. Penstock, riveted-steel pipe 18 in. in diameter to power house.

Power house and transmission system.—Power house, plain concrete building, dimensions 47 by 27.5 by 17 ft., on rubble masonry foundations. One end used for machinery equipment, other for attendant's living quarters. Set of 1-ton chain blocks used for handling machinery. Installation, one 537-hp. 50-in. Doble impulse water wheel direct connected to one 312-kw. 2,300-v. General Electric generator. Exciter, belt driven from main shaft, is one 12-kw.125-v. General Electric d. c. generator. Operating head at plant 756 ft., static head 776 ft. Current leaves plant at 2,200 and 11,000 v.; practically all used in the vicinity.

TOOELE PLANT (10HA 6).

Location and plan of development.—On Settlement Creek in sec. 33, T. 3 S., R. 4 W., Salt Lake meridian, near city of Tooele, Tooele County, Utah.

Ownership and market.—Owner, Clark Electric Power Co. Market, mines at Ophir, Utah, and towns of Grantsville, Burmaster, and Stockton, in Toele County.

Chronologic summary.—Plant built in 1902 by Clark Electric Power Co.

Water supply.—Source of water, Settlement Creek and Left Fork. Rights acquired by appropriation and use. Estimated Q90 flow 2 sec.-ft., Q50 flow 5 sec.-ft.; corresponding power capacities 85 and 210 hp., respectively. Water sufficient to operate plant at capacity about 3 months each year.

Hydraulic features.—Wooden head-gate boxes in creek. Wooden intake boxes with wooden screens. Steel pipe line 11,850 ft. long; pipe 10 in. in diameter from intake on Left Fork to power house, laid on average grade of 7.11 to 100 ft. Pipe line 13,758 ft. long from intake on Settlement Creek to power house; diameter of pipe 20 to 14 in. Upper 1¼ miles of line wire-wound wooden-stave pipe; rest steel. Average grade of line 3.84 ft. to 100 ft. About 300 ft. of open ditch leads from Settlement Creek diversion to intake pipe.

Power house and transmission system.—Power house on north side of creek; brick building with concrete floor, dimensions 22 by 60 ft. Sheet-metal addition built onto west side of power house, originally for steam auxiliary, now converted into ice-manufacturing plant, capacity about 5 tons daily. Installation, one double-runner 400-hp. Pelton water wheel, direct connected to one 250-kva. 6,600-v. 3-phase 450-r. p. m. General Electric generator. Static head of pipe lines on Settlement Creek and on Left Fork 530 and 852 ft., respectively. Exciter generator, belt driven from main shaft, 125-v. 72-a. 900-r. p. m. General Electric. A 11-kv. transmission line from plant to Grantsville, 12½ miles, thence to Burmaster, 6 miles farther, and another line to Stockton, 7½ miles, connected through substation with South Willow and Ophir plants. Outdoor substation connects Tooele plant through 6½ miles of line with Terminal-Arthur-Salt Works-Bingham 44-kv. line of Utah Power & Light Co. Power purchased from this company part of year. Territory served about 35 miles long and 14 miles wide, population 6,500, and two small mining plants having a combined maximum load of 100 hp. Operating headquarters at Tooele; all distribution lines 2,300 v.

SOUTH WILLOW PLANT (10HA 7).

Location and plan of development.—On South Willow Creek, 6 miles south of Grantsville, Tooele County, Utah. Diversion from creek into pipe line in SW. ¼ sec. 6, T. 4 S., R. 6 W., Salt Lake base and meridian; power house in SE. ¼ sec. 27, T. 3 S., R. 6 W. (Pl. III).

Ownership and market.—Owner, Ophir Hill Consolidated Mining Co. Market, towns and mines in Tooele County. (See Tooele plant, above.)

Chronologic summary.—Plant built in 1912–13.

Water supply.—Source of water, South Willow Creek. Rights acquired by appropriation and use. Stream flow sufficient $4\frac{1}{2}$ months each year to operate plant at capacity. Estimated Q90 flow 2 sec.-ft., Q50 flow 3 sec.-ft.; corresponding power capacities 180 and 270 hp., respectively.

Hydraulic features.—Diversion immediately below spring that supplies most of the creek flow. Conduit, wooden-stave wire-wound pipe and iron pipe. Diameter 20 to 12 in., length $4\frac{1}{2}$ miles, wooden pipe $1\frac{1}{4}$ miles long, rest iron.

Power house and transmission system.—Power house, rock masonry with concrete floor; inside dimensions 25 by 45 ft.; on north side of creek. Installation, two 275-hp. 4-ft. diameter Doble-Pelton water wheels direct connected to two 200-kva. 2,400-v. 3-phase 600-r. p. m. Westinghouse generators, gross head 1,116 ft. Two Westinghouse d. c. exciter generators, belt driven from main shaft, each 6 kw. 125 v. 1,480 r. p. m. Current leaves plant at 11,000 v. over transmission line to Stockton substation, thence to mines of Ophir Hill Consolidated Mining Co. at Ophir. All power in excess of needs at mine and mill is handled by Clark Electric Co.

OPHIR PLANT (10HA 8).

Location and plan of development.—On Ophir Creek near Ophir mining camp, about 8 miles southwest of Bingham, Utah, in T. 5 S., R. 4 W., Salt Lake base and meridian (Pl. III). Diversion from Ophir Creek into pipe line leading to power house.

Ownership and market.—Owner, Ophir Hill Consolidated Mining Co. Market, mines and towns in Tooele County, Utah. (See Tooele plant, p. 106.)

Chronologic summary.—Plant built in 1902–3.

Water supply.—Source of water, Ophir Creek. Rights acquired by appropriation and use. Estimated Q90 flow 2.5 sec.-ft., Q50 flow 5 sec.-ft.; corresponding power capacities 150 and 290 hp., respectively. Stream flow sufficient to run plant at capacity about 5 months a year.

Hydraulic features.—Small masonry and wooden dam in creek, 2,207 ft. of 18-in. wooden pipe, 3,000 ft. of 16-in. wooden pipe, 3,000 ft. of 18-in. iron pipe, 1,420 ft. of 15-in. iron pipe, 2,730 ft. of 14-in. iron pipe, and 7,900 ft. of 12-in. iron pipe. Total head 957 ft.

Power house and transmission system.—Power house, rubble masonry with concrete floor, inside dimensions 21 by 41 ft., on south side of creek. Installation, one 600-hp. 4-ft. diameter Pelton water wheel direct connected to one 300-kva. 2,300-v. 3-phase 60-cycle 450-r. p. m. General Electric generator. One General Electric exciter generator, 125-v. 60-a. 1,800-r. p. m. d. c., belt driven from main shaft. Current sent over $2\frac{1}{2}$ miles of transmission line to Ophir substation, where line is connected with 11,000-v. line from Stockton.

Remarks.—Besides contributing any surplus power it may generate to the system of the Clark Electric Power Co., this plant gives emergency service to pump in Ophir Hill mines during times of trouble. The pipe line extends through the Ophir mining camp, and at several places it is tapped and water is taken out for milling purposes and for domestic supply for the camp.

SUMMARY.

Developed power sites on Willard, Farmington, and Box Elder creeks and streams in Tooele and Rush valleys.

Index No.	Name of plant.	Creek.	Static head (H).	Rated capacity of installed water wheels.	With existing flow. Q90	Q50	Horsepower. 0.08HQ90	0.08HQ50
			Feet.	*Horsepower.*	*Sec.-ft.*	*Sec.-ft.*		
10HA 1	Brigham	Box Elder	560	1,500	19	30	850	1,340
10HA 3	Willard	Willard	1,209	700	3	4	290	390
10HA 4	Farmington	Farmington	776	537	4.4	5.7	270	350
10HA 6	Tooele	Settlement	{ 852 530 }	400	2	5	85	210
10HA 7	South Willow	South Willow	1,116	550	2	3	180	270
10HA 8	Ophir	Ophir	957	600	2.5	5	150	290
				4,287			1,825	2,850

UNDEVELOPED WATER POWER.

FACTORS AFFECTING CAPACITY OF POWER SITES.

Considerable knowledge of the possibilities and limitations of a contemplated water-power development is of primary importance. An urgent demand is usually the impelling force in developing all hydroelectric projects, and the feasibility of any particular project depends upon whether the revenue to be received from the sale of the energy is sufficient to warrant the necessary expenditures.

In order to make determinations, complete and accurate data are essential, but the numerous factors entering into the computations are variable, and accuracy in these computations is merely relative, so that for preliminary investigations a range of error of 10 to 15 per cent should be allowed.

The head available at any power site can be determined readily, but not so the amount of water available. The amount of water can be measured, but one measurement or many measurements of a flashy mountain stream are not enough to determine the low and high water periods of the stream. The value of a stream-flow record is directly proportional to the length of the record, or, in other words, the time element must be considered.

The minimum power that can be made available at any site is the power that can be developed during the period of lowest flow of the stream—a period which on the streams of the Great Salt Lake basin extends over only a few days or weeks in the winter. For the rest of the year a greater amount of power could be developed. It is therefore usually wise not to design a plant for an actual minimum flow but to "overdevelop" to some extent and provide for auxiliary power to carry the load over the periods of shortage. No definite rules can be given that will apply to the percentage of overdevelopment for all projects. Each project offers a separate problem, whose solution depends upon the local conditions. For example, at one site the market demand may be so distributed that the peak demand occurs when the stream flow is high, and only a small amount of auxiliary power may be needed each year to be supplied from a steam plant or from storage reservoirs, if reservoir sites are available. It may be advisable under such conditions to design a plant having a capacity for several times as much as the minimum stream flow. The same conclusion would apply if the plant is to be connected into a system that contains several hydroelectric plants having storage reservoirs and perhaps one or more steam plants, a combination that is very flexible and one that usually allows a high percentage of overdevelopment, even on a stream where there are no storage-reservoir sites.

With these facts in mind it is quite obvious that the power capacity of any power site ranges from the minimum to the maximum stream-flow capacity, and that any figures given to indicate the potential power at such site must be qualified by the time factor. In other words, the potential power must be expressed as so many horsepower or kilowatts for a definite percentage of the time.

The power capacities considered in this report are divided somewhat arbitrarily into two groups based on time elements. The power capacity available 90 per cent of the time corresponds to the stream flow that is available for about eleven months in a year. With a small amount of storage this capacity might be maintained continuously. The power capacity available 50 per cent of the time corresponds to the flow that is available for six months in a year. If this flow is less than the mean flow this capacity might be maintained continuously by means of storage, provided sufficient storage capacity is available above the particular site considered. The 90 per cent capacity is nearly always exceeded in power-house installations; the 50 per cent capacity is generally exceeded only where auxiliary steam power is available or the market conditions are exceptional.

The power capacity of the power sites that are considered here is the continued product of the factor 0.08, the average static head in feet (H), and the quantity of water in cubic feet per second estimated to be available for 90 per cent of the time (Q90) and for 50 per cent of the time (Q50). The factor 0.08 represents the horsepower at 70 per cent efficiency of 1 cubic foot of water per second falling through a head of 1 foot. Its use in calculating power capacities involves the assumption that 70 per cent of the theoretical power indicated by the stream flow and the static head can be made available for transmission, an assumption that conforms closely to the average results that can be realized in strictly modern power plants.

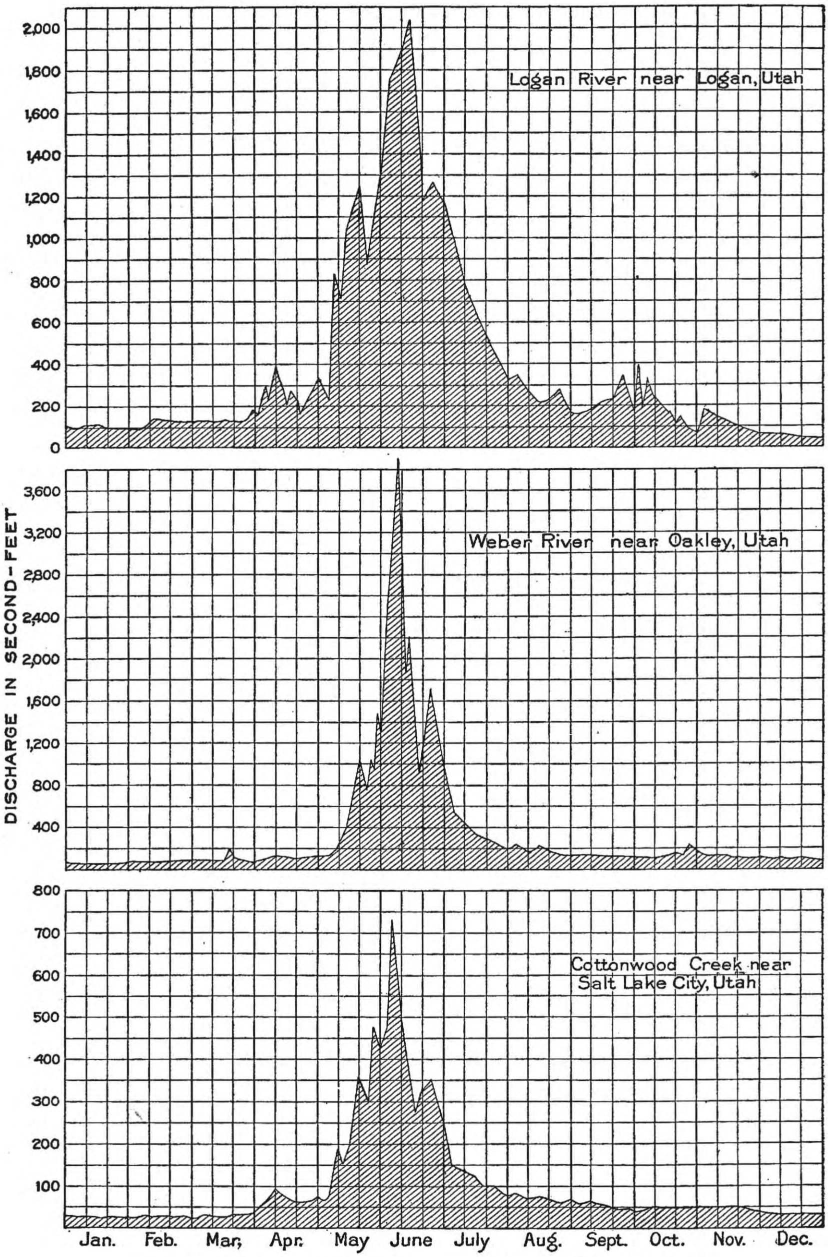

FIGURE 7.—Typical hydrographs of streams in the Great Salt Lake basin.

Figure 7 shows three hydrographs of different streams in the Great Salt Lake basin. These are typical of the streams in the basin and show the close relation between the Q50 and the Q90 flow. The season of high-water flow is usually not more than three months in length, and there is a decided peak in June. The ratio of the Q50 to the Q90 flow $\left(\frac{Q50}{Q90}\right)$ ranges from 1 to about 2.3 on the streams in the basin and is highest for the years of low run-off. The average ratio for the entire basin, however, is about 1.5.

AVAILABLE FLOW.

The stream-flow records presented in this report (pp. 173-265) indicate the amount of water available at the gaging stations that are nearest to the power sites. There are no gaging stations at any of the power sites, and for that reason the flow that might be expected for 90 and 50 per cent of the time at these sites has been estimated from the data available. Only those streams that show a power capacity of at least 100 horsepower for 90 per cent of the time have been considered.

SITES IN BEAR RIVER BASIN.

Evanston or Big Bend site.—On Bear River about 20 miles southeast of Evanston (10HB 1 [38]). The point of diversion is in Utah, and the power-plant site is in Wyoming. The topography is suitable for a low diversion dam across the river channel and for a canal leading along the west side of the river. A canal 6 miles long heading in sec. 30, T. 3 N., R. 10 E., Salt Lake base and meridian, and leading to a power house in sec. 13, T. 12 N., R. 120 W., Wyoming, would provide a head of 400 feet, which, with a Q90 flow of 25 second-feet, would develop 800 horsepower (600 kilowatts). The Q50 flow at this site is probably very little, if any, greater than the Q90 flow because of the short flood season.

Wyuta sites.—Four water-power sites were investigated by the Wyuta Development Co. in connection with an irrigation project that contemplated the diversion of flood waters from Bear River into reservoirs on Yellow and Coyote creeks for use on lands in Utah and Wyoming to the south, west, and northwest of Evanston. The plan was to build a crib dam across the channel of Bear River about 1 mile south of the Utah-Wyoming boundary, in sec. 19, T. 13 N., R. 10 E., Salt Lake base and meridian, a canal of 850 second-feet capacity that would extend along the hills west of the river and over a low divide into the Yellow Creek drainage basin, a reservoir on Yellow Creek and another on Coyote Creek, and a system of canals and laterals that would carry the water to about 54,200 acres of land. The diversion canal would be about 6.3 miles long. The main power plant (10HB 2) would be near the SE. ¼ sec. 15, T. 12 N.,

[38] The numbers correspond to those used on the map (Pl. III).

R. 120 W. sixth principal meridian, at the terminus of the canal, and the Big Bend plant (10HB 3) would be about 3 miles from the diversion dam, near the south line of sec. 13, T. 12 N., R. 120 W., at a place where there is a drop of 79 feet. The head available at the proposed main plant is 268 feet, and the power capacity with a Q90 flow of 25 second-feet is 540 horsepower (400 kilowatts). With the same flow at the Big Bend plant, the power capacity is 160 horsepower (120 kilowatts).

The Wright plant (10HB 5) was to be built near the mouth of Coyote Creek, in sec. 26, T. 14 N., R. 121 W., and supplied with water from a feeder canal that would carry water from the Yellow Creek reservoir to the Coyote Creek reservoir. The part of the flow passing through the power plant would go directly into Yellow Creek. The head available at this site is 117 feet, and the power capacity with a Q90 flow of 25 second-feet is 230 horsepower (170 kilowatts).

The Forbes plant (10HB 6) was to be built on Yellow Creek in sec. 12, T. 14 N., R. 121 W., in Wyoming. The water would be supplied through the Wyuta canal. This canal would divert water from Yellow Creek just below the mouth of Coyote Creek and would extend along the foothills toward Evanston. At the power site the canal would be 80 feet above the creek and only about 300 feet distant. The power capacity of the site with a Q90 flow of 25 second-feet is 160 horsepower (120 kilowatts). The Q50 flow at these Wyuta sites is very little, if any, greater than the Q90 flow.

Woodruff Narrows site.—On Bear River 7 miles east of Woodruff, Utah (10HB 4). The river enters a narrows in sec. 32, T. 18 N., R. 120 W., in Wyoming, and at this place the topography is favorable for a good dam site. Surveys of this site indicate that a dam 100 feet high would form a storage reservoir having a capacity of 233,000 acre-feet, and that a drawdown of 20 feet from such a reservoir would furnish about 86,000 acre-feet of water. It is estimated that the natural Q90 flow of Bear River at this place may be as small as 30 second-feet and that the period of low-water flow extends not only through the winter but also through the irrigation season, comprising in all about eight months of the year. Accordingly, the power capacity of this site is based on the use of the upper 20 feet of the reservoir for storage, to be used during this low-water period. The average head is taken as 85 feet, and the Q90 flow is estimated at 200 second-feet, giving a capacity of 1,360 horsepower (1,010 kilowatts). With a Q50 flow of 275 second-feet the capacity of the site is 1,870 horsepower (1,400 kilowatts).

Montpelier site.—On Montpelier Creek about 6 miles above Montpelier, Idaho (10HB 7). In this stretch between the powerhouse site and the town the creek has a fall of 450 feet, but the water supply of the town is diverted from the creek about 5 miles up the canyon and is not available for the development of power. In the next 4 miles up the canyon the fall is 200 feet, and the topography is favorable for a low diversion dam and for a pipe line leading along the side of the canyon to a power house. The estimated Q90 flow of the creek is about 15 second-feet, which with an average head of 200 feet gives a power capacity of 240 horsepower (180 kilowatts). The estimated Q50 flow is 24 second-feet, and the corresponding power capacity of the site is 380 horsepower (285 kilowatts).

St. Charles site.—About 2 miles northwest of St. Charles, Idaho, above the irrigation canals on St. Charles Creek (10HB 8). This stream, perhaps the largest one that flows into Bear Lake, is about 12 miles long and flows through a steep, narrow canyon. The water supply is apparently furnished by springs during the low-water period, and the estimated Q90 flow is about 45 second-feet. The available head in the 3-mile stretch of the stream above the highest irrigation canal is at least 175 feet, giving the site a power capacity of 630 horsepower (480 kilowatts). The estimated Q50 flow is 70 second-feet, and the corresponding power capacity is 980 horsepower (735 kilowatts).

Bloomington site.—On Bloomington Creek 4 miles west of Bloomington, Idaho, in T. 14 S., R. 43 E. Boise meridian (10HB 9). The stream has its source in several small deep lakes near the crest of the Bear River Range, and the estimated Q90 flow is 18 second-feet at the point of diversion, which is about 2 miles above the power-house site. The fall in this 2-mile stretch of the canyon is about 750 feet, and the topography is suitable for a pipe line on either side. The power capacity of the site is 1,080 horsepower (810 kilowatts). The estimated Q50 flow is 29 second-feet, which gives a power capacity of 1,740 horsepower (1,300 kilowatts). (See maps of Preston and Montpelier quadrangles.)

Other sites on Bear River.—The flow of Bear River below Bear Lake is regulated by the stored water from the lake to suit the power and irrigation demands along the river. The Oneida plant, the largest and main-control plant of the entire Utah Power & Light Co.'s system, and three other hydroelectric power plants are already in operation on this stretch of the river. The further development of the river contemplates at least four more plants having a total capacity of about 21,000 horsepower (15,750 kilowatts), at the Soda Point (10HC 1), Lava (10HC 2), Narrows (10HC 3), and Mink (10HC 4) sites. (See Pl. III.)

A plan and profile[39] of the river covering the 83-mile stretch from Novene to Preston, Idaho, includes these power sites, and the physical features along this stretch of river are shown. The maps are made on a scale of 2 inches to the mile and show land lines, power plants, transmission lines, and other artificial features as existing in 1913. The topography is shown along the stream with contour intervals of 25 feet on the land and 5 feet on the river surface. The vertical scale of the profile is 1 inch to 20 feet, and the horizontal scale is the same as that of the map.

The importance of these sites to the complete power development of Bear River lies not only in the additional amount of power that can be developed but also in the fact that a certain amount of storage capacity will be created above each dam, which in conjunction with Bear Lake will add greatly to the reliability and flexibility of the power system as a whole and make possible a more accurate regulation of the flow of the river for all purposes.

The Soda Point[40] and Lava[41] sites are immediately above the intake of the present Grace power plant, and the Narrows and Mink sites[42] are immediately below the present Oneida plant (Pl. XI, *A*). The entire head at each site would be obtained by the construction of a dam, and the power house at each site would be made a part of the dam or constructed adjacent to it. The proposed heads to be developed at these sites are 75 feet at Soda Point, 85 feet at Lava, 45 feet at Narrows, and 60 feet at Mink.

The available stream flow is regulated almost entirely by the irrigation demands along the river and the power demand on the Utah Power & Light Co.'s system, as the Bear River plants are used to maintain the necessary power reserve for supplying any excessive fluctuation in demand. The flow is regulated by the stored water from Bear Lake. It is estimated, however, that the regulated flow would range from 900 to 2,000 second-feet or more as these demands are made, and that the average flow at the power sites would be about 900 second-feet at Soda Point, 900 second-feet at Lava, 1,100 second-feet at Narrows, and 1,150 second-feet at Mink. The corresponding power capacities of the sites are 5,400, 6,100, 4,000, and 5,500 horsepower, respectively.

An alternative plan for developing that stretch of the river above Grace dam would be to build a dam 87 feet high in Bear River in the NE. ¼ sec. 30, T. 9 S., R. 41 E. Boise meridian, about 1 mile above the diversion dam of the Last Chance Irrigation Co., and to build an open canal along the west side of the river about 1½ miles long to a power house in the NE. ¼ sec. 31 of the same township. This plan

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[39] U. S. Geol. Survey Water-Supply Paper 350, pl. 1 (six sheets).
[40] Idem, pl. 1, C, near mile 53; profile, pl. 1, E.
[41] Idem, pl. 1, B, near contour crossing 5,550 feet; profile, pl. 1, E.
[42] Idem, pl. 1, A; profile, pl. 1, D.

involves the use of the entire flow of Bear River at the diversion dam, with a provision for supplying the rights of the Last Chance Irrigation Co. by means of a pipe line from the power house to the canal on the opposite side of the river. The water thus turned into the irrigation canal would be used for the development of power through a drop of 75 feet, and that which would be returned to the river would be used through a drop of 126 feet. The estimated Q90 flow of the river at the dam site is 900 second-feet, and the corresponding power capacity of the site is about 9,070 horsepower.

Georgetown site.—Immediately above the intake of the power plant on Georgetown Creek and about 4 miles above Georgetown, Idaho (10HC 5). It is estimated that an average static head of 175 feet is available in the first 2 miles above this point, and with a Q90 flow of probably 15 second-feet the power capacity of the site is 210 horsepower (158 kilowatts). The estimated Q50 flow is 24 second-feet, and the corresponding capacity is 340 horsepower (255 kilowatts).

Co-op site.—On Co-op Creek, a small spring and snow fed stream that flows into Nounan Valley in T. 11 S., R. 43 E. Boise meridian (10HC 6). The creek flows nearly due east through its canyon, and in the first mile above the highest irrigation canal it has a fall of about 400 feet. The topography is favorable for a diversion dam below all important tributaries, a pipe line along the south side of the canyon, and a power house 1 mile below the dam. The estimated Q90 flow of the creek is 5 second-feet, which, with an average head of 400 feet, gives a power capacity for the site of 160 horsepower (120 kilowatts). The estimated Q50 flow is 8 second-feet, and the corresponding capacity is 260 horsepower (195 kilowatts).

Eightmile site.—On Eightmile Creek 9 miles south of Soda Springs, Idaho (10HC 7). The creek apparently derives much of its flow from small springs, and it is used entirely for irrigation below sec. 29, T. 10 S., R. 42 E. Above this point, however, the grade is rather steep and the topography seems to be suitable for the construction of a low diversion dam across the creek and for a pipe line leading along the side of the canyon to a power house. A static head of at least 350 feet is available in the 3-mile stretch above the highest irrigation diversion. The estimated Q90 flow is 5 second-feet, which gives a power capacity of 140 horsepower (105 kilowatts). The estimated Q50 flow is 8 second-feet, and the corresponding capacity is 220 horsepower (165 kilowatts).

Soda Springs site.—On Soda Creek about 1 mile north of Soda Springs, Idaho (10HC 8). Soda Creek has its source in large springs that rise in the broken lava plateau just north of the town. Some of these springs are highly impregnated with soda. Many irrigation diversions are made from the stream; the largest ones are below the northwest corner of T. 9 S., R. 42 E. Boise meridian. In the first 3 miles above this point an average static head of about 130 feet is available. The estimated Q90 flow is 42 second-feet, and the corresponding power capacity is 440 horsepower (330 kilowatts). The stream is very constant, and the Q50 flow at this site is practically the same as the Q90 flow.

Bridge site.—On Bridge or Williams Creek in secs. 28 and 29, T. 12 S., R. 41 E., in Idaho (10HC 9). The creek rises in springs in the NE. ¼ sec. 28, and an irrigation canal known as the Stalker ditch diverts water from it just below the springs. This ditch extends along the north side of the creek and is about 350 feet higher than the stream at the point where the stream swings to the north across the north line of sec. 29. A penstock extending from this point to the creek at the head of the next irrigation canal, in the NW. ¼ sec. 29, would be about 700 feet lomg. An average static head of at least 350 feet is available and also the entire flow of the creek except during the irrigation season, when the Stalker ditch is entitled to the use of 9.3 second-feet. The estimated Q90 flow is 20 second-feet, and the corresponding power capacity is 560 horsepower (420 kilowatts). The estimated Q50 flow is 30 second-feet, and the corresponding capacity is 840 horsepower (630 kilowatts).

Mink Creek site.—On Mink Creek just above the intake of the Oneida canal and about half a mile from the Mink Creek settlement (10HC 10). (See map of Preston quadrangle.) Mink Creek has its source in large springs in the upper part of its canyon, and the low-water flow ranges from about 50 to 60 second-feet. In the spring, however, the melting snow increases the flow to as much as 500 second-feet. Many irrigation canals divert water from the creek; the largest one is the Oneida canal, which takes practically all the low flow in the summer. One canal heads in the SW. ¼ sec. 28, T. 13 S., R. 41 E. Boise meridian, and swings around a point to the north into Strawberry Creek, a tributary of Mink Creek. From the point where this canal empties into Strawberry Creek downstream to the head of the Oneida canal, a distance of 4 miles, the creek has a fall of at least 400 feet, which could be utilized by developing power. The topography is favorable for a low diversion dam on Strawberry Creek in the NW. ¼ sec. 20, T. 13 S., R. 41 E., and a pipe line extending along the west side of the creek to a power house in the SE. ¼ sec. 1, T. 14 S., R. 40 E.

An average static head of 400 feet could be developed, and by means of the canal which connects Mink Creek and Strawberry Creek practically the entire flow of the creek at the power-house site would be available for the use of power.

The estimated Q90 flow is 50 second-feet, and the power capacity of the site is accordingly 1,600 horsepower (1,200 kilowatts). The estimated Q50 flow is 80 second-feet, and the corresponding capacity is 2,560 horsepower (1,920 kilowatts).

Cub site.—On Cub River 8 miles east of Preston, Idaho (10HC 11). Several irrigation canals divert water from Cub River; the highest one of importance heads in the NW. ¼ sec. 28, T. 15 S., R. 41 E., in Idaho. After paralleling the creek for about 2½ miles it swings to the north over a low pass and empties into Worm Creek. At the place where this ditch turns northward it is nearly 400 feet higher than Cub River, and the topography is favorable for a penstock leading down to a power-house site in the NE. ¼ sec. 24, T. 15 S., R. 40 E. Boise meridian, just above the intake of the canal that serves the power plant in sec. 34 of the same township.

As there are no important irrigation diversions between the headings of these two canals, the upper canal could be enlarged to carry water for power as well as for irrigation. An average static head of 350 feet could be utilized, and with a penstock about 800 feet long and a Q90 flow of 20 second-feet the power capacity of the site is 560 horsepower (420 kilowatts). If the Willow Flat reservoir site were developed in connection with this project the Q90 flow would probably be as much as 30 second-feet, giving a power capacity of 840 horsepower (630 kilowatts). The estimated Q50 flow of this site without storage is 30 second-feet, and with storage as above indicated it is 40 second-feet. The corresponding power capacities are 840 horsepower (630 kilowatts) and 1,120 horsepower (840 kilowatts), respectively.

Maple site.—On Maple Creek 3½ miles northeast of Franklin, Idaho (10HC 12). The stream has its source in springs, and the run-off is used largely for irrigating lands near Franklin. Above the highest irrigation diversion the creek has a grade of about 250 feet to the mile. The topography indicates that a diversion could be made in the NW. ¼ sec. 6, T. 16 S., R. 41 E. Boise meridian, and that a pipe line could be laid along the east side of the creek, terminating through a penstock at a power house in the SW. ¼ sec. 12, T. 16 S., R. 40 E. The available head is 450 feet in a distance of less than 2 miles, and with an estimated Q90 flow of 5 second-feet the power capacity of the site is 180 horsepower (135 kilowatts.). The estimated Q50 flow is 8 second-feet, and the corresponding capacity is 290 horsepower (220 kilowatts).

High Creek site.—On High Creek 4½ miles northeast of Richmond, Utah, immediately above the irrigation diversion near the northeast corner of sec. 7, T. 14 N., R. 2 E., Salt Lake base and meridian (10HC 13). In the next 2 miles above this point the creek has a fall of 600 feet, and the topography is favorable for a low diversion dam and for a pipe line leading along the south side of the canyon. With an average static head of 600 feet and an estimated Q90 flow of 5 second-feet, the power capacity of the site is 240 horsepower (180 kilowatts). The estimated Q50 flow is 8 second-feet, and the corresponding capacity is 380 horsepower (285 kilowatts).

Summit site.—In Smithfield Canyon 2 miles northeast of Smithfield, Utah (10HC 14). The power-house site is at the mouth of the canyon, just above a large irrigation diversion dam that diverts water onto the highlands north and east of the town. The grade of the creek above this dam is approximately 200 feet to the mile, and the topography as shown on the Logan topographic map suggests a diversion in the NW. ¼ sec. 17, T. 13 N., R. 2 E., Salt Lake base and meridian, and a pipe line leading along the south side of the canyon. The head in this stretch of the canyon is 600 feet, and the power capacity of the site with an estimated Q90 flow of 10 second-feet is 480 horsepower (360 kilowatts). The estimated Q50 flow is 15 second-feet, and the corresponding capacity is 720 horsepower (450 kilowatts).

Logan River sites.—A plan and profile [43] of Logan River and Blacksmith Fork were made in 1914 by the Geological Survey. Logan River was mapped from the mouth of its canyon upstream to Tony Grove Creek, a distance of 22 miles, and Blacksmith Fork was mapped from the mouth of its canyon to Curtis Creek, a distance of 15½ miles.

The topography of the canyons is shown with contours of 25-foot intervals on the land and river surface; all elevations are referred to mean sea level datum, and the maps are on a scale of 4,000 feet to the inch. The vertical scale of the profiles is 1 inch to 100 feet. Among the features shown, in addition to the topography and stream locations, are land lines, power plants, transmission lines, dams, gaging stations, and roads.

There are three hydroelectric power plants in the first 3 miles of Logan Canyon above its mouth, and in the next 16 to 18 miles the river has a fall of 1,500 feet. The stream is one of the best adapted for the development of power in the Great Salt Lake basin, as it has a relatively high run-off per square mile of drainage basin and a long, narrow canyon having a steep grade. The topography of the canyon, however, suggests that the 1,500-foot fall be developed in at least two and perhaps better in three units, which for identification may be designated the upper, middle, and lower sites. (See topographic map of Logan quadrangle.)

The upper site (10HC 15) extends from the mouth of Beaver Creek near the north line of sec. 36, T. 14 N., R. 3 E., Salt Lake base and meridian, down to the mouth of Temple Fork, a distance of 6½ miles. A head of 800 feet is available, and with an estimated Q90 flow of 70 second-feet the power capacity of the site is 4,480 horsepower

[43] U. S. Geol. Survey Water-Supply Paper 420, pls. 9, 10, 1916.

(3,460 kilowatts). The estimated Q50 flow is 120 second-feet, and the corresponding capacity is 7,680 horsepower (5,760 kilowatts).

The middle site (10HC 16) extends from the mouth of Temple Fork down to the mouth of Right Fork, a distance of about 6 miles An average static head of 500 feet is available in this stretch of the canyon, and with an estimated Q90 flow of 110 second-feet the power capacity of the site is 4,400 horsepower (3,300 kilowatts). The estimated Q50 flow is 185 second-feet, and the corresponding capacity is 7,400 horsepower (5,550 kilowatts).

The lower site (10HC 17) is the smallest of the three. The grade of the canyon is much flatter here, and the available head is about 200 feet in a distance of 4½ miles. The stream flow, however, is greater at this site, because the diversion dam is below all the principal tributaries. The estimated Q90 flow is about 155 second-feet, and the power capacity of the site is 2,480 horsepower (1,860 kilowatts). The estimated Q50 flow is 264 second-feet, and the corresponding capacity is 4,220 horsepower (3,165 kilowatts).

Besides possessing some value for power projects, Logan Canyon is an excellent summer camping ground. The stream is well stocked with fish, and the many wooded nooks make ideal spots for canyon homes. In order to preserve the natural beauties of the canyon the State legislature in 1917 passed an act (chap. 7, sec. 3570), prohibiting the diversion for power of any of the waters of Logan River between Ricks Spring, just above the mouth of Temple Fork, and the intake of the Logan city power plant, thus precluding the possibility of developing the middle and lower power sites.

Blacksmith Fork sites.[44]—From the mouth of Blacksmith Fork canyon, 2 miles east of Hyrum, Utah, to the mouth of Curtis Creek, a distance of 15½ miles, the stream falls 850 feet, but the fall is not uniformly distributed over this distance. The steepest place is just above the mouth of the canyon, in a 2½-mile stretch that has a fall of approximately 100 feet to the mile and has already been developed for power. For the remainder of the distance the grade ranges from 25 to 75 feet to the mile, the steepest place being the 2½-mile stretch above the mouth of Left Fork. Here, at what might be called site No. 1 (10HC 19), a head of 150 feet is available, and the topography appears to be suitable for a pipe line on either side of the canyon. The estimated Q90 flow is 70 second-feet, giving a power capacity for the site of 840 horsepower (630 kilowatts). The estimated Q50 flow is 120 second-feet, and the corresponding capacity is 1,440 horsepower (1,080 kilowatts).

[44] For a plan and profile see U. S. Geol. Survey Water-Supply Paper 420, 1916.

Above the junction of Sheep Creek and Blacksmith Fork, about 2 miles beyond the mouth of Curtis Creek, both Sheep Creek and Blacksmith Fork have steep grades. The topography (see Logan topographic map) is favorable for a power development on each stream.

On Blacksmith Fork at site No. 2 (10HC 18), a diversion dam could be made in the NW. ¼ sec. 31, T. 10 N., R. 4 E., Salt Lake base and meridian, and a pipe line could be led along the north side of the canyon to a power house in the SE. ¼ sec. 23, T. 10 N., R. 3 E., a distance of about 2 miles. A head of 400 feet is available, and with an estimated Q90 flow of 50 second-feet 1,600 horsepower (1,200 kilowatts) could be developed. The estimated Q50 flow at this site is 75 second-feet, and the corresponding capacity is 2,400 horsepower (1,800 kilowatts).

On Sheep Creek (10HC 20) a diversion could be made in the NW. ¼ sec. 24, T. 9 N., R. 3 E., Salt Lake base and meridian, and a pipe line could be led along the east side of the canyon to a power house in the NE. ¼ sec. 14, a distance of little more than a mile. A head of 350 feet is available, and with an estimated Q90 flow of 5 second-feet 140 horsepower (105 kilowatts) could be developed. The estimated Q50 flow is 8 second-feet, and the corresponding capacity is 220 horsepower (165 kilowatts).

SUMMARY.

Undeveloped power sites in the Bear River basin.

[Estimates of power based on static head and over-all plant efficiency of 70 per cent.]

Index No.	Power site.	Stream.	Static head (H).	With existing flow.				With regulated flow.			
				Q90	Q50	Horsepower.		Q90	Q50	Horsepower	
						0.08HQ90	0.08HQ50			0.08HQ90	0.08HQ50
			Feet.	*Sec.-ft.*	*Sec.-ft.*			*Sec.-ft.*	*Sec.-ft.*		
10HB 1	Evanston	Bear River	400	25	25	800	800				
10HB 2	Main (Wyuta)	do	268	25	25	540	540				
10HB 3	Big Bend (Wyuta)	do	79	25	25	160	160				
10HB 4	Woodruff (Narrows)	do	85	30	40	200	270	200	275	1,360	1,870
10HB 5	Wright (Wyuta)	Yellow Creek	117	25	25	230	230				
10HB 6	Forbes (Wyuta)	do	80	25	25	160	160				
10HB 7	Montpelier	Montpelier Creek	200	15	24	240	380				
10HB 8	St. Charles	St. Charles Creek	175	45	70	630	980				
10HB 9	Bloomington	Bloomington Creek	750	18	29	1,080	1,740				
10HC 1	Soda	Bear River	75					900	1,300	5,400	7,800
10HC 2	Lava	do	85					900	1,300	6,100	8,840
10HC 3	Narrows	do	45					1,100	1,600	4,000	5,760
10HC 4	Mink	do	60					1,150	1,650	5,500	7,920
10HC 5	Georgetown	Georgetown Creek	175	15	24	210	340				
10HC 6	Co-op	Co-op Creek	400	5	8	160	260				
10HC 7	Eightmile	Eightmile Creek	350	5	8	140	220				
10HC 8	Soda Springs	Soda Creek	130	42	42	440	440				
10HC 9	Bridge	Bridge Creek	350	20	30	560	840				
10HC 10	Mink Creek	Mink Creek	400	50	80	1,600	2,560				
10HC 11	Cub	Cub River	350	20	30	560	840	30	40	840	1,120
10HC 12	Maple	Maple Creek	450	5	8	180	290				
10HC 13	High Creek	High Creek	600	5	8	240	380				
10HC 14	Summit	Summit Creek	600	10	15	480	720				
10HC 15	Upper (Logan)	Logan River	800	70	120	4,480	7,680				
10HC 16	Middle (Logan)	do	500	110	185	4,400	7,400				
10HC 17	Lower (Logan)	do	200	155	264	2,480	4,220				
10HC 18	No. 2	Blacksmith Fork	400	10	17	320	540	50	75	1,600	2,400
10HC 19	No 1	do	150	70	120	840	1,440				
10HC 20	Sheep Creek	Sheep Creek	350	5	8	140	220				
						21,270	33,650			22,550	35,510

SITES IN WEBER RIVER BASIN.

A plan and profile[45] of Weber River for about 32 miles upstream from the settlement of Wanship were made by the United States Geological Survey in 1920; and similar data were obtained on certain tributaries of the river. These maps are on a scale of 2 inches to the mile, and the topography is shown by contours with an interval of 25 feet on the land and river surface. The vertical scale of the profiles is 1 inch to 80 feet. The maps are printed in three colors, like the standard topographic maps of the Survey, and in addition to the topography of the canyon and the location of the streams they show all land lines, power and dwelling houses, roads, and other artificial features.

Oakley sites.[46]—Above Oakley, Utah, Weber River flows through a well-defined canyon and has a fall of 1,020 feet in the first 12 miles. A gaging station is maintained at the mouth of the canyon by the United States Geological Survey, and the records indicate that the Q90 flow is about 70 second-feet. The topography and the fact that two large tributaries empty into the river in this stretch suggest that the complete power development should be made in two units at an upper and a lower site. The proposed point of diversion for the upper site (10HE 1) is near the center of sec. 21, T. 1 N., R. 8 E., Salt Lake base and meridian, and the power-house site is in sec. 28, T. 1 N., R. 7 E., just above the mouth of Smith and Moorehouse Creek, about 5½ miles below the dam site. The fall is 520 feet, and the estimated Q90 flow is 55 second-feet, giving a power capacity of 2,290 horsepower (1,715 kilowatts). This capacity would, however, be increased to about 3,120 horsepower (2,340 kilowatts) if on further investigation the Larabee Flat reservoir site should be found to be feasible and be developed.

The point of diversion for the lower site (10HE 2) is immediately below the mouth of Smith and Moorehouse Creek, and the power-house site is near the mouth of the canyon, above the intake of the irrigation canal, in sec. 15, T. 1 S., R. 6 E., Salt Lake base and meridian. The pipe line would lead along the north side of the canyon, and a branch line would extend across the canyon into South Fork to carry the flow of that stream. A head of 500 feet is available in a distance of about 6 miles, and the estimated Q90 flow is 70 second-feet, giving a power capacity for the site of 2,800 horsepower (2,100 kilowatts). If the Smith and Moorehouse reservoir site were found to be feasible and were developed the Q90 flow would be about 85 second-feet and the corresponding capacity would be 3,400 horsepower (2,550 kilowatts). By utilizing the Larabee Flat reservoir

[45] Plan and profile of Weber River and certain tributaries above Coalville and of East Canyon Creek from the mouth to Taylor Creek, Utah (six sheets, for sale by the Geological Survey at 60 cents for the set).

[46] Idem, sheets B and E.

site and the Smith and Moorehouse site a Q90 flow of about 107 second-feet could be maintained, and the capacity would be 4,280 horsepower (3,210 kilowatts). The natural Q50 flow of Weber River at the Oakley sites is practically the same as the Q90 flow, as the stream has a relatively uniform low flow, and the flood season is short.

The Q50 flow at the upper site with regulation at the Larabee Flat reservoir site would probably be 90 second-feet, and the corresponding capacity would be 3,740 horsepower (2,805 kilowatts).

The regulated Q50 flow at the lower site, if the Larabee Flat and Smith and Moorehouse reservoir sites were utilized, is estimated at 125 second-feet, and the corresponding capacity would be 5,000 horsepower (3,750 kilowatts). (See topographic map of Coalville quadrangle, also stream-survey sheets, Weber River.)

Devils Slide site.—On Weber River in the narrow canyon that connects Henefer and Round valleys, about 3 miles east of Morgan, Utah (10HE 3). The topography appears to be favorable for a diversion dam across the river channel about 2 miles above the mouth of Lost Creek, but the fact that the main line of the Union Pacific Railroad runs through the canyon would probably present some difficulties in locating the pipe line, which would be about 5 miles long. The estimated Q90 flow at this site is 110 second-feet, and the available head is at least 120 feet, giving a power capacity of 1,060 horsepower (795 kilowatts). The estimated Q50 flow is 154 second-feet, and the corresponding capacity is 1,480 horsepower (1,110 kilowatts).

Weber site.—On Weber River immediately above the intake of the Devils Gate plant (10HE 4). In 1910 the Weber Reservoir, Power & Irrigation Co. investigated the possibillties of further utilizing the run-off of the stream, and in connection with a high-line canal, which was planned to reach the bench lands south of Weber Canyon, in the Great Salt Lake valley, power was to be developed at the mouth of the canyon by returning to the river the water required to satisfy prior rights below. The proposed point of diversion is in the northeast corner of sec. 17, T. 4 N., R. 2 E., Salt Lake base and meridian, and at the mouth of the canyon, about 7 miles downstream, an effective head of about 300 feet would be available. Subsequent to that time, however, a part of this fall has been used by the Devils Gate plant, and in order to return the water to the stream above its intake a head of only 150 feet could be used. Under these conditions the conduit line would be about 5 miles long, and with a Q90 flow of 250 second-feet the power capacity of the site is 3,000 horsepower (2,250 kilowatts). The estimated Q50 flow at this site is 420 second-feet, and the corresponding capacity is 5,040 horsepower (3,780 kilowatts).

Chalk Creek site.[47]—On Chalk Creek 2 miles east of Coalville, Utah (10HE 5). Below the mouth of South Fork Chalk Creek enters a narrow canyon about 2½ miles long, with a total fall of 160 feet. The topography of this canyon suggests a dam half a mile below the mouth of South Fork and a pipe line leading along the south side of the creek to a power house at the mouth of the canyon. With an average static head of 160 feet and an estimated Q90 flow of 20 second-feet the power capacity of the site is 260 horsepower (195 kilowatts). If the undeveloped reservoir site (10HE 6) just above the proposed diversion dam, mentioned under "Reservoirs and reservoir sites" (p. 50), were on complete investigation determined to be physically feasible, the stream flow could very probably be entirely regulated, and the power capacity of the site increased. However, for power development alone the cost would be very high, and the additional amount of power produced would not be large. The estimated Q50 flow at this site is 28 second-feet, and the corresponding capacity is 360 horsepower (260 kilowatts).

East Canyon site.[48]—On East Canyon Creek 7 miles south of Morgan, Utah, immediately below the reservoir of the Davis & Weber Counties Canal Co. (10HE 6). For a distance of nearly 4 miles below this reservoir the creek flows through a narrow canyon in which the total fall is 290 feet. The topography is favorable for a low diversion dam across the creek channel a short distance below the reservoir dam and for a pipe line leading along the north side of the canyon to a power house about 4 miles downstream. With a head of 290 feet and a Q90 flow of 15 second-feet the power capacity of the site is 350 horsepower (260 kilowatts). During the irrigation season, however, water is released from the reservoir, and though at times the flow at the power site may be 200 second-feet or more it is released only to meet the irrigation demands, and whether or not it may be used advantageously for power depends on the market demand for power.

Hardscrabble site.—On Hardscrabble Creek 7 miles southwest of Morgan, Utah (10HE 7). The stream is a small tributary of East Canyon Creek, and its power possibilities have been investigated at different times. The topography of the canyon is favorable for a low diversion dam in the northern part of sec. 4, T. 2 N., R. 2 E., Salt Lake base and meridian, and for a pipe line extending along the side of the canyon to a power house in the northeast corner of sec. 34, T. 3 N., R. 2 E., a distance of about 2 miles. A head of 200 feet is available, and the estimated Q90 flow is 10 second-feet, giving a power capacity of 160 horsepower (120 kilowatts). The estimated Q50 flow is 14 second-feet, and the corresponding capacity is 220 horsepower (165 kilowatts).

[47] Op. cit., sheets C and F.

[48] Op. cit., sheets D and F.

In the winter of 1912–13 part of this site was developed by the Como Light & Power Co., to supply power to the city of Morgan, but after the transmission line of the Utah Power & Light Co. was extended through Weber Canyon this small plant was abandoned. The project consisted of a crude stone and brush dam, a 22-inch wire-wound wooden-stave pipe line laid along the banks of the creek, and a small red-sandstone power house. The pipe line was about 2,200 feet long, the effective head was approximately 60 feet, and the installation consisted of one 5-foot impulse water wheel direct-connected to one 3-phase 60-cycle 2,300-volt Westinghouse generator of 175-kilowatt capacity, run at 900 revolutions per minute. The load carried by the plant was about 75 kilowatts.

Ogden South Fork site.—On the South Fork of Ogden River 5 miles east of Huntsville, Utah (10HE 8). The city of Ogden has at different times considered the development of this site. A profile survey of the stream was made by the city engineer, and all potential reservoir sites were surveyed in a study of the water supply available for municipal purposes. The country along the stream consists largely of rolling hills covered with a sparse vegetation, and the topography is favorable for the plan of development which has been suggested by the city, to place a diversion dam in the stream near the center of sec. 34, T. 7 N., R. 3 E., Salt Lake base and meridian, just below the junction of Right and Left forks, and to lay a pipe line along the north side of the canyon, leading to the power house in the SW. ¼ sec. 11, T. 6 N., R. 2 E., a distance of 4½ miles. A head of 350 feet is available in this stretch of the canyon, and by intercepting the flow of Beaver Creek at the point where the pipe line crosses it practically the entire flow of South Fork would be utilized. No continuous records of this flow have been kept, but miscellaneous measurements have been made at different times by persons interested in the stream, and it is estimated that a Q90 natural flow of 40 second-feet might be available. It may be possible to increase this to 50 second-feet by building the Right Fork or Skull Crack reservoir, which is now being considered by the city of Ogden.

The power capacity of the site with a Q90 flow of 50 second-feet would be 1,400 horsepower (1,050 kilowatts), and the transmission distance to Ogden is about 15 miles. The estimated Q50 flow with storage is 75 second-feet, and the corresponding capacity is 2,100 horsepower (1,575 kilowatts).

SUMMARY.

Undeveloped power sites in Weber River drainage basin.

[Estimates of power based on static head and over-all plant efficiency of 70 per cent]

Index No.	Power site.	Stream.	Static head (H).	With existing flow.				With regulated flow.			
				Q90	Q50	Horsepower.		Q90	Q50	Horsepower.	
						0. 08HQ90	0. 08HQ50			0. 08HQ90	0. 08HQ50
			Feet.	*Sec.-ft.*	*Sec.-ft.*			*Sec.-ft.*	*Sec -ft.*		
10HE 1	Upper Oakley	Weber River	520	55	55	2, 290	2, 290	75	90	3, 120	3, 740
10HE 2	Lower Oakley	do	500	70	70	2, 800	2, 800	107	125	4, 280	5, 000
10HE 3	Devils Slide	do	120	110	154	1, 060	1, 480				
10HE 4	Weber	do	150	250	420	3, 000	5, 040				
10HE 5	Chalk Creek	Chalk Creek	160	20	28	260	360				
10HE 6	East Canyon	East Canyon Creek	290	15	15	350	350				
10HE 7	Hardscrabble	Hardscrabble Creek	200	10	14	160	220				
10HE 8	Ogden South Fork	Ogden River	350	50	75	1, 400	2, 100				
						11, 320	14, 640			7, 400	8, 740

SITES IN JORDAN RIVER AND UTAH LAKE BASINS.

Plans and profiles [49] of certain streams tributary to Utah Lake were made by the United States Geological Survey in 1920. The maps are on a scale of 2 inches to the mile, and the topography is shown by contours with an interval of 25 feet on the land and river surface. The vertical scale of the profiles is 1 inch to 200 feet. The maps are printed in three colors, like the standard topographic maps of the Survey, and in addition to the topography of the canyon and the location of the streams they show all land lines, power and dwelling houses, roads, and other artificial features.

American Fork sites.[50]—Along the upper part of American Fork 10 miles or more northeast of the town of American Fork. From the mouth of Mary Ellen Creek down American Fork canyon to the mouth of South Fork, a distance of about 5½ miles, the creek falls 1,416 feet. The topography of this stretch is not so rugged as that in the lower part of the canyon, below the mouth of South Fork, and two power sites have been definitely outlined above South Fork, commonly known as the Earl and Clark sites.

At the Earl site (10HF 1) it is proposed to build a low diversion dam in the creek immediately below the mouth of Mary Ellen Creek and to extend a pipe line down the canyon to a power house at the mouth of Mill Creek, a distance of about 3½ miles. The static head is 1,085 feet, and it is estimated that the Q90 flow will never be less than 5 second-feet, so that the power capacity of the site is 430 horsepower (324 kilowatts). The estimated Q50 flow is 9 second-feet, and the corresponding capacity is 780 horsepower (585 kilowatts).

At the Clark site (10HF 2) it was planned to build a storage dam across the canyon immediately below the mouth at Deer Creek and thence to carry the water through a pipe line to a power house at the mouth of South Fork, a distance of about 2 miles. The topography, however, suggests the following modification of the Clark plan: To build a storage dam about a quarter of a mile below the mouth of Deer Creek, extend a pipe line along the south side of the canyon to a power house at the mouth of South Fork, and run another pipe line, three-quarters of a mile long, from the power house up South Fork canyon to a low diversion dam in South Fork. The average static head at this site is 250 feet, and the Q90 flow would be about 35 second-feet, if the storage reservoir site is feasible and if it could be developed to a capacity of 7,000 acre-feet. Under these conditions the power capacity is 700 horsepower (525 kilowatts).

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[49] Plan and profile of Provo River, Utah County line to Charleston and above Heber; North Fork of Provo River; Diamond Creek above Spanish Fork; American Fork; and Hobble Creek, Sixth Water, Payson, Santaquin, and Salt creeks, Utah (ten sheets, for sale by the Geological Survey at $1 for the set).

[50] Idem, sheets D and I.

The estimated Q50 flow at this site is 50 second-feet, and the corresponding capacity is 1,000 horsepower (750 kilowatts).

If only the natural flow of the creek were used the estimated Q90 flow would be 17 second-feet, and the power capacity would be 340 horsepower (255 kilowatts). The estimated Q50 natural flow is 29 second-feet, and the corresponding capacity is 580 horsepower (430 kilowatts).

Thistle site.—On Thistle Creek, a tributary of Spanish Fork, just south of Thistle, Utah (10HF 3). This creek is about 20 miles long and has an average fall of nearly 60 feet to the mile for 15 miles above its mouth. It joins Soldier Fork at Thistle to form Spanish Fork. The country around this site consists of smooth rolling hills. The power site is in the first 6 miles of Thistle Canyon, where a head of 450 feet is available. The estimated Q90 flow is 10 second-feet, and the power capacity of the site is 360 horsepower (270 kilowatts). The estimated Q50 flow is 14 second-feet, and the corresponding capacity is 500 horsepower (375 kilowatts).

Soldier Fork site.—On Soldier Fork, a tributary of Spanish Fork, just east of Thistle, Utah (10HF 4). The stream is about 24 miles long and has a total fall of about 75 feet to the mile in the first 8 miles above its mouth. The walls of its canyon are smooth rolling hills covered with underbrush. The power site is in the first 6 miles of the canyon above Thistle, and in this distance a static head of 450 feet is available. The topography is favorable for a low diversion dam across the creek channel and for a pipe line leading along the north side of the creek to a power house near Thistle. The estimated Q90 flow is 10 second-feet, and the corresponding power capacity of the site is 360 horsepower (270 kilowatts). The estimated Q50 flow is 14 second-feet, and the corresponding capacity is 500 horsepower (375 kilowatts).

Diamond Fork sites.[51]—From the west portal of the Strawberry tunnel to the confluence of Diamond and Spanish forks the total fall is 2,507 feet. The topography is favorable for the following general plan of developing power below West Portal. Four distinct projects are proposed—first (10HF 5), to divert water at the west portal and carry it along the north side of the canyon to a power house in sec. 32, T. 7 S., R. 6 E., Salt Lake base and meridian, on Sixth Water Creek about 1½ miles west of the diversion dam; second (10HF 6), to divert water just below the creek forks at the first power house and carry it to a power house in sec. 2, T. 8 S., R. 5 E., on Diamond Fork about 1 mile below the mouth of Shingle Mill Fork; third (10HF 7), to divert water from Diamond Fork just below the second power house and return it to the creek through a power

[51] Op. cit, sheets B, C, and H.

house in sec. 27, T. 8 S., R. 5 E., at the mouth of Fifth Water Creek; and fourth (10HF 8), to divert water from Diamond Fork just below the mouth of Second Water Creek and return it through a power house near the south line of sec. 17, T. 9 S., R. 4 E., at the confluence with Spanish Fork. In this way the natural flow from the principal tributaries would be utilized. It is obvious, however, that the water stored in the Strawberry reservoir is intended for irrigation, and accordingly it is not available for use in developing power except when it is released for irrigation or is made available for irrigation by secondary storage below the power plant. The latter provision is possible to a small extent for the three upper sites, as there is a reservoir site that would have a capacity of about 22,000 acre-feet with a dam about 60 feet high, on Diamond Fork at Beckstead's ranch, about midway between the diversion dam and the power house of the fourth site. It is estimated that by using this reservoir site 50 second-feet of water could be taken from the Strawberry reservoir during the nonirrigation season. This amount added to the natural flow of the creeks would make available a Q90 flow of 57, 62, and 65 second-feet at the first, second, and third power sites, respectively. The heads at these sites are 275, 680, and 670 feet, and the corresponding power capacities are 1,250 horsepower (940 kilowatts), 3,370 horsepower (2,530 kilowatts), and 3,480 horsepower (2,610 kilowatts). At the fourth site, where no stored water could be used, the estimated Q90 flow is 20 second-feet, and with a head of 500 feet the power capacity is 800 horsepower (600 kilowatts). (See fig. 5, p. 57.) The estimated Q50 flows at these four sites are 60, 70, 85, and 50 second-feet, respectively, and the corresponding capacities are 1,320 horsepower (990 kilowatts), 3,810 horsepower (2,860 kilowatts), 4,560 horsepower (3,420 kilowatts), and 2,000 horsepower (1,500 kilowatts).

Payson site.[52]—On Payson or Peteetneet Creek, 3 miles above Payson, Utah (10HF 9). In the first mile of Payson Canyon above its mouth the city of Payson at one time built a small power plant, consisting of a low diversion dam, about 1 mile of pipe line, and a small frame power house which was equipped with one small water wheel of about 150 horsepower capacity and a generator. The total head at the plant is 140 feet. Since the United States Reclamation Service built the Strawberry Valley plant Payson has been supplied with power from that source, and the municipal plant has been abandoned. In the next 2½ miles up the canyon from the old diversion dam, which is now used to store water for irrigation, the creek has a fall of 459 feet, and the topography suggests that this stretch might be developed for power. The estimated Q90 flow is 6 second-

[52] Op. cit., sheets B and G.

feet, and with a head of 459 feet the power capacity of the site is 220 horsepower (165 kilowatts). The estimated Q50 flow is 8 second-feet, and the corresponding capacity is 290 horsepower (220 kilowatts).

Santaquin site.[53]—On Santaquin Creek 4 miles southeast of Santaquin (10HF 10). The creek is a small stream that flows through a very rough, rocky canyon. One power plant already occupies the lower 2½ miles of the canyon, but in the next 2 miles of the canyon above its diversion dam a head of 1,000 feet is available. The topography of this site is rough, with steep slopes, and this would add difficulties to the construction of the pipe line. The estimated Q90 flow is 5 second-feet, and the power capacity of the site is 400 horsepower (300 kilowatts). With an estimated Q50 flow of 7 second-feet the capacity is 560 horsepower (420 kilowatts).

Salt Creek site.[53]—In Salt Creek canyon, 6 miles east of Nephi, Utah (10HF 11). This canyon is broad and has an average grade of about 100 feet to the mile. Two power plants occupy the lower 3 miles of it, and in the 3-mile stretch above the intake of the upper power plant the creek has a fall of 325 feet. The topography suggests a low diversion dam across the creek immediately below the mouth of Pole Canyon Creek and a pipe line leading along the west side of the canyon to a power house about a quarter of a mile above the intake of the upper power plant. With a head of 325 feet and an estimated Q90 flow of 15 second-feet the power capacity of the site is 390 horsepower (290 kilowatts). The estimated Q50 flow is 20 second-feet, and the corresponding capacity is 520 horsepower (390 kilowatts).

Provo River sites.[54]—Along Provo River in the 7-mile stretch below the mouth of North Fork, a few miles above Woodland, Utah, and above all important irrigation diversions. The total fall available is 600 feet, but the topography is favorable for development at two sites rather than one—the upper one (10HG 1) to extend from the mouth of North Fork down to the mouth of South Fork, a distance of 4 miles, and the lower one (10HG 2) to extend from the South Fork down to the first important irrigation heading in sec. 7, T. 3 S., R. 7 E., Salt Lake base and meridian, a distance of 3 miles. A static head of 300 feet is available at the upper site, and the Q90 flow is estimated to be at least 30 second-feet, so that the power capacity is 720 horsepower (540 kilowatts). The estimated Q50 flow is 40 second-feet, and the corresponding capacity is 960 horsepower (720 kilowatts). At the lower site (10HG 2) the head is 300 feet and the estimated Q90 flow is 38 second-feet, giving a power capacity of 910 horsepower (680 kilowatts). The estimated

[53] Op. cit., sheets A and G.

[54] Op. cit., sheets E, F, and J.

Q50 flow is 49 second-feet, and the corresponding capacity is 1,180 horsepower (880 kilowatts).

The Lake Creek site (10HG 3) is 6 miles east of Heber, Utah, on Lake Creek, a tributary of Provo River. The stream rises in a number of small lakes and springs on the west slopes of the Uinta Mountains and flows through a steep, rugged canyon which has a fall of 800 feet in the 2½-mile stretch covered by the power site. This site, as suggested by the topography of the canyon (see Strawberry Valley topographic map), might be developed by placing a low diversion dam across the channel of the creek at the forks of the stream near the center of sec. 10, T. 1 N., R. 6 E., Salt Lake base and meridian, and by extending a pipe line downstream along the south side of the canyon to a power house near the northwest corner of sec. 8 of the same township. With a static head of 800 feet and an estimated Q90 flow of 10 second-feet the power capacity of the site is 640 horsepower (480 kilowatts). The Q50 flow is estimated at 13 second-feet, and the corresponding capacity is 830 horsepower (624 kilowatts).

The North Fork site[55] (10HG 4) is on the lower North Fork of Provo River, 10 miles above Provo, Utah. North Fork is a small stream formed by two branches that join about 2½ miles above its confluence with Provo River. It has a steep grade through a narrow canyon. A static head of 1,600 feet is available in a distance of about 4 miles. Several studies of this site and some miscellaneous measurements of the stream flow have been made. The low-water flow is supplied by springs, and the results of these measurements indicate a Q90 flow of 8 second-feet. The topography is favorable for a low diversion dam on the north branch, just below a large spring about 1½ miles above the junction of the two branches, and for a pipe line along the south side of the stream intercepting the flow of the south branch and extending down to a power house on Provo River near the mouth of North Fork. The power capacity of the site under these conditions is 1,020 horsepower (765 kilowatts). The Q50 flow is estimated to be 10 second-feet, and the corresponding capacity is 1,280 horsepower (960 kilowatts).

Little Cottonwood sites.—A plan and profile[56] of Little Cottonwood, Cottonwood, and Mill creeks, the principal tributaries of Jordan River, were made by the United States Geological Survey in 1920. The maps are on a scale of 2 inches to the mile, and the topography is shown by contours with an interval of 25 feet on the land and river surface. The vertical scale of the profiles is 1 inch to 200 feet. The maps are printed in three colors, like the standard topographic maps

[55] Op. cit., sheets C and I.

[56] Plan and profile of Cottonwood, Little Cottonwood, and Mill creeks, tributary to Jordan River, Utah (four sheets, for sale by the Geological Survey at 40 cents for the set).

of the Survey, and in addition to the topography of the canyon and the location of the streams they show all land lines, power and dwelling houses, roads, and other artificial features.

The Little Cottonwood sites[58] are along Little Cottonwood Creek a few miles southeast of Murray, Utah. The canyon is a narrow rock gorge with a steep grade. Above the intake of the Columbus Consolidated Mining Co.'s power plant the fall in the creek is about 400 feet to the mile, and at one time the Flagstaff Copper Mining Co. proposed to develop about 2½ miles of this stretch of the canyon. At this site, which for identification may be designated the Flagstaff site (10HH 1), a static head of 1,000 feet is available. The estimated Q90 flow is 12 second-feet, as the Wasatch mines drain tunnel, which empties into the creek above, has a continuous flow of about 10 second-feet. The power capacity of the site is accordingly 960 horsepower (720 kilowatts). The estimated Q50 flow is 18 second-feet, and the corresponding capacity is 1,440 horsepower (1,080 kilowatts).

The Lower Canyon site (10HH 2) lies between the Columbus Consolidated Mining Co.'s plant and the intake of the Murray city plant, near the mouth of the canyon. In this 3-mile stretch a head of 1,180 feet can be developed, and because of the almost sheer rocky walls of the canyon the best method of development may be to build more than one unit. The Q90 flow is estimated to be 20 second-feet, and the corresponding power capacity of the site is 1,890 horsepower (1,420 kilowatts). The estimated Q50 flow is 30 second-feet, and the corresponding capacity is 2,830 horsepower (2,124 kilowatts). Within this power site about 1 mile of the stream has been developed by three small plants, which were built by the Cottonwood Granite Co., of Salt Lake City, for use in quarrying. The upper and lower plants have heads of 51 and 73 feet and a water-wheel capacity of 94 and 133 horsepower, respectively. The water wheels are used to drive air compressors, and the compressed air is used for drilling and handling the derricks in the quarry adjacent to the plants. No electricity is generated, and the plants are operated only during the summer. The middle plant has a head of 223 feet and a water-wheel capacity of 610 horsepower. It is now leased by the Whitmore Oxygen Co., and a 400-kilowatt generator has been installed for making oxygen electrolytically from the water of the creek.

The Russell site (10HH 3), partly covered by a filing made in the State engineer's office by Samuel Russell, embraces the first mile of Little Cottonwood Creek below the Murray city power plant. The topography is favorable for a low diversion dam just below the Murray plant and for a pipe line extending along the east side of the creek. A static head of 200 feet is available, and the estimated Q90 flow is 25 second-feet, so that the power capacity of the site is 400 horse-

[58] Op. cit., sheets A and C.

power (300 kilowatts). The estimated Q50 flow is 37 second-feet, and the corresponding power capacity is 590 horsepower (444 kilowatts).

Cottonwood sites.[59]—On Cottonwood Creek above and below the present power plants a few miles east of Murray, Utah. From the small city reservoir immediately below the lower power plant, near the mouth of the canyon, downstream to the first important irrigation diversion the distance is about 1½ miles, and the fall of the creek in this stretch is 320 feet. The topography at this site, commonly called the Progress site (10HH 6), is favorable for a low diversion dam immediately below the city reservoir and for a pipe line extending along the north side of the creek to a power house one-fifth of a mile above the irrigation diversion. This distance provides a better location for a penstock than would be available if the power house were farther downstream. The average static head is 300 feet. The estimated Q90 flow at this site is only 19 second-feet, owing to the fact that Salt Lake City diverts much of the flow into its water system. The corresponding power capacity of the site is 460 horsepower (345 kilowatts). The estimated Q50 flow is 30 second-feet, and the corresponding capacity is 720 horsepower (540 kilowatts).

Cottonwood Canyon is a narrow rocky gorge having steep rugged walls, and in the first 6 miles above the weir at the intake of the Stairs power plant it has a fall of 1,445 feet. Several large tributaries enter the stream in this stretch. This fact and the rugged topography of the canyon suggest that perhaps the best way to develop the stream for power would be in at least two units—one diverting water from the creek at Reynolds Flat, in the NE. ¼ sec. 18, T. 2 S., R. 3 E., Salt Lake base and meridian, with a pipe line extending downstream along the south side of the canyon to a power house at the mouth of Mineral Fork, and the other diverting water from the creek just below Mineral Fork, in the SW. ¼ sec. 14, T. 2 S., R. 2 E., with a pipe line extending downstream to a power house above the intake of the Stairs plant in the SE. ¼ sec. 20, T. 2 S., R. 2 E. At each site the power house would be nearly 3 miles below the diversion dam. The average static head available at the upper site (10HH 4) is 600 feet and at the lower site (10HH 5) 825 feet. The estimated Q90 flow is about 15 second-feet at the upper site and 20 second-feet at the lower site, and the respective power capacities of the sites are 720 horsepower (540 kilowatts) and 1,320 horsepower (990 kilowatts). The estimated Q50 flow is 23 second-feet at the upper site and 30 second-feet at the lower site and the corresponding capacities are 1,100 horsepower (825 kilowatts) and 1,980 horsepower (1,485 kilowatts).

If the Reynolds Flat reservoir site were developed to a capacity of 12,000 acre-feet for an additional water supply for the city, the stored water could be released for municipal purposes to the advantage of

[59] Op. cit., sheets B and D.

the power developments, and under these conditions the power capacities might be increased materially for certain periods of the year.

Another plan which suggests itself in the combination of power development and city water supply is to develop both of the reservoir sites on Cottonwood Creek—the Reynolds Flat site to a capacity of 12,000 acre-feet and the one immediately below it to 15,300 acre-feet—of course on the assumption that they prove feasible on a more detailed investigation. This plan, however, would preclude the development of both the upper and lower power sites, but one plant could probably be built that would divert water from the creek immediately below the lower reservoir and carry it through a pipe line to a power house just above the intake of the Stairs plant, a distance of about 4 miles. The fall in this stretch of the canyon is 1,145 feet, and if the water in the reservoir could be utilized for power without interfering with the municipal use, a Q90 flow of about 77 second-feet would be available and the power capacity of the site would be 7,000 horsepower (5,775 kilowatts). The Q50 flow of the site would probably be greatly affected by the city's use of the water and is therefore not estimated.

Perhaps among the most important tributaries of Cottonwood Creek, so far as the development of power is concerend, are Mineral Fork (10HH 7) and Mill B South Fork (10HH 8). Both streams flow through steep, narrow canyons and enter the main stream from the south. Mineral Fork has a fall of 700 feet in the first half mile above its mouth and below all important tributaries. It has an estimated Q90 flow of 3 second-feet. Mill B South Fork has a fall of more than 600 feet in the first three-quarters of a mile above its mouth and below all important tributaries. The estimated Q90 flow is 3.5 second-feet. The power capacity at each of these sites is 170 horsepower (125 kilowatts). The estimated Q50 flows are 4.5 and 5.3 second-feet respectively, and the corresponding capacity is 250 horsepower (190 kilowatts) at each site.

Mill Creek site.[60]—On Mill Creek 12 miles southeast of Salt Lake City, just above intake of upper Mill Creek power plant (10HH 9). In the 3-mile stretch above the mouth of Elbow Fork Mill Creek has a fall of 938 feet, and in the 6 miles to the mouth of the canyon from this point the fall is 1,633 feet, practically all of which is developed in two power plants. The stream flow available at the upper power plant is lowest in winter, and during the coldest periods it is about 5 second-feet. The topography of the canyon at this power site is favorable for a low diversion dam across the channel of the creek in the SW. ¼ sec. 32, T. 1 S., R. 3 E., Salt Lake base and

[60] Op. cit., sheets A and D.

meridian, and for a pipe line extending along the north side of the canyon to a power house in the NE. ¼ sec. 26, T. 1 S., R. 2 E. No large tributaries flow into the creek in this stretch, but there are small springs in the canyon, so that the stream flow available at the point of diversion would be somewhat less than that at the intake of the upper power plant. Accordingly, the estimated Q90 flow is about 3 second-feet, and the power capacity of the site is 220 horsepower (165 kilowatts). The estimated Q50 flow is about 4.2 second-feet, and the corresponding capacity is 310 horsepower (240 kilowatts).

Parleys site.—On Parleys Creek 6 miles southeast of Salt Lake City, at the mouth of Parleys Canyon, just above the city's distributing reservoir (10HH 10). The canyon is a narrow gorge with rugged walls and has a grade of about 100 feet to the mile. The Park City branch of the Denver & Rio Grande Western Railroad runs through it. From the outlet of the Mountain Dell reservoir down to the power-house site, a distance of about 4½ miles, the total fall is 679 feet. As the stream flow is usually lowest in winter, the city releases water from the Mountain Dell reservoir at that time to supplement the other sources of supply and meet the city's needs. In this way the low flow is increased to some extent. The static head is 679 feet, and the Q90 flow is 8 second-feet, giving a power capacity at the site of 430 horsepower (320 kilowatts). The estimated Q50 flow is 11 second-feet, and the corresponding capacity is 600 horsepower (450 kilowatts).

City Creek site.—On City Creek about 4 miles northeast of the center of Salt Lake City (10HH 11). The creek is a small stream that flows through a steep, narrow canyon, having a fall of about 1,200 feet in the 4-mile stretch above the highest intake of the city's waterworks. The stream is one of the principal sources of water supply for Salt Lake City and is devoted entirely to that purpose. The topography is suitable for the construction of a low diversion dam across the channel of the creek about 8 miles from the center of the city and for a pipe line extending along the side of the canyon to a power house at the highest diversion point. With an average static head of about 1,200 feet and a Q90 flow of 4.5 second-feet at the point of diversion the power capacity of the site is 430 horsepower (320 kilowatts). The estimated Q50 flow is 6.4 second-feet, and the corresponding capacity is 600 horsepower (450 kilowatts).

SUMMARY.

Undeveloped power sites in Jordan River and Utah Lake basins.

[Estimates of power based on static head and over-all plant efficiency of 70 per cent.]

Index No.	Power site.	Stream.	Static head (H).	With existing flow.				With regulated flow.			
				Q90	Q50	Horsepower.		Q90	Q50	Horsepower.	
						0.08HQ90	0.08HQ50			0.08HQ90	0.08HQ50
			Feet.	*Sec.-ft.*	*Sec.-ft.*			*Sec.-ft.*	*Sec.-ft.*		
10HF 1	Earl	American Fork	1,085	5	9	430	780				
10HF 2	Clark	do	250	22	37	340	580	35	50	700	1,000
10HF 3	Thistle Fork	Thistle Fork of Spanish Fork	450	10	14	360	500				
10HF 4	Soldier Fork	Soldier Fork of Spanish Fork	450	10	14	360	500				
10HF 5	First (Diamond Fork)	Diamond Fork of Spanish Fork	275	57	60	1,250	1,320				
10HF 6	Second (Diamond Fork)	do	680	62	70	3,370	3,810				
10HF 7	Third (Diamond Fork)	do	670	65	85	3,480	4,560				
10HF 8	Fourth (Diamond Fork)	do	500	20	50	800	2,000				
10HF 9	Payson	Payson or Peteetneet Creek	459	6	8	220	290				
10HF 10	Santaquin	Santaquin Creek	1,000	5	7	400	560				
10HF 11	Salt Creek	Salt Creek	325	15	20	390	520				
10HG 1	Upper Provo	Provo River	300	30	40	720	960				
10HG 2	Lower Provo	do	300	38	49	910	1,180				
10HG 3	Lake Creek	Lake Creek (Provo River)	800	10	13	640	830				
10HG 4	North Fork (Lower)	North Fork of Provo River	1,600	8	10	1,020	1,280				
10HH 1	Flagstaff	Little Cottonwood Creek	1,000	12	18	960	1,440				
10HH 2	Lower Canyon	do	1,180	20	30	1,890	2,830				
10HH 3	Russell	do	200	25	37	400	590				
10HH 4	Upper	Cottonwood Creek	600	15	23	720	1,100				
10HH 5	Lower	do	825	20	30	1,320	1,980				
10HH 6	Progress	do	300	19	30	460	720				
10HH 7	Mineral Fork	Mineral Fork (Cottonwood)	700	3	4.5	170	250				
10HH 8	Mill B South Fork	Mill B South Fork (Cottonwood)	600	3.5	5.3	170	250				
10HH 9	Mill Creek	Mill Creek	938	3	4.2	220	310				
10HH 10	Parleys	Parleys Creek	679	8	11	430	600				
10HH 11	City Creek	City Creek	1,200	4.5	6.4	430	600				
						21,860	30,340			700	1,000

SITES ON FARMINGTON AND SOUTH WILLOW CREEKS.

Farmington Creek site.—On Farmington Creek near Farmington, Utah (10HA 1). The creek flows through a rough, steep canyon that opens into the Great Salt Lake valley about 1 mile northeast of Farmington. The total fall of the stream in a distance of 4 miles is about 1,800 feet, part of which is utilized by the power plant near the mouth of the canyon. From the power house downstream to the first irrigation diversion, nearly half a mile, the fall is 250 feet, and in the 2-mile stretch above the diversion dam of the power project the fall is 1,000 feet. A static head of 1,250 feet is therefore available along this creek at two sites. The estimated Q90 flow is 4 second-feet, and the combined power capacity of the sites is 400 horsepower (300 kilowatts). The estimated Q50 flow is 6 second-feet, and the corresponding capacity is 600 horsepower (450 kilowatts).

South Willow Creek site.—There are no power sites on streams in Tooele and Rush valleys except a small one on South Willow Creek (10HA 2), a small spring-fed stream that flows through a short, steep canyon. A power plant occupies the lower part of the canyon, and from the power house the water is carried through a cement pipe line along the side slope of the valley about 4 miles to the head of an irrigation canal near Grantsville. Before this pipe line was laid much of the water sank into the creek bed before it reached the irrigation diversion. From the power house to the irrigation intake a head of about 350 feet is available, and the estimated Q90 flow is 5 second-feet, so that the power capacity of the site is 140 horsepower (105 kilowatts). With a Q50 flow of 7 second-feet the capacity is 200 horsepower (150 kilowatts).

RECAPITULATION.

Summary of undeveloped power sites in Great Salt Lake basin.

Drainage basin.	Number of sites.	Horsepower with existing stream flow.		Horsepower with regulated stream flow.	
		0.08HQ90	0.08HQ50	0.08HQ90	0.08HQ50
Bear River	29	22,550	35,510	43,910	66,120
Weber River	8	11,320	14,640	13,830	18,290
Jordan River and Utah Lake	26	21,860	30,340	22,220	30,760
Farmington and South Willow creeks	2	540	800		
	65	56,270	81,290	79,960	115,170

WATER RIGHTS AND APPROPRIATIONS.

GENERAL CONDITIONS.

The waters of the streams of the Great Salt Lake basin have three principal uses—for domestic supply, for irrigation, and for the development of power or other miscellaneous purposes. The future prosperity and development of the basin require that these waters be put to the highest use. To accomplish this end each of the three States concerned—Wyoming, Idaho, and Utah—has a code of laws governing the acquisition of water rights. In Wyoming and Utah the law is administered by the State engineer, and in Idaho by the commissioner of reclamation. The waters within each State are declared to be the property of the State, and the use for beneficial purposes is a public use to be granted through the State engineer's or commissioner's office. As certain of these beneficial or public uses are of a higher order than others, an order of preference is fixed by the statutes, so that water which has been applied to a lower use may be taken by process of law, upon due compensation, and applied to a higher use. Such transfers are sometimes made through public necessity arising from increased population and development. Domestic use is considered to be the highest use, then irrigation, and finally power, mining, and other miscellaneous uses.

STATE ADMINISTRATION.

The office of the State engineer is peculiar to the arid States, and Wyoming was one of the first States to create it. As early as 1886 Wyoming had a Territorial engineer to whom was given general supervision of the diversion of water and of the work of the water commissioners who were to distribute the water. He was also to make measurements of stream flow and collect data regarding irrigation systems and reservoirs.

In 1890 Wyoming was admitted as a State, and by constitutional provisions a principle new to American irrigation law was outlined, namely, the adjudication of water rights by an administrative body and the acquisition of rights through application to a public official, who had power to deny the application under certain circumstances. Prior to this time water was taken from a stream by posting and filing a claim as notice to others of the existence of the right. For defining the rights which had already thus been acquired a board of control was organized in April, 1891, composed of the State engineer as president and the superintendents of the four water divisions into which the State was divided. For adjudicating these rights the State engineer makes the necessary surveys of the stream flow, irrigation system, and irrigated lands or lands susceptible of irrigation from the constructed systems on the stream and makes a map showing these data. The superintendent of the division in which the stream is situated takes testimony as to dates of original construction and subsequent improvements or extensions. After the taking of testimony is completed the data are open to inspection, and any claim may be contested. If the claim is not contested, the board usually instructs its secretary to issue certificates to the claimants.

In Idaho the office of State engineer was created in 1895, after the passage of the Carey Act. The duties of the State engineer were to examine plans submitted under that act and determine whether or not a project was feasible and beneficial to the public; whether or not the water supply was sufficient; whether a permit for the appropriation of the water had been issued; whether the works planned were of sufficient capacity to properly supply the land; whether the maps filed complied with the regulations of the Department of the Interior and with the regulations of the State engineer's office; and whether or not the land covered by the application was of desert character. If it became necessary, in order to determine any of these things, the engineer was authorized to make surveys. The reports of his findings were submitted to the State land board, which has the approval of plans under the Carey Act. Prior to 1903 the engineer had nothing to do with the acquisition of rights or the distribution of water, his duties being chiefly that of making general surveys of water resources of the State and those indicated in connection with the Carey Act projects. In 1903, however, a law was passed to provide a system of public control of the water supply of the State, with the State engineer as administrating officer. The definition of old rights was left with the courts, and until the rights to any supply are adjudicated neither the State engineer nor any intending irrigator can tell how much unappropriated water there is in any stream. In 1919 the office of State engineer was abolished and replaced by a department of reclamation, with a commissioner of reclamation at the head. The functions of this department are (1) to exercise the rights, powers, and duties vested by the law in the State engineer; (2) to exercise the rights, powers, and duties vested by law in the State Board of Land Commissioners (so far as their duties relate to the administration of the Carey Act); and (3) to exercise the rights, powers, and duties vested by law in the State Board of Land Commissioners under chapter 241 of the compiled laws.

In the early history of Utah there was to some extent public control of the use of water for irrigation, but after some time the matter was regarded with considerable indifference, and when Utah became a State (1896) efforts to obtain State control of the streams resulted only in the recognition of existing water rights. The next year the office of State engineer was created, but he was given no control over the sources of water supply. His duties, which were similar to those of the first State engineer of Idaho, were to examine and report on reservoir sites for the State Board of Land Commissioners; to supervise the construction of reservoirs by the State; to examine and pass upon all irrigation work in which the State was interested; to keep a record of stream flow; and to inspect all dams more than 10 feet high. In 1901 these duties were enlarged. Provision was made for the distribution of water by commissioners appointed by the county commissioners, under supervision of the State engineer, and for making surveys and maps of streams and irrigated lands. In 1903 the waters of the State were declared to be the property of the public, subject to existing rights, and the State engineer was given "general supervision of the waters of the State, and of their measurement, apportionment, and appropriation." In the manner of defining existing rights the Utah system is a composite of the Colorado and Wyoming systems, providing for adjudication, initiated through the State engineer's office and with the aid of that office, as in Wyoming, but leaving it in the courts, as in Colorado. A condition similar to that in Idaho exists in Utah, for until the rights to any supply are adjudicated, neither the State engineer nor any intending irrigator can tell how much unappropriated water there is in the stream.

METHODS OF ACQUIRING WATER RIGHTS.

WYOMING.

The person who wishes to acquire a water right in Wyoming must, before beginning construction work, make application to the State engineer and receive a permit from him. The application must be accompanied by maps in duplicate, one of which must be on tracing linen and is retained by the State engineer; the other, which may be a blue print, is returned to the applicant with the approval marked thereon. These maps must be prepared from survey data by a qualified engineer or surveyor. They must show all details of the proposed project as outlined in the "Manual of regulations and instructions for filing applications" issued by the State engineer and must conform to one of the sizes specified therein. A filing fee must also accompany the application in accordance with the following schedule:

1. For filing and examining applications: (*a*) For ditch or enlargement permit, $2; (*b*) for reservoir permit, $1.
2. For recording any other instrument: (*a*) For first hundred words, $1; (*b*) for each subsequent hundred words, $0.15.
3. For making copy of any permit or certificate of appropriation, $1; certified copy, $2.

4. For making copies of records: (*a*) For first hundred words, $1; (*b*) for each subsequent hundred words $0.15; (*c*) for attaching certificates thereto, $1.
5. For making blue prints of maps on file, minimum charge $0.50.
6. For copying maps, $2 for each hour or fraction thereof.

The application must show the name and post office address of the applicant, the use to which the water is to be applied, the name of ditch or canal, the source of the proposed appropriation, the location of the head gate, the length and carrying capacity of the ditch, the nature of the material to be moved, the estimated cost of the work, the time when the work will begin, the time when the work will be completed, and the time when the water is to be applied to beneficial use. If the permit is for irrigation the application must also show the land to be irrigated.

As soon as the application is received in the State engineer's office it is given a temporary number and acknowledged. If it is not complete it is returned to the applicant for correction and must be sent back to the State engineer within 90 days. When it is finally approved it becomes a permit and is returned to the applicant with a notice calling his attention to the law requiring the submitting of proof of completion of works. "The law requires applications to be made and approved before work begins. No application that states that work has been begun or has been completed will be approved."

Construction work must be started within one year after the date of approval, and if proof of completion has not been previously received, a short time before the expiration of the time allowed for the completion of works under the permit, a notice is sent calling the attention of the applicant to the fact that the time is about to expire and warning him that his permit will be canceled unless proof is submitted within 30 days.

The proof of appropriation must show the name and address of the appropriator, the permit number, the purpose for which the water is taken, the dates of beginning and completion of construction and of applying the water to a beneficial use, the dimensions of the waterway, the location of the land irrigated, the crops grown, the time of the year when the water is used, the amount of investment in the project, and whether or not the map filed with the application shows correctly the project as built. This statement must be sworn to by the appropriator. The proof of appropriation is accompanied by a statement from the superintendent of the water division in which the project is situated, that he has examined the works and found them to be as stated in the proof, or otherwise, as the case may be; that the proof has been open for public inspection; and that he recommends the issuance of a certificate of appropriation in accordance with the proof.

Applications for the enlargement of existing works are made on an "enlargement blank," which is substantially the same as the one used for original applications, except that it calls for descriptions of the works as they are and as they are to be.

Applications for permit to divert water for power purposes must be accompanied by plans in duplicate showing profiles of supply conduits, plans of the plant, intake works, and other features. The plans should be shown in sufficient detail to enable a computation to be made of the amount of water to be diverted. They should include the diameter, length, effective drop, and carrying capacity of supply conduits, and if possible the kind of machinery to be installed, giving size, make, and manufacturer's number of the turbines or wheels. * * * The point where the water is to be returned to the stream should be described by course and distance from a Government corner.

The State engineer has authority to refuse an application if there is no unappropriated water in the stream or if the granting of the application would be contrary to public policy. Although some applications have been refused it is not the usual practice, for there is often some flood water and always the possibility of an increased supply through more economical use by the holders of prior rights. Accordingly, permits are frequently granted when the records of the engineer's office show little unappropriated water. All pertinent factors, however, such as location of the proposed diversion and possible interference with the older rights, are considered in such cases, and the following form of notice is stamped across the face of the permit:

The records of the State engineer's office show the waters of ---------------- to be largely appropriated. The appropriator under this permit is hereby notified of this fact and that the issuance of this permit grants the right to divert and use the surplus or waste water of the stream and confers no rights which will interfere with or impair the use of water by prior appropriators.

IDAHO.

To acquire a water right in Idaho it is first necessary to make application to the commissioner of reclamation in proper form. This application must set forth the name and post office address of the applicant; the quantity of water claimed; the source of the water supply; the location of the point of diversion; the nature of the proposed use; the estimated cost of the project works; the description of the project works; the time required for the completion of construction of such works, which in no case shall exceed five years from the date of approval of the application; and the time required for the complete application of the water to the proposed use, which must be within six years after the date set for the completion of such works, unless the project covers more than 25,000 acres, when proof of beneficial use may be made at any time within a period of 10 years from the date set for the completion of works.

The application shall be accompanied by a plan and map in duplicate of the proposed works for the diversion and application of the water to a beneficial use, showing the character, location, and dimensions of the proposed reservoirs, dams, canals, ditches, pipe lines, and all other works proposed to be used by them in the diversion of the water and the area and location of the lands proposed to be irrigated.

When the amount of water claimed is not more than 10 second-feet, blank forms furnished by the commissioner may be used for the maps; when it is more than 10 second-feet and less than 25 second-feet, the maps must conform to one of three specified sizes, and one copy must be made on tracing linen, to be retained by the commissioner. If more than 25 second-feet is claimed, the maps must contain a certificate of the engineer who made them. If the applicant wishes to use the water for the development of power, the point where the water is returned to the stream must be definitely located on the maps.

Upon receipt of an application accompanied by the filing fee of $1 for amounts of 1 cubic foot or less a second and 10 cents for each additional cubic foot or fraction thereof, the commissioner indorses on it the date of its receipt and makes a record of it in a suitable book. All applications that do not comply with the law or the regulations of the commissioner's office are sent back for correction and must be returned corrected by the applicant within 60 days.

The commissioner of reclamation is required to approve all applications that are in proper form and that contemplate a beneficial use of the water. This provision eliminates a great deal of the responsibility which is placed upon the engineers in States where they are given power to reject an application if there is no unappropriated water in the source of supply, if the granting of the application would be contrary to public policy, or if the applicant does not show sufficient financial ability to carry out the proposed plan, and for this reason it makes the water right just that much less valuable. If the engineer is required to reject an application because there is no unappropriated water in the proposed source of supply, his approval gives some assurance that his permit may have a value, but in Idaho it means no more than that the application was in proper form and it places on the applicant the burden of finding out whether or not there is any unappropriated water. For the benefit of the appropriator, however, the following important notice is published in the "Manual of instructions for filing water-right applications" in Idaho:

It should be remembered that many of the streams of the State are already overappropriated and that in such cases, although a permit can be issued, it must take its place after all older rights and may not therefore convey any real right to the use of water. Before filing an application the applicant should first determine, as nearly as possible, whether or not a water supply is available to fill the right he would acquire. Such information can be secured in part from the records of the State engineer's office; but under the present law, whereby a valid water right may be secured without recording same in any manner, the records of the State engineer's office may not contain all the rights on the stream in question. Consequently, the information relating to water rights as obtained from this source should be supplemented by further inquiry and examination along the proposed source of supply to ascertain whether or not there are any valid rights that are not recorded.

The time limit for construction of works as provided in an application is five years, and the water must be put to beneficial use on projects of less than 2,500 acres within a further period of six years, but the commissioner in approving an application may require that the proofs be made in shorter periods. One-fifth of the work must be done at the expiration of one-half of the time allowed for completion of works, and works having a capacity of less than 25 cubic feet per second must be begun within 60 days from the approval of the application. If the permit is for more than 25 cubic feet per second, the holder must, within 60 days of the issue thereof, file a bond, the amount of which is fixed by the commissioner, not to exceed $10,000, conditioned upon faithful completion of the works as specified.

On or before the date named in a permit for the completion of works the holder of the permit must be prepared to submit proof of such completion. At least 60 days before the expiration of the time allowed the holder must send to the commissioner of reclamation, by registered mail, a notice that he will be prepared to submit proof of completion on a stated day, and if the works are to carry more than 50 cubic feet per second the facts set forth in this notice must be certified to by a competent engineer. The notice is prepared on a form furnished by the commissioner and gives the date when proof will be submitted, the name and post-office address of the permit holder, the number of the permit, the purpose for which the water is to be used, the capacity of the works, the area of land to be irrigated, and the name of the newspaper in which the holder wishes notice of his intentions published.

Upon receipt of this notice the commissioner of reclamation orders it published for a period of four weeks in a newspaper designated by the permit holder and published in the county in which the project is situated. The expense of this publication is borne by the appropriator. If the permit claims 6.4 second-feet of water or less, proof of completion of works may be made without publication by filing with the commissioner on or before the date set for such completion an affidavit on a blank furnished, setting forth the required information.

Before the certificate of completion of works is issued the permit holder must pay the following fee: For ditches or canals having a capacity of 10 cubic feet per second or less, $5; for ditches or canals having a capacity of more than 10 second-feet, $5 for the first 10 second-feet and 30 cents additional for each additional second-foot.

A similar procedure is followed for making proof of the application of the water to beneficial use, and when such proof has been made the commissioner of reclamation issues a license which gives, among other things, the number of the application, the permit, the certificate of completion, the amount of water, the source of supply, and the use and which constitutes a final water right. At the time of making final proof, however, the applicant must pay a fee of $2 for each subdivision of 40 acres, or fraction thereof in the case of an irrigation right, and a fee of $5 if the water is to be utilized for power or for uses other than irrigation.

UTAH.

Any one wishing to acquire the right to the use of any unappropriated public water in the State of Utah must, before commencing construction work on any project contemplating the use of such water, make an application to the State engineer. Blank forms are provided by the engineer for this purpose, and separate forms are used for irrigation, power, mining, stock watering, domestic and municipal, and miscellaneous applications. No maps are required with the application, but the application must show the name and post-office address of the applicant, the nature of the proposed use to which appropriated water is to be applied, the quantity of water in acre-feet or the flow of water in second-feet and the time during which it is to be used each year, the name of the stream or other source from which the water is to be diverted, the place where the water is to be diverted and the nature of the diverting works, the dimensions, grade, shape, and nature of the proposed channel, and such other facts as will clearly define the full purpose of the appropriation. If the applicant proposes to use the water for irrigation, the lands to be irrigated must be shown; if for power, the application must show the number, size, and kind of water wheels to be employed, the head under which each wheel is to be operated, the amount of power to be produced, the purposes for which and the places where it is to be used, and the point where the water is to be returned to the natural stream or source. The place of diversion and place of return of the water must be designated with reference to the United States land corners or mineral monuments, when either the point of diversion or the point of return is within 6 miles of the nearest United States land corner.

When an application is received it is recorded at once if it is accompanied by the proper fees; otherwise no record is made until the applicant has been notified and the fees paid. It is then examined to see if it contains the required facts. If it does not it is sent back for correction or additions, and if the applicant does not return it within 60 days no further proceedings are had. When the application is in proper form the engineer at once publishes, at the expense of the applicant, a notice of the application. This notice is published in a newspaper having a general circulation within the boundaries of the river system referred to for a period of four weeks. In addition to the description of the proposed diversion the published notice contains a statement to the effect that all protests against the granting of said application, stating the reasons therefor, must be made by affidavit in duplicate and filed in the State engineer's office within 30 days after the completion of the publication of the notice.

It is the duty of the State engineer, upon the payment of the approval fee, to approve all applications that comply with the provisions of the law, where the proposed use will not impair the value of existing rights or will not interfere with the more beneficial use of the water, and if the information at hand is insufficient to determine these facts action may be withheld until an investigation is made.

If there is no unappropriated water in the proposed source of supply, or if the proposed use will conflict with prior applications or existing rights, or if the approval of the application would, in the opinion of the State engineer, interfere with a more beneficial use or would prove detrimental to the public welfare, the State engineer must reject the application. The engineer is also given authority to inquire into the financial ability of applicants and into their good faith, but there is no authority to reject an application on either of these grounds.

In approving an application the engineer fixes the time at which the work must be completed. Actual construction work must begin within six months from the date of such approval and be diligently prosecuted to completion. The water must also be applied to beneficial use within a time fixed by the engineer, not to exceed 14 years from the date of the approval of the application, except as may be ordered after petition and hearing by the district court.

Sixty days before the date set for the completion of works the applicant is notified by the engineer of the date when proof of completion of works will be due. The proof, made on blanks furnished by the engineer, consists in statements by the appropriator, sworn to by himself and two disinterested witnesses, and a map, profile, and drawings made on tracing linen by a "reputable civil engineer," showing the location with reference to the United States land surveys, the nature and extent of the completed works, the natural stream or source from which and the place where the water is diverted, the place and manner of connecting with other works or streams, the ground and grade lines, cross sections, and dimensions of the various forms of the diverting channel, the character of the materials moved and used in construction, the several appliances used to divert, measure, and regulate the water, the character of all structures which cross, support, or constitute the diverting channel or any part of it, and such other data as will fully and correctly delineate the work done and conform to the general rules and regulations of the State engineer's office. The map, profile, and drawings must be certified to under oath, by the engineer who has made them and by the applicant whose works they represent.

When the proof of completion of works has been accepted and approved the engineer indorses such acceptance and approval upon the applicant's certificate of proof, and this constitutes a record of the completion of the works. The rules of the engineer require that the maps shall be in duplicate on tracing linen, on sheets 24 by 30 inches, on a scale of 400 feet to an inch, and if the whole project can not be shown on one sheet more than one must be used. Profiles must show the ground line of the diverting channel in india ink, the grade line of the channel in red ink, cross sections of the various forms of the channel, and the dimensions thereof. Drawings must show in detail the diverting dam, head gates, measuring devices, crossings, flumes, trestles, bridges, and other structures, and the character of materials to be used. All these drawings must be certified to by the engineer who made them.

The applicant is again notified by the engineer of the date when proof of application of the water to beneficial use is due, in a manner similar to that used in notifying him regarding the proof of completion of works. Then,

upon its being made to appear to the satisfaction of the State engineer that an appropriation has been perfected in accordance with the application therefor and that the water applied for has been put to a beneficial use, it shall be the duty of the State engineer to issue a certificate, in duplicate, to the party making the same, setting forth the name and post-office address of the person, corporation, or association by whom the water is to be used; the quantity of water in acre-feet or the flow of water in second-feet appropriated; the purpose for which the water is to be used; the time during which the water is to be used each year; the name of the stream or source from which the water is to be diverted; the date of the appropriation; and such other information as will fully and completely define the extent and conditions of actual application of the water to a beneficial use.

If the applicant so desires he may make proof of appropriation instead of making the two proofs as above outlined.

This certificate constitutes a final water right. One copy of it is filed with the State engineer, and the other must be recorded within 30 days in the office of the recorder of the county where the water is diverted. The distinctive feature of the Utah certificates is that they define the part of each year during which the water may be used.

The fees required under the Utah law are as follows:

For examining and filing applications to appropriate 10 cubic feet of water per second or less, $2.50.

For examining and filing applications to appropriate 500 acre-feet of water or less, $2.50.

For examining and filing applications to appropriate more than 10 cubic feet of water per second, a fee of $2.50 plus $1 for each cubic foot per second in excess of that flow.

For examining and filing applications to appropriate more than 500 acre-feet of water, a fee of $2.50 for the first 500 acre-feet and 2 cents per acre-foot in excess of that volume.

For approving and recording completed applications, $2.50.

For examining and filing proof of completion of works, $6.

For examining and filing proof of beneficial use, $6.

For examining and filing proof of appropriation which may be made in place of the two proofs, namely, completion of works and beneficial use, $6.

For final certificate, $1.

WATER-POWER RIGHTS IN GREAT SALT LAKE BASIN.

Since the creation of the office of State engineer more than 187 applications have been made for power projects in the Great Salt Lake basin. Of the 65 undeveloped power sites described in this report more than two-thirds, or practically all the more favorable sites, have at some time been filed upon.

On Bear River and its tributaries in Wyoming there is only one adjudicated power right, on Pine Creek, where the McNeice or Cokeville power plant is built. In Idaho at least 38 power filings have been made on Bear River and its tributaries, and in the Great Salt Lake basin in Utah more than 147 power filings are on record. At least 35 of the 50 power plants now operating in the basin were built after the office of State engineer was established and in compliance with the laws of the State in which they are situated. Most of the others do not comply with the provisions of the laws.

IRRIGATION AND ITS RELATION TO THE DEVELOPMENT OF WATER POWER.

Agriculture and mining are the two principal industries in the Great Salt Lake basin. The agriculture is almost entirely dependent upon irrigation, and for this reason the streams are the lifeblood of the industrial development.

The first attempt in the United States to raise crops by irrigation was made on lands now in the heart of Salt Lake City, by diverting into small plowed furrows the streams that flow from the Wasatch Range east of the city.

All the streams in the basin are used for irrigation, and more than 800,000 acres of land is irrigated. The irrigation laws of Wyoming, Idaho, and Utah place use of the streams for irrigation before their use for power, yet only a few of the 50 power plants operating are intimately associated with irrigation. In these few, however, irrigation takes precedence during the irrigation season.

Most of these power plants do not interfere with irrigation because most of the streams are short and flow in the upper parts of their courses through steep, narrow canyons. The power value of each stream is accordingly in this canyon, usually above all irrigation diversions. Furthermore, owing to these same physical conditions no reservoir sites are available for equalizing the flow, and the natural stream flow must be used for both irrigation and power.

The exceptions to this general rule may conveniently be divided into three classes—plants that are situated above all irrigation diversions but have a small amount of reservoir storage; plants that are built as an adjunct to irrigation enterprises; and plants above and below which important irrigation diversions are made.

The Battle Creek plant is an example of the first class. The stream is entirely appropriated for irrigation. The plant is at the mouth of the canyon, above the irrigation diversions. The plant was built to carry short-time peak loads. This required at times a flow greater than the natural flow of the creek, and to provide this excess without interfering with the irrigation rights a small reservoir was built at the head of the intake, and an equalizing reservoir was built below the power house. In this way a sufficient amount of water could be retained above the plant to increase the stream flow for power for a few hours during the peak load, and the flow could be equalized again below the plant. A plan similar to this was worked out at the lower Mill Creek plant, near the mouth of Mill Creek canyon, just east of Salt Lake City.

Examples of the second class of power plants are Paris, High Creek, Wheelon, Riverdale, Hyrum city, Knudsen, Gordon, Bennion, Jordan, Heber, and Strawberry. The largest of these are the Wheelon, Riverdale, and Strawberry plants. In all these enterprises the power plants are supplied with water through irrigation canals, and the use of water for power during the irrigation season depends entirely upon the amount of water needed for irrigation below the power plant. Some of the plants are so situated as to allow the use of all the water required to supply irrigation rights below the power diversion; in others it is necessary to supply intervening canals from the tailrace; and at the Wheelon plant, at least, it is often necessary to close the plant down entirely.

Examples of the third class of plants are the Grace, Cove, and Oneida plants, on Bear River. The Weber plant, at the mouth of Weber Canyon, also belongs to this class, but it is so situated that the irrigation diversions above it do not affect it, because all water stored in the East Canyon Creek reservoir of the Davis & Weber Counties

Canal Co. must pass the plant before it is diverted into the company's canal, and it is therefore available for use for power at the plant.

At the plants on Bear River irrigation and power are very intimately associated, and the two uses are undoubtedly compatible. In order to set forth the general conditions along the river it may be divided into three sections—(1) the upper stretch, extending from the headwaters down to Border, Wyo.; (2) the middle stretch, extending from Border, Wyo., to Preston, Idaho; and (3) the lower stretch, extending from Preston, Idaho, to Great Salt Lake.

In section 1 the average altitude of the valley lands is about 6,500 feet above sea level. The growing season is very short, and the principal crop is hay. Irrigation is practiced to some extent, usually not later than July 15, and the flood run-off nearly always supplies all the water needed to produce a crop. Power has not been developed in this stretch of the stream. In section 2 the altitude of the valley lands ranges from 4,500 feet above sea level at Preston to 6,100 feet at Border. The growing season is longer, and crops requiring irrigation up to September 15 are grown. Section 3 embraces Cache Valley and lower Bear River valley, two of the most fertile and productive valleys in the basin. The lands of Cache Valley are irrigated largely by water from small tributaries of Bear River. Lower Bear River valley, which contains the largest and oldest community along the river, is irrigated from the main stream.

The history of the development of irrigation along Bear River indicates that the systems in lower Bear River valley were built first, probably because of the lower altitude, which affords a longer growing season, and of the close proximity to Salt Lake City, which early became the commercial center for this section.

In section 3 the canals that divert in Bear River canyon supply water to about 50,000 acres, and there is almost as much more to be irrigated. The West Cache canal also diverts in this section and irrigates approximately 15,000 acres on the west side of the river in Cache Valley. In addition to those, several small canals divert water from Bear River near the mouth of Oneida Canyon and irrigate a total of about 2,000 acres.

In section 2 the Last Chance Canal Co. and its subsidiaries divert water above the Grace diversion dam and irrigate about 25,000 acres. The Gentile Valley Irrigation Co. and Thatcher Irrigation Co. divert through one canal sufficient water to irrigate 4,000 acres. In this section are the Grace, Cove, and Oneida power plants, which have installed capacities of 44,000, 7,500 and 30,000 kilowatts, respectively.

The rights for water diverted from Bear River for all irrigation and power uses have recently been adjudicated by the Federal court of Idaho and are shown in the following table:

Adjudicated rights for all water diverted from Bear River.

Date.	Cubic feet per second.	Use.	Name.
May 1, 1879	2.2	Irrigation	A. W. Harris
May 1, 1880	6.5	do	Nelson Ditch Co.
May 1, 1882	13.0	do	Riverdale Irrigation Co.
May 1, 1882	5.5	do	A. C. Bosen et al.
June 10, 1883	3.0	do	Riverdale-Preston Irrigation Co.
July 10, 1883	5.0	do	West Cache canal.
Mar. 1, 1889	333.0	do	Utah-Idaho Sugar Co.
June 1, 1889	33.0	do	Gentile Valley canal.
Mar. 1, 1897	200.0	do	Last Chance canal system.
Aug. 31, 1897	.9	do	Frank W. Harris.
Aug. 31, 1898	1.0	do	Ethel H. Ellsmore.
Sept. 12, 1899	186.0	do	West Cache canal.
Feb. 23, 1901	35.0	do	Gentile Valley canal.
May 14, 1901	133.0	do	Utah-Idaho Sugar Co.
May 14, 1901	240.0	do	Last Chance canal system.
June 10, 1902	6.5	do	Riverdale-Preston Irrigation Co.
Dec. 1, 1903	270.0	Power	Utah Power & Light Co. (Wheelon).
Apr. 18, 1904	12.0	Irrigation	Gentile Valley canal.
June 1, 1904	95.0	do	Utah-Idaho Sugar Co.
Dec. 28, 1905	500.0	Power	Utah Power & Light Co. (Grace).
Dec. 1, 1906	135.0	do	Utah Power & Light Co. (Wheelon).
July 6, 1908	500.0	do	Utah Power & Light Co. (Grace).
Dec. 1, 1908	135.0	do	Utah Power & Light Co. (Wheelon).
Aug. 9, 1909	138.16	Irrigation	Last Chance canal system.
Dec. 31, 1909	25.6	do	Do.
June 17, 1910	1,000.0	Power	Utah Power & Light Co. (Oneida).
July 29, 1910	54.0	Irrigation	Last Chance canal system.
Jan. 18, 1911	1,500.0	Power	Utah Power & Light Co. (Oneida).
Mar. 1, 1911			Utah Power & Light Co. (storage).
Sept. 11, 1912			Do.
Dec. 2, 1912	500.0	Power	Utah Power & Light Co. (Wheelon).
May 1, 1914	43.0	Irrigation	Utah-Idaho Sugar Co.
Mar. 9, 1916	1,500.0	Power	Utah Power & Light Co. (Cove).

The preceding table shows a total of 1,571.35 second-feet of water decreed for the purpose of irrigating about 100,000 acres between Alexander, Idaho, and Great Salt Lake. The maximum quantity decreed for power is 1,500 cubic feet per second. During the average season the river below the Wheelon dam, which serves to divert water both for the lowest irrigator and for the Wheelon plant, is so nearly dry that the water which is used to generate power at the three plants above is also used for irrigation. As very little water is wasted, an extremely high utilization of the water results.

The quantity of water available in any given season depends, of course, on the amount of precipitation in the mountains during the preceding winter. The precipitation necessarily varies from year to year, though the average for a given number of consecutive years will compare closely with the average for another similar period. There are seasons, however, when the run-off is less than 1,500 cubic feet per second and is not sufficient to supply the needs of both irrigation and power. To meet this condition, Bear Lake has been developed as a reservoir.

Bear Lake lies in the south end of the Bear Lake valley. This lake lies partly in Idaho and partly in Utah and is walled in on the east, south, and west by mountains; on the north the country, which is flat, extends northward, converging with the valley of Bear River, which breaks through the mountains to the east, near Border, Wyo., and passes through the north end of the Bear Lake valley. It has an area of approximately 70,000 acres at its maximum altitude, which is 5,923.5 feet, and the topography of the surrounding country is such that water is taken from the river in the northeast corner of the valley, conveyed through the Rainbow canal to Bear Lake, and later released as required through the outlet canal, which joins Bear River in the northwest corner of the valley, at a point west of Montpelier. Under normal conditions only the upper 3.5 feet of the lake at maximum stage, or the water between altitudes of 5,920 and 5,923.5 feet, is available for storage, for when the water surface of the lake recedes below 5,920 feet the hydraulic gradient is so flat that water will not flow from the lake to the river in sufficient quantities to take care of the needs of irrigation and power downstream. To remedy this condition a pumping plant having a capacity of 1,500 cubic feet per second has been installed at the north edge of the lake, which lifts the water from the lake and raises the water surface in the outlet canal sufficiently to permit the water to flow to the river. This serves a twofold purpose: It furnishes water to the river that would not otherwise be available, and it creates additional storage capacity in Bear Lake, making of it a reservoir that is not limited to the flood run-off of one year but that can store the maximum floods over a period of years, thereby equalizing the abnormally wet seasons with the abnormally dry seasons.

These canals and reservoir were built and are controlled and operated by the Utah Power & Light Co.; the water impounded is used for both irrigation and power. An illustration of this combined use is shown in the operations during the irrigation seasons of 1915 and 1919.

Stored water used from Bear Lake for irrigation in 1915.

Month.	Stored water released.	Flow of river below Wheelon.	Stored water used for irrigation.	Per cent of stored water released used for irrigation.
	Acre-feet.	*Acre-feet.*	*Acre-feet.*	
July	34,360	11,030	23,330	68
August	33,450	7,450	26,000	78

During July and August 32 and 47 per cent, respectively, of the total quantity of the water used for irrigation by canals diverting from Bear River in section 2 was stored water released from Bear Lake.

During July and August, 1919, Bear River became almost dry so far as natural flow was concerned. At Dingle, near the upper end of section 2, the natural flow was as small as 12 second-feet on many days, and at Alexander, about 3 miles above the Last Chance canal, the natural flow on several occasions was less than 50 second-feet; this was the only water available for the irrigation of 25,000 acres. Conditions were equally bad all along the river. The Bear River canals that divert at the gates, above the Wheelon plant, which have the oldest rights on the river, would have required all the natural flow to take care of their rights, and as a result the crops under the other projects would literally have burned up.

The Wheelon power plant is below all irrigation and power diversions, and consequently the water in the river below this plant is wasted into Great Salt Lake.

Water released from Bear Lake during July and August, 1919, and total quantity of water in Bear River below the Wheelon power plant.

Month.	Storage release.	Below Wheelon.	Used for irrigation.	Per cent of stored water used for irrigation.
	Acre-feet.	*Acre-feet.*	*Acre-feet.*	
June 10 to 30	28,084	5,959	22,825	81
July	66,241	8,995	57,246	86
August	58,246	15,754	42,492	73
	152,571		122,563	80.3

In these computations it has been assumed that all the water in the river below Wheelon was stored water.

During the irrigation season of 1919 the advantage of having a large reservoir at the head of the stream was forcibly shown. In the average year the stored water runs in the stream with the natural flow and is used either for irrigation or for power, but in years of scarcity crops would be a total failure if there were no reserve supply such as is provided in the Bear Lake reservoir.

The extension of irrigation onto higher bench lands by pumping in Bear River valley has made rapid strides during the last six years. The Lewiston-Bear Lake Irrigation Co. has built a pumping plant on Bear River near Fairview, Idaho. This plant has a capacity of 100 second-feet and raises the water about 90 feet to furnish a supplemental supply for the irrigation of 15,000 acres of bench land near Lewiston, Idaho. By the original project water was brought by gravity from Cub River, a distance of 15 miles, to irrigate these lands. About 150 second-feet is required for this purpose, but during the summer less than 50 second-feet is available from that source.

Furthermore, the canyon sections of the canal were subject to frequent failures, which required that the water be turned out entirely for periods of varying length, sometimes for as long as three or four days, while repairs could be made. The loss incident to these breaks and lack of water was so great that the company finally decided to build a pumping plant and pump water from Bear River during seasons of scarcity. This was the pioneer pumping project of any magnitude in this part of the country, and it has proved so successful that others of lesser magnitude have followed rapidly, until now water is being pumped by 20 or 25 plants to irrigate about 10,000 acres and to supplement the irrigation from natural flow of about 15,000 acres. This phase of the development, which represents the most intimate relation between the use of the water for power and that for irrigation, will continue to grow rapidly, and its economic value to the community in reclaming new lands is considerable.

The use of Bear Lake as a reservoir has shown that in actual practice irrigation and power developments can exist together without impairment of the possibilities of either and that a harmonious simultaneous development of both uses is conducive to rapid industrial progress.

Irrigated land in Great Salt Lake basin, in acres.

Drainage basin.	1902	1919	1920
Bear River and tributaries	276,300	454,300	642,500
Bear River direct	70,000	221,700	340,000
Tributaries of Bear River and small streams flowing into Great Salt Lake	206,300	232,600	302,500
Weber River and tributaries	80,400	97,600	149,100
Weber River direct	42,000	44,700	83,800
Ogden River	22,400	22,000	27,100
Other tributaries of Weber River	16,000	30,900	38,200
Jordan River and Utah Lake drainage basin	180,400	270,600	414,900
Jordan River direct	32,400	48,000	90,500
Cottonwood Creek	8,800	11,000	13,200
Little Cottonwood Creek	7,700	12,100	16,700
American Fork	20,400	19,100	20,400
Provo River	36,900	54,800	62,700
Spanish Fork	23,800	61,400	96,200
Other tributaries of Jordan River and Utah Lake	50,400	64,200	115,200
Grand total	537,100	822,500	1,206,500

Increase from 1902 to 1919, 53.1 per cent.

MARKET CONDITIONS IN THE GREAT SALT LAKE BASIN.

The principal factors governing the development of water power are available water supply, available fall, cost, and market for the power. In all studies of water power where extensive developments are contemplated market is the one factor that determines the economic feasibility of the project, and in projects of public service it is the force that compels the development.

A few years ago the power had to be developed very close to the market, and this fact precluded the development of many excellent power sites that were remote from the centers of civilization. Now the power can be carried more than 200 miles to market, and the result is a much more rapid industrial growth of the entire country. In connection with this growth it is interesting to note the rapid

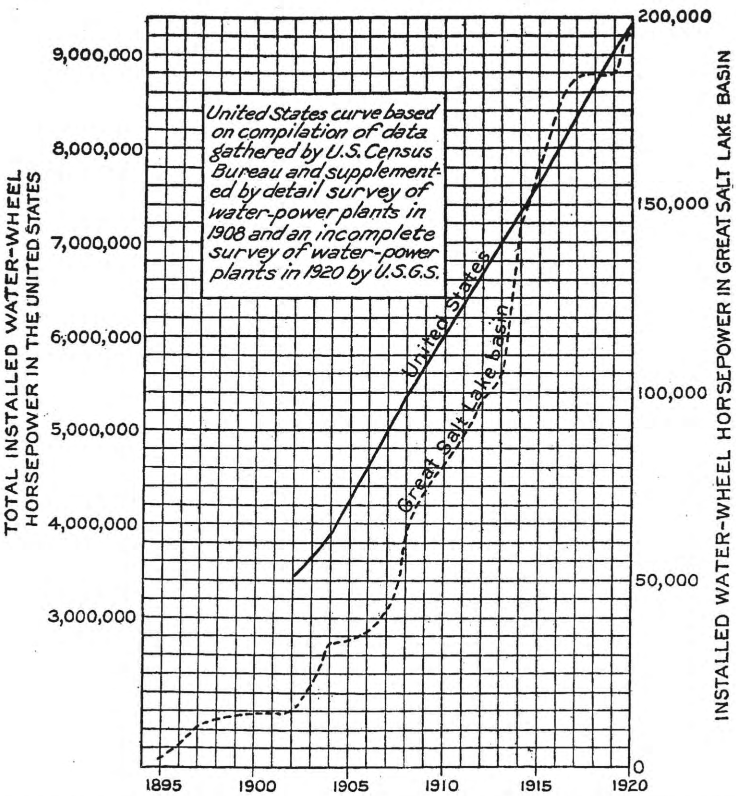

FIGURE 8.—Curves showing water-power development in the United States and in the Great Salt Lake basin.

strides that have been made since 1910 in the rate of growth of the hydroelectric industry, as shown in Figure 8. The market demand has increased so rapidly that a correspondingly large increase in the size of unit installations has become necessary. About 4,500 horsepower was the maximum water-wheel unit in the United States prior to 1910, but units of 70,000 horsepower are now being installed, and even larger ones are possible.

The hydroelectric development in the Great Salt Lake basin has kept pace with and during the period 1914–1917 even exceeded that in the rest of the United States. It is fair to assume that the industrial development of the basin has expanded likewise, because the hydroelectric progress is directly dependent on the industrial progress.

NATURAL RESOURCES.

The Great Salt Lake basin and the territory which lies within transmission distance of its water-power sites are well provided with natural resources. The coal regions to the southeast rank among the larger fields of the United States and furnish much of the coal used in the Rocky Mountain region. Some of the coal is the best obtainable for coking, and more than 200,000 tons of coke is produced yearly for use principally in the smelter industry in Utah, Montana, California, and Idaho.

At Sunnyside, Utah, 819 coke ovens are operated, and the by-products from these ovens give opportunity for an industry that would supply much gas and lighter oils for commercial use. South of the basin there is one of the largest iron deposits in the world.[61] As coal and iron are thus within easy reach, a large market for power may yet be created by the establishment of iron and steel mills in the West. San Francisco and other western ports, within 1,000 miles of the Great Salt Lake basin, furnish an accessible outlet to the Orient for all iron and steel products. One steel plant is now being erected near Provo to utilize these resources.

The Great Basin is an important mining and smelter center and ranks among the greatest producers of copper, silver, and lead in the United States. Its phosphate and potash industries are still young, but both are growing rapidly and will no doubt contribute an appreciable amount to the wealth of the region in the future, as well as furnish an additional market for power. The marble and stone quarries in this region are also capable of producing a greater supply than is needed for local use. The manufacture of Portland cement is a thriving industry at three localities and will doubtless be extended to many others. The basin is singularly fortunate in possessing a wealth of raw materials to serve as the basis for a chemical industry of colossal proportions. Coal and its products of distillation, limestone, sulphuric acid, and common salt are considered the most important requisites of chemical manufactures. Coal is within easy reach of the basin, limestone is plentiful, sulphuric acid is made extensively as a by-product at the smelters, and the supply of salt in Great Salt Lake and its surrounding deposits is immense.

It is estimated that a production of 100,000 tons of salt annually from Great Salt Lake would not exhaust the supply for centuries.

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[61] Leith, C. K., and Harder, E. C., The iron ores of the Iron Springs district, southern Utah: U. S. Geol. Survey Bull. 338, 1908.

In addition the deposit at Salduro, about 112 miles west of Salt Lake City along the line of the Western Pacific Railroad, is said to cover more than 100 square miles, to be 3 to 5 feet thick in places, thinning out at the edges, and to weigh 80 or 90 pounds to the cubic foot. More than 90 per cent of this deposit is common salt; the remainder is chiefly calcium and sodium sulphates, with smaller quantities of potassium and magnesium salts.

When the supply of potash salts from Germany was shut off a widespread search for new sources began in America. The arid and semiarid West was extensively prospected, especially those areas which were formerly covered by saline lakes, because the famous Stassfurt deposits of central Germany were formed by the drying up of salt seas. It was found that the Salduro deposits contained a workable amount of potash salts, and a plant was built at Salduro for manufacturing potash.

Common salt, known technically as sodium chloride, is used in the manufacture of hydrochloric (muriatic) acid, chlorine and all kinds of chlorine derivatives, salt cake (sodium sulphate), soda ash (sodium carbonate), washing soda (hydrated sodium carbonate), caustic soda (sodium hydroxide), and an endless number of sodium salts. In the form of derivatives it finds application in the manufacture of glass, soap, cleansing agents, water glass, fireproofing and insulating compounds, medicines, water-purifying compounds, and many other useful substances. Enormous quantities of salt are used in the household and dairy, for food packing, for fish curing, as food for livestock, for making brine in cold-storage plants, and for freezing mixtures. All these industries use power and add materially to the general power market.

Irrigation as a means toward establishing the agricultural industry in the Rocky Mountain States was first practiced in 1847, in the Great Salt Lake basin, where Salt Lake City now stands. Since that time most of the lands in this basin that are economically susceptible of irrigation by gravity systems have been put under canals, and within the last few years the problems involved in pumping water onto the higher bench lands has been studied carefully. This method of irrigation has already proved successful at many places throughout the intermontane region and will be extended to many thousands of acres of new lands. The successful operation of the Lewiston-Bear Lake Irrigation Co.'s plant on Bear River has prompted the building of another plant farther down the river. The Bonneville Irrigation District, in the south end of Davis County, has a plant to pump water from Jordan River to heights of 150 and 300 feet to irrigate about 6,000 acres of new land, and about 50,000 acres of virgin land in Tooele County may be irrigated by water pumped from Utah Lake and carried through a canal around the north end of the Stansbury Range. Already the connected irrigation pumping load in the basin is 9,400 kilowatts, and this is rapidly growing with the progress being made in this method of irrigation.

INDUSTRIAL DEVELOPMENT.

This basin is connected with all important markets, both in the East and in the West, by five steam railroads, and its principal cities and towns are linked by three electric interurban lines. These transportation facilities and plenty of cheap power are inducements for rapid growth in manufacturing industries. The rate of this growth is indicated in the following table, which shows that the development of power has kept pace with the increasing demand.

Progress of hydroelectric development in Great Salt Lake basin, 1895–1923.

Year.	Number of plants built.	Installed capacity of water wheels (horsepower).	Total horsepower.	Year.	Number of plants built.	Installed capacity of water wheels (horsepower).	Total horsepower.
1895	2	2,640	2,640	1910	[b] 3	7,837	82,679
1896	1	2,700	5,340	1911	4	4,780	87,459
1897	2	[a] 8,000	11,340	1912	[b] 1	11,250	98,709
1898	1	1,344	12,684	1913	4	5,600	104,309
1899	0	0	12,684	1914	3	39,700	144,009
1900	2	1,608	14,292	1915	2	15,140	159,149
1901	1	3,000	17,292	1916	[b] 0	15,000	174,149
1902	1	400	17,692	1917	2	10,600	184,749
1903	4	4,550	22,242	1918	0	0	184,749
1904	3	11,500	33,742	1919	0	0	184,749
1905	1	300	34,042	1920	[b] 0	15,000	199,749
1906	[b] 1	1,900	35,942	1921	[d] 1	1,500	200,449
1907	4	6,850	42,792	1922	[b] 0	7,700	208,149
1908	[c] 5	19,450	61,442	1923	[b] 0	17,000	225,149
1909	6	12,600	74,842				

[a] Includes one 2,000-horsepower plant later abandoned and not included in total.
[b] Indicates additional installation in plants already built.
[c] Includes old Brigham city plant, 800 horsepower, abandoned and not included in total after new plant installed, 1921.
[d] Replaces old 800-horsepower plant built by Brigham city in 1908.

NOTE.—Water-wheel capacities at some plants determined from rated generator capacities.

The Granite plant on Cottonwood Creek, the first commercially successful hydroelectric plant in the basin, was built in 1895. A small plant was built on Ogden River in 1889, and the attempt was made at that time to supply Ogden with lights, but it was more of a disappointment than a success. For some time prior to the advent of hydroelectric power electricity was generated by steam at Ogden, Salt Lake City, and some mining plants, but these plants have been replaced, except one at Salt Lake City which is maintained by the Utah Power & Light Co., to use as an auxiliary source of power in emergencies or during the coldest winter periods when the streams are frozen too thickly to supply the market demand.

For this reason the record of the development of water power may not show correctly the market growth in the earlier years and in the years that the hydroelectric plants absorbed the load carried by the steam plants. However, the average increase in the connected power load for the period from 1895 to 1920, inclusive, is about 7,400 horsepower a year. Mining represents the largest single item in the industrial load, amounting to about 37 per cent of the total connected load in the basin, most of which was at one time supplied from steam plants. If we assume that the mining industry will for some time require very little if any additional power and that the other industries will increase at the same rate as in the last few years, the market will need at least 4,500 to 5,000 horsepower additional each year, without taking into consideration the possibility of a large new industry springing up which may require several times that much.

More than 100 communities are served with electric power and light from the 50 hydroelectric power plants in the Great Salt Lake basin, the Grace project being counted as two plants because it was developed as such and by two different companies. Of these plants 29 are operated by the Utah Power & Light Co. in one interconnected system, 7 are municipal plants operated independently by the towns owning them, 1 is a State plant that furnishes power for the Agricultural College and other State institutions, 1 is owned by the Federal Government and is operated by the United States Bureau of Reclamation in connection with the Strawberry reclamation project, and the remaining 12 are owned by small independent companies, private individuals, or mining companies.

Prior to 1912 most of the plants now included in the Utah Power & Light Co.'s system were operated as individual stations or were grouped into several small systems, each of which was operated by a different company. This multiplicity of systems in the same territory did not make for economy in operation and provided no insurance for the continuity of service required by the growing demand in mining, smelting, and manufacturing operations. The consolidation and reorganization of these various interests was therefore accomplished, and the Utah Power & Light Co.'s system now represents the activities of about 70 companies, including the original ones, which were formed many years ago in the early days of the electrical industry, and all subsequent consolidations and reorganizations.

The growth of the Utah Power & Light Co. during the ten years 1914–1923 is indicative of the general industrial growth in the Great Salt Lake basin and is shown in condensed form in the following table. The table covers the entire system of the company, most of which, however, is in the Great Salt Lake basin. The part lying outside of this basin consists of the Idaho Falls division, which has an installed capacity of 2,625 kilowatts and 4,045 customers, and the Western Colorado Power Co. division, which has an installed capacity of 9,780 kilowatts and 4,808 customers.

Growth of Utah Power & Light Co., 1914–1923.

	1914	1917	1920	1923
Population of territory served	250,000	300,000	351,670	362,000
Total number of customers, electric	46,707	61,188	72,146	83,656
Kilowatt-hours generated, 12-month period	281,134,027	502,183,000	519,853,582	663,837,000
Combined peak load ... kilowatts	50,000	79,105	84,177	112,042
Number of electric generating plants, hydroelectric	33	35	35	36
Installed generator capacity, hydroelectric ... kilowatts	93,750	124,907	132,487	149,337
Transmission lines (11,000 volts and over) ... miles	1,003	1,227	1,549	1,875
Distributing lines (under 11,000 volts) ... do	1,552	2,090	2,240	2,357

GENERATION AND DISTRIBUTION OF POWER.

The hydroelectric industry was young when activity in it began in the Great Sa t Lake basin, and the results of experiments made at the earlier plants in the basin mark epochs in the history of the entire industry. The Pioneer plant at Ogden, built by the Pioneer Electric Power Co., which was organized in 1893, was at that time the largest plant in the United States. The laying of a continuous wooden-stave pipe line along the almost vertical rugged rock walls of a narrow river gorge, at least 300 feet above the stream, was a remarkable engineering feat and did much to show the possibilities of such work. It was the high-voltage transmission experiments at this plant that demonstrated the possibility of commercially using 30,000 volts for transmission, and the success of these experiments led to the consolidation of the electrical plants in Salt Lake City and the Pioneer plant through a transmission line 36 miles long—at that time an exceptional length.

While the Pioneer plant was being constructed (1896–97) the Telluride Power Co. built a plant on Provo River near Provo, Utah. This plant was known as Nunn's plant, as Mr. L. L. Nunn was actively directing the affairs of the company. The plant consisted of a rubble masonry building on stone and concrete foundations and had two 48-inch wooden-stave pipe penstocks fed from a wooden flume. Two 1,000-horsepower Leffel turbines were each direct-connected to a General Electric 750-kilovolt-ampere generator and operated under a head of 122.5 feet. The plant was built to furnish power for the Mercur mining district, 35 miles to the west, and here again another step forward was made in transmission voltage, for 40,000 volts were used, except for the 30,000 volts developed at about the same time at the Pioneer plant nearly three times anything used previously on commercial transmission lines. In 1904 the company built the Olmsted plant on Provo River, and the Nunn plant was abandoned.

The Telluride Power Co. was also one of the first to try the systematic operation of alternators in parallel and to solve the problem of synchronism, which has made possible the interconnection of plants and systems.

The 50 hydroelectric power plants in the Great Salt Lake basin were built by 41 different power companies, municipalities, mining companies, and individuals, and the resulting diversity of interests precluded the best utilization of the developed power. The consolidation effected by the Utah Power & Light Co. has now placed about 95 per cent of the total installed water-wheel capacity in one system, and the remaining 5 per cent is represented in 21 small plants, most of which are of less than 500 horsepower in capacity.

The following table shows in chronologic order the hydroelectric plants in the basin:

Hydroelectric power plants in the Great Salt Lake basin, listed in order of year built.

No. on map.	Name.	Year put in operation.	By whom built.	Present owner.	Remarks.
10HH 7	Granite	1895	Utah Power Co	Utah Light & Traction Co.	Leased to Utah Power & Light Co.
10HG 4	Park City	1895	Ontario Mining Co.	Utah Power & Light Co.	
10HH 6	Stairs	1896	Big Cottonwood Power Co.	Utah Light & Traction Co.	Do.
10HE 4	Pioneer	1897	Pioneer Electric Co.	do	Do.
10HH 1	Jordan	1898	Salt Lake City Water & Electrical Power Co.	Utah Power & Light Co.	
10HC 13	Hyrum City	1900?	City of Hyrum	City of Hyrum	
10HF 3	Lower American Fork.	1900	Utah County Light & Power Co.	Utah Power & Light Co.	
10HC 10	Logan	1903	Telluride Power Co.	do	
10HA 6	Tooele	1902	Clark Electric Co	Clark Electric Co	
10HA 8	Ophir	1903?	Ophir Hill Consolidated Mining Co.	Ophir Hill Consolidated Mining Co.	
10HC 5	Wheelon	1903	Utah Sugar Co	Utah Power & Light Co.	
10HH 3	Columbus Consolidated Mining Co.	1903	Columbus Consolidated Mining Co.	Wasatch Power Co.	
10HF 5	Springville	1903	City of Springville	City of Springville	
10HG 3	Olmsted	1904	Telluride Power Co.	Utah Power & Light Co.	
10HC 9	Logan City	1904	City of Logan	City of Logan	
10HH 9	Gordon	1904?	Progress Co	Progress Co	
10HC 6	Georgetown	1905	Montpelier Electric Co.	Utah Power & Light Co.	
10HH 8	Knudson	1906	Progress Co	Progress Co	
10HH 11	Upper Mill Creek.	1907	Mill Creek Power Co.	Utah Power & Light Co.	
10HF 2	Upper American Fork.	1907	Utah County Light & Power Co.	do	
10HF 4	Battle Creek	1907	Telluride Power Co.	do	
10HF 8	Nephi Plaster	1907	Nephi Plaster & Manufacturing Co.	Nephi Plaster & Manufacturing Co.	
10HC 1	Old Grace	1908	Telluride Power Co.	Utah Power & Light Co.	
10HC 7	Soda Springs	1908	William Horsley	Soda Springs Electric Co.	
10HC 8	High Creek	1908?	High Creek Electric Co.	Utah Power & Light Co.	
10HA 1	Brigham	1908	City of Brigham	City of Brigham	Replaced by new plant built in 1921.
10HA 3	Willard	1909	M. S. Browning	Utah Power & Light Co	

Hydroelectric power plants in the Great Salt Lake basin, listed in order of year built—Continued.

No. on map.	Name.	Year put in opera-tion.	By whom built.	Present owner.	Remarks.
10HE 1	Weber or Devils Gate.	1909	Utah Light & Railway Co.	Utah Light & Traction Co.	Leased to Utah Power & Light Co.
10HG 5	Snake Creek	1909	Snake Creek Power Co.	Utah Power & Light Co.	
10HG 2	Heber	1909	City of Heber	City of Heber	
10HF 6	Strawberry	1909	United States Reclamation Service.	United States Bureau of Reclamation.	
10HF 7	Santaquin	1909	Knight Investment Co.	Utah Power & Light Co.	
10HA 4	Davis or Farmington.	1910	Davis County Light & Power Co.	do	
10HH 10	Lower Mill Creek	1910	Knight Power Co	do	
10HF 1	Alpine	1910	Utah County Light & Power Co.	do	
10HB 3	Paris	1911?	Bear Lake Power Co.	do	
10HH 2	Bennion	1911	Bennion Flour & Seed Mill.	Bennion Flour & Seed Mill.	
10HG 1	Murdock	1911	Knight Power Co	Utah Power & Light Co.	
10HF 8	Nephi	1911	City of Nephi	City of Nephi	
10HE 2	Riverdale	1912	Davis & Weber Counties Canal Co.	Utah Power & Light Co.	
10HC 11	Agricultural College.	1913	State of Utah	State of Utah	
10HC 12	Hyrum	1913	Blacksmith Fork Light & Power Co.	Utah Power & Light Co.	
10HE 3	Butler	1913	G. M. Butler	G. M. Butler	
10HA 7	South Willow	1913	Ophir Hill Consolidated Mining Co.	Ophir Hill Consolidated Mining Co.	
10HC 2	New Grace	1914	Utah Power & Light Co.	Utah Power & Light Co.	
10HH 5	Murray	1914	City of Murray	City of Murray	
10HC 4	Oneida	1915	Utah Power & Light Co.	Utah Power & Light Co.	
10HB 2	Swan Creek	1915	A. Z. Cook et al	A. Z. Cook et al	
10HC 3	Cove	1917	Utah Power & Light Co.	Utah Power & Light Co.	
10HB 1	McNeice	1917	Irwin McNeice	Cokeville Light & Power Co.	
10HA 1	Brigham	1922	City of Brigham	City of Brigham	

The Utah Power & Light Co.'s system in the Great Salt Lake basin comprises 29 hydroelectric power plants, one large steam plant, a large pumping plant at the outlet of Bear Lake, 1,875 miles of high-voltage transmission lines, and substations and extensive distribution systems. Bear Lake is used as a reservoir and has sufficient storage capacity to equalize the flow of Bear River. The water is drawn from the lake by the pumping plant when it becomes too low to flow by gravity. The pumping plant has a capacity of 1,500 second-feet. The largest plants of the system are on Bear River at Grace and Oneida. The Oneida plant, having a capacity of 30,000 kilovolt-amperes, has an excellent regulating reservoir immediately above it and is used to take care of all heavy fluctuations in the load.

The steam plant is on Jordan River just west of Salt Lake City. It was built by the Utah Light & Railway Co. primarily for a relay and was used as an auxiliary before Bear Lake was developed. It is a brick building and contains an installation of 22,300 boiler-horsepower and a total generator capacity of 16,000 kilowatts. It is now used only in emergency or as an auxiliary source of power in the coldest part of the winter if the hydroelectric plants become hampered by ice. The capacity of this plant is now being increased by 20,000 kilowatts.

The advantages inherent in an interconnected system of this sort are many, especially in a region such as this. It is apparent from the data given in this report that the water-power resources of the basin are intensively developed, and with the present tendency toward the installation of large units as a measure of efficiency and economy the value of the undeveloped power sites is greatly reduced. Accordingly it is obvious that the most efficient use of the resources must be made, and this is possible only through a large and flexible system. All the streams in the basin except the few larger ones are rapid mountain streams that have a flashy run-off and lack reservoir sites to equalize the flow. Consequently, in order to make the most use of the water when it is available, power plants have been built large enough to take advantage of at least part of the flood flow. To do this successfully, however, on any individual stream or even on several streams, without reservoirs or a sufficiently large steam auxiliary plant, would be rather difficult, because the fluctuations in load might not correspond with the fluctuations in stream flow.

By means of this interconnected system it is possible to operate all the small plants at full capacity when the stream flow is sufficient, and as a result considerable water can be stored in Bear Lake during the flood season, to be available later for both power and irrigation use on Bear River. In other words, a twofold advantage is gained by interconnection, and the flood waters of the small streams on which no storage sites are available are, to speak figuratively, stored in Bear Lake to be used along Bear River. This makes possible a much more intensive development of that stream. Such a centralization of power-distribution systems results not only in economy of operation and greater continuity of service but in a more complete utilization of the streams of the entire drainage basin.

The power generated at these Bear River plants is carried over a 130,000-volt steel transmission line to the terminal station, 6 miles west of Salt Lake City. Here the pressure is reduced, and the current is fed onto the feeder lines connecting with the several distribution systems, comprising more than 1,800 miles of lines. This primary transmission line is about 135 miles long and is one of the notable high-tension lines of the country. The 11-foot wooden-stave pipe line at the new Grace plant is, both in diameter and in length, one of the largest wooden-stave pipe lines ever constructed.

DIVERSIFIED MARKET IN IRRIGATION AND MINING DISTRICTS.

A well-diversified market for power is afforded in the Great Salt Lake basin. In addition to the energy for lighting and miscellaneous purposes required in the many communities served, the mining districts use large amounts of power continuously. Irrigation pumping plants provide a substantial demand during the irrigation season, in steadily increasing amounts. The large farming area in northern Utah and southeastern Idaho is served with power for lighting and milling, and the street and interurban electric railways have large requirements.

Consumers on the Utah Power & Light Co.'s system in the Great Salt Lake basin, by principal industries.

[Includes Western Colorado Power Co.]

Brick plants	7	Railroads, electric	6
Canneries and dairies	90	Railroads and shops, steam	33
Cement factories	3	Salt manufacturing	1
Food products	91	Sugar factories and other beet-handling plants	99
Flour and feed mills	121	Textile manufacturing	40
Foundries and machine shops	75	Vehicles and accessories	317
Gas, water, and steam-heat companies	8	Power, municipal (schools, etc.)	153
Glass works	1	Power, resale	16
Hotels	381	Power, small installations	808
Irrigation	199	Telephone companies	27
Ice manufacturing	15	Residential lighting	64, 703
Lumber plants	72	Commercial lighting	9, 816
Mining, coal	26	Municipal lighting	140
Mining, metal	101	Heating and cooking, commercial	733
Packing plants, fruits and meat cold storage	62	Heating and cooking, residential	5, 479
Powder manufacturing	1		
Quarries	19		83, 643

The economy attained in any hydroelectric system is largely dependent on uniformity of demand, and every effort is made to minimize excessive fluctuations. In general terms, the mining, smelting, and manufacturing industries furnish the most steady demand for power. The large percentage of this kind of load in the Great Salt Lake basin and the numerous other diversified uses tend to stabilize the total demand at a remarkably constant load factor. Communities where industrial activities are undeveloped require power chiefly for lighting and traction, and the diversity of use is not sufficient to absorb the off-peak power. The result is usually a series of peaks and saddles in the load curve, with wide variations.

The revenue of a generation and distribution system varies in direct proportion to the salable energy it delivers, and the initial cost of installation varies directly with the capacity of plant that must be held in readiness to serve the demand. As the average load is an index of the energy sold and the maximum load indicates the necessary machinery capacity, knowledge of the load factor, or the relation between these two amounts, is of the utmost importance in designing plants and determining the necessary auxiliary power. The ideal condition is of course 100 per cent load factor, and this condition is most nearly approached by building up a diversified load with the purpose of eliminating if possible any extensive fluctuations.

The Utah Power & Light Co.'s system affords a good example of favorable operating conditions. The total connected load on the system in the Great Salt Lake basin is 274,450 kilowatts, and the total installed capacity of the hydroelectric plants operated by the company was 149,337 kilowatts at the end of 1923. In this excess of connected load the diversity of uses adjusts the total demand to such an extent that the load curve shows no excessive fluctuations. The average load is 70,000 kilowatts, the average minimum 24-hour available power in 1919 was 40,000 kilowatts, and the average maximum 24-hour available power in 1920 was 90,000 kilowatts. The average output is 50,000,000 kilowatt-hours a month.

With the slackening of mining operations since the World War, it has become necessary to adjust the demand for electric power somewhat in order to maintain a constant load. This adjustment has been accomplished to some extent by the establishment of new industries and an increase in the use of electrical appliances, which now number more than 100,000 in the basin.

RELATION OF THE FEDERAL GOVERNMENT TO THE DEVELOPMENT OF WATER POWER IN THE GREAT SALT LAKE BASIN.

LEGAL BASIS FOR FEDERAL CONTROL.

Federal control of the development of water power and its electrical transmission rests on the constitutional prerogatives of the Federal Government "to regulate commerce with foreign nations, among the several States, and with the Indian tribes" and "to dispose of and make all needful rules and regulations respecting the territory or other property belonging to the United States."

The power of Congress to control the disposition and use of public lands is of vital importance in relation to the future utilization of the water-power resources discussed in this report. The Federal Government holds public lands both as sovereign and as proprietor. As sovereign, its property is alienable only with its consent. Guaranties have without exception been inserted in the enabling acts creating the different States and in their constitutions, maintaining the integrity of Federal control of public lands against possible encroachment by States or individuals. Thus public lands are not subject to condemnation except where such condemnation may have been authorized by Congress, and they may be appropriated only in so far as the Federal statutes direct. Because they are owned by the United States, the lands are also free from taxation by the States. In its capacity as proprietor, the Federal Government may do with its lands everything that any other proprietor may do, and the lands of the United States have all the appurtenances that the lands of any other owner may have.

The Federal rights in the waters flowing in or adjacent to public lands are somewhat indefinite. It seems clear, however, that under the act of July, 1866, and under the desert-land act of 1877, Congress has sanctioned the appropriation of the waters flowing over public lands—subject, however, to State and local regulations. Where such appropriations have actually been made and the water put to beneficial use in accordance therewith, lands still in public ownership may have thereby been deprived of a certain share of the absolute property right originally appurtenant to them in waters flowing over or past them. But as the authority to appropriate the waters of the public lands is purely permissive, it is also clear that Congress may at any time resume complete control of the unappropriated waters or legislate to any needed extent regarding them. In such a case State statutes or local regulations relating to the unappropriated waters would of necessity become ineffective in so far as they might conflict with congressional enactments. The resumption of complete control over unappropriated waters flowing over public lands would, however, create a dual system of control without apparent advantage to the State, the Federal Government, or the public generally—except perhaps on interstate streams.

The chief relation of the public lands to the present problem arises from the fact that it is necessary to utilize parts of them for the emplacement of structures and to overflow other parts as a result of construction of dams. For both purposes the consent of the United States is necessary. This consent may be given by Congress in a general enactment that does not require administrative action by the offices of the Federal Government, or Congress may empower the administrative offices to authorize the use of the public lands for the purpose needed.

The earliest act of Congress that deals with rights of way across public lands for the utilization of water is section 9 of the act of July 26, 1866 (R. S. 2339). Its language is broad and general in character, the terms describing the purposes for which the water could be used being especially inclusive. All rights to occupy the public lands for ditches and canals rested upon this act until the passage of the act of March 3, 1891 (26 Stat. 1101), relating to rights of way for irrigation, and the act of January 21, 1895 (28 Stat. 635), relating to rights for the conveyance of water for mining purposes. This act, however, was superseded by the act of May 14, 1896 (29 Stat. 120), relating to rights of way for the development of electric power; the act of May 11, 1898 (30 Stat. 404), permitting the use of irrigation rights of way for water power and other purposes; the act of February 15, 1901 (31 Stat. 790), relating to rights of way for irrigation, water power, and other purposes; the act of February 1, 1905 (33 Stat. 628), relating to rights of way for mining, milling, and municipal purposes in national forests; and the act of March 4, 1911 (36 Stat. 1235, 1253), relating to rights of way for transmission lines and other purposes.

The question as to the effect of the passage of these later acts on the acquirement of rights under the act of 1866 was carried to the Supreme Court in a case filed November 14, 1913 (United States *vs.* Utah Power & Light Co.), and the decision of that court makes it incumbent on those seeking to utilize the public lands for rights of way for the development of water power to acquire rights of way under the specific acts which control such development.

Inasmuch as any control by the Federal Government of the development of water power on streams such as those in the Great Salt Lake basin depends on the ownership of public lands, it has become a well-established national policy to retain in public ownership land essential to such development of power.

DEVELOPMENT OF POLICY.

Widespread public interest was first focused on the disposition of water power by two messages of President Roosevelt to Congress in April, 1908, and January, 1909, vetoing acts conferring franchises for the development of water power on the ground that adequate provision for the protection of the interests of the general public had not been incorporated therein. His attitude toward the disposition of water power was clearly expressed in a letter to the Senate Committee on Commerce on March 13, 1908, in which he states:

> No right involving water power should be granted to any corporation in perpetuity, but only for a length of time sufficient to allow them to conduct their business profitably. A reasonable charge, of course, should be made for valuable rights and privileges which they obtain from the National Government. The values for which this charge is made will ultimately, through the national growth and orderly development of our population and industries, reach enormous amounts. A fair share of the increase should be safeguarded for the benefit of the people from whose labor it springs.

While this question of legislative policy was being discussed, administrative action for the purpose of preventing the alienation of water power was in progress. The Reclamation Service, under instructions from Secretary Garfield, recommended for his approval withdrawals affecting approximately 3,500,000 acres along western rivers in the period from December 4, 1908, to February 27, 1909. These withdrawals had their legal basis in part in the general powers of the Secretary of the Interior as the supervisor of public lands, and in part in the authority conferred by the reclamation act (June 17, 1902, 32 Stat. 388) to withhold from disposition public lands necessary to reclamation projects. The Forest Service, in the period from March to August, 1908, similarly recommended the withdrawal as administrative sites of a large number of small tracts within or near national forests, which were believed to occupy strategic positions with relation to the future of the development of power. The purpose of these administrative sites as regards power was not generally apparent, however, until March 2, 1909, when Secretary Garfield recommended their withdrawal from all entry except that under right of way acts, thus specifically holding them for use in connection with irrigation and the development of power. This was one of the last acts of Secretary Garfield's administration.

His successor, Secretary Ballinger, undertook almost immediately the consideration of the water-power situation and directed his attention to the advisability of retaining in force the "first form" and administrative withdrawals, approved by Secretary Garfield. Fearing as a result of his investigation that the withdrawals rested on no secure statutory foundation, he directed their revocation, with the result that in April, 1909, nearly all withdrawn lands were restored to entry. Strong opposition to this action arose almost immediately, and as a result the matter was reconsidered. On April 23, 1909, after a conference between the Secretary, the Director of the Reclamation Service, and the Director of the Geological Survey, the last-named official was directed to "make an investigation of water-power sites on the public domain outside of national forests, which are not included in withdrawals for reclamation projects, with a view to obtaining at the next session of Congress legislation to control and regulate their disposition." Investigations were immediately undertaken by the United States Geological Survey, and as a result large areas of public lands controlling streams valuable for the development of power were promptly withdrawn. These withdrawals were styled "temporary power-site withdrawals" and were in terms in aid of legislation.

During the next session of Congress consideration was given to the entire subject of withdrawals of public land, and as a result a general act was passed—the act of June 25, 1910 (36 Stat. 847)—authorizing the President to make withdrawals. A special provision (36 Stat. 855) was enacted on the same day as sections 13 and 14 of the Indian appropriation act, authorizing the Secretary of the Interior to withdraw water-power sites on Indian reservations.

Almost immediately after the passage of the general withdrawal act the President confirmed under its provisions all outstanding withdrawals in an order dated July 2, 1910.

The act of June 25, 1910, made certain exceptions to the force of withdrawals in that it excluded from its operation bona fide settlements, homesteads, desert-land claims, and mineral claims except coal, oil, gas, and phosphate. The act of August 24, 1912 (37 Stat. 497), amended the act in its relation to mineral claims, so that only metalliferous mineral deposits were excepted from its operation. No further legislative action was taken by Congress upon this subject until the passage of the Federal water-power act, approved June 10, 1920 (41 Stat. 1063). This act was amended March 3, 1921, to exclude all national parks and national monuments from its provisions.

This act, which supersedes all previous acts relating to right of way for power, except those involving power other than water power, Indian allotments, certain national parks and national monuments, sites in which are still governed by the acts of February 15, 1901 (31 Stat. 790), and March 4, 1911 (36 Stat. 1235, 1253), established a commission to be known as the Federal Power Commission, composed of the Secretary of War, the Secretary of the Interior, and the Secretary of Agriculture.

DUTIES AND FUNCTION OF THE FEDERAL POWER COMMISSION.

The Federal Power Commission has general administrative control over all power sites on the navigable waters and the public lands and reservations of the United States, except existing national parks and national monuments, and over the location, design, construction, maintenance, and operation of power plants upon such sites. It has the power and duty under certain conditions of regulating the financial operations, fixing the rates, and determining the character of service and of making physical valuations of the properties of licensees who utilize such sites. It is authorized to make general investigations of broad scope and is required to make certain special investigations and report thereon to Congress.

Briefly, the commission is charged with the duty of issuing permits and licenses for the utilization of all power sites over which it has jurisdiction to all bona fide, financially responsible applicants whose plans for development are not at variance with the full utilization of the stream to the best public interest.

The various duties and functions of the commission in performing this work are segregated into groups in the following pages, and references are made to the particular section of the act relating thereto.

General administration of water powers.—The act places the following general duties upon the commission:

To give notice to "any State or municipality likely to be interested" of the filing of any application for a license, and to publish notice of such application for eight weeks [sec. 4d].

To file with local land offices notice of any application for a license, and a description of the lands of the United States affected thereby [sec. 24].

To investigate all projects proposed to be constructed on any stream over which Congress has jurisdiction but which is not defined as "navigable waters" whenever declaration of intention to construct such project is filed with the commission [sec. 23].

To hold hearings when desirable or necessary in connection with any application for a permit or license [sec. 4g].

To issue preliminary permits for power projects [sec. 4c].

To issue license for power projects and transmission lines on navigable waters, public lands, and reservations of the United States, except existing national parks or national monuments [sec. 4d and amendment to the act of March 3, 1921].

To investigate and take action on all voluntary transfers of licenses [sec. 8].

To investigate and take action on all contracts for power made by a licensee which will extend beyond the termination of the license [sec. 22].

To provide for the proportionate distribution of annual costs of headwater improvements between owner and licensee benefited thereby [sec. 10f].

To assess against all licensees benefited the annual cost of any headwater improvement constructed by the United States [sec. 10f].

To prescribe rules and fix annual license charges, and to determine the relation of such charges to prices to consumers [sec. 10e].

To put the above provisions into effect, the commission is authorized to make rules and regulations for administration of the act (sec. 46) and is required to submit annually to Congress on or before the first Monday in December a classified report showing permits and licenses issued, the parties thereto, the terms thereof, and the moneys received (sec. 4c).

Design, construction, and operation of project works.—The commission has authority to pass upon the general scheme of development of power sites, upon the plans and specifications of the works, and upon certain features of maintenance and operation of project works, and it is its duty

To require that "the project adopted * * * shall be such as in the judgment of the commission will be best adapted to a comprehensive scheme of improvement and utilization" and that plans be modified when necessary to secure such scheme [sec. 10a].

To approve maps, plans, and specifications of project works [sec. 9].

To pass upon and approve prior to construction any substantial alteration in project plans [sec. 10b].

To require that project works be properly maintained and kept in efficient operating conditions [sec. 10c].

To prescribe the time within which projects shall be begun and completed [sec. 13].

To keep in touch with the conditions of the power market tributary to every development in order to require extensions as rapidly as conditions warrant [sec. 13].

To prescribe rules and regulations for the protection of life, health, and property in connection with the construction or operation of project works by licensees [sec. 10c].

Regulation of financial operations.—Under the provisions of the act, the commission has authority and it is its duty

To prescribe a system of accounting for licensees [sec. 4f].

To require the submission of financial statements and reports [sec. 4f].

To prescribe rules for the establishment and maintenance of depreciation reserves by licensees [sec. 10c].

To devise principles for the proper apportionment of surplus earnings to amortization reserves [sec. 10b].

To regulate under certain conditions the amount and character of securities which may be issued for the financing of power projects [secs. 19f, 20], and to hold hearings in connection therewith [sec. 4g].

Regulation of rates and service.—Jurisdiction over the regulation of rates and service is conferred upon the commission

In intrastate business whenever the State has not provided an agency with power of regulation [sec. 19].

In interstate business whenever the States concerned have not the power to act individually or can not reach mutual agreement [sec. 20].

Valuation of properties of licensees.—It is a fundamental principle of the act that valuation for the purpose of rate making or of purchase at the termination of the license period shall be based upon the net investment in the property, and that this amount shall be determined currently either through the system of accounting or through physical valuation. For this purpose, it is the duty of the commission

To require the filing of statements showing the cost of construction of project works and the price paid for water rights, rights of way, lands, and interests in lands [sec. 4a].

To make valuation of all projects brought under license which have been constructed in whole or in part prior to application for license [sec. 23].

To make valuation in case of condemnation of the properties of a licensee by the United States [sec. 14].

To determine the net investment and severance damages in the event that properties of a licensee are taken over by the United States at the termination of a license period [sec. 14].

General investigations.—In addition to its duties of general administration and regulation of water-power developments, the commission is authorized, or the performance of certain of its duties will require it, to undertake general investigations and to collect and record data concerning

The utilization of the water resourses of any region to be developed [sec. 4a]

The water-power industry and its relation to other industries and to interstate or foreign commerce [sec. 4a].

The location, capacity, cost of development, and relation to market of power sites [sec. 4a].

Whether the power from Government dams can be advantageously used by the United States for its public purposes and what is the fair value of such power [sec. 4a].

Lands of the United States reserved as power sites to determine whether or not they may be opened to entry subject to a reservation of the power rights of the United States [sec. 24].

Deterioration of structures and equipment for the purpose of establishing rates of depreciation and amount of annual depreciation reserves [sec. 10c].

In connection with such investigation, the commission is authorized

To hold hearings and to require the attendance of witnesses and the production of evidence [sec. 4g].

To make public from time to time the information secured and to provide for the publication of its reports and investigations [sec. 4c].

To cooperate with State and National governments in its general power investigations [sec. 4b].

Special investigations.—In addition to the general investigations which the commission is authorized to undertake, it is required to make special investigations and to submit to Congress

Reports in all cases when it finds that a Government dam may advantageously be used by the United States for public purposes in addition to navigation [sec. 4d].

The results of its examination and surveys, together with plans and cost estimates in connection with any project which it believes should be undertaken by the United States [sec. 7].

Reports with cost estimates on all projects on navigable streams in which it appears that the construction of suitable navigation structures can not be undertaken by the applicant [sec. 12].

The commission would also be required to make special investigations and assist in the conduct of legal proceedings brought for cancellation of licenses or for requiring specific performance of the provisions of a licensee or of the act (sec. 25).

Rules and regulations.—Rules and regulations for the issuance of permits and licenses under the act are published by the commission and cover the following topics: General definitions; applications—general requirements; and applications for preliminary permits.

APPENDIX.

RECORDS OF STREAM FLOW.

BEAR RIVER BASIN.

BEAR RIVER NEAR EVANSTON, WYO.

LOCATION.—In sec. 1, T. 15 N., R. 121 W., 300 feet above highway bridge and 3½ miles northwest of Evanston, Uinta County. Nearest tributary a small stream entering from southwest half a mile above.

DRAINAGE AREA.—645 square miles (measured on topographic map and on map issued by the United States Geological Survey, scale 1 to 500,000).

RECORDS AVAILABLE.—October 26, 1913, to September 30, 1920.

GAGE.—Chain gage on left bank 300 feet above bridge; read by Mrs. Alex. Morrow.

DISCHARGE MEASUREMENTS.—Made by wading or from cable just below gage.

CHANNEL AND CONTROL.—Bed composed of coarse gravel. Control at riffle a short distance below gage; permanent. Left bank is overflowed at stage about 5 feet, the amount of overflow increasing with the stage; right bank is also overflowed at stage above 5 feet, but to a much less extent than left bank.

ICE.—Stage-discharge relation seriously affected by ice; observations discontinued during winter.

DIVERSIONS.—Prior to December 1, 1916, there were adjudicated diversions of 249 second-feet from Bear River in Wyoming above station and 516 second-feet below.

REGULATION.—None.

ACCURACY.—Stage-discharge relation practically permanent except as affected by ice. Records excellent.

Monthly discharge of Bear River near Evanston, Wyo.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1913–14.				
October 26–31	117	75	89.3	1,060
November	135	68	96.4	5,740
December 1–21	108	63	75.6	3,150
March 26–31	311	152	219	2,610
April	1,100	231	611	36,400
May	2,390	435	1,480	91,000
June	2,220	415	1,210	72,000
July	475	187	326	20,000
August	562	30	131	8,060
September	40	27	32.9	1,960
1914–15.				
October	216	43	121	7,440
November 1–16	112	36	75.1	2,380
March 25–31	510	223	335	4,650
April	1,010	252	487	29,000
May	795	268	472	29,000
June	1,240	430	877	52,200
July	470	30	167	10,300
August	40	18	28.1	1,730
September	217	25	68.8	4,090

Monthly discharge of Bear River near Evanston, Wyo.—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1915-16.				
October	115	53	74.6	4,590
November	72	51	61.2	3,640
March 20-31	1,290	262	756	18,000
April	1,170	345	653	38,900
May	1,600	502	872	53,600
June	1,600	277	1,040	61,900
July	277	15	101	6,210
August	102	18	46.1	2,830
September	44	8	21.0	1,250
1916-17.				
October	121	25	88.8	5,460
November 1-18	70	46	56.6	2,020
April 15-30	1,890	524	1,150	36,500
May	1,740	401	911	56,000
June	2,500	890	1,790	107,000
July	1,560	252	701	43,100
August	352	49	141	8,670
September	134	58	81.1	4,830
				263,580
1917-18.				
October	89	54	65.2	4,010
November	79	54	65.8	3,920
March 18-31	810	208	417	11,600
April	382	130	215	12,800
May	810	251	570	35,000
June	1,940	208	1,180	70,200
July	660	46	149	9,160
August	44	3	20.8	1,280
September	40	2	10.4	619
				148,589
1918-19.				
October	86	23	61.0	3,750
November 1-23	77	64	70.3	3,210
March 27-31	382	348	365	3,620
April	440	128	262	15,600
May	1,380	365	781	48,000
June	995	61	395	23,500
July	56	.8	5.84	359
August	6.6	.1	2.42	149
September	23	2.8	12.4	738
				98,926
1919-20.				
October	102	41	78.6	4,830
November	113	81	98.0	5,830
March 21-31	72	51	61.6	1,340
April	1,260	67	411	24,500
May	2,520	1,140	1,700	105,000
June	2,170	660	1,190	70,800
July	502	59	163	10,000
August	70	43	56.3	3,460
September	60	35	46.5	2,770
				228,530

BEAR RIVER AT HARER, IDAHO.

LOCATION.—In SE. ¼ sec. 22, T. 14 S., R. 45 E., three-fourths mile north of Harer siding on Oregon Short Line Railroad, Bear Lake County, 7 miles by road above Dingle, and 14 miles southeast of Montpelier.

DRAINAGE AREA.—2,780 square miles (determined by Utah Power & Light Co.).

RECORDS AVAILABLE.—June 21, 1913, to September 30, 1916; January, 1919, to September 30, 1920.

GAGE.—Stevens continuous water-stage recorder on right bank; installed August 24, 1914; inspected by employees of Utah Power & Light Co. Inclined staff on right bank about 1,500 feet downstream prior to August 24, 1914; control different from that of present gage.

DISCHARGE MEASUREMENTS.—Made by wading or from cable just below gage.

CHANNEL AND CONTROL.—Bed composed of clean, hard material. Banks are overflowed at extremely high stages. Control permanent during 1915 and 1916.

ICE.—Stage-discharge relation seriously affected by ice from November to March. Winter flow determined from current-meter measurements and from charts of water-stage recorder.

DIVERSIONS.—No large diversions above station.

REGULATION.—None.

ACCURACY.—Stage-discharge relation permanent except as affected by ice. Records good except those for November to March, which, owing to effect of ice, are somewhat uncertain.

COOPERATION.—Gage-height record furnished and most of the discharge measurements made by Utah Power & Light Co.

Monthly discharge of Bear River at Harer, Idaho.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1913.				
June	918	549	647	12,800
July	1,850	428	853	52,400
August	486	258	355	21,800
September	347	279	328	19,500
				106,000
1913–14.				
October	456	300	384	23,600
November	428		374	22,300
December			230	14,100
January			240	14,800
February			250	13,900
March			475	29,200
April	2,370	1,110	1,950	116,000
May	3,440	2,130	2,950	181,000
June	3,280	1,180	2,350	140,000
July	1,040	581	804	49,400
August	707	300	420	25,800
September	344	286	305	18,100
The year	3,440		896	648,000
1914–15.				
October	417	318	380	23,400
November			[a] 343	20,400
December			[a] 200	12,300
January			[a] 200	12,300
February			[a] 210	11,700
March	680		[a] 397	24,400
April	730	548	630	37,500
May	588	340	457	28,100
June	1,080	544	795	47,300
July	615	243	406	25,000
August	234	135	187	11,500
September	249	133	179	10,700
The year	1,080	133	365	265,000

[a] Gage not working properly Mar. 22–27 and Sept. 18–22; discharge estimated. Stage-discharge relation affected by ice Nov. 16 to Mar. 17.

Monthly discharge of Bear River at Harer, Idaho—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1915–16.				
October	275	192	231	14,200
November	310		b 252	15,000
December			b 220	13,500
January			b 190	11,700
February			b 205	11,800
March	3,610		b 1,330	81,800
April	1,880	1,140	1,470	87,500
May	2,450	1,190	1,880	116,000
June	1,970	937	1,510	89,800
July	868	394	588	36,200
August	378	253	306	18,800
September	286	221	253	15,100
The year	3,610		704	511,000
1919.				
January			176	10,800
February			196	10,900
March	1,240		470	28,900
April	1,080	481	720	42,800
May	845	570	703	43,000
June	1,010	158	465	27,700
July	149	93	113	6,950
August	136	83	108	6,640
September	136	81	104	6,190
The period				184,000
1919–20.				
October	355	144	203	12,500
November	394		285	17,000
December			189	11,600
January			175	10,800
February			228	13,100
March			346	21,300
April	1,440		940	55,900
May	3,860	967	2,500	154,000
June	3,860	1,010	2,450	146,000
July	944	394	583	35,800
August	394	266	314	19,300
September	311	266	286	17,000
The period	3,860		709	514,000

b Gage not working Sept. 26–29; discharge interpolated. Stage-discharge relation affected by ice Nov. 27 to Feb. 22.

BEAR RIVER AT DINGLE, IDAHO.

Location.—In sec. 7, T. 14 S., R. 45 E., 100 yards south of Oregon Short Line Railroad, half a mile southeast of Dingle station, Bear Lake County, and 10 miles above outlet of Bear Lake.

Drainage area.—2,890 square miles.

Records available.—May 9, 1903, to December 31, 1914, when station was discontinued.

Gage.—Inclined staff on right bank; read by M. K. Hopkins.

Discharge measurements.—Made from cable about 30 feet below gage.

Channel and control.—Bed composed of gravel; control not permanent. Banks high and not subject to overflow.

Ice.—River usually frozen over from December to March; ice smooth and about 15 inches thick; stage-discharge relation seriously affected.

DIVERSIONS.—Several canals divert above station for irrigation. During spring of 1911 Telluride Power Co. began to divert about 2 miles above station for storage in a branch of Bear Lake, known as Mud or North Lake. This water, when released, returns to the river above the Alexander station.

Monthly discharge of Bear River at Dingle, Idaho.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1903.				
May 10-31	915	475	704	30,720
June	1,410	805	1,179	70,155
July	805	241	458	28,161
August	241	131	191	11,744
September	153	131	145	8,628
1903-4.				
October	178	153	159	9,776
November	530	131	205	12,198
December [a]	860	82	218	13,404
January	110	60	87.3	5,368
February	590	110	215	12,370
March	1,230	590	854	52,510
April	1,460	590	1,059	63,020
May	3,175	1,375	2,302	141,500
June	3,175	1,190	2,177	129,500
July	1,085	370	711	43,730
August	455	260	305	18,750
September	295	260	271	16,130
The year	3,175	60	713	518,000
1904-5.				
October	295	225	277	17,030
November	635	160	339	20,170
December	540	260	322	19,800
January	310	180	259	15,920
February	310	195	259	14,380
March	590	180	365	22,440
April	370	295	348	20,710
May	370	208	294	18,080
June	765	190	467	27,790
July	242	90	157	9,654
August	110	75	89	5,472
September	135	90	113	6,724
The year	765	75	274	198,000
1905-6.				
October	160	135	138	8,485
November	160	75	141	8,390
December 1-6	147	135	137	1,630
April	1,020	740	825	49,100
May	2,720	685	1,480	91,000
June	2,820	1,080	2,050	122,000
July	988	410	732	45,000
August	565	242	385	23,700
September	517	295	389	23,100
The period				372,000
1906-7.				
October	295	225	266	16,400
November 1-21	295	225	287	12,000
January	430	175	234	14,400
February	750	240	392	21,800
March	2,280	450	1,040	64,000
April	3,080	1,020	2,130	127,000
May	4,050	2,180	3,090	190,000
June	4,050	3,070	3,600	214,000
July	3,290	1,250	2,550	157,000
August	1,180	482	689	42,400
September	590	390	468	27,800
The year	4,050	175	1,229	887,000

[a] Dec. 24 and 27-31, estimated.

Monthly discharge of Bear River at Dingle, Idaho—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1907–8.				
October	412	390	393	24, 200
November	390	106	316	18, 800
December	650	276	351	21, 600
January	330	250	290	17, 800
February	320	285	298	17, 100
March	1, 250	250	587	36, 100
April	770	390	596	35, 500
May	650	276	466	28, 700
June	1, 750	294	859	51, 100
July	1, 180	312	576	35, 400
August	350	276	306	18, 800
September	276	226	246	14, 600
The year	1, 750	106	440	320, 000
1908–9.				
October	350	259	324	19, 900
November	350	106	276	16, 400
December	350	220	292	18, 000
January	1, 150	260	502	30, 900
February	440	200	249	13, 800
March	1, 110	220	458	28, 200
April	2, 320	1, 000	1, 770	105, 000
May	3, 810	2, 020	2, 630	162, 000
June	3, 990	2, 960	3, 580	213, 000
July	2, 850	620	1, 430	87, 900
August	590	312	386	23, 700
September	434	312	378	22, 500
The year	3, 990	106	1, 023	742, 000
1909–10.				
October	303	242	272	16, 700
November	458	180	292	17, 400
December	331	180	234	14, 400
January			250	14, 900
February			210	11, 700
March			1, 380	84, 800
April	2, 150	960	1, 330	76, 500
May	2, 150	690	1, 300	77, 400
June	740	200	493	28, 400
July	200	128	172	10, 200
August	122	66	86	5, 120
September	150	106	128	7, 360
The period	2, 150	66	512	365, 000
1910–11.				
October	200	150	172	10, 200
November	230	174	193	11, 100
December			190	11, 300
January			183	11, 300
February			385	21, 400
March	3, 650		1, 010	62, 100
April	2, 470	674	1, 170	69, 600
May	1, 610	886	1, 270	78, 100
June	1, 720	781	1, 130	67, 200
July	606	268	386	23, 700
August	268	89	166	10, 200
September	194	89	145	8, 630
The year	3, 650		533	389, 000
1911–12.				
October	207	194	202	12, 400
November		80	229	13, 600
December			200	12, 300
January			250	15, 400
February			225	12, 900
March			225	13, 800
April	1, 020	428	664	39, 500
May	2, 040	668	1, 100	67, 600
June	3, 180	1, 780	2, 490	148, 000
July	1, 690	472	883	54, 300
August	1, 020	447	597	36, 700
September	480	374	420	25, 000
The year	3, 180		624	452, 000

Monthly discharge of Bear River at Dingle, Idaho—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1912–13.				
October	458	394	427	26,300
November			426	25,300
December			b 260	16,000
January			b 250	15,400
February			b 250	13,900
March			b 370	22,800
April	1,520	830	1,130	67,200
May	1,610	890	1,290	79,300
June	1,290	304	617	36,700
July	1,290	380	673	41,400
August	401	194	285	17,500
September	286	222	259	15,400
The year	1,610	194	521	377,000
1913–14.				
October	360	269	322	19,800
November	322	194	295	17,600
December			211	13,000
January			217	13,300
February			226	12,600
March	647		334	20,500
April	2,290	596	1,230	73,200
May	3,560	2,100	2,890	178,000
June	3,340	1,120	2,290	136,000
July	984	468	676	41,600
August	513	291	369	22,700
September	291	260	265	15,800
The year	3,560		780	564,000
1914.				
October	363	260	316	19,400
November	343	352	306	18,200
December	308		c 222	13,600
The period				51,200

b Estimated. c Mean discharge Dec 10–31, estimated 200 second-feet.

BEAR RIVER AT ALEXANDER, IDAHO.

Location.—In NW. ¼ sec. 18, T. 9 S., R. 41 E., half a mile upstream from post office near Grace, 4 miles above intake of Last Chance canal, and 30 miles below confluence of Bear Lake outlet and Bear River.

Drainage area.—Not measured.

Records available.—March 27, 1911, to September 30, 1916; April 17, 1919, to September 30, 1920.

Gage.—Stevens water-stage recorder on right bank installed September 15, 1914; inspected by employees of Utah Power & Light Co. March 27 to November 14, 1911, an inclined staff on right bank 1,000 feet upstream was used; November 15, 1911, to September 14, 1914, an inclined and vertical staff at the present site. Present gage at same datum as staff gage used November 15, 1911, to September 14, 1914.

Discharge measurements.—Made from cable about 400 feet above gage.

Channel and control.—Bed composed of gravel and sand. One channel at all stages. Control permanent during 1915 and 1916.

Ice.—Stage-discharge relation seriously affected by ice during winter.

Diversions.—Water is diverted above the station for irrigation and for storage for the development of power.

Regulation.—Water is diverted from Bear River to North or Mud Lake during the spring and released for the development of power during the summer. This water is returned to Bear River about 30 miles above the station.

ACCURACY.—Stage-discharge relation permanent except as affected by ice. Records, except those for winter, good.

COOPERATION.—Gage-height record furnished and a large number of discharge measurements made by the Utah Power & Light Co.

Monthly discharge of Bear River at Alexander, Idaho.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1911.				
March 27-31	4,740	2,010	3,250	22,300
April	4,650	1,470	2,320	138,000
May	2,200	1,740	2,000	123,000
June	2,150	1,480	1,800	107,000
July	1,630	596	851	52,300
August	596	506	564	34,700
September	660	506	589	35,000
The period				522,000
1911-12.				
October	692	506	642	39,500
November	506		442	26,300
December			500	30,700
January			504	31,000
February	622	422	497	28,600
March	622	380	471	29,000
April	1,990	622	1,460	86,900
May	2,830	1,350	1,920	118,000
June	3,900	2,550	3,320	198,000
July	2,550	1,430	1,950	120,000
August	1,840	927	1,260	77,500
September	927	801	861	51,200
The year	3,900		1,150	837,000
1912-13.				
October	993	801	918	56,400
November	993	741	933	55,500
December	741	683	735	45,200
January			[a] 565	34,700
February	927		[a] 700	38,900
March	927	683	762	46,900
April			2,700	161,000
May	2,300	1,600	2,000	123,000
June	1,760	712	1,070	63,700
July	1,760	800	1,180	72,600
August	860	741	802	49,300
September	985	800	879	52,300
The year			1,100	800,000
1913-14.				
October	922	741	837	51,500
November	860	683	799	47,500
December			604	37,100
January			650	40,000
February			685	38,000
March	1,240	741	997	61,300
April	3,000	1,240	2,410	143,000
May	3,940	2,690	3,470	213,000
June	3,840	2,200	3,140	187,000
July	2,110	1,050	1,440	88,500
August	1,120	922	979	60,200
September	1,020	860	941	56,000
The year	3,940		1,410	1,020,000

[a] Estimated.

Monthly discharge of Bear River at Alexander, Idaho—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1914–15.				
October	1,080	800	945	58,100
November	860	729	803	47,800
December			b 870	53,500
January			b 850	52,300
February			b 856	47,500
March	1,080	770	892	54,800
April	1,150	649	837	49,800
May	800	430	573	35,200
June	891	521	675	40,200
July	954	770	887	54,500
August	770	672	710	43,700
September	830	415	583	34,700
The year		415	790	572,000
1915–16.				
October	527	430	471	29,000
November			c 443	26,400
December			c 550	33,800
January			c 850	52,300
February			c 647	37,200
March	1,940	543	1,010	62,100
April	1,050	741	878	52,200
May	1,320	741	915	56,300
June	1,720	830	1,160	69,000
July	1,600	954	1,090	67,000
August	1,320	922	1,040	64,000
September	1,150	830	974	58,000
The year	1,940		838	607,000
1919.				
April 17–30	648	524	623	17,300
May	792	411	557	34,200
June	972	756	848	50,500
July	1,280	1,000	1,150	70,700
August	1,140	940	1,040	64,000
September	1,100	810	955	56,800
				294,000
1919–20.				
October	875		698	42,900
November			596	35,500
December			871	53,600
January			962	59,200
February	861	652	797	45,800
March	968	536	672	41,300
April	1,160	630	822	48,900
May	1,480		1,160	71,300
June		936	1,240	73,800
July	1,380	1,130	1,230	75,600
August	1,230	1,060	1,120	68,900
September	1,000	725	897	53,400
The year	1,480		923	670,000

b Gage not working May 17–23; discharge interpolated. Discharge estimated because of ice from discharge measurements, recorder graph, and climatic data as follows: Dec. 10–31, 900 second-feet; Jan. 1–31, 850 second-feet; Feb. 1–12, 830 second-feet.

c Gage not working Sept. 26–29; discharge interpolated. Stage-discharge relation affected by ice Nov. 27 to Feb. 22; mean discharge estimated.

BEAR RIVER NEAR COLLINSTON, UTAH.

Location.—In W. ½ sec. 34, T. 13 N., R. 2 W., a quarter of a mile below Wheelon plant of Utah Power & Light Co. at Wheelon siding, 4 miles north of Collinston, Box Elder County. Below all large tributaries except Little Malad River, which enters 20 miles below station.

Drainage area.—6,000 square miles.

Records available.—July 1, 1889, to September 30, 1920.

Gage.—Gurley 8-day water-stage recorder on left bank about 12 feet above cable; used February 26, 1914, to September 30, 1920. Inspected by H. G.

Stone. Friez recorder used November 8, 1913, to February 25, 1914. Gage installed July 1, 1889, and read to February 9, 1905, was a vertical iron bar driven into bed of stream on right bank directly opposite present gage. Gage used February 10, 1905, to November 7, 1913, was an inclined staff on right bank. Datum of gage in well to which recording gage is referred, is 0.05 foot higher than that of the vertical and slope gages.

DISCHARGE MEASUREMENTS.—Made from cable.

CHANNEL AND CONTROL.—Bed composed of gravel and sand. Left bank high and not subject to overflow; right bank fairly high, but might be overflowed by exceptionally high floods. Control not well defined, but practically permanent.

ICE.—Stage-discharge relation not seriously affected by ice. Open-water rating curve applicable except for short periods.

DIVERSIONS.—Numerous diversions for irrigation and power above this station. West Side canal and Hammond (East Side) canal divert water by means of a low dam about 2 miles above station and near the upper end of Bear River Canyon. Water can be used from either or both of these canals to supply the Wheelon power plant and can be siphoned across at the plant from one canal to the other. Water passing the Wheelon penstocks is used for irrigation or can be wasted into the river.

REGULATION.—Flow at station regulated to some extent by operation of power plant.

ACCURACY.—Stage-discharge relation permanent. Rating curve well defined. Water-stage recorder gave satisfactory gage-height record except for three short periods in March, June, and September. Daily discharge ascertained by applying to rating table the mean daily gage height determined from recorder graph by inspection. Records excellent.

Monthly discharge of Bear River near Collinston, Utah.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1906-7.				
October [a]	1,315	1,105	1,150	82,800
November [a]	1,365	1,150	1,270	91,400
December [a]	1,690	1,315	1,460	105,300
January	1,500	1,250	1,320	81,200
February	3,460	1,260	2,340	130,000
March	5,980	2,120	3,410	210,000
April	8,790	5,850	7,270	433,000
May	9,280	6,000	7,350	452,000
June	10,200	7,130	8,600	512,000
July	6,850	3,000	4,740	291,000
August	3,250	900	1,870	115,000
September	2,080	810	1,590	94,600
The year	10,200	810	3,531	2,598,000
1907-8.				
October	2,300	1,750	1,940	119,000
November	2,080	1,860	1,980	118,000
December	3,530	900	1,960	121,000
January	2,080	1,530	1,890	116,000
February	2,420	1,310	1,810	104,000
March	3,820	1,970	2,610	160,000
April	3,670	2,300	2,800	167,000
May	2,420	1,530	1,870	115,000
June	5,470	2,420	3,980	237,000
July	2,970	385	1,020	62,700
August	725	500	646	39,700
September	1,000	645	803	47,800
The year	5,470	385	1,942	1,407,000

[a] Estimated from gage height taken once weekly.

Monthly discharge of Bear River near Collinston, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1908–9.				
October	1,860	1,100	1,580	97,200*
November	1,860	1,200	1,670	99,400
December	1,860	500	1,360	83,600
January	4,620	1,420	2,850	175,000
February	3,980	500	2,210	123,000
March	4,460	1,420	3,020	186,000
April	8,660	3,250	5,370	320,000
May	9,640	6,150	7,300	449,000
June	11,600	6,320	9,220	549,000
July	5,640	1,420	3,300	203,000
August	1,860	810	1,200	73,800
September	2,550	1,000	2,010	120,000
The year	11,600	500	3,421	2,479,000
1909–10.				
October	2,300	2,080	2,120	130,000
November	4,460	1,800	2,610	155,000
December	3,250	1,970	2,370	146,000
January	2,830	1,970	2,460	151,000
February	2,420	1,860	2,130	118,000
March	7,800	1,860	5,950	366,000
April	6,200	4,350	5,060	301,000
May	5,520	2,000	3,900	240,000
June	2,000	250	1,050	62,500
July	310	20	141	8,670
August	310	160	262	16,100
September	780	250	515	30,600
The year	7,800	20	2,381	1,725,000
1910–11.				
October	1,350	780	1,100	67,600
November	1,350	1,150	1,220	72,600
December	1,450	1,150	1,320	81,200
January	5,010	960	1,790	110,000
February	8,800	1,290	2,720	151,000
March	4,140	1,390	2,950	181,000
April	5,770	2,830	3,970	236,000
May	4,460	3,530	3,930	242,000
June	3,680	2,200	2,780	165,000
July	2,020	275	769	47,300
August	375	275	331	20,400
September	995	340	666	39,600
The year	8,800	275	1,962	1,414,000
1911–12.				
October	1,610	995	1,350	83,000
November	1,500	1,090	1,340	79,700
December	1,390	995	1,260	77,500
January	1,500	1,090	1,320	81,200
February	2,080	1,090	1,500	86,300
March	2,140	1,290	1,700	105,000
April	4,160	1,940	3,170	189,000
May	6,200	2,880	4,530	279,000
June	6,380	4,000	5,730	341,000
July	3,880	1,090	2,170	133,000
August	2,020	923	1,560	95,900
September	1,660	905	1,280	76,200
The year	6,380	905	2,240	1,627,000
1912–13.				
October	1,490	960	1,320	81,200
November	1,760	1,320	1,540	85,500
December	3,110	1,490	1,960	121,000
January	6,250	3,590	4,980	296,000
February	4,570	2,350	3,620	223,000
March	2,350	453	1,220	72,600
April	2,200	254	1,140	70,100
May	604	228	360	22,100
June	1,380	582	1,090	64,900
July	1,620	1,270	1,410	86,700
August	1,650	1,320	1,480	88,100
September	1,710	912	1,370	84,200
The year	6,250	228	1,790	1,300,000

Monthly discharge of Bear River near Collinston, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1913–14.				
October	1,620	1,270	1,410	86,700
November	1,640	1,270	1,470	87,500
December	1,700	882	1,360	83,600
January	3,680	1,030	1,800	111,000
February	3,180	1,010	1,760	97,000
March	3,340	1,980	2,650	163,000
April	5,990	2,860	5,090	303,000
May	6,580	5,070	5,920	364,000
June	6,580	2,790	4,870	290,000
July	2,490	716	1,390	85,500
August	980	437	700	43,000
September	1,630	640	1,170	69,600
The year	6,580	437	2,460	1,785,000
1914–15.				
October	2,020	940	1,640	101,000
November	1,720	1,270	1,560	92,800
December	2,080	----------	1,540	94,700
January	1,610	----------	1,520	93,500
February	2,610	1,510	1,800	100,000
March	1,800	1,420	1,640	101,000
April	2,280	1,320	1,720	102,000
May	1,750	728	1,320	81,200
June	1,830	80	855	50,900
July	481	75	214	13,200
August	240	71	145	8,920
September	940	144	630	37,500
The year	2,610	71	1,210	877,000
1915–16.				
October	1,150	619	899	55,300
November	1,260	752	1,000	59,500
December	1,680	684	1,080	66,400
January	1,750	1,130	1,360	83,600
February	1,880	1,070	1,550	89,200
March	6,340	1,440	3,610	222,000
April	4,850	2,880	3,650	217,000
May	4,700	1,680	3,140	193,000
June	2,560	1,680	2,060	123,000
July	1,680	325	763	46,900
August	709	437	548	33,700
September	1,320	286	768	45,700
The year	6,340	286	1,700	1,240,000
1916–17.				
October	2,100	898	1,430	87,900
November	1,680	995	1,390	82,700
December	2,240	898	1,600	98,400
January	----------	----------	1,780	109,000
February	2,400	----------	1,860	103,000
March	2,880	1,560	1,940	119,000
April	6,390	2,320	4,250	253,000
May	8,070	3,710	6,060	373,000
June	8,070	5,870	7,140	425,000
July	5,870	1,310	2,810	173,000
August	1,880	950	1,300	79,900
September	2,020	1,000	1,410	83,900
The year	8,070	898	2,740	1,990,000
1917–18.				
October	2,090	1,680	1,870	115,000
November	2,390	1,810	1,970	117,000
December	2,240	1,360	1,960	121,000
January	2,240	1,300	1,910	117,000
February	2,160	1,420	1,810	101,000
March	4,470	1,300	2,590	159,000
April	3,630	1,880	2,590	154,000
May	2,630	1,180	1,940	119,000
June	1,880	841	1,370	81,500
July	1,070	248	639	39,300
August	765	223	554	34,100
September	1,360	235	830	49,400
The year	4,470	223	1,670	1,210,000

Monthly discharge of Bear River near Collinston, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1918–19.				
October	1,880	1,050	1,500	92,200
November	2,390	1,070	1,650	98,200
December	2,090	1,120	1,790	110,000
January	2,090	1,120	1,670	103,000
February	2,160	1,480	1,730	96,100
March	3,300	1,370	2,270	140,000
April	3,760	1,850	2,610	155,000
May	2,900	841	1,640	101,000
June	1,520	65	465	27,700
July	267	62	124	7,620
August	540	80	226	13,900
September	910	235	668	39,700
The year	3,760	62	1,360	984,000
1919–20.				
October	1,920	841	1,280	78,700
November	2,020	1,040	1,470	87,500
December	2,090	900	1,520	93,500
January	2,280	1,350	1,740	107,000
February	2,010	1,260	1,670	96,100
March	2,300	1,150	1,720	106,000
April	4,460	1,420	2,510	149,000
May	6,410	2,620	4,920	303,000
June	4,740	1,020	2,360	140,000
July	1,320	30	467	28,700
August	1,000	30	354	21,800
September	1,680	422	1,040	61,900
The year	6,410	30	1,750	1,270,000

BEAR LAKE INLET CANAL NEAR DINGLE, IDAHO.

LOCATION.—In sec. 13, T. 14 S., R. 44 E., three-fourths mile south of Dingle and 2½ miles below intake of canal.

RECORDS AVAILABLE.—June 21, 1911, to September 30, 1913. Measurements only during 1913.

GAGE.—Schaub water-stage recorder installed about half a mile above point where canal crosses road leading south from Dingle. Zero of staff gage used in 1911, to which all measurements in 1913 have been reduced, corresponds to 5,952.18 feet on the automatic gage.

CHANNEL AND CONTROL.—Gravel; shifts almost continuously. Banks high.

DISCHARGE MEASUREMENTS.—Made by wading at different sections or from flumes or bridges across the canal.

COOPERATION.—All gage heights and discharge measurements, except that of April 16, 1913, were furnished by the Utah Power & Light Co. in 1913, and by the Telluride Power Co. during 1911 and 1912, except measurement made May 27, 1912.

Records show water diverted from Bear River into the branch of Bear Lake known as Mud Lake. The quantity thus diverted should be added to the discharge of Bear River at Dingle to make the records for that station comparable with those obtained prior to 1911.

Monthly discharge of Bear River near Collinston, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1913–14.				
October	1,620	1,270	1,410	86,700
November	1,640	1,270	1,470	87,500
December	1,700	882	1,360	83,600
January	3,680	1,030	1,800	111,000
February	3,180	1,010	1,760	97,000
March	3,340	1,980	2,650	163,000
April	5,990	2,860	5,090	303,000
May	6,580	5,070	5,920	364,000
June	6,580	2,790	4,870	290,000
July	2,490	716	1,390	85,500
August	980	437	700	43,000
September	1,630	640	1,170	69,600
The year	6,580	437	2,460	1,785,000
1914–15.				
October	2,020	940	1,640	101,000
November	1,720	1,270	1,560	92,800
December	2,080		1,540	94,700
January	1,610		1,520	93,500
February	2,610	1,510	1,800	100,000
March	1,800	1,420	1,640	101,000
April	2,280	1,320	1,720	102,000
May	1,750	728	1,320	81,200
June	1,830	80	855	50,900
July	481	75	214	13,200
August	240	71	145	8,920
September	940	144	630	37,500
The year	2,610	71	1,210	877,000
1915–16.				
October	1,150	619	899	55,300
November	1,260	752	1,000	59,500
December	1,680	684	1,080	66,400
January	1,750	1,130	1,360	83,600
February	1,880	1,070	1,550	89,200
March	6,340	1,440	3,610	222,000
April	4,850	2,880	3,650	217,000
May	4,700	1,680	3,140	193,000
June	2,560	1,680	2,060	123,000
July	1,680	325	763	46,900
August	709	437	548	33,700
September	1,320	286	768	45,700
The year	6,340	286	1,700	1,240,000
1916–17.				
October	2,100	898	1,430	87,900
November	1,680	995	1,390	82,700
December	2,240	898	1,600	98,400
January			1,780	109,000
February	2,400		1,860	103,000
March	2,880	1,560	1,940	119,000
April	6,390	2,320	4,250	253,000
May	8,070	3,710	6,060	373,000
June	8,070	5,870	7,140	425,000
July	5,870	1,310	2,810	173,000
August	1,880	950	1,300	79,900
September	2,020	1,000	1,410	83,900
The year	8,070	898	2,740	1,990,000
1917–18.				
October	2,090	1,680	1,870	115,000
November	2,390	1,810	1,970	117,000
December	2,240	1,360	1,960	121,000
January	2,240	1,300	1,910	117,000
February	2,160	1,420	1,810	101,000
March	4,470	1,300	2,590	159,000
April	3,630	1,880	2,590	154,000
May	2,630	1,180	1,940	119,000
June	1,880	841	1,370	81,500
July	1,070	248	639	39,300
August	765	223	554	34,100
September	1,360	235	830	49,400
The year	4,470	223	1,670	1,210,000

Monthly discharge of Bear River near Collinston, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1918-19.				
October	1,880	1,050	1,500	92,200
November	2,390	1,070	1,650	98,200
December	2,090	1,120	1,790	110,000
January	2,090	1,120	1,670	103,000
February	2,160	1,480	1,730	96,100
March	3,300	1,370	2,270	140,000
April	3,760	1,850	2,610	155,000
May	2,900	841	1,640	101,000
June	1,520	65	465	27,700
July	267	62	124	7,620
August	540	80	226	13,900
September	910	235	668	39,700
The year	3,760	62	1,360	984,000
1919-20.				
October	1,920	841	1,280	78,700
November	2,020	1,040	1,470	87,500
December	2,090	900	1,520	93,500
January	2,280	1,350	1,740	107,000
February	2,010	1,260	1,670	96,100
March	2,300	1,150	1,720	106,000
April	4,460	1,420	2,510	149,000
May	6,410	2,620	4,920	303,000
June	4,740	1,020	2,360	140,000
July	1,320	30	467	28,700
August	1,000	30	354	21,800
September	1,680	422	1,040	61,900
The year	6,410	30	1,750	1,270,000

BEAR LAKE INLET CANAL NEAR DINGLE, IDAHO.

LOCATION.—In sec. 13, T. 14 S., R. 44 E., three-fourths mile south of Dingle and 2½ miles below intake of canal.

RECORDS AVAILABLE.—June 21, 1911, to September 30, 1913. Measurements only during 1913.

GAGE.—Schaub water-stage recorder installed about half a mile above point where canal crosses road leading south from Dingle. Zero of staff gage used in 1911, to which all measurements in 1913 have been reduced, corresponds to 5,952.18 feet on the automatic gage.

CHANNEL AND CONTROL.—Gravel; shifts almost continuously. Banks high.

DISCHARGE MEASUREMENTS.—Made by wading at different sections or from flumes or bridges across the canal.

COOPERATION.—All gage heights and discharge measurements, except that of April 16, 1913, were furnished by the Utah Power & Light Co. in 1913, and by the Telluride Power Co. during 1911 and 1912, except measurement made May 27, 1912.

Records show water diverted from Bear River into the branch of Bear Lake known as Mud Lake. The quantity thus diverted should be added to the discharge of Bear River at Dingle to make the records for that station comparable with those obtained prior to 1911.

Monthly discharge of Bear Lake inlet canal near Dingle, Idaho.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1911.				
May	405	0	37.6	2,310
June	405	0	261	15,500
July	230	0	86.8	5,340
1912.				
February 16-29	47	0	27.4	762
March	105	6	33.6	2,070
April	374	2	77.3	4,600
May	518	12	111	6,820
June	87	43	63.7	3,790
July	78	43	57.9	3,560
August	50	0	19.3	1,190
The period				22,800

GEORGETOWN CREEK NEAR GEORGETOWN, IDAHO.

LOCATION.—In sec. 4, T. 11 S., R. 44 E., 50 feet below power house of Bear Lake Power Co., 3 miles northeast of Georgetown post office, and 4 miles from Georgetown railway station.

DRAINAGE AREA.—22 square miles (Forest Service records).

RECORDS AVAILABLE.—October 23, 1911, to September 30, 1914, when station was discontinued.

GAGE.—Vertical staff on right bank.

DISCHARGE MEASUREMENTS.—Made by wading.

CHANNEL AND CONTROL.—Rocky; fairly permanent; discharge relation at times affected by moss and brush.

WINTER FLOW.—Discharge relation not seriously affected by ice, as station is immediately below power house; open-channel rating curves used.

DIVERSIONS.—Practically all diversions for irrigation are made below station.

REGULATION.—Pondage available at power plant is negligible; flow probably affected somewhat by operation of plant.

ACCURACY.—Records poor; gage readings infrequent and irregular; and rating curves poorly defined.

COOPERATION.—Gage readings furnished by United States Forest Service; occasional discharge measurements also furnished by United States Forest Service and the Utah Power & Light Co.

Monthly discharge of Georgetown Creek near Georgetown, Idaho.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1911-12.				
October 23-31			a 26	464
November			a 28	1,670
December	28	26	26.9	1,650
January	27	23	26.2	1,610
February	28	28	27.8	1,600
March	32	23	26.3	1,620
April	28	26	26.5	1,580
May	98	28	45.5	2,800
June	162	52	96.3	5,730
July	49	46	48.1	2,960
August	46	41	44.7	2,750
September	41	36	39.4	2,340
The period	162	23	38.5	26,800

a Estimated.

Monthly discharge of Georgetown Creek, near Georgetown, Idaho—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1912-13.				
October	36	36	36	2,210
November	36	34	35	2,090
December	34	30	32	1,980
January			30	1,840
February			30	1,670
March			28	1,720
August			32	1,970
September			31	1,840
1913-14.				
October			31.4	1,930
November			34.0	2,020
December			31.0	1,910
January			30.0	1,840
February			30.0	1,670
March			28.7	1,760
April			37.5	2,230
May			81.7	5,020
June			66.4	3,950
July			50.3	3,090
August			47.3	2,910
September			41.6	2,480
The year			42.6	30,800

NOTE.—Monthly means estimated, based on very infrequent gage heights and about one discharge measurement a month, and are roughly approximate.

SODA CREEK NEAR SODA SPRINGS, IDAHO.

LOCATION.—In sec. 24, T. 8 S., R. 41 E., at George Schmidt's ranch, one-eighth mile below confluence of two branches of creek and 5 miles north of Soda Springs, Bannock County.

DRAINAGE AREA.—Not measured.

RECORDS AVAILABLE.—March 5, 1913, to September 30, 1920.

GAGE.—Vertical staff on left bank about one-fourth mile south of ranch house, installed August 1, 1913; read by George Schmidt. Gage used March 5 to July 31, 1913, was 30 feet upstream, but had same control. Datum of old gage between 0.1 and 0.2 foot above that of present gage.

DISCHARGE MEASUREMENTS.—Made by wading.

CHANNEL AND CONTROL.—Bed composed of lava rock. Control is a reef about 15 feet below the gage. Stage-discharge relation affected by growth of moss during summer. During 1915 stage-discharge relation affected by extension of a wing dam at head of small ditch, which takes water from right bank at control.

ICE.—Stage-discharge relation unaffected by ice.

DIVERSIONS.—Practically no water diverted above the station; a small ditch diverts water just below the gage.

REGULATION.—None.

ACCURACY.—Stage-discharge relation not permanent on account of effect of aquatic growth; not affected by ice. Records good.

Monthly discharge of Soda Creek near Soda Springs, Idaho.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1913.				
March 5-31	95	82	88.1	4,720
April	324	103	180	10,700
May	126	99	109	6,700
June	149	99	109	6,490
July	128	90	97.7	6,010
August	94	80	85.2	5,240
September	94	73	79.8	4,750
The period				44,600
1913–14.				
October	104	71	81.8	5,030
November	87	67	76.2	4,530
December	67	58	60.6	3,730
January	60	50	56.1	3,450
February	58	48	51.4	2,850
March	60	48	53.4	3,280
April	241	63	123	7,320
May	112	90	98.5	6,060
June	108	90	98.5	5,860
July	103	84	88.3	5,430
August	87	79	82.1	5,050
September	101	82	87.6	5,210
The year	241	48	79.9	57,800
1914–15.				
October	94	73	79.8	4,910
November	73	63	68.7	4,090
December	63	58	60.2	3,700
January	60	58	59.0	3,630
February	58	58	58.0	3,220
March	108	54	65.5	4,030
April	77	59	65.1	3,870
May	67	58	61.8	3,800
June	63	46	52.8	3,140
July	52	45	47.4	2,910
August	48	45	46.7	2,870
September	49	45	46.4	2,760
The year	108	45	59.3	42,900
1915–16.				
October	46	44	44.7	2,750
November	46	44	44.9	2,670
December	46	44	44.7	2,750
January	44	39	40.7	2,500
February	42	40	40.8	2,350
March	95	38	56.0	3,440
April	61	52	55.1	3,280
May	59	52	55.3	3,400
June	64	55	60.0	3,570
July	55	49	51.5	3,170
August	49	47	48.4	2,980
September	49	47	47.7	2,840
The year	95	38	49.2	35,700
1916–17.				
October	48	44	46.8	2,880
November	48	46	46.8	2,780
December	48	46	46.2	2,840
January	46	46	46.0	2,830
February	49	45	47.0	2,610
March	47	45	45.9	2,820
April	193	45	72.0	4,280
May	170	66	77.1	4,740
June	73	63	68.6	4,080
July	73	55	62.8	3,860
August	62	55	59.4	3,650
September	65	55	60.0	3,570
The year	193	44	56.6	40,900

Monthly discharge of Soda Creek near Soda Springs, Idaho—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1917–18.				
October	59	57	57.6	3,540
November	57	54	55.8	3,320
December	60	54	55.0	3,380
January	57	52	55.1	3,390
February	54	52	53.4	2,970
March	150	54	69.8	4,290
April	140	65	71.0	4,220
May	65	57	61.6	3,790
June	72	58	62.9	3,740
July	69	55	59.8	3,680
August	55	52	53.2	3,270
September	53	49	50.1	2,980
The year	150	49	58.5	42,600
1918–19.				
October	60	51	57.3	3,520
November	63	57	61.0	3,630
December	57	48	54.0	3,320
January	51	38	41.5	2,550
February	43	41	42.0	2,330
March	123	41	48.2	2,960
April	231	75	10.6	6,310
May	83	67	73.9	4,540
June	67	54	60.9	3,620
July	58	54	55.8	3,430
August	54	51	51.3	3,150
September	58	51	51.3	3,050
The year	231	38	58.6	42,400
1919–20.				
October	60	54	55.5	3,410
November	83	58	62.5	3,720
December	58	51	54.1	3,330
January	51	46	49.3	3,030
February	51	46	47.6	2,740
March	58	46	48.3	2,970
April	179	48	84.5	5,030
May	113	78	85.0	5,230
June	123	60	71.2	4,240
July	86	65	72.6	4,460
August	75	66	67.5	4,150
September	75	66	69.3	4,120
The year	179	46	64.0	46,400

LOGAN RIVER ABOVE STATE DAM, NEAR LOGAN, UTAH.

LOCATION.—In NW. ¼ NE. ¼ sec. 36, T. 12 N., R. 1 E., at Logan plant of Utah Power & Light Co., 125 feet above confluence of tailrace with river and 2½ miles above Logan, Cache County.

DRAINAGE AREA.—218 square miles. Practically the same as at old station on Logan River near Logan, Utah.

RECORDS AVAILABLE.—May 7, 1913, to September 30, 1920; at old station a quarter of a mile downstream, June 1, 1896, to July 17, 1903, and April 14, 1904, to December 31, 1912; flow at station plus that of tailrace comparable to that at old station.

GAGE.—Stevens continuous water-stage recorder on right bank about 100 feet west of power house. Inspected by employee of Utah Power & Light Co.

DISCHARGE MEASUREMENTS.—Made by wading at gage; high-water measurements made from footbridge at the switch rack about 1,200 feet below, and flow in tailrace deducted.

CHANNEL AND CONTROL.—Banks fairly high, clean, and not subject to overflow. Right bank is a dry rubble retaining wall. Control is concrete cut-off wall about 6 feet below the gage. Stage of zero flow, 0.45 foot.

ICE.—Stage-discharge relation not affected by ice.

DIVERSIONS.—The Utah Power & Light Co. diverts water above station for power and the Logan, Hyde Park & Smithfield canal diverts for irrigation. The city of Logan has a municipal power plant about 2 miles above station, but water is returned to river above the two diversions noted. The city of Logan is entitled to divert for municipal supply from 4 to 10 second-feet of water from springs in sec. 22, T. 12 N., R. 2 E., the quantity depending on flow in the river.

REGULATION.—Some diurnal fluctuation is caused at times by operation of the two power plants.

ACCURACY.—Stage-discharge relation affected during the winter by backwater from the State dam. Records good.

Monthly discharge of Logan River above State dam, near Logan, Utah.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1913.				
May 7–31	559	323	451.0	22,400
June	430	145	251.0	14,900
July	178	36	78.8	4,850
August	34	19	25.3	1,560
September	21	13	17.0	1,010
The period	559	13	152.0	44,720
1913–14.				
October	23	13	15.6	959
November	31	20	24.5	1,460
December	25	20	22.7	1,400
January	30	19	21.4	1,320
February	25	18	22.0	1,220
March	39	22	27.8	1,710
April	444	30	241.0	14,300
May	1,080	289	721.0	44,300
June	1,200	352	629.0	37,400
July	327	87	168.0	10,300
August	108	45	61.8	3,800
September	67	26	36.5	2,170
The year	1,200	13	166.0	120,000
1914–15.				
October	66	27	35.6	2,190
November	26	18	20.9	1,240
December	48	13	25.3	1,560
January	100	53	88.5	5,440
February	100	75	88.8	4,930
March	127	78	94.9	5,840
April	355	112	220.0	13,100
May	284	177	232.0	14,300
June	365	100	216.0	12,900
July	95	41	64.1	3,940
August	47	25	36.0	2,210
September	36	24	27.0	1,610
The year	355	13	95.6	69,300
1915–16.				
October	24	12	16.8	1,030
November	28	12	19.2	1,140
December	30	8	16.7	1,030
January	35	20	25.7	1,580
February	32	26	28.7	1,650
March	325	29	104	6,400
April	770	161	355	21,100
May	847	480	634	39,000
June	834	542	692	41,200
July	532	151	302	18,600
August	139	70	97.4	5,990
September	100	59	76.9	4,580
The year	847	8	197	143,000

Monthly discharge of Logan River above State dam, near Logan, Utah—Contd.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1916–17.				
October	89	53	65.6	4,030
November	54	24	37.7	2,240
December	----------	25	31.2	1,920
January	----------	----------	37.8	2,320
February	----------	----------	39.6	2,200
March	61	36	46.2	2,840
April	290	42	102	6,070
May	722	135	472	29,000
June	1,040	661	841	50,000
July	802	226	451	27,700
August	211	81	130	7,990
September	94	62	76.7	4,560
The year	1,040	24	195	141,000
1917–18.				
October	83	47	64.3	3,950
November	49	32	38.9	2,310
December	52	35	45.9	2,820
January	54	41	45.6	2,800
February	66	45	52.5	2,920
March	167	49	80.5	4,950
April	261	94	174	10,400
May	641	218	484	29,800
June	741	201	543	32,300
July	178	54	93.2	5,730
August	75	42	57.7	3,550
September	133	28	44.4	2,640
The year	741	28	144	104,000
1918–19.				
October	45	28	33.5	2,060
November	----------	29	40.8	2,430
December	93	45	55.5	3,410
January	----------	74	99.5	6,120
February	102	55	85.6	4,750
March	135	54	70.7	4,350
April	366	100	162	9,640
May	641	266	469	28,800
June	465	98	223	13,300
July	106	58	74.4	4,570
August	71	40	47.8	2,940
September	51	38	42.5	2,530
Total	641	28	117	84,900
1919–20.				
October	44	----------	----------	----------
November	70	28	38.8	2,390
December	66	27	39.7	2,360
January	58	44	50.9	3,130
February	48	41	49.5	3,040
March	56	38	43.0	2,470
April	308	40	46.3	2,850
May	1,150	49	138	8,210
June	1,080	364	775	47,700
July	472	506	816	48,600
August	130	111	231	14,200
September	96	76	108	6,640
	1,150	70	83.5	4,970
The year	----------	27	202	146,000

LOGAN RIVER BELOW STATE DAM, NEAR LOGAN, UTAH.

Location.—In sec. 35, T. 12 N., R. 1 E., 280 feet below State dam and power plant and 2 miles above Logan.

Drainage area.—Not measured.

Records available.—April 29, 1913, to September 30, 1914; June 1, 1896, to December 31, 1912, half a mile above old station, which was flooded out in January, 1913, by backwater from State dam.

GAGE.—Stevens water-stage recorder, with outside staff and inside hook gage, on left bank 100 feet above head of Logan Northern canal.

DISCHARGE MEASUREMENTS.—Made from cable about one-fourth mile below gage or by wading.

CHANNEL AND CONTROL.—Channel gravel and boulders; one at all stages. A concrete cut-off wall, 12 inches thick, built across the stream just below the gage house, acts as a permanent control.

WINTER FLOW.—Discharge relation not affected by ice.

DIVERSIONS.—Not known.

REGULATION.—Flow at station is affected, especially during periods of low water, by operation of State power plant just above.

ACCURACY.—Records considered excellent because of continuous gage-height record and well-defined rating curves.

Monthly discharge of Logan River below State dam, near Logan, Utah.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1913.				
April 29-30	514	488	501	2,000
May	757	314	566	34,800
June	652	244	355	21,100
July	298	159	198	12,200
August	159	141	147	9,040
September	144	95	140	8,330
The period	757	95	282	87,470
1913-14.				
October	122	78	105	6,460
November	112	84	99.6	5,930
December	105	78	94.8	5,830
January	110	82	93.6	5,760
February	112	80	90.8	5,040
March	144	82	115	7,070
April	458	116	296	17,600
May	1,170	346	837	51,500
June	1,220	418	765	45,500
July	377	204	269	16,500
August	210	161	173	10,600
September	164	135	149	8,870
	1,220	78	258	187,000

LOGAN RIVER BELOW LOGAN NORTHERN CANAL, NEAR LOGAN, UTAH.

LOCATION.—In NW. ¼ sec. 36, T. 12 N., R. 1 E., 500 feet below heading of Logan Northern canal, 850 feet below State dam, and 2 miles above Logan, Cache County.

DRAINAGE AREA.—Not measured.

RECORDS AVAILABLE.—July 26, 1915, to June 13, 1917. Station discontinued.

GAGE.—Stevens continuous water-stage recorder on left bank about 200 feet southwest of the bridge by which State road crosses Logan Northern canal.

DISCHARGE MEASUREMENTS.—Made by wading or from cable 125 feet below gage.

CHANNEL AND CONTROL.—Bed composed of gravel and large boulders. Shifting. Banks not subject to overflow. One channel at all stages.

ICE.—Stage-discharge relation not seriously affected by ice.

DIVERSIONS.—Logan, Hyde Park & Smithfield canal, and Logan Northern canal divert water above station for irrigation. The city of Logan is entitled to divert for municipal supply from 4 to 10 second-feet of water from springs in sec. 22, T. 12 N., R. 2 E., the quantity depending on flow in the river.

REGULATION.—Operation of power plants above causes some diurnal fluctuation at times during low-water periods.

ACCURACY.—Rating curves fairly well defined between 50 and 700 second-feet. Records good.

Monthly discharge of Logan River below Logan Northern canal, near Logan, Utah.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1915.				
July 26–31	85	82	84.0	1,000
August	90	65	74.1	4,560
September	105	65	82.5	4,910
The period				10,500
1915–16.				
October		26	62.2	3,820
November	82	57	69.4	4,130
December	84	55	71.5	4,400
January	82	66	74.6	4,590
February	89	72	81.7	4,700
March	325	82	170	10,500
April	718	234	411	24,500
May	814	435	594	36,500
June	737	468	634	37,700
July	445	164	283	17,400
August	194	109	142	8,730
September	118	95	108	6,430
The year	814	26	225	164,000
1916–17.				
October	167	115	145	8,920
November	137	115	127	7,560
December	132	108	113	6,950
January	118		103	6,330
February			101	5,610
March	109	81	101	6,210
April	342	103	162	9,640
May	665	205	478	29,400
June 1–13	898	657	757	19,600
The period				100,000

UTAH POWER & LIGHT CO.'S TAILRACE NEAR LOGAN, UTAH.

LOCATION.—In NE. ¼ sec. 36, T. 12 N., R. 1 E., 100 feet below power house at plant of Utah Power & Light Co. and 2½ miles above Logan, Cache County.

RECORDS AVAILABLE. May 7, 1913, to September 30, 1920.

GAGE.—Friez water-stage recorder on right bank just above weir; inspected by employee of Utah Power & Light Co.

DISCHARGE MEASUREMENTS.—Made from footbridge just above gage.

CHANNEL AND CONTROL.—Rectangular wooden weir, with metal crest strip, just below gage. Capacity of channel above weir not sufficient to eliminate all velocity of approach. Stage of zero flow, zero on gage.

ICE.—Stage-discharge relation not affected by ice.

REGULATION.—Flow at station affected by operation of power plant.

ACCURACY.—Stage-discharge relation permanent. Records good.

Monthly discharge of Utah Power & Light Co.'s tailrace near Logan, Utah.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1913.				
May 7-31	150	89	144	7,140
June	154	127	149	8,870
July	152	135	149	9,160
August	146	130	141	8,670
September	145	135	139	8,270
The period				42,100
1913-14.				
October	142	108	132.0	8,120
November	132	102	114.0	6,780
December	112	86	100.0	6,150
January	106	81	97.3	5,980
February	100	85	92.3	5,130
March	137	88	115.0	7,070
April	154	109	142.0	8,450
May	150	115	140.0	8,610
June	142	107	127.0	7,560
July	131	81	120.0	7,380
August	132	89	121.0	7,440
September	141	112	133.0	7,910
The year	154	81	120.0	86,600
1914-15.				
October	139	106	132.0	8,120
November	138	108	128.0	7,620
December	120	60	97.6	6,000
January	41	16	19.9	1,220
February	31	14	17.8	989
March	21	12	15.5	953
April	16	13	14.5	863
May	63	8.2	25.1	1,540
June	92	13	60.4	3,590
July	97	85	90.4	5,560
August	97	73	87.4	5,370
September	90	85	88.0	5,240
The year	139	8.2	65.0	47,100
1915-16.				
October	99	72	92.5	5,690
November	99	66	86.5	5,150
December	87	55	77.2	4,750
January	76	60	68.4	4,210
February	77	65	72.7	4,180
March	99	70	83.5	5,130
April	85	51	72.9	4,340
May	58	29	40.7	2,500
June	36	19	28.7	1,710
July	92	12	73.3	4,510
August	93	84	87.6	5,390
September	91	68	85.8	5,110
The year	99	12	72.5	52,700
1916-17.				
October	95	84	92.7	5,700
November	103	95	101	6,010
December	104	80	97.2	5,980
January	94		72.8	4,480
February	85	40	64.3	3,570
March	73	34	58.2	3,580
April	104	73	87.2	5,190
May	100	45	95.0	5,840
June	106	32	87.7	5,220
July	103	87	99.7	6,130
August	112	99	102	6,270
September	118	80	112	6,660
The year	118	32	89.2	64,600

Monthly discharge of Utah Power & Light Co.'s tailrace near Logan, Utah—Contd.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1917-18.				
October			[a] 118	7,260
November			[a] 115	6,840
December			[a] 110	6,760
January		69	84.3	5,180
February	82	56	71.9	3,990
March	112	72	95.2	5,850
April	117	40	98.9	5,880
May	107	0	28.4	1,750
June	113	12	54.0	3,210
July	118	89	113	6,950
August	117	109	113	6,950
September	117	35	105	6,250
The year		0	92.5	66,900
1918-19.				
October	120	99	113	6,950
November	109	66	94.3	5,610
December	89	29	70.1	4,310
January	33	0	11.6	713
February	64	7	25.6	1,420
March	66	0	45.3	2,790
April	80	0	31.5	1,870
May	84	24	77.3	4,750
June	80	71	78.1	4,650
July	80	55	78.2	4,810
August	79	55	76.7	4,720
September	83	77	79.4	4,720
The year	120	0	65.3	47,313
1919-20.				
October	83	77	80.5	4,950
November	80	47	72.8	4,330
December	62	44	52.6	3,230
January	62	41	50.2	3,909
February	64	50	59.4	3,420
March	67	33	57.4	3,530
April	73	3	34.8	2,070
May	82	3	48.7	2,990
June	86	77	82.5	4,910
July	87	77	81.0	4,980
August	81	60	74.2	4,560
September	82	73	78.1	4,650
The year	87	3		46,700

[a] Estimated.

LOGAN, HYDE PARK & SMITHFIELD CANAL NEAR LOGAN, UTAH.

LOCATION.—In NW.¼ NE. ¼ sec. 31, T. 12 N., R. 2 E., at concrete rating flume half a mile below head of canal, 1 mile below city power plant, 1 mile above plant of Utah Power & Light Co., and 3½ miles from Logan, Cache County.

RECORDS AVAILABLE.—Fragmentary 1904–1912. Fairly continuous April 22, 1912, to September 30, 1920.

GAGE.—Stevens continuous water-stage recorder on right bank near lower end of rating flume; installed June 6, 1913. Records April 22, 1912, to March 31, 1913, obtained from vertical staff gage at point about 1½ miles below present gage; two wasteways between the two points. Gage inspected by G. B. Folkman.

DISCHARGE MEASUREMENTS.—Made by wading or from a foot plank at the flume.

CHANNEL AND CONTROL.—Rectangular concrete rating flume. Stage of zero flow after control board was installed in April, 1915, 0.35 foot.

WINTER FLOW.—Recording gage usually removed during winter. A small flow of water is maintained for domestic use.

DIVERSIONS.—None above the gage.

REGULATION.—Flow regulated by headgates at diversion works.

ACCURACY.—Stage-discharge relation permanent; record discontinued during winter. Rating curve well defined below 120 second-feet. Operation of water-stage recorder satisfactory. Daily discharge ascertained by applying to rating table mean daily gage height determined by inspecting recorder graph. Records excellent.

Canal diverts water from Logan River in the NE. ¼ NE. ¼ sec. 31, T. 12 N., R. 2 E., for irrigation and domestic use in the territory north of Logan. The water is not returned to the river.

Monthly discharge of Logan, Hyde Park & Smithfield canal near Logan, Utah.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1912.				
April 22-30	14	5	9.4	168
May	81	8	42.0	2,580
June	90	40	66.1	3,930
July	105	85	92.7	5,700
August	88	52	62.0	3,810
September	69	36	48.6	2,890
The period				19,000
1912-13.				
October 20-31	11	6.4	7.95	189
November	8	2	6.07	361
December	9.5	3	6.65	409
January	14	6.6	8.4	516
February	11	6.8	8.6	478
March	11	6.4	9.4	578
June 6-30	97	22	76.8	3,810
July	105	21	66.1	4,060
August	70	39	51.2	3,150
September	43	20	30.2	1,800
The period				15,000
1913-14.				
October	23	15	17.7	1,090
March 9-31	11	5.8	8.22	374
April 1-9	18	0	4.13	246
May 4-31	102	0	71.9	4,420
June	103	30	58.6	3,490
July	106	82	99.3	6,110
August	85	48	66.2	4,070
September	53	28	42.3	2,520
The period				22,000
1914-15.				
October	28	13	20.8	1,280
November 1-11	19	16	17.4	380
April 3-30	99	4	19.6	1,090
May	100	22	71.8	4,410
June	104	60	77.3	4,600
July	60	42	48.4	2,980
August	42	30	33.6	2,070
September	37	21	26.7	1,590
The period				18,000

Monthly discharge of Logan, Hyde Park & Smithfield canal near Logan, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1915–16.				
October	26	21	23.0	1,410
November	21	3.7	14.5	863
December	14	5.8	11.2	689
January	9.3	7.5	8.55	526
April 24–30	8.7	2.6	5.91	82.1
May	102	8.1	75.2	4,620
June	102	76	92.0	5,470
July	109	99	105	6,460
August	108	49	84.0	5,160
September	80	38	42.9	2,550
The period				28,000
1916–17.				
October			24.9	1,530
November 1–24	23	13	17.5	833
June 13–30	102	59	91.7	3,270
July	115	99	109	6,700
August	108	64	96.8	5,950
September 1–19	67	59	62.2	2,340
1917–18.				
April 21–30	78	1.5	47.2	936
May	91	1.3	55.2	3,390
June	110	63	93.5	5,560
July	113	22	98.5	6,060
August	60	39	49.9	3,070
September	44	0	29.4	1,750
The period				20,800
1918–19.				
October		15	19.0	1,170
November 1–6	15	15	15.0	179
May	117	0	88.4	5,440
June	118	77	103	6,130
July	80	35	54.1	3,330
August	49	26	35.3	2,170
September	28	14	21.6	1,290
1919–20.				
October 1–10	14	12	13.7	272
May 7–31	116	0	45.8	2,270
June	123	109	115	6,840
July	121	112	116	7,130
August	111	51	78.5	4,830

NOTE.—No record kept Nov. 25, May 9, May 16 to June 12, and Sept. 20 to 30.

LOGAN NORTHERN CANAL NEAR LOGAN, UTAH.

LOCATION.—In NW. ¼ sec. 36, T. 12 N., R. 1 E., at upper end of timber-lined section, 800 feet below head of canal and 2 miles above Logan, Cache County.

RECORDS AVAILABLE.—June 6, 1913, to September 30, 1914; May 13, 1915, to October 2, 1916. Station discontinued.

GAGE.—Stevens continuous water-stage recorder on right bank immediately above lined section of canal. Inspected by employee of Logan Northern Canal Co.

DISCHARGE MEASUREMENTS.—Made by wading or from foot plank.

CHANNEL AND CONTROL.—Bed at gage is of earth and gravel; immediately below is a timber-lined rectangular section which contracts the width very slightly. A low-control board has been installed at upper end of this section making stage of zero flow 0.45 foot.

WINTER FLOW.—No record kept during the winter; canal is usually dry.

DIVERSIONS.—Above all diversions.

REGULATION.—Flow regulated by headgates at point of diversion.

ACCURACY.—Stage-discharge relation permanent. Rating curve fairly well defined between 20 and 90 second-feet. Operation of water-stage recorder satisfactory except for breaks in record. Daily discharge ascertained by applying to rating table the mean daily gage height determined by inspecting recorder graph, except for days when there was considerable fluctuation, for which the mean of hourly discharge was used. Records good.

Monthly discharge of Logan Northern canal near Logan, Utah.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1913.				
June 6–30	92	50	75.8	3,760
July	94	47	68.8	4,230
August	69	46	58.5	3,600
September	51	6	36.3	2,160
The period				14,000
1913–14.				
October	5.4	.2	1.38	84.8
April	17	.2	2.89	126
May	104	16	62.8	3,860
June	104	38	72.2	4,300
July	88	1	69.5	4,270
August	81	53	66.6	4,100
September	54	1	24.6	1,460
The period				18,000
1914–15.				
October	.3	.1	.2	.5
April 3–15	13	0	6.5	170
May 13–31	74	.5	40.6	771
June	108	3.8	54.5	1,634
July	72	42	50.5	1,563
August	40	31	35.1	2,160
September	31	3	19.2	1,140
The period				7,000
1915–16.				
October	72	18	30.5	1,870
November	38	7	20.5	1,215
December	16	1	5.5	335

BLACKSMITH FORK ABOVE UTAH POWER & LIGHT CO.'S DAM, NEAR HYRUM, UTAH.

LOCATION.—In NE. ¼ sec. 8, T. 10 N., R. 2 E., 1 mile above diversion dam, 3½ miles above power plant of Utah Power & Light Co., and 6 miles east of Hyrum, Cache County.

DRAINAGE AREA.—About 260 square miles (measured on topographic maps and map of Cache National Forest).

RECORDS AVAILABLE.—July 19, 1900, to December 31, 1902; November 28, 1913, to September 30, 1916.

GAGE.—Stevens continuous water-stage recorder on left bank 500 feet above wagon bridge and nearly a mile above dam; installed November 28, 1913. Gage at old tollgate in mouth of canyon about 3½ miles downstream was used July 19, 1900, to December 31, 1902. Flow approximately the same at both points. Gage inspected by employee of Utah Power & Light Co.

DISCHARGE MEASUREMENTS.—Made by wading about three-eighths mile above gage, or from cable a quarter of a mile above gage. Conditions at wading section good; at cable poor, especially at high stages.

CHANNEL AND CONTROL.—Bed rough but fairly permanent; one channel at all stages.

ICE.—Stage-discharge relation affected by ice for short periods.

DIVERSIONS.—Above all important diversions.

REGULATIONS.—None.

ACCURACY.—Stage-discharge relation practically permanent. Records fair.

Monthly discharge of Blacksmith Fork above Utah Power & Light Co.'s dam, near Hyrum, Utah.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1913-14.				
December	89	65	79.6	4,890
January	109	74	85.7	5,270
February	94	74	81.6	4,530
March	182	87	124	7,620
April	610	139	354	21,100
May	508	262	386	23,700
June	299	170	212	12,600
July	168	148	156	9,590
August	150	130	144	8,850
September	148	130	138	8,210
The period				106,000
1914-15.				
October	122	98	109	6,700
November	110	94	102	6,070
December	117	90	106	6,520
January	108	68	93.4	5,740
February	99	89	93.6	5,200
March	98	84	91.9	5,650
April	114	86	103	6,130
May	107	94	101	6,210
June	105	90	97.5	5,800
July	90	74	82.0	5,040
August	75	68	70.8	4,350
September	86	70	76.5	4,550
The year	122	68	93.9	68,000
1915-16.				
October	81	80	80.9	4,970
November	84	78	80.0	4,760
December	77		71.0	4,370
January	73	65	68.5	4,210
February	87	66	74.0	4,260
March	467	77	176	10,800
April	900	214	454	27,000
May	622	223	371	22,800
June	236	163	194	11,500
July	161		152	9,350
August			129	7,930
September			124	7,380
The year	900		165	119,000
1916-17.				
October	129	107	113	6,950
November	107	90	97.8	5,820
December	96	72	89.2	5,480
January	86		82.7	5,080
February	92	71	80.1	4,450
March	110	72	81.5	5,010
April	593	102	228	13,600
May	1,300		682	41,900
June	593	282	436	25,900
July	274	195	228	14,000
August	204	169	180	11,100
September	167	142	156	9,280
The year	1,300	71	205	149,000

Monthly discharge of Blacksmith Fork above Utah Power & Light Co.'s dam, near Hyrum, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1917-18.				
October	142	133	138	8,480
November	131	119	126	7,500
December	119	110	114	7,010
January	109	95	102	6,270
February	119	87	104	5,780
March			[a] 160	9,840
April			[a] 215	12,800
May			[a] 265	16,300
June			[a] 150	8,930
July			[a] 135	8,300
August			123	7,560
September	110	99	105	6,250
The period		87	145	105,000
1918-19.				
October	112	91	99.0	6,090
November	95	84	92.1	5,480
December	91	78	86.3	5,310
January	82	66	79.4	4,880
February	84	78	81.4	4,520
March	150	78	98.0	6,030
April	252	114	167	9,940
May	239		166	10,200
June			112	6,660
July			85.0	5,230
August	85	77	79.6	4,890
September	85	78	79.8	4,750
The year	252	66	102	73,980
1919-20.				
October	87	74	78.9	4,850
November	78	67	73.1	4,350
December	77	39	67.1	4,130
January	73	68	69.5	4,270
February	73	65	68.3	3,930
March	97	68	77.0	4,730
April	284	88	161	9,580
May	777	303	573	35,200
June	364	177	233	13,900
July	175	141	153	9,410
August	148	124	133	8,180
September	130	110	123	7,320
The year	777	39	151	110,000

[a] Estimated.

BLACKSMITH FORK BELOW UTAH POWER & LIGHT CO.'S PLANT, NEAR HYRUM, UTAH.

LOCATION.—In sec. 2, T. 10 N., R. 2 E., 600 or 700 feet below heading of Hyrum power canal and mouth of Utah Power & Light Co.'s tailrace and 2½ miles east of Hyrum, Cache County.

DRAINAGE AREA.—Not measured.

RECORDS AVAILABLE.—July 19, 1900, to December 31, 1902; May 16, 1904, to December 31, 1910; April 15, 1914, to December 13, 1916. Station discontinued.

GAGE.—Stevens continuous water-stage recorder on right bank, installed April 15, 1915. Gage used 1904–1910 was vertical staff about 300 feet above present site and at different datum. Gage inspected by Joseph Appleyard.

DISCHARGE MEASUREMENTS.—Made by wading at various sections or from cable about 100 feet below gage. Conditions for measuring poor and there are many springs along this section of the river.

CHANNEL AND CONTROL.—Bed composed of gravel and boulders; steep. Banks low and covered with willows, but probably not overflowed except during extraordinary floods. Concrete wall about 10 feet below gage acts as control.

ICE.—Stage-discharge relation not usually affected by ice, on account of springs in the vicinity.

DIVERSIONS.—Water diverted above station by Hyrum power canal is returned to river about a quarter of a mile downstream. Utah Power & Light Co. diverts water about 2½ miles upstream, but the tailrace of this plant enters just above head of Hyrum canal.

REGULATION.—Flow at gage affected by operation of the two plants.

ACCURACY.—Records good.

Monthly discharge of Blacksmith Fork below Utah Power & Light Co.'s plant, near Hyrum, Utah.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1914.				
April 15–30	394	257	316	10,000
May	352	194	283	17,400
June	208	93	133	7,910
July	94	46	67.5	4,150
August	52	35	44.9	2,760
September	45	34	36.1	2,150
The period				44,400
1914–15.				
October	39	23	30.0	1,840
November	28	17	22.7	1,350
December	21	12	16.2	996
January	23	12	14.7	904
February	14	11	12.2	678
March	12	9	10.1	621
April	27	10	19.0	1,130
May	50	18	23.7	1,460
June	26	14	21.7	1,290
July	17	11	14.2	873
August	14	10	12.0	738
September	14	10	10.4	619
The year	50	9	17.3	12,500
1915–16.				
October	10	2	4.71	290
November	5	3	3.47	206
December	5	3	3.61	222
January	14	3	7.71	474
February	77	3	55.1	3,170
March	481	71	171	10,500
April	840	212	464	27,600
May	640	238	400	24,600
June	252	160	202	12,000
July	150	80	114	7,010
August	83	45	63.2	3,890
September	45	34	41.7	2,480
The year	840	2	127	92,400

BLACKSMITH'S FORK AT UTAH POWER & LIGHT CO.'S PLANT, NEAR HYRUM, UTAH.

LOCATION.—In sec. 11, T. 10 N., R. 1 E., immediately above wagon bridge, 300 feet above confluence of Utah Power & Light Co.'s tailrace with main stream, and 2½ miles east of Hyrum, Cache County.

DRAINAGE AREA.—Not measured.

RECORDS AVAILABLE.—April 15, 1914, to September 30, 1920.

GAGE.—Stevens continuous water-stage recorder on right bank; inspected by Joseph Appleyard.

DISCHARGE MEASUREMENTS.—Made by wading or from cable at gage.

CHANNEL AND CONTROL.—Bed composed of gravel overgrown with aquatic plants. Concrete cut-off wall about 10 feet below gage forms control.

ICE.—Stage-discharge relation not affected by ice, as low-water flow is maintained by springs a short distance above gage.

DIVERSIONS.—Water diverted for power development by Utah Power & Light Co. 2½ miles above station is returned to river 300 feet below it. During periods of low water entire flow is diverted and records obtained at gage represent inflow from springs between diversion dam and gage. The Hyrum power canal diverts 300 feet below gage at the mouth of the Utah Power & Light Co.'s tailrace. Station is above all diversions for irrigation.

REGULATION.—See diversions.

ACCURACY.—Stage-discharge relation practically permanent; not affected by ice. Rating curve well defined except for extreme low stages. Records excellent for high stages and good for low stages.

Monthly discharge of Blacksmith Fork at Utah Power & Light Co.'s plant, near Hyrum, Utah.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1914.				
April 15–30	450	211	306	9,710
May	371	165	260	16,000
June	158	43	74.1	4,410
July	144	44	74.1	4,560
August	63	14	27.2	1,670
September	22	14	15.8	940
The period				37,300
1914–15.				
October	89	14	33.6	2,070
November	23	11	14.8	881
December	16	11	12.2	750
January	12	9.6	11.1	682
February	13	9.6	11.6	644
March	13	11	11.6	713
April	20	11	13.9	827
May	12	10	10.8	664
June	11	8.6	9.53	567
July	9.6	9.0	9.17	564
August	10	9.6	9.83	604
September	11	9.6	10.1	601
The year	89	8.6	13.2	9,570
1915–16.				
October	10	8	9.16	563
November	10	10	10.0	595
December	10	9	9.71	597
January	15	10	11.5	707
February	17	15	15.6	897
March	402	14	104	6,400
April	754	132	344	20,500
May	445	132	240	14,800
June	143	48	86.5	5,150
July	42	23	30.8	1,890
August	26	10	16.4	1,010
September	14	10	10.8	643
The year	754	8	73.9	53,800
1916.				
October	42	26	35.2	2,160
November	34	23	29.3	1,740
December 1–13	30	19	23.8	614
				4,510

WEST SIDE CANAL NEAR COLLINSTON, UTAH.

LOCATION.—In NW. ¼ sec. 34, T. 13 N., R. 2 W., at Wheelon siding on Oregon Short Line Railroad, 600 feet below penstock of Utah Power & Light Co.'s Wheelon plant, 1,000 feet northwest of gaging station on Bear River, and 4 miles north of Collinston, Box Elder County.

RECORDS AVAILABLE.—June 1, 1912, to September 30, 1920.

GAGE.—Friez water-stage recorder on left bank installed May 22, 1914, at same site and datum as inclined gage used prior to that time.

DISCHARGE MEASUREMENTS.—Made from footbridge at gage or by wading.

CHANNEL AND CONTROL.—Bed composed of earth and gravel. Banks steep and clean. Control not well defined; stage-discharge relation probably affected by vegetal growth and slight silt deposit.

ICE.—Stage-discharge relation seriously affected at times by ice.

DIVERSIONS.—Water is taken out of canal, about 600 feet above gage, for the power plant, and, if necessary, water can also be siphoned across the river to Hammond ditch.

REGULATION.—Flow can be regulated at headgates and also at forebay of power plant.

ACCURACY.—Stage-discharge relation not permanent. Records good except during winter, for which they are poor.

COOPERATION.—Record of mean daily gage height and part of discharge measurements furnished by Utah Power & Light Co.

Monthly discharge of West Side canal near Collinston, Utah.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1912.				
June	548	14	438	26,100
July	563	392	476	29,300
August	392	128	284	17,500
September	435	220	337	20,100
The period				93,000
1912-13.				
October	227	122	165	10,100
November	91	53	71.7	4,270
December	79	46	63.7	3,920
January	104	68	88.0	5,410
February	86	0	30.5	1,690
March	19	13	17.5	1,080
April	20	0	4.6	274
May	529	9	259	15,900
June	534	274	414	24,600
July	555	0	360	22,100
August	494	412	464	28,500
September	390	144	226	13,400
The year	555	0	182	131,000
1913-14.				
October	151	22	127	7,810
November	135	110	118	7,020
December	114	42	69.6	4,280
January	90	27	45.9	2,820
February	31	17	25.8	1,430
March	20	1.5	16.5	1,010
April	17	1.5	4.97	296
May	498	1.5	242	14,900
June	492	81	317	18,900
July	492	376	450	27,700
August	526	388	463	28,500
September	512	162	292	17,400
The year	526	1.5	182	132,000

Monthly discharge of West Side canal near Collinston, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet
	Maximum.	Minimum.	Mean.	
1914–15.				
October	102	94	98.6	6,090
November	101	85	94.2	5,610
December	94	86	91.0	5,600
January	99	70	90.5	5,560
February	91	80	84.8	4,710
March	91	84	86.7	5,330
April	111	88	103	6,130
May	104	54	88.6	5,450
June	97	67	77.7	4,620
July	83	62	66.7	4,100
August	71	60	65.4	4,020
September	83	67	71.0	4,220
The year	111	54	84.8	61,400
1915–16.				
October	168	82	117	7,190
November	86		58.0	3,450
December			37.2	2,290
January			35.0	2,150
February		0	17.8	1,020
March	7	0	2.74	168
April	37	0	4.50	268
May	411	0	195	12,000
June	510	299	438	26,100
July	524	464	499	30,700
August	532	464	497	30,600
September	493	233	377	22,400
The year	532	0	190	138,000
1916–17.				
October	246	100	133	8,180
November	125	26	80.7	4,800
December	93	41	58.9	3,620
January			36.4	2,240
February			35.0	1,940
March			21.8	1,340
April	7	0	1.57	93
May	86	0	32.8	2,020
June	490	69	261	15,500
July	554	469	507	31,200
August	513	447	479	29,500
September	493	223	421	25,100
The year	554	0	137	126,000
1917–18.				
October	269	148	196	12,100
November	182	119	139	8,270
December		45	59.3	3,650
January			50	3,070
February			50	2,780
March	54	0	25.4	1,560
April	21	0	1.70	101
May	474	74	360	22,100
June	539	382	492	29,300
July	539	132	487	29,900
August	512	58	461	28,300
September	473	365	423	25,200
The year	539	0	230	166,000
1918–19.				
October	359	146	255	15,700
November	156	60	131	7,800
December	68	30	44.2	2,720
January	80	57	74.9	4,610
February	65	38	55.8	3,100
March	59	0	39.1	2,400
April	61	0	6.1	360
May	542	40	381	23,400
June	557	357	496	29,500
July	554	484	538	33,100
August	540	484	524	32,200
September	456	276	375	22,300
The year	557	0	245	177,000

Monthly discharge of West Side canal near Collinston, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1919–20.				
October	298	98	162	9,960
November	116	68	98.5	5,860
December	76	29	51.9	3,190
January	63	37	53.4	3,280
February	55	0	22.9	1,320
March	0	0	0	0
April	0	0	0	0
May	498	0	130	7,990
June	589	506	565	33,600
July	609	573	594	36,500
August	597	336	550	33,800
September	460	154	344	20,500
The year	609	0	215	156,000

NOTE.—Monthly discharge, 1917–18, computed by U. S. Geol. Survey.

HAMMOND (EAST SIDE) CANAL NEAR COLLINGSTON, UTAH.

LOCATION.—In NW. ¼ sec. 34, T. 13 N., R. 2 W., at Wheelon siding on Oregon Short Line Railroad, 400 feet below penstock of Utah Power & Light Co. and 4 miles north of Collinston, Box Elder County.

RECORDS AVAILABLE.—June 1, 1912, to September 30, 1920.

GAGE.—Friez water-stage recorder on right bank, installed May 22, 1914, at same side and datum as inclined staff used until that date; inspected by H. G. Stone.

DISCHARGE MEASUREMENTS.—Made from footbridge at gage or by wading.

CHANNEL AND CONTROL.—Bed composed of earth and gravel. Control not well defined. Canal subject to small slides, which no doubt affect stage-discharge relation.

WINTER FLOW.—No record during the winter.

DIVERSIONS.—Water taken from this canal about 400 feet above gage for power plant.

REGULATION.—Flow can be regulated at headgates and by means of a wasteway at power plant fore bay; is also affected by operation of plant.

ACCURACY.—Stage-discharge relation permanent. Records good.

COOPERATION.—Records of mean daily gage height and part of discharge measurements furnished by Utah Power & Light Co.

Monthly discharge of Hammond (East Side) canal near Collinston, Utah.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1912.				
June	90	66	75.6	4,500
July	113	63	91.2	5,610
August	82	62	72.4	4,450
September	84	18	53.6	3,190
The period				17,700
1912–13.				
October 1–28	38	2.8	9.5	528
May 24–31	69	42	53.8	853
June	113	0	59.0	3,510
July	93	6.3	63.5	3,900
August	99	5.6	82.3	5,060
September	87	16	40.5	2,410
The period				16,000

Monthly discharge of Hammond (East Side) canal near Collinston, Utah—Contd.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1913–14.				
October	19	0	6.76	416
November 1–17	7.2	6.3	6.40	216
May	87	3	62.9	3,870
June	105	40	67.1	3,990
July	95	4	75.6	4,650
August	100	87	92.7	5,700
September	95	38	65.8	3,920
1914–15.				
October	183	139	156	9,590
November	139	48	86.6	5,150
December 1–14	52	45	48.5	1,350
February 21–28	23	17	18.8	298
March	22	12	17.9	1,100
April	25	0	6.43	383
May	176	24	107	6,580
June	516	87	308	18,300
July	503	451	479	29,500
August	490	301	416	25,600
September	451	168	255	15,200
1915–16.				
October	17	3.9	10.5	646
November 1–18	5.7	0	4.18	149
May 3–21	107	0	49.7	2,860
June	99	72	88.8	5,280
July	120	86	107	6,580
August	122	99	113	6,950
September	128	25	94.2	5,610
1916–17.				
October 1–23	39	0	16.0	730
June 16–30	113	9.4	51.8	1,540
July	113	69	96.8	5,950
August	111	55	91.0	5,600
September	104	9.2	68.4	4,070
The period				17,900
1917–18.				
October	12	8	10.9	670
November	11	8	8.80	524
December	7	0	.42	26
January	0	0	.00	0
February	0	0	.00	0
March	0	0	.00	0
April	0	0	.00	0
May	82	12	50.9	3,130
June	100	54	85.8	5,110
July	111	95	101	6,210
August	120	108	113	6,950
September	114	30	85.8	5,110
The year	120	0	38.3	27,700
1918–19.				
October	74	10	24.0	1,480
November	11	0	5.5	325
December	0	0	0	0
January	0	0	0	0
February	0	0	0	0
March	0	0	0	0
April	0	0	0	0
May	100	11	73.3	4,510
June	113	56	80.4	4,780
July	136	4	82.9	5,100
August	137	117	127	7,810
September	125	67	89.1	5,300
The year	137	0	40.5	29,300
1919–20.				
October	74	10	23.2	1,430
November	12	0	7.7	458
December	0	0	0	0
January	0	0	0	0
February	0	0	0	0
March	0	0	0	0
April	0	0	0	0

NOTE.—Monthly discharge, 1917–18, computed by U. S. Geol. Survey.

Monthly discharge of Hammond (East Side) canal near Collinston, Utah—Contd.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1919-20.				
May	86	0	23.5	1,440
June	137	44	107	6,370
July	142	110	128	7,870
August	138	46	117	7,190
September	123	24	80.5	4,790
The year	142	0	40.7	29,500

LITTLE MALAD RIVER NEAR MALAD, IDAHO.

Location.—In sec. 36, T. 12 S., R. 34 E., at Schwartz ranch, three-fourths mile below Kerns & Tovey reservoir site, 2½ miles above Elkhorn reservoir site, and 14 miles northwest of Malad.

Records available.—August 2, 1911, to August 16, 1913, when station was discontinued.

Drainage area.—Not measured.

Gage.—Inclined staff about 175 feet above a 3-foot fall in the river.

Channel and control.—Small boulders embedded in clay and hardpan; shifts occasionally; right bank may be overflowed at extreme high stages.

Discharge measurements.—Made by wading about 150 feet above the gage.

Winter flow.—Discharge relation affected by ice for short periods during the coldest part of the winter.

Accuracy.—Records good.

Monthly discharge of Little Malad River near Malad, Idaho.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1911.				
August 7-31	13	13	13.0	645
September	13	13	13.0	774
1911-12.				
October	18	13	13.2	812
November	18	13	14.2	845
December	13	13	13.0	799
January	22	13	15.8	972
February	22	17.5	18.2	1,050
March	50	17.5	29.6	1,820
April	57	27	35.8	2,130
May	39	22	28.9	1,780
June	32	17.5	24.8	1,480
July	46	17.5	21.2	1,300
August	61	13.5	22.4	1,380
September	17.5	13.5	17.0	1,010
The year	61	13	21.2	15,400
1912-13.				
October	17.5	17.5	17.5	1,080
November	17.5	17.5	17.5	1,040
December	17.5	13.5	13.9	855
January	13.5	13.5	13.5	830
February	13.5	13.5	13.5	750
March	45	13.5	18.0	1,110
April	61	22	26.4	1,570
May	27	22	22.2	1,360
June	22	17.5	19.6	1,170
July	22	15.5	18.1	1,110
August 1-16	17.5	17.5	17.5	555
The period				11,400

Note.—Owing to low range of stage, monthly estimates are considered very reliable.

BOX ELDER CREEK AT BRIGHAM, UTAH.

LOCATION.—In sec. 13, T. 9 N., R. 2 W., Salt Lake base and meridian, at highway bridge three blocks north of courthouse at Brigham, Utah.

RECORDS AVAILABLE.—May 20, 1909, to Dec. 31, 1912; August 5, 1918, to September 30, 1920.

DRAINAGE AREA.—Not measured.

GAGE.—Vertical staff. Datum was lowered 2 feet February 24, 1910.

CHANNEL.—Shifting.

DISCHARGE MEASUREMENTS.—Made by wading or from bridge at the gage.

WINTER FLOW.—Ice forms at this station and affects the relation of gage height to discharge during certain periods.

DIVERSIONS.—During the summer the entire flow of the creek is used for irrigation above the station.

ACCURACY.—Records poor, because of constantly shifting stream bed and unreliable gage heights.

Monthly discharge of Box Elder Creek at Brigham, Utah.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1909.				
May 20-31	98	17	52	1,240
June	37	0	12	714
July	0	0	0	0
August	0	0	0	0
September	6	0	2	119
The period				2,073
1909-10.				
October	2	1	2	123
November	52	28	32	1,900
December [a]			20	1,230
January			20	1,230
February	30	22	27	1,500
March	88	14	31	1,910
April	85	26	54	3,210
May	35	6	21	1,290
June	9	0	2	119
July	0	0	0	0
August	0	0	0	0
September [a]			10	595
The year				13,100
1910-11.				
October [a]			15	922
November [a]			15	893
December [a]			15	922
January	147	15	37.7	2,320
February	159	10	25.9	1,440
March	48	18	33.0	2,030
April	56	23	35.6	2,120
May	41	0	12.2	750
The period				11,400
1911-12.				
October	7	5	5.8	360
November	13	7	9.7	580
December	18	7	11.2	689
January	12	9	10.5	646
February	20	12	13.9	800
March	28	15	23.5	1,440
April	56	26	36.8	2,190
May	122	23	59.2	3,640
June	17	0	2.7	161
July	0	0	0	0
August	0	0	0	0
September	0	0	0	0
The year	122	0	14.4	10,500

[a] Estimated for month.

NOTE.—Discharge Mar. 6-25, 1910, estimated at 25 second-feet. Creek dry from May 22 to Sept. 30, 1911.

Monthly discharge of Box Elder Creek at Brigham, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1918.				
August 5-31			25.7	1,380
September			25.4	1,510
1918-19.				
October	37	25	27.1	1,670
November	34		29.5	1,760
December			24.6	1,510
January			22.9	1,410
February	46		27.6	1,530
March	63	28	39.2	2,410
April	52	38	46.3	2,760
May	47	27	36.0	2,210
June	28	21	23.0	1,370
July	26	23	24.9	1,530
August	22	19	20.8	1,280
September	25	21	22.5	1,340
The year	63	19	28.7	20,800
1919-20.				
October	32	24	30.2	1,860
November	34	29	31.2	1,860
December	33	19	30.2	1,860
January			30.1	1,850
February	39	30	32.4	1,860
March	48	32	38.5	2,370
April	80	39	53.4	3,180
May	76	35	57.1	3,510
June	36	21	26.3	1,560
July	24	20	22.0	1,350
August	26	21	21.9	1,350
September	27	23	25.3	1,510
The year	80	19	33.2	24,100

WEBER RIVER BASIN.

WEBER RIVER NEAR OAKLEY, UTAH.

LOCATION.—In NE. ¼ sec. 15, T. 1 S., R. 6 E., near mouth of canyon, 3 miles above Oakley, Summit County. South Fork of Weber River enters 2 miles above station, and Beaver or Kamas Creek 6 miles below.

DRAINAGE AREA.—163 square miles.

RECORDS AVAILABLE.—October 22, 1904, to September 30, 1920.

GAGE.—Inclined staff on left bank about a quarter of a mile above the upper ditch diverting from Weber River. Read by John Franson.

DISCHARGE MEASUREMENTS.—Made from cable at gage or by wading.

CHANNEL AND CONTROL.—Bed composed of gravel and boulders; steep and rough but apparently fairly permanent. One channel at all stages.

ICE.—Stage-discharge relation seriously affected by ice.

DIVERSIONS.—None above station but several canals take out below for irrigation use around Oakley and between Oakley and Kamas.

REGULATION.—None.

ACCURACY.—Stage-discharge relation permanent. Records obtained by use of rating table for stages above 200 second-feet, good; others fair.

Monthly discharge of Weber River near Oakley, Utah.

Month.	Discharge in second-feet.			Run-off in acre-feet
	Maximum.	Minimum.	Mean.	
1904-5.				
October 23-31	82	82	82.0	1,464
November 1-26	100	66	72.1	3,718
March	73	58	64.3	3,954
April	241	66	124	7,379
May	686	180	372	22,870
June	1,580	312	808	48,080
July	275	90	156	9,592
August	90	58	70.4	4,329
September	100	52	58.9	3,505
The period				104,900
1905-6.				
October	100	58	73.0	4,488
November	66	58	59.9	3,564
April	516	66	182	10,800
May	1,310	225	760	46,700
June	2,480	655	1,150	68,400
July	748	154	419	25,800
August	312	109	153	9,410
September	180	82	116	6,900
The period				176,000
1906-7.				
October	82	66	75	4,600
November	73	58	69	2,580
January			66	4,060
February	73	66	67	3,720
March	130	58	91	5,610
April	690	109	341	20,300
May	1,850	360	847	52,100
June	2,360	840	1,600	95,200
July	4,010	385	1,660	102,000
August	410	142	226	13,900
September	142	90	106	6,310
The period				310,000
1907-8.				
October	90	73	86	5,260
November	73	66	72	4,260
December			74	4,560
January			58	3,570
February			52	3,000
March	73	46	52	3,210
April	315	58	160	9,520
May	542	194	415	25,500
June	2,490	360	1,120	66,600
July	975	154	414	25,500
August	295	90	160	9,840
September	167	73	92	5,490
The year	2,490	46	230	166,000
1908-9.				
October	142	109	128	7,870
November	120	66	88	5,220
December			69	4,270
January			66	4,060
February			58	3,220
March			58	3,570
April	315	58	149	8,870
May	1,620	241	860	49,200
June	4,110	1,110	2,380	142,000
July	1,890	243	682	41,900
August	407	166	232	14,300
September	279	129	161	9,580
The year	4,110	58	411	294,000

Monthly discharge of Weber River near Oakley, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1909–10.				
October	129	99	114	7,010
November	153	99	112	6,660
December			95	5,840
January			[a] 85	5,230
February			[a] 75	4,170
March	412	80	180	11,100
April	1,090	205	515	30,600
May	1,600	568	952	58,500
June	1,790	190	608	36,200
July	190	96	141	8,670
August	120	74	81	4,970
September	85	65	72	4,280
The year	1,790	65	252	183,000
1910–11.				
October	96	74	80	4,940
November	74	65	68	4,060
December	878	65	260	16,000
January			[a] 75	4,610
February			[a] 85	4,720
March	96	60	70.2	4,320
April	364	120	188	11,200
May	948	320	715	44,000
June	2,220	625	1,380	82,100
July	568	74	287	17,600
August	133	64	90.9	5,590
September	96	55	65.3	3,890
The year	2,220	55	280	203,000
1911–12.				
October	133	74	85.2	5,240
November	96	74	76.5	4,550
December			[a] 75	4,610
January			[a] 65	4,000
February			[a] 75	4,310
March			82	5,040
April	120	64	100	5,950
May	1,510	108	587	36,100
June	3,850	900	1,710	102,000
July	811	205	365	22,400
August	240	120	165	10,100
September	146	108	120	7,140
The year	3,850		292	211,000
1912–13.				
October	205	108	132	8,200
November	146	108	122.5	7,300
January			67.8	4,300
February			69.8	3,890
March			83.4	5,170
April	454	114	228	13,600
May	1,690	354	831	51,100
June	1,250	308	680	40,500
July	508	154	232	14,300
August	198	92	122	7,500
September	168	103	129	7,680
The period	1,690		224	163,500
1913–14.				
October	168	114	141	8,670
November	127	72	108	6,430
December	86	70	81	4,980
January	114	82	86.2	5,300
February	92	70	80.8	4,490
March	127	72	94.5	5,810
April	508	127	289	17,200
May	2,210	429	1,280	78,700
June	2,310	610	1,280	76,200
July	580	205	319	19,600
August	240	103	139	8,550
September	103	80	91.5	5,440
The year	2,310	70	331	241,400

[a] Estimated.

Monthly discharge of Weber River near Oakley, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1914–15.				
October	143	103	120	7,380
November	103		87.9	5,230
December			75	4,610
January			80	4,920
February	91	70	86.1	4,780
March	91	70	82.2	5,050
April	580	91	225	13,400
May	770	222	439	27,000
June	1,230	440	782	46,500
July	415	91	194	11,900
August	91	62	74.9	4,610
September	143	62	86.5	5,150
The year	1,230	62	194	141,000
1915–16.				
October	102	75	82.3	5,060
November	112	75	91.2	5,430
December			90.6	5,570
January			65.0	4,000
February			69.2	3,980
March	192		102	6,270
April	775	124	301	17,900
May	1,240	519	728	44,800
June	1,940	707	1,310	78,000
July	674	92	279	17,200
August	227	92	124	7,620
September	92	75	79.6	4,740
The year	1,940		276	201,000
1916–17.				
October	161	92	123	7,560
November		68	95.7	5,690
December	161	75	98.8	6,080
January			49.0	3,010
February			60	3,330
March			70.9	4,360
April	358	75	140	8,330
May	995	161	541	33,300
June	2,760	642	1,730	103,000
July	1,840	260	766	47,100
August	222	101	136	8,360
September	110	78	92.4	5,500
The year	2,760	0	325	236,000
1917–18.				
October	85	66	77.5	4,770
November	78		74.9	4,460
December			66.0	4,060
January			66.0	4,060
February			[a] 62.0	3,440
March	110		78.8	4,850
April	241	92	134	7,970
May	710	158	525	32,300
June	2,110	260	1,120	66,600
July	241	92	147	9,040
August	92	60	75.0	4,610
September	72	60	62.6	3,720
The year	2,110		207	150,000
1918–19.				
October	186	62	102	6,270
November	76		64.0	3,810
December			65	4,000
January			50	3,070
February			56.3	3,130
March	93	50	60.3	3,710
April	410	76	164	9,760
May	1,580	430	791	48,600
June	667	156	416	24,800
July	141	81	97.7	6,010
August	84	56	64.7	3,980
September	141	56	68.3	4,060
The year	1,580		167	121,000

[a] Estimated.

Monthly discharge of Weber River near Oakley, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1919-20.				
October	115	62	91.4	5,620
November	84	69	75.9	4,520
December	76		55.8	3,430
January			56.2	3,460
February			62.0	3,570
March			65.1	4,000
April	141	69	90.9	5,410
May	2,040	170	961	59,100
June	2,340	562	1,330	79,100
July	516	131	273	16,800
August	170	93	120	7,380
September	93	76	85.3	5,080
The year	2,340		272	197,000

WEBER RIVER AT DEVILS SLIDE, UTAH.

LOCATION.—In SW. ¼ sec. 19, T. 4 N., R. 4 E., 300 feet north of hotel and 500 feet downstream from highway bridge at Devils Slide, Morgan County. Lost Creek enters from right a quarter of a mile above station.

DRAINAGE AREA.—1,090 square miles.

RECORDS AVAILABLE.—February 1, 1905, to September 30, 1920.

GAGE.—Vertical staff on left bank just above cable, installed September 21, 1915, at same site and datum as inclined staff used March 9, 1912, to September 20, 1915. Original gage used February 1, 1905, to March 8, 1912, was an inclined staff at same datum, but on opposite bank of river. Read by A. E. Lucas.

DISCHARGE MEASUREMENTS.—Made from cable or by wading.

CHANNEL AND CONTROL.—Bed composed of gravel and sand; shifts occasionally. One channel at all stages.

ICE.—Stream does not freeze at this point, but there is occasionally a little shore ice; stage-discharge relation not seriously affected.

DIVERSIONS.—A number of canals divert water from Weber River and tributaries in the vicinity of Oakley and Kamas for irrigation and domestic use.

REGULATION.—None, other than diversions for irrigation.

ACCURACY.—Records good.

Monthly discharge of Weber River at Devils Slide, Utah.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1905.				
February	214	114	175	9,719
March	319	195	246	15,130
April	605	214	346	20,590
May	782	368	574	35,290
June	1,650	214	876	52,130
July	195	50	119	7,317
August	73	50	52.2	3,210
September	128	50	73	4,344
The period				148,000

Monthly discharge of Weber River at Devils Slide, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1905–6.				
October	160	99	115	7,071
November	178	144	157	9,342
December	178	73	112	6,887
January	274	99	145	8,920
February	233	99	157	8,720
March	985	160	327	20,100
April	1,300	368	802	47,700
May	2,940	754	1,660	102,000
June	3,150	856	1,850	110,000
July	1,090	160	474	29,100
August	627	152	268	16,500
September	472	195	280	16,700
The year	3,150	73	529	383,000
1906–7.				
October	236	177	192	11,800
November	240	177	215	12,800
December	368	166	236	14,500
January	240	166	205	12,600
February	1,170	221	408	22,700
March	2,430	202	680	41,800
April	3,570	646	1,930	115,000
May	4,620	1,530	2,750	169,000
June	3,420	1,730	2,460	146,000
July	2,790	599	1,600	98,400
August	655	261	382	23,500
September	395	217	280	16,700
The year	4,620	166	945	685,000
1907–8.				
October	305	217	271	16,700
November	261	217	258	15,400
December	305	217	240	14,800
January	261	217	226	13,900
February	261	217	229	13,200
March	545	175	317	19,500
April	773	261	440	26,200
May	977	545	778	47,800
June	2,110	773	1,280	76,200
July	1,050	217	561	34,500
August	349	217	252	15,500
September	545	217	264	15,700
The year	2,110	175	426	309,000
1908–9.				
October	443	261	330	20,300
November	305	217	262	15,600
December	261	217	248	15,200
January	1,210	217	667	41,000
February	395	261	307	17,000
March	655	305	426	26,200
April	3,060	655	1,480	88,100
May	5,120	1,730	3,260	200,000
June	5,120	2,550	3,460	206,000
July	2,320	443	971	59,700
August	599	349	418	25,700
September	655	395	494	29,400
The year	5,120	217	1,027	744,000
1909–10.				
October	395	305	370	22,800
November	837	305	394	23,400
December	305	305	305	18,800
January	349	305	319	19,600
February	395	305	348	19,300
March	1,550	713	1,320	81,200
April	2,550	1,210	1,920	114,000
May	1,890	740	1,230	75,600
June	1,100	160	493	29,300
July	160	160	160	9,840
August	160	132	136	8,360
September	132	106	120	7,140
The year	2,550	106	594	429,000

Monthly discharge of Weber River at Devils Slide, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1910–11.				
October	190	132	168	10,300
November	190	190	190	11,300
December	262	190	198	12,200
January	2,270	190	290	17,800
February	2,070	265	399	22,200
March	1,600	265	531	32,600
April	1,090	472	593	35,300
May	1,600	870	1,190	73,200
June	2,070	525	1,350	80,300
July	495	157	218	13,400
August	157	80	119	7,320
September	103	80	82.3	4,900
The year	2,270	80	444	321,000
1911–12.				
October	157	129	155	9,530
November	157	157	157	9,340
December	157	157	157	9,650
January			a140	8,610
February			a160	9,200
March	398		260	16,000
April	920	412	621	37,000
May	3,090	604	1,610	99,000
June	3,910	796	2,050	122,000
July	740	187	308	18,900
August	408	202	264	16,200
September	288	211	238	14,200
The year	3,910		510	370,000
1912–13.				
October	500	211	278	17,100
November	344	201	271	16,100
December	288	128	170	10,500
January	193	105	156	9,590
February	178	114	154	8,550
March	1,010	144	252	15,500
April	2,460	595	992	59,000
May	1,650	725	1,130	69,500
June	1,650	274	765	45,500
July	855	144	377	23,200
August	535	135	219	13,500
September	265	185	232	13,800
The year	2,460	105	417	302,000
1913–14.				
October	500	233	302	18,600
November	320	188	269	16,000
December	258	115	191	11,700
January	560	145	242	14,900
February	495	136	224	12,400
March	722	244	476	29,300
April	2,080	560	1,320	78,500
May	3,420	1,440	2,380	146,000
June	2,740	575	1,540	91,600
July	695	330	425	26,100
August	557	88	182	11,200
September	142	95	112	6,660
The year	3,420	88	640	463,000
1914–15.				
October	545	152	280	17,200
November	244	158	206	12,300
December	227	100	159	9,780
January	235	142	178	10,900
February	280	176	216	12,000
March	617	188	316	19,400
April	849	380	597	35,500
May	786	273	482	29,600
June	1,430	320	891	53,000
July	273	59	117	7,190
August	75	50	65.2	4,010
September	182	48	129	7,680
The year	1,430	48	302	219,000

Monthly discharge of Weber River at Devils Slide, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1915–16.				
October	102	75	82.3	5,060
November	112	75	91.2	5,430
December			90.6	5,570
January			65.0	4,000
February			69.2	3,980
March	192		102	6,270
April	775	124	301	17,900
May	1,240	519	728	44,800
June	1,940	707	1,310	78,000
July	674	92	279	17,200
August	227	92	124	7,620
September	92	75	79.6	4,740
The year	1,940		276	201,000
1916–17.				
October	492	202	341	21,000
November	309	169	240	14,300
December	288	141	210	12,900
January	249		163	10,000
February	268	163	191	10,600
March	651	163	224	13,800
April	2,670	276	1,060	63,100
May	4,120	279	2,360	145,000
June	3,610	2,390	2,910	173,000
July	2,390	315	952	58,500
August	415	176	239	19,700
September	251	153	197	11,700
The year	4,120			549,000
1917–18.				
October	231	194	205	12,600
November	271	212	232	13,800
December	263	176	233	14,300
January	247	133	202	12,400
February	280	127	199	11,100
March	836	176	416	25,600
April	723	415	535	31,800
May	1,190	654	839	51,600
June	2,280	280	1,300	77,400
July	353	113	201	12,400
August	113	69	85.7	5,270
September	176	69	100	5,950
The year	2,280	69	379	274,000
1918–19.				
October	339	153	244	15,000
November	280	159	227	13,500
December	394		186	11,400
January	140	99	125	7,690
February	153	121	133	7,390
March	875	113	350	21,500
April	926	315	560	33,300
May	1,630	738	1,090	67,000
June	1,050	51	376	22,400
July	57	38	43.9	2,700
August	159	34	50.2	3,090
September	94	31	69.3	4,120
The year	1,630	31	289	209,000
1919–20.				
October	243	105	185	11,400
November	271	133	230	13,700
December	239	121	166	10,200
January	159	105	139	8,550
February	315	127	176	10,100
March	499	153	246	15,100
April	1,410	190	616	36,700
May	5,500	1,050	3,060	188,000
June	3,250	689	1,710	102,000
July	665	127	236	14,500
August	257	151	190	11,700
September	232	136	181	10,800
The year	5,500	105	596	433,000

JORDAN RIVER BASIN.

JORDAN RIVER NEAR LEHI, UTAH.

LOCATION.—In sec. 25, T. 5 S., R. 1 W., 800 feet below pump house at outlet of Utah Lake and 4 miles southwest of Lehi, Utah County.

DRAINAGE AREA.—2,570 square miles.

RECORDS AVAILABLE.—May 30 to December 31, 1904; July 22, 1913, to September 30, 1920.

GAGE.—Vertical staff in stilling well on right bank about 25 feet above bridge January 6, 1914, to September 30, 1920; read by W. A. Knight. Gage used May 30 to December 31, 1904, and July 22, 1913, to January, 5, 1914, was vertical staff nailed to upstream side of right bridge abutment; same datum 1904–1920.

DISCHARGE MEASUREMENTS.—Made from cable about 400 feet above gage or by wading.

CHANNEL AND CONTROL.—Bed composed of clay and hardpan. Banks clean and low; not subject to overflow. One channel at the gage. Area slightly constricted below by highway bridge. Slope is very flat and stage-discharge relation may be slightly affected when flashboards are placed on the old impounding dam in Jordan Narrows, 6 miles north of the station (12 miles by river).

ICE.—Stage-discharge relation seldom seriously affected by ice. During unusually cold weather, however, the river sometimes freezes over below station and the open-channel rating is not applicable.

DIVERSIONS.—None above the station. In the Narrows about 6 miles north (several miles farther by river) a number of large canals divert for irrigation in Salt Lake Valley and for use by the smelters, etc., in the vicinity of Garfield.

REGULATIONS.—During the irrigation season, when the natural flow from Utah Lake is inadequate for the demands below, water is pumped from the lake into Jordan River. A pumping plant with a capacity of about 800 cubic feet per second is at outlet of lake, 800 feet above gage, and is owned and operated by various companies interested in the stream.

ACCURACY.—Stage-discharge relation not permanent, because of slight shifts in control, variable effect of wind on both river and lake, increased velocities due perhaps to pumping, and possible backwater from flashboards on dam at Jordan Narrows. Records fair.

Monthly discharge of Jordan River near Lehi, Utah.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1904.				
May 30-31	414	250	304	18, 090
June	440	371	422	25, 110
July	440	354	410	25, 210
August	414	367	402	24, 720
September	406	320	392	23, 330
October, 22 days	320	23	192	8, 363
November	26	24	25. 1	1, 494
December	38	26	28. 1	1, 728
The period				128, 000
1913.				
July 22-31	647	306	578	11, 500
August	647	569	607	37, 300
September	647	111	469	27, 900
The period				76, 700

Monthly discharge of Jordan River near Lehi, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1913–14.				
October	145	112	130	7,990
November	154	42	78.4	4,660
December	137	64	104	6,400
January	407	131	203	12,500
February	482	389	430	23,900
March	521	367	494	30,400
April	646	515	578	34,400
May	794	511	705	43,300
June	787	699	751	44,700
July	730	425	625	38,400
August	646	463	555	34,100
September	644	312	521	31,000
The year	794	42	431	312,000
1914–15.				
October	352	112	208	12,800
November	112	112	112	6,660
December	457	112	266	16,400
January	484	450	468	28,800
February	594	484	546	30,300
March	642	596	623	38,300
April	656	463	624	37,100
May	646	425	602	37,000
June	710	472	642	38,200
July	755	662	707	43,500
August	676	431	644	39,600
September	640	247	456	27,100
The year	755	112	491	356,000
1915–16.				
October	284	228	233	14,300
November	230	68	117	6,960
December	120	28	90.2	5,550
January	142	35	90.6	5,570
February	347	144	262	15,100
March	474	303	389	23,900
April	716	392	515	30,600
May	597	464	565	34,700
June	702	534	612	36,400
July	755	648	704	43,300
August	726	640	673	41,400
September	652	338	563	33,500
The year	755	28	402	291,000
1916–17.				
October	308	126	178	10,900
November	209	114	168	10,000
December	------	132	165	10,100
January	331	206	293	18,000
February	465	319	373	20,700
March	514	457	492	30,300
April	639	498	549	32,700
May	862	540	731	44,900
June	922	720	880	52,400
July	922	692	794	48,800
August	724	560	642	39,500
September	564	408	513	30,500
The year	922	114	482	349,000
1917–18.				
October	564	408	477	29,300
November	484	446	472	28,100
December	524	446	509	31,300
January	606	496	566	34,800
February	661	604	624	34,700
March	751	604	686	42,200
April	753	604	712	42,400
May	699	594	658	40,500
June	692	604	662	39,400
July	707	644	678	41,700
August	654	624	640	39,400
September	622	196	452	26,900
The year	753	196	594	431,000

Monthly discharge of Jordan Rioer near Lehi, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1918–19.				
October	195	149	174	10, 700
November	195	154	167	9, 940
December	256	172	215	13, 200
January	217	138	178	10, 900
February	347	203	274	15, 200
March	451	383	412	25, 300
April	520	410	471	28, 000
May	773	471	697	42, 900
June	820	625	753	44, 800
July	802	712	760	46, 700
August	684	0	533	32, 800
September	642	0	519	30, 900
The year	820	0	430	311, 000
1919–20.				
October	453	0	44. 5	2, 740
November	0	0	0	0
December	0	0	0	0
January	0	0	0	0
February	0	0	0	0
March	0	0	0	0
April	0	0	0	0
May	810	0	314	19, 300
June	812	712	768	45, 700
July	810	762	787	48, 400
August	782	656	750	46, 100
September	654	271	566	33, 700
The year	812	0	270	196, 000

SUMMIT CREEK NEAR SANTAQUIN, UTAH.

Location.—In sec. 12, T. 10 S., R. 1 E., at power plant of Utah Power & Light Co., 1 mile from Santaquin, Utah County.

Drainage area.—27.5 square miles.

Records available.—March 8, 1910, to September 30, 1916.

Gage.—Hook gage at a 4-foot, rectangular, sharp-crested weir with complete end contractions, in the power-plant tailrace, and a vertical staff above a similar 5-foot weir in the main creek; there is also a vertical staff fastened to a cottonwood tree on left bank of creek about 250 yards above the power house.

Discharge measurements.—Made by wading.

Channel and control.—Bed of rocks and coarse gravel; may shift slightly. Banks high and clean. Controls for both gages formed by weirs. One channel at all stages at upper gage in creek.

Ice.—Stage-discharge relation not seriously affected by ice.

Diversions.—Above all irrigation diversions.

Regulation.—Flow may be affected at times by operation of power plant.

Accuracy.—No definite information.

Cooperation.—Record of daily discharge furnished by Utah Power & Light Co.

Monthly discharge of Summit Creek near Santaquin, Utah.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1910.				
March			18	805
April	121	17	51	3,030
May	154	48	65	4,000
June	48	16	21	1,260
July	16	11	13	787
August	11	9	10	621
September	16	8	10	575
The period				11,000
1910–11.				
October	13.0	8.3	9.03	555.0
November	8.3	7.5	7.80	464.0
December	7.5	5.2	6.85	421.0
January	8.1	6.2	7.1	437.2
February	10.3	5.5	6.9	385.6
March	8.6	6.6	7.4	455.6
April	16.1	7.4	10.2	608.7
May	23.1	13.5	20.0	1,231.2
June	21.5	9.8	14.8	879.7
July	9.8	7.7	8.8	540.1
August	7.5	6.3	6.8	416.5
September	7.3	6.1	6.3	376.5
The year	23.1	5.2	9.33	6,770.0
1911–12.				
October	6.7	5.7	6.2	382.2
November	7.4	2.3	5.4	323.3
December	7.8	4.5	5.6	345.7
January	6.2	4.0	5.3	328.8
February	5.7	4.5	5.1	294.9
March	7.8	3.6	5.5	338.0
April	9.8	6.0	8.0	478.0
May	128.0	7.9	56.2	3,459.0
June	134.8	41.2	72.5	4,314.0
July	25.3	11.5	14.8	910.6
August	12.6	9.0	10.2	624.2
September	9.3	8.4	8.8	525.6
The year	134.8	2.3	17.0	12,300.0
1912–13.				
October	9.8	7.6	8.7	535.9
November	8.9	7.0	7.9	469.3
December	8.7	5.6	7.1	437.0
January	7.8	5.5	6.3	387
February	6.4	3.5	5.9	328
March	8.7	5.4	6.1	375
April	39.3	9.7	20.2	1,202
May	76.1	25.1	51.4	3,160
June	48.4	15.1	24.6	1,464
July	14.2	9.7	11.9	732
August	9.9	6.8	8.8	541
September	25.7	10.9	12.8	762
The year	76.1	3.5	14.4	10,400
1913–14.				
October	13.5	10.9	11.9	732
November	11.8	7.8	10.4	619
December	10.8	6.9	9.4	578
January	7.5	2.8	6.22	382
February	6.9	4.7	6.29	349
March	13.7	5.6	9.63	592
April	66.4	11.1	33.2	1,980
May	105	27.4	76.7	4,720
June	63.2	22.6	37.4	2,230
July	34.6	14.5	18.2	1,120
August	17.3	11.0	14.2	873
September	12.2	8.9	10.3	613
The year	105	2.8	20.3	14,800

Monthly discharge of Summit Creek near Santaquin, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1914–15.				
October	15.4	9.9	11.4	701
November	10.4	8.2	9.21	548
December	13.1	5.5	7.76	477
January	8.0	4.6	6.93	426
February	7.0	4.2	5.56	309
March	8.2	5.2	6.08	374
April	36.6	8.2	21.9	1,300
May	48.9	19.7	32.6	2,000
June	45.1	16.3	29.2	1,740
July	16.8	10.9	13.2	812
August	11.0	9.2	10.2	627
September	9.9	8.5	9.20	547
The year	48.9	4.2	13.6	9,860
1915–16.				
October	8.6	7.7	7.98	491
November	8.8	3.8	7.30	434
December	7.5	5.6	6.54	402
January	6.9	1.9	5.75	354
February	6.4	5.0	5.97	343
March	25	6.0	10.8	664
April	97	13	28.2	1,680
May	83	42	58.3	3,580
June	64	20	41.6	2,480
July	19	11	13.8	848
August	12	9.0	10.1	621
September	9.8	8.3	8.86	527
The year	97	1.9	17.1	12,400

PETEETNEET CREEK NEAR PAYSON, UTAH.

LOCATION.—In SE. ¼ SW. ¼ sec. 29, T. 9 S., R. 2 E., half a mile above power canal intake and 3 miles above Payson, Utah County.

DRAINAGE AREA.—28 square miles.

RECORDS AVAILABLE.—August 1, 1910, to September 30, 1916; miscellaneous measurements, 1909–10.

GAGE.—Inclined staff on left bank.

DISCHARGE MEASUREMENTS.—Made from footbridge at gage or by wading.

CHANNEL AND CONTROL.—Bed composed of rocks and gravel; may shift during extremely high water. Banks high and not subject to overflow.

ICE.—Stage-discharge relation possibly affected by ice. Open-water rating curves used.

DIVERSIONS.—None above the station.

REGULATION.—City of Payson has constructed several small reservoirs above the station which regulate the flow to some extent.

COOPERATION.—Since January 1, 1911, records have been furnished by the United States Reclamation Service.

Monthly discharge of Peteetneet Creek near Payson, Utah.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1910.				
August	11.3	10.0	10.3	633
September	10.1	9.8	9.99	595
The period				1,228
1910–11.				
October	11.0	9.5	9.83	604
November	10.9	9.6	9.84	586
December	10.0	8.9	9.59	590
January	6.4	5.0	5.54	340.75
February	7.5	5.0	6.31	350.29
March	7.5	5.7	6.46	397.49
April	34.0	7.9	16.67	991.95
May	38.7	16.3	25.01	1,537.61
June	15.0	7.6	10.17	605.17
July	17.0	6.6	9.41	578.39
August	10.2	6.8	8.35	513.73
September	7.8	5.0	5.52	328.87
The year	38.7	5.0	10.2	7,420
1911–12.				
October	7.2	5.4	5.95	365.95
November	7.2	4.8	6.0	356.83
December	6.3	4.6	5.39	331.24
January	5.0	2.8	3.6	220.2
February	6.2	4.2	5.0	228.0
March	6.5	4.2	5.4	332.4
April	10.0	5.0	7.7	459.2
May	121.7	10.8	59.2	3,639.1
June	69.1	9.2	29.5	1,757.2
July	11.6	7.4	9.4	580.4
August	10.0	7.1	8.0	489.5
September	10.0	4.4	7.7	458.8
The year	121.7	2.8	12.7	9,280
1912–13.				
October	5.6	4.2	4.8	296.9
November	6.2	4.0	4.8	284.2
December	4.4	1.7	2.4	146.8
January	5.4	2.6	3.8	234
February	8.0	4.4	5.5	306
March	8.8	4.8	5.8	357
April	153.5	10.3	41.9	2,493
May	144.2	32.5	74.9	4,605
June	31.9	16.3	23.4	1,392
July	17.1	10.0	14.4	885
August	12.6	11.0	11.7	719
September	12.9	8.9	10.5	625
The year	153.5	1.7	17.1	12,300
1913–14.				
October	10	6.7	7.8	480
November	9.1	5.4	7.5	446
December	9.1	6.3	7.5	461
January	16.2	7.5	9.7	596
February	16.2	7.3	9.6	533
March	18.8	5.6	9.9	609
April	108.7	18.8	55.0	3,272
May	200.0	41.0	107.0	6,579
June	43.9	14.6	25.6	1,523
July	14.1	12.6	13.4	824
August	14.1	10.5	12.3	756
September	12.6	2.0	8.6	506
The year	200	2.0	22.9	16,600

Monthly discharge of Peteetneet Creek near Payson, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1914–15.				
October	8.7	6.3	7.5	461
November	7.7	6.1	6.8	405
December	8.4	6.6	7.4	455
January	7.5	4.3	6.7	412
February	6.8	5.3	5.9	328
March	6.8	4.8	6.0	369
April	93.0	7.2	37.1	2,208
May	39.0	23.4	31.5	1,937
June	29.7	11.0	19.8	1,178
July	12.4	9.4	10.2	627
August	10.0	8.4	9.4	578
September	10.0	6.3	8.3	494
The year	93.0	4.3	13.1	9,452
1915–16.				
October	8.7	6.3	6.70	412
November	7.4	6.3	6.77	403
December	7.4	4.3	6.40	394
January	12.4	5.5	8.22	505
February	10.7	8.0	9.51	547
March	12.1	9.5	10.3	633
April	165	13.2	46.6	2,770
May	159	41	87.0	5,350
June	37.3	11.0	17.7	1,050
July	12.4	8.6	10.0	615
August	12.4	8.4	9.94	611
September	9.8	8.4	9.03	537
The year	165	4.3	19.1	13,800

SPANISH FORK AT THISTLE, UTAH.

LOCATION.—In SW. ¼ SW. ¼ sec. 28, T. 9 S., R. 4 E., in Thistle, Utah County 800 feet below point at which Soldier Fork and Thistle Creek unite to form Spanish Fork and 3 miles above Diamond Fork.

DRAINAGE AREA.—490 square miles.

RECORDS AVAILABLE.—December 3, 1907, to September 30, 1920.

GAGE.—Inclined staff on right bank 10 feet below cable. Used May 4, 1915, to September 30, 1920; read by Mrs. Effie Gordon. November 21, 1912, to May 3, 1915, a vertical staff on right bank at same site and datum. December 3, 1907, to November 20, 1912, a vertical staff on left bank about a mile downstream.

DISCHARGE MEASUREMENTS.—Made from cable at gage or by wading.

CHANNEL AND CONTROL.—Bed composed of gravel and sand. One channel at all stages. Left bank low and subject to overflow; right bank high and partly wooded. Channel straight for 100 feet above and 600 feet below gage. Gravel bar about 30 feet below gage, shifting.

ICE.—Stage-discharge relation affected by ice for short periods.

DIVERSIONS.—No important diversions above the station.

REGULATION.—None.

COOPERATION.—Records since January 1, 1911, furnished by United States Reclamation Service.

Monthly discharge of Spanish Fork at Thistle, Utah.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1908.				
January 11-31	86	54	68.4	2,850
February	86	54	69.0	3,970
March	101	45	68.2	4,190
April	101	50	79.9	4,750
May	157	94	132	8,120
June	147	68	106	6,310
July	582	50	88.0	5,410
August	438	37	66	4,060
September	203	37	51.2	3,050
1908-9.				
October	54	37	42.2	2,590
November	54	45	45.5	2,710
December			37.7	2,320
January	407	38	85.9	5,280
February	61	38	48.3	2,680
March	184	49	104	6,400
April	621	123	268	15,900
May	860	373	661	40,600
June	865	158	397	23,600
July	149	98	120	7,380
August	106	83	89.3	5,490
September	149	69	86.1	5,120
The year	865	37	166	120,000
1909-10.				
October	83	69	70.1	4,310
November	83	69	72.7	4,330
December			66.0	4,060
January			130	8,000
February			125	6,800
March	307	92	186	11,400
April	485	206	307	18,300
May	440	200	296	18,200
June	195	69	114	6,780
July	76	56	69	4,250
August	69	34	50	3,070
September	56	34	39	2,300
The year			127	91,800
1910-11.				
October	69.0	34.0	47.3	2,910
November	56.0	56.0	56.0	3,330
December	56.0	50.0	55.1	3,390
January	522.0	48.8	116.5	7,160
February	87.5	49.0	67.2	3,732
March	152.0	49.0	66.8	4,108
April	106.0	59.5	72.9	4,337
May	180.0	87.5	147.4	9,066
June	106.0	59.5	79.8	4,747
July	59.5	44.5	50.4	3,101
August	49.0	24.5	32.7	2,012
September	40.5	22.8	28.8	1,716
The year	522.0	22.8	68.4	49,600
1911-12.				
October	33.5	27.5	31.0	1,909
November			[a] 33.1	1,970
December			[a] 27.8	1,707
January	41.0	32.0	36.5	2,242
February	41.0	32.0	36.6	2,102
March	53.2	35.6	42.6	2,617
April	62.0	46.0	55.1	3,281
May	327.4	62.0	191.4	11,768
June	313.4	75.4	157.9	9,401
July	75.4	49.0	60.4	3,716
August	51.6	29.3	38.5	2,370
September	38.3	32.9	37.2	2,212
The year	327.4		62.3	45,300

[a] Estimated.

Monthly discharge of Spanish Fork at Thistle, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1912–13.				
October	48.5	38.3	40.6	2,498
November	49.0	27.5	40.6	2,416
December	41.6	25.0	34.5	2,118
January	41.0	41.0	41.0	2,521
February	53.0	41.0	46.0	2,555
March	238.8	41.0	72.8	4,476
April	335.4	118.0	213.7	12,716
May	433.6	222.5	323.1	19,866
June	209.0	74.8	116.2	6,914
July	80.0	43.4	57.7	3,548
August	57.2	34.0	44.3	2,724
September	163.6	39.0	51.3	3,053
The year	433.6	25.0	90.4	65,400
1913–14.				
October	53	41	46.8	2,878
November	53	47	49.0	2,916
December	53	18.5	37.3	2,294
January	89.9	46.0	61.0	3,751
February	101.3	53.8	68.8	3,821
March	154.0	70.6	125.8	7,735
April	611.5	138	402.1	23,927
May	920	393	624.3	38,387
June	537	134.4	247.7	14,729
July	180.8	86.2	109.4	6,726
August	93.7	60.0	71.7	4,409
September	88.8	52.0	58.7	3,493
The year	920	18.5	158.6	115,000
1914–15.				
October	109.0	72.8	79.5	4,888
November	76.0	55.0	66.5	3,957
December	75.0	50.0	62.2	3,824
January	166.0	52.0	91.8	5,645
February	67.6	48.6	55.8	3,099
March	121.0	52.1	79.0	4,858
April	243.0	85.9	161.5	9,610
May	320.0	136.0	162.2	9,973
June	186.0	67.6	111.7	6,646
July	79.8	28.7	50.1	3,075
August	37.2	19.7	27.5	1,691
September	61.8	26.1	37.9	2,314
The year	320.0	19.7	82.1	59,580
1915–16.				
October	50.2	35.6	44.0	2,710
November	63.7	34.0	48.8	2,900
December 1–23	59.8	38.9	50.9	2,320
April 11–30	618	202	337	13,400
May	822	318	509	31,300
June	318	102	188	11,200
July	94.3	53.6	75.8	4,660
August	69.1	41.0	52.3	3,220
September	49.0	41.0	45.5	2,710
1916–17.				
October	110	52	60.6	3,730
November	85	39	47.3	2,810
December	71	30	43.5	2,670
January	126	49	84.6	5,200
February	160	46	61.9	3,440
March	227	46	75.5	4,640
April	327	80	160	9,520
May	662	208	455	28,000
June	733	176	421	25,100
July	157	70	103	6,330
August	81	50	61.1	3,760
September	71	55	61.3	3,650
The year	733	30	136	98,800

NOTE.—Monthly discharge, 1916–1918, computed by U. S. Geol. Survey.

Monthly discharge of Spanish Fork at Thistle, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1917-18.				
October	64	55	58.6	3,600
November	75	56	65.1	3,870
December	73	58	66.9	4,110
January	80	52	69.5	4,270
February	95	52	75.3	4,180
March	192	80	113	6,950
April	235	95	144	8,570
May	283	155	232	14,300
June	155	65	104	6,190
July	65	40	56.6	3,480
August	40	38	38.6	2,370
September	40	38	39.3	2,340
The year	283	38	88.8	64,200
1918-19.				
October	52	40	51	3,130
November	52	40	49	3,020
December	52	52	52	3,200
April	266	100	168	10,000
May	352	104	216	13,300
June	104	45	68	4,050
July	47	39	42	2,560
August	45	30	34	2,110
September	51	30	34	2,040
1919-20.				
October	44	34	38.5	2,370
November	43	32	37.6	2,240
December 1-6	41	36	38.8	462
February 3-29	49	30	40.9	2,190
March	147	45	62.4	3,840
April	206	45	116	6,900
May	1,010	283	596	36,600
June	453	118	211	12,600
July	109	50	71.0	4,370
August	131	44	74.8	4,600
September	88	67	76.0	4,520

SPANISH FORK NEAR SPANISH FORK, UTAH

LOCATION.—In SW. ¼ sec. 2, T. 9 S., R. 3 E., half a mile below United States Reclamation Service diversion dam of Strawberry Valley project, half a mile above intake of East Bench canal, 5 miles southeast of Spanish Fork, Utah County.

DRAINAGE AREA.—670 square miles.

RECORDS AVAILABLE.—May 23, 1900, to November 30, 1901; March 26, 1903, to September 30, 1917.

GAGE.—Inclined staff on right bank January 1, 1913, to September 30, 1916; original gage inclined staff on right bank about 600 feet above East Bench canal heading, May 23, 1900, to November 30, 1901, and March 26, 1903, to July 31, 1912; temporary gage one-fourth mile above original gage, August 1 to December 31, 1912.

DISCHARGE MEASUREMENTS.—Made from cable at gage or by wading.

CHANNEL AND CONTROL.—Bed composed of gravel and rocks; one channel at all stages; straight for about 200 feet above and 150 feet below gage. Banks high and may cave off during floods. Water is turbulent and control generally shifts during high water.

ICE.—Stage-discharge relation affected by ice at times.

DIVERSIONS.—Above all important diversions except the United States Reclamation Service power canal which supplies the high-line canal, the power plant, and the Salem canal; water can also be returned to the river at the power plant. In 1916 this canal diverted 85,000 acre-feet.

The Strawberry reservoir (present capacity about 250,000 acre-feet) has been constructed to store the waters of Strawberry River, a stream in the Colorado River basin; this water can be diverted to the Spanish Fork basin by means of a tunnel.

REGULATION.—Natural flow affected by diversion by the United States Reclamation Service half a mile above the station and will also be affected whenever water is supplied from the Strawberry reservoir.

COOPERATION.—Since January 1, 1911, records have been furnished by the United States Reclamation Service.

Monthly discharge of Spanish Fork near Spanish Fork, Utah.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1903.				
April 6-30	193	89	122	6,049
May	319	143	227	13,958
June	388	107	218	12,972
July	103	53	79	4,858
August	64	39	48	2,951
September	85	46	52	3,094
The period				43,900
1903-4.				
October	96	39	55	3,382
November	78	28	50	2,975
December	85	28	50	3,074
January	113	58	77.6	4,771
February	126	58	79.1	4,550
March	240	63	85.8	5,276
April	229	110	174	10,3[illegible]0
May	415	236	343	21,090
June	255	111	162	9,640
July	121	80	94.6	5,817
August	92	67	75.8	4,661
September	75	65	68.0	4,046
The year	415	28	109	79,600
1904-5.				
October	69	65	67.8	4,169
November	72	49	61.5	3,660
December	77	40	54.3	3,339
January	85	39	67.7	4,163
February	106	52	83.2	4,621
March	115	72	88	5,411
April	178	71	111	6,605
May	410	136	257	15,800
June	336	58	156	9,283
July	56	42	46.1	2,835
August	95	38	48.6	2,988
September	228	43	59.3	3,529
The year	410	38	91.7	66,400
1905-6.				
October	92	50	58.5	3,597
November	68	50	60.7	3,612
December	114	35	54.7	3,363
January	89	48	66.4	4,080
February	100	57	76.0	4,220
March	455	53	158	9,720
April	594	122	369	22,000
May	907	354	661	40,600
June	456	180	304	18,100
July	169	104	132	8,120
August	148	88	99.5	6,120
September	120	81	93.6	5,570
The year	907	35	178	129,000

Monthly discharge of Spanish Fork near Spanish Fork, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1906-7.				
October	81	74	80.3	4,940
November	88	68	81.0	4,820
December	120	62	84.7	5,210
January	96	62	80.8	4,970
February	684	96	178	9,890
March	358	148	207	12,700
April	908	290	571	34,000
May	1,970	534	889	54,700
June	1,190	294	674	40,100
July	280	156	197	12,100
August	196	126	147	9,040
September	156	108	122	7,260
The year	1,970	62	276	199,000
1907-8.				
October	136	108	118	7,260
November	108	77	96.3	5,730
December	108	77	92.0	5,660
January	92	64	80.4	4,940
February	108	46	84.4	4,850
March	166	64	110	6,760
April	174	100	126	7,500
May	290	118	180	11,100
June	240	102	177	10,500
July	318	73	101	6,210
August	135	60	85.0	5,230
September	174	66	81.0	4,820
The year	318	46	110.9	80,560
1908-9.				
October	94	73	82.0	5,040
November	94	54	75.7	4,500
December			57.6	3,540
January	582	54	146	8,980
February	127	74	97.7	5,430
March	387	87	174	10,700
April	1,150	194	482	28,700
May	1,530	667	1,190	73,200
June	1,400	288	710	42,200
July	288	176	220	13,500
August	190	156	170	10,500
September	204	134	158	9,400
The year	1,530		297	216,000
1909-10.				
October	160	115	144	8,850
November	180	134	149	8,870
December	168	96	130	7,990
January	47	37	45.7	2,810
February	47	37	44.1	2,450
March	443	47	207	12,700
April	708	197	411	24,500
May	647	186	389	23,900
June	176	68	116	6,900
July	76	30	49.3	3,030
August	31	16	20.8	1,280
September	44	11	21.6	1,290
The year	708	11	144.0	105,000
1910-11.				
October	44	16	25.8	1,590
November	24	0	14.1	839
December	11	6	7.1	437
January	694.0	5.3	64.7	3,981.3
February	433.2	5.3	34.9	1,937.9
March	145.1	5.8	60.3	3,709.1
April	112.9	54.0	68.3	4,067.2
May	185.0	87.4	138.5	8,500.5
June	124.6	32.8	64.4	3,818.0
July	44.1	15.3	24.7	1,521.4
August	19.2	4.2	10.0	616.9
September	26.3	2.0	9.7	578.9
The year	694.0	0	43.5	31,600

Monthly discharge of Spanish Fork near Spanish Fork, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1911–12.				
October	25.3	2.7	10.9	669.4
November	12.3	0	6.4	381.4
December	16.8	0	4.1	254.9
January	13.2	0	6.0	371.3
February	26.0	4.2	11.0	632.7
March	39.5	11.8	19.0	1,167.5
April	68.0	20.0	35.6	2,119.8
May	500.4	53.0	248.2	15,260.3
June	419.6	51.5	173.1	10,302.7
July	50.0	19.0	35.2	2,163.0
August	24.0	7.9	12.5	766.8
September	110.0	10.6	17.1	1,016.9
The year	500.4	0	48.3	35,100
1912–13.				
October	39.3	10.6	15.7	964.6
November	35.2	6.4	16.2	966.6
December	12.9	0	1.7	104.3
January	0	0	0	0
February	23.2	3.6	12.9	716
March	179.8	8.4	43.8	2,693
April	391.3	115.6	244.1	14,525
May	458.8	210.5	337.1	20,727
June	189.7	70.0	110.7	6,587
July	113.0	27.5	50.0	3,074
August	50.0	6.8	27.2	1,672
September	117.3	27.5	41.9	2,493
The year	458.8	0	75.3	54,500
1913–14.				
October	98.6	30.8	77.5	4,765
November	102	20	68.5	4,076
December	22	0	10.1	621
January	82	0	27.2	1,672
February	120.8	14.0	34.0	1,888
March	228.5	40.6	146.3	8,996
April	863.4	186	574.4	34,179
May	1,201.6	395.6	796.2	48,956
June	424.4	119.6	253.4	15.079
July	153.2	72.0	94.3	5,798
August	71.0	48.4	56.6	3,480
September	48.4	40.6	44.0	2,618
The year	1,201.6	0	181.9	132,000
1914–15.				
October	90.2	47.6	54.3	3,339
November	46.8	32.9	41.1	2,446
December	43.6	26.0	33.5	2,060
January	135.0	20.0	63.6	3,909
February	39.0	16.5	29.0	1,611
March	193.0	30.2	62.5	3,843
April	283.0	79.1	158.0	9,402
May	265.0	169.0	197.7	12,156
June	200.5	71.3	114.5	6,813
July	137.0	82.5	116.1	7,139
August	75.0	16.0	55.0	3,383
September	48.5	16.0	26.5	1,577
The year	283.0	16.0	79.7	57,678
1915–16.				
October	14.5	6.9	11.5	707
November	23.2	6.4	13.2	786
December	16.0	0	10.8	664
February 4–29	63.4	0	38.9	2,010
March	879	44.1	253	15,600
April	846	140	464	27,600
May	788	195	444	27,300
June	237	131	179	10,700
July	179	104	143	8,790
August	106	41.6	74.0	4,550
September	82.0	52.5	71.2	4,240

Monthly discharge of Spanish Fork near Spanish Fork, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1916–17.				
October	137	30	52.9	3,250
November	66	19	45.8	2,730
December	88	0	49.5	3,040
January	208		37.0	2,280
February	84		57.1	3,170
March	150	6.4	40.0	2,460
April	528	63	209	12,400
May	1,023	309	564	34,700
June	639	180	409	24,300
July	412	182	229	14,100
August	256	66	150	9,220
September	148	81	92.8	5,520
The year	1,023	0	162	117,000

DIAMOND FORK NEAR THISTLE, UTAH.

LOCATION.—In NE. ¼ SE. ¼ sec. 17, T. 9 S., R. 4 E., at footbridge 200 yards above mouth, 2½ miles from Thistle, Utah County.

DRAINAGE AREA.—157 square miles.

RECORDS AVAILABLE.—December 2, 1907, to September 30, 1917, when publication by United States Geological Survey was discontinued.

GAGE.—Inclined staff on left bank about 5 feet above footbridge.

DISCHARGE MEASUREMENTS.—Made from footbridge or by wading.

CHANNEL AND CONTROL.—Bed composed of small gravel; shifts. One channel at all stages; straight for 100 feet above and below gage. Banks covered with cottonwood trees; subject to overflow during extreme floods.

ICE.—Stage-discharge relation slightly affected by ice for short periods.

DIVERSIONS.—No important diversions.

REGULATION.—Natural flow affected by water supplied from the Strawberry reservoir.

COOPERATION.—Since January 1, 1911, all records have been furnished by the United States Reclamation Service.

Monthly discharge of Diamond Fork near Thistle, Utah.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1908.				
January 11–31	21	11	14.1	587
February	33	12	22.9	1,320
March	31	12	23.8	1,460
April	47	22	31.5	1,870
May	53	32	39.5	2,430
June	59	32	44.9	2,670
July	32	16	21.4	1,320
August	22	14	16.9	1,040
September	37	11	13.2	786
The period	59	11	25.3	13,400

Monthly discharge of Diamond Fork near Thistle, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1908–9.				
October	15	12	14.4	885
November	14	12	12.2	726
December			12.3	756
January	63	6	18.8	1,160
February	28	8	17.5	972
March	76	21	42.6	2,620
April	395	76	184	10,900
May	735	350	596	36,600
June	552	106	280	16,700
July	100	55	76.6	4,710
August	129	20	47.7	2,930
September	61	24	31.2	1,860
The year			111	80,800
1909–10.				
October	28	24	26.6	1,640
November	38	20	27.3	1,620
December			24.0	1,480
January			50	3,070
February			50	2,780
March	217	33	100	6,150
April	286	100	209	12,400
May	250	60	149	9,160
June	60	38	50.6	3,010
July	38	24	30.0	1,840
August	20	20	20.0	1,230
September	28	20	22.8	1,360
The year			63.3	45,800
1910–11.				
October	28	24	24.3	1,490
November	28	24	24.5	1,460
December	24	16	23.3	1,430
January	90.5	7.8	25.1	1,540
February	25.7	11.2	19.5	1,080
March	61.7	25.7	33.3	2,050
April	61.7	36.2	45.6	2,710
May	75.8	25.7	54.3	3,340
June	36.2	13.6	23.6	1,400
July	21.2	17.0	19.9	1,220
August	19.4	11.2	15.1	928
September	25.7	11.2	13.2	786
The year	90.5	7.8	26.9	19,400
1911–12.				
October	18.6	13.6	16.8	1,030
November 1–11	30.6	18.6	24.0	524
December				
January	22.8	11.4	12.8	787
February	27.0	12.2	20.3	1,170
March	34.2	20.4	25.4	1,560
April	41.7	24.0	32.5	1,930
May	170	44.0	112	6,890
June	131	39.5	70.8	4,210
July	39.5	30.2	35.2	2,160
August	35.2	21.0	24.8	1,520
September	27.0	21.0	21.9	1,300
1912–13.				
October	27.0	21.0	22.3	1,370
November	22.8	21.6	21.7	1,290
December	21.6	10.0	15.6	959
January	29.0	15.5	16.3	1,002
February	29.0	16.6	21.2	1,177
March	88.6	16.6	28.2	1,734
April	142.5	59.0	115.3	6,861
May	177.9	100.4	139.0	8,547
June	92.0	43.0	59.6	3,546
July	43.0	30.2	35.4	2,177
August	30.6	22.0	27.4	1,685
September	51.8	22.0	26.3	1,565
The year	177.9	10.0	44.1	31,900

Monthly discharge of Diamond Fork near Thistle, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1913–14.				
October	27.6	19.8	24.2	1,488
November	22.7	19.3	20.6	1,226
December	25.5	11.5	20.3	1,248
January	17.0	17.0	17.0	1,045
February	25.0	17.0	19.5	1,083
March	68.0	23.0	44.7	2,748
April	296.2	63.5	226.1	13,454
May	363.5	144.0	275.9	16,965
June	163.2	62.0	101.4	6,034
July	69.0	45.0	54.3	3,339
August	45.0	31.0	36.5	2,244
September	31.9	27.8	29.8	1,773
The year	363.5	11.5	72.5	52,600
1914–15.				
October	42.0	29.4	31.4	1,931
November	29.4	28.6	29.1	1,732
December	28.6	9.0	21.8	1,340
January	18.6	13.0	16.4	1,008
February	32.5	21.6	25.2	1,400
March	45.1	27.2	35.8	2,201
April	71.6	45.1	58.1	3,457
May	70.4	59.2	67.1	4,126
June	82.5	41.0	61.8	3,677
July	124.0	72.0	104.4	6,415
August	94.2	57.5	74.7	4,593
September	75.0	27.0	49.2	2,928
The year	124.0	9.0	47.6	34,800
1915–16.				
October	27.0	24.9	26.2	1,610
November	34.0	18.6	26.5	1,580
December	29.8	7.6	21.4	1,320
January	12.0	4.2	8.68	534
February	18.8	7.2	15.2	874
March	192	16.8	59.1	3,630
April	381	88	203	12,100
May	457	142	252	15,500
June	270	128	210	12,500
July	349	132	251	15,400
August	440	138	169	10,400
September	180	113	158	9,400
The year	457	4.2	117	84,800
1916–17.				
October	162	30	82.4	5,070
November	123	15	50.0	2,980
December	72	14	41.5	2,550
January	52	25	37.0	2,280
February	68	24	47.7	2,650
March	68	17	26.7	1,640
April	248	30	104	6,190
May	518	150	259	15,900
June	398	120	218	13,000
July	560	288	460	28,300
August	342	260	295	18,100
September	288	230	274	16,300
The year	560	14	159	115,000

UNITED STATES RECLAMATION SERVICE POWER CANAL NEAR SPANISH FORK, UTAH.

LOCATION.—In SW. ¼ sec. 2, T. 9 S., R. 3 E., near mouth of canyon, half a mile below canal headgates, about 5 miles southeast of Spanish Fork, Utah County.

RECORDS AVAILABLE.—January 1, 1909, to September 30, 1917, when publication by United States Geological Survey was discontinued.

GAGE.—Inclined staff on right bank graduated to tenths from zero to 5 feet.

DISCHARGE MEASUREMENTS.—Made from footbridge or by wading at gage.

CHANNEL AND CONTROL.—Concrete-lined section; bottom width 4.0 feet, side slopes 1 to 1, and maximum depth of water will be about 6 feet. Control not permanent owing to earth and rock slides below the gage.

ICE.—Stage-discharge relation sometimes affected by ice.

DIVERSIONS.—None above station.

REGULATION.—Flow controlled by headgates half a mile above gage.

COOPERATION.—Since January 1, 1911, all records have been furnished by the United States Reclamation Service.

Monthly discharge of United States Reclamation Service power canal near Spanish Fork, Utah.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1909.				
January	82.1	15.8	54.9	3,380
February	66.0	46.6	58.3	3,240
March	66.0	0	29.5	1,810
April	41.6	20.2	32.3	1,920
May	44.0	27.0	38.8	2,390
June	188	39.3	47.2	2,810
July	40.6	41.6	44.0	2,710
August	54.5	39.3	45.9	2,820
September	123	49.1	90.8	5,400
The period	188	0	49.1	26,400
1909-10.				
October	115	96.1	101	6,210
November	123	92.5	104	6,190
December	115	54.5	87.1	5,360
January	115	92.5	106	6,520
February	115	72.2	103	5,720
March	131	78.7	111	6,820
April	123	54.5	90.5	5,390
May	78.7	54.5	66.5	4,090
June	78.7	62.5	66.7	3,970
July	86.2	72.8	81.4	5,000
August	93.9	60.1	68.9	4,240
September	78.7	63.0	69.9	4,160
The year	131	54.5	88.0	63,700
1910-11.				
October	86.9	55.6	69.3	4,260
November	96.1	73.5	80.9	4,810
December	91.8	64.8	81.6	5,020
January	98.2	46.0	73.8	4,540.4
February	79.9	58.6	73.3	4,072.1
March	104.2	80.6	89.1	5,481.6
April	98.2	46.5	78.3	4,657.3
May	94.3	47.4	68.0	4,183.4
June	79.9	61.3	69.7	4,148.5
July	62.5	50.3	55.4	3,406.3
August	51.3	38.9	46.6	2,867.9
September	63.6	46.5	53.0	3,151.2
The year	104.2	38.9	69.9	50,600
1911-12.				
October	65.4	54.9	58.2	3,579.2
November	67.1	40.6	60.5	3,601.8
December	62.5	47.0	57.4	3,527.1
January	67.1	57.0	62.9	3,865.1
February	74.6	55.4	64.7	3,725.4
March	75.9	63.5	69.2	4,252.2
April	79.2	63.5	69.3	4,122.1
May	105.3	72.1	87.3	5,368.5
June	111.0	70.8	81.4	4,841.9
July	75.3	68.3	71.9	4,421.2
August	73.3	54.9	63.0	3,870.8
September	76.6	56.4	60.7	3,614.7
The year	111.0	40.6	67.2	48,800

Monthly discharge of United States Reclamation Service power canal near Spanish Fork, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1912–13.				
October	74.6	61.9	65.6	4,033.4
November	75.9	58.1	65.4	3,893.6
December	67.1	33.5	55.6	3,416.0
January	114.2	45.1	66.4	4,083
February	72.1	58.6	64.0	3,554
March	82.0	60.2	70.4	4,329
April	103.7	79.9	91.8	5,463
May	102.9	69.0	89.3	5,491
June	91.3	63.0	72.1	4,290
July	82.7	65.4	72.1	4,433
August	85.5	55.9	69.0	4,243
September	80.6	55.9	63.6	3,785
The year	114.2	33.5	70.5	51,000
1913–14.				
October 1–9	75.9	61.3	69.0	1,232
November 19–30	77.9	60.8	68.9	1,640
December	70.8	40.8	61.0	3,761
January	94.3	58.1	70.5	4,335
February	95.9	60.2	72.2	4,010
March	107.0	65.4	78.2	4,808
April	132.1	61.3	96.7	5,754
May	156.5	61.9	86.0	5,105
June	79.2	65.4	73.1	4,350
July	93.6	70.8	78.0	4,796
August	82.0	69.0	74.0	4,550
September	77.3	65.9	68.5	4,076
1914–15.				
October	92.8	72.1	75.5	4,642
November	72.7	62.5	68.4	4,070
December	70.2	54.9	63.5	3,904
January	65.9	58.1	63.3	3,894
February	77.3	60.8	69.2	3,843
March	84.8	65.9	73.0	4,489
April	91.3	47.1	68.3	4,064
May	59.1	48.1	53.6	3,296
June	51.6	40.0	44.3	2,636
July	44.8	40.8	42.6	2,619
August	94.3	49.1	62.2	3,824
September	101.3	61.9	78.0	4,641
The year	101.3	40.0	63.4	45,900
1915–16.				
October	72.7	67.7	70.9	4,360
November	76.6	62.5	71.3	4,240
December	75.3	40.0	67.1	4,130
January	72.2	53.5	62.6	3,850
February	100.8	53.0	77.1	4,430
March	88.2	0	52.5	3,230
April	184	0	74.3	4,420
May	247	151	215	13,200
June	260	214	231	13,700
July	243	123	187	11,500
August	184	126	148	9,100
September	158	142	149	8,870
The year	260	0	117	85,000
1916–17.				
October	163	69	118	7,260
November	123	70	88.3	5,250
December	104	54	89.1	5,480
January	85	56	72.7	4,470
February	80	66	71.8	3,990
March	81	69	74.6	4,590
April	78	67	71.7	4,270
May	214	72	117	7,190
June	303	139	201	12,000
July	397	234	284	17,500
August	341	125	206	12,700
September	204	122	185	11,000
The year	397	54	132	95,700

HOBBLE CREEK NEAR SPRINGVILLE, UTAH.

LOCATION.—In sec. 7, T. 8 S., R. 4 E., 150 feet below Springville power plant, 1 mile above mouth of canyon, and 4 miles southeast of Springville, Utah County.

DRAINAGE AREA.—120 square miles.

RECORDS AVAILABLE.—March 23, 1904, to December 31, 1916, when station was discontinued.

GAGE.—Vertical staff fastened to large tree on right bank, 75 feet below cable, June 1, 1909, to September 30, 1916; original gage vertical staff about 1,000 feet downstream, installed March 23, 1904, washed out by flood April 2, 1907; temporary gage, vertical staff at same site as original gage, installed June 1, 1907, washed out by flood about May 1, 1909.

DISCHARGE MEASUREMENTS.—Made from cable or by wading.

CHANNEL AND CONTROL.—Bed composed of boulders and coarse gravel; fairly permanent. One channel at all stages; banks high and wooded.

ICE.—Flow largely from springs. Stage-discharge relation not seriously affected by ice.

DIVERSIONS.—The only diversion above the station is the power canal and this water is returned to the stream about 150 feet above gage.

REGULATION.—Low-water flow may be somewhat affected by operation of power plant.

COOPERATION.—Since January 1, 1911, all records have been furnished by the United States Reclamation Service.

Monthly discharge of Hobble Creek near Springville, Utah.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1904.				
March	55	25	39.7	709
April	141	47	93.9	5,587
May	188	95	133	8,178
June	90	10	45.8	2,725
July [a]				1,960
August				1,220
September				950
The period				21,300
1904–5.				
October				1,090
November				950
December				980
January	24	22	22.8	1,402
February	28	24	25.6	1,422
March	30	24	27.0	1,660
April	78	28	45.2	2,690
May	132	48	81.0	4,980
June	99	30	59.4	3,534
July	26	11	18.6	1,144
August	107	8	18.3	1,125
September	26	14	17.1	1,018
The year				22,000
1905–6.				
October	16	7	12.5	769
November	22	13	16.9	1,006
December	18	7	14.6	808
January [b]				

[a] Discharge for July to December, 1904, estimated.
[b] Discharges for 1906 and the early part of 1907 can not be computed because of insufficient data.

Monthly discharge of Hobble Creek near Springville, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1907.				
June	410	112	240	14,300
July	112	48	73.9	4,540
August	48	39	43.0	2,640
September	43	37	40.9	2,430
The period				23,900
1907–8.				
October	37	32	34.6	2,130
November	37	35	36.3	2,160
December	37	35	36.7	2,260
January	37	35	36.0	2,210
February	35	34	34.3	1,970
March	43	34	36.2	2,230
April	68	41	53.1	3,160
May	84	46	54.2	3,330
June	112	55	68.3	4,060
July	59	37	43.8	2,690
August	37	32	35.1	2,160
September	34	31	32.2	1,920
The year	112	31	41.7	30,300
1908–9.				
October	35	31	32.7	2,010
November	39	35	37.3	2,220
December	39	37	37.3	2,290
January	84	36	46.5	2,860
February	38	38	38.0	2,110
March	97	38	54.5	3,350
April	788	97	414	24,600
May	820	357	611	37,600
June	558	130	252	15,000
July	115	45	75.9	4,670
August	45	26	36.9	2,270
September	45	18	30.8	1,830
The year	820	18	139	100,000
1909–10.				
October	26	11	24.6	1,510
November	35	26	31.5	1,870
December	35	30	30.7	1,890
January	30	30	30.0	1,840
February	30	22	28.5	1,580
March	343	35	141	8,670
April	296	130	212	12,600
May	228	88	112	6,890
June	88	35	65.2	3,880
July	35	26	26.9	1,650
August	26	11	19.5	1,200
September	30	14	20.6	1,230
The year	343	11	61.9	44,800
1910–11.				
October	26	18	21.5	1,320
November	26	22	22.5	1,340
December	26	18	20.5	1,260
January	52.0	23.8	26.93	1,655.63
February	57.0	26.5	30.24	1,679.40
March	71.8	26.5	43.15	2,653.33
April	81.8	67.0	73.64	4,381.75
May	92.0	57.0	70.70	4,346.05
June	57.0	29.6	46.15	2,745.96
July	29.6	20.3	28.15	1,731.00
August	20.1	17.9	18.80	1,154.40
September	21.3	17.5	18.40	1,094.70
The year	92.0	17.5	35.0	25,360

Monthly discharge of Hobble Creek near Springville, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1911-12.				
October	29.6	21.3	22.6	1,390.43
November	22.2	19.5	21.3	1,267.85
December	20.3	18.2	19.5	1,197.84
January	21.0	14.0	19.0	1,166.9
February	20.5	18.5	19.9	1,144.9
March	23.8	20.5	21.6	1,330.3
April	89.0	24.0	40.9	2,434.6
May	189.0	65.5	136.0	8,361.6
June	134.6	41.5	81.8	4,865.5
July	41.5	25.0	33.0	2,028.7
August	41.5	20.0	24.4	1,502.3
September	29.0	18.5	22.2	1,319.2
The year	189.0	14.0	38.5	28,000
1912-13.				
October	35.0	20.0	22.5	1,384.3
November	29.0	22.0	24.3	1,448.2
December	22.0	20.0	20.8	1,276.8
January	23.0	18.0	22.3	1,371
February	23.0	21.5	22.1	1,227
March	30.0	21.7	25.5	1,568
April	231.0	31.0	162.0	9,640
May	190.0	55.5	111.8	6,874
June	83.0	40.5	51.2	3,047
July	37.5	23.0	28.5	1,740
August	24.3	20.5	22.2	1,365
September	28.0	21.5	24.4	1,452
The year	231.0	18.0	44.7	32,400
1913-14.				
October	28	24	25.6	1,574
November	28	24.7	26.2	1,559
December	24	19.5	21.6	1,322
January	28.5	23.5	25.2	1,550
February	25.0	23.5	24.6	1,366
March	98.7	26.0	59.6	3,665
April	461.4	92.5	269.4	16,031
May	270.0	87.2	181.6	11,166
June	92.5	43.0	71.7	4,266
July	46.5	35.3	39.8	2,447
August	36.0	26.5	30.4	1,869
September	29.7	25.9	27.8	1,654
The year	461.4	19.5	67.0	48,500
1914-15.				
October	32.0	26.5	29.3	1,802
November	28.7	25.9	27.6	1,642
December	28.7	25.9	27.0	1,660
January	25.0	22.0	24.2	1,488
February	27.1	21.8	25.5	1,414
March	38.2	25.0	28.5	1,755
April	118.5	36.8	85.0	5,043
May	87.1	59.4	73.0	4,487
June	69.5	34.8	46.5	2,768
July	34.8	23.6	28.6	1,731
August	25.0	21.2	24.0	1,475
September	27.1	21.2	24.2	1,440
The year	118.5	21.2	36.7	26,705
1915-16.				
October	25.0	22.3	23.5	1,450
November	27.1	22.3	25.7	1,530
December	27.1	23.6	25.8	1,590
January	22.3	18.2	19.9	1,220
February	25.8	17.4	21.3	1,230
March	674	21.5	193	11,900
April	824	254	531	31,600
May	569	136	345	21,200
June	224	77.0	165	9,820
July	71.0	39.5	48.6	2,990
August	39.5	23.3	29.9	1,840
September	30.0	20.6	22.7	1,350
The year	824	17.4	121	87,700

PROVO RIVER AT FORKS, UTAH.

LOCATION.—In sec. 26, T. 5 S., R. 3 E., at Vivian Park summer resort, just above Forks, Utah County, 1 mile below mouth of North Fork of Provo River, which enters on right; 400 feet above South Fork, which enters on left; 1 mile above Utah Power & Light Co.'s diversion dam; and 12 miles up Provo Canyon from Provo, on highway and railroad from Provo to Heber.

DRAINAGE AREA.—600 square miles (measured on topographic maps).

RECORDS AVAILABLE.—November 17, 1911, to September 30, 1920. Records have been obtained at various points below the mouth of South Fork since 1890.

GAGE.—Vertical staff on right bank 16 feet above steel bridge; installed July 21, 1920. Read by J. F. Carter. From October 5, 1915, to July 20, 1920, staff gage on right bank half a mile upstream was used.

DRAINAGE MEASUREMENTS.—Made from cable from highway bridge or by wading.

CHANNEL AND CONTROL.—Bed composed of gravel and large boulders; fairly permanent. Banks fairly high and not subject to overflow; one channel at all stages. Control is gravel riffle. Point of zero flow on October 2, 1920, at about 0.8 foot.

ICE.—Stage-discharge relation slightly affected by ice.

DIVERSIONS.—Station is below diversions for irrigation in Heber Valley and above those in the vicinity of Provo.

REGULATION.—A number of small lakes at the headwaters have been utilized as storage reservoirs and flow is regulated to slight extent.

ACCURACY.—Stage-discharge relation practically permanent. Records fair.

Monthly discharge of Provo River at Forks, Utah.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1911–12.				
November 16–30	284	204	257	7,600
December	269	211	232	14,300
January	337	226	277	17,000
February	284	229	265	15,200
March	442	261	351	21,600
April	518	337	398	23,700
May	1,900	371	687	42,200
June	2,110	440	1,100	65,400
July	396	238	275	16,900
August	309	232	253	15,600
September	335	252	297	17,700
The period				257,000
1912–13.				
October	540	278	337	20,700
November	430	328	373	22,200
December	345	249	300	18,400
January	328	238	284	17,500
February	284	238	260	14,400
March	740	252	327	20,100
April	1,160	464	680	40,500
May	974	520	757	46,500
June	666	247	393	23,400
July	394	205	248	15,200
August	224	200	213	13,100
September	242	220	235	14,000
The year	1,160	200	368	266,000

Monthly discharge of Provo River at Forks, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1913–14.				
October	341	227	298	18,300
November	358	255	307	18,300
December	324	224	275	16,900
January	760	200	322	19,800
February	466	229	281	15,600
March	524	290	396	24,300
April	1,060	394	744	44,300
May	1,760	659	1,170	71,900
June	1,610	322	843	50,200
July	338	259	292	18,000
August	306	256	272	16,700
September	273	217	243	14,500
The year	1,760	200	454	329,000
1914–15.				
October	412	236	318	19,600
November	298	254	279	16,600
December	298	206	250	15,400
January	267	199	246	15,100
February	284	224	259	14,400
March	508	260	341	21,000
April	630	341	435	25,900
May	528	170	285	17,500
June	714	250	457	27,200
July	250	178	234	14,400
August	180	164	170	10,500
September	228	155	190	11,300
The year	714	155	288	209,000
1915–16.				
October	259	211	238	14,600
November	328	211	269	16,000
December	331	226	292	18,000
January	309	213	258	15,900
February	303	226	270	15,500
March	1,820	279	640	39,400
April	1,140	514	743	44,200
May	1,280	507	798	49,100
June	1,180	363	863	51,400
July	363	256	290	17,800
August	297	208	244	15,000
September	337	242	271	16,100
The year	1,820	208	431	313,000
1916–17.				
October	524	349	401	24,700
November	349	256	318	18,900
December	366	256	306	18,800
January	333	256	285	17,500
February	451	242	281	15,600
March	847	227	310	19,100
April	1,420	333	748	44,500
May	1,810	679	1,130	69,500
June	2,450	979	1,660	98,800
July	1,360	286	585	36,000
August	399	256	288	17,700
September	382	256	332	19,800
The year	2,450	227	554	401,000
1917–18.				
October	349	238	286	17,600
November	332	253	278	16,500
December	332	300	325	20,000
January	332	253	300	18,400
February	506	253	318	17,700
March	720	316	429	26,400
April	524	284	390	23,200
May	720	284	459	28,200
June	1,240	210	749	44,600
July	332	186	243	14,900
August	213	149	174	10,700
September	284	155	190	11,300
The year	1,240	149	345	250,000

Monthly discharge of Provo River at Forks, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1918–19.				
October	312	203	269	16,500
November	315	244	267	15,900
December	392	190	258	15,900
January			191	11,700
February	236	197	218	12,100
March	657	200	361	22,200
April	755	335	504	30,000
May	1,110	460	785	48,300
June	730	200	313	18,600
July	202	135	174	10,700
August	142	126	133	8,180
September	263	135	174	10,400
The year	1,110	126	305	220,000
1919–20.				
October	312	205	253	15,600
November	330	230	297	17,700
December	347	210	260	16,000
January	260	202	231	14,200
February	682	231	272	15,600
March	453	257	304	18,700
April	738	285	443	26,400
May	2,300	591	1,390	85,500
June	2,000	353	971	57,800
July	342	232	271	16,700
August	258	220	234	14,400
September	238	205	223	13,300
The year	2,300	202	429	312,000

PROVO RIVER NEAR PROVO, UTAH.

LOCATION.—One mile above Telluride Power Co.'s dam, one-fourth mile below mouth of South Fork, and 1¼ miles below mouth of North Fork, in NW. ¼ SW. ¼ sec. 26, T. 5 S., R. 3 E.

RECORDS AVAILABLE.—February 1, 1905, to December 31, 1911, when it was discontinued and new stations were established on the main river and the South Fork to obtain better conditions for measuring. A station was maintained at the mouth of canyon from 1889 to 1906.

DRAINAGE AREA.—640 square miles.

GAGE.—Vertical staff installed June 14, 1909, by the Telluride Power Co., to replace vertical gage which was set July 24, 1908, and washed out June 14, 1909. Datum of gage set June 15, 1909, probably the same as that of the gage installed July 24, 1908, but there is no record to this effect. The gage installed February 1, 1905, was an inclined staff on the left bank.

CHANNEL.—One channel at all stages except at low water, when a bar near the left bank divides the current of the stream.

DISCHARGE MEASUREMENTS.—From car and cable.

WINTER FLOW.—No ice forms at this station.

DIVERSIONS.—A little water is diverted in Heber Valley near the head of the river.

ACCURACY.—Low because of shifting channel.

COOPERATION.—Station maintained in cooperation with Telluride Power Co.

Monthly discharge of Provo River near Provo, Utah.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1905.				
February	332	114	190	10,550
March	359	82	239	14,700
April	499	191	288	17,140
May	661	184	396	24,350
June	1,438	95	687	40,880
July	129	20	50.1	3,080
August	44	16	26.8	1,648
September (17 days)	76	15	32.6	1,099
The period				113,000
1905-6.				
October	56	26	37.1	2,281
November	129	21	73.0	4,344
December 1-18	66	16	38.3	1,368
January			274	16,800
February	340	153	250	13,900
March	657	240	360	22,100
April	774	340	527	31,400
May	1,680	340	973	59,800
June	1,860	500	1,090	64,900
July	479	240	331	20,400
August	359	210	260	16,000
September	322	256	295	17,600
The year			375	271,000
1906-7.				
October	272	240	258	15,900
November	340	210	289	17,200
December	479	240	320	19,700
January	340	196	280	17,200
February	774	272	450	25,000
March	750	322	460	28,300
April	1,560	418	897	53,400
May	2,340	634	1,170	71,900
June	2,340	1,120	1,650	98,200
July	2,100	479	1,120	68,900
August	458	359	387	23,800
September	500	359	400	23,800
The year	2,340	196	640	463,000
1907-8.				
October	398	378	381	23,400
November	378	378	378	22,500
December	458	305	378	23,200
January	378	240	329	20,200
February	458	225	330	19,000
March	458	322	372	22,900
April	870	322	515	30,600
May	1,070	500	886	54,500
June	1,800	970	1,230	73,200
July [a]	1,070		579	35,600
August	346	225	260	16,000
September	364	225	253	15,100
The year	1,800	225	491	356,000
1908-9.				
October	504	328	386	23,700
November	382	258	364	21,700
December	495	310	365	22,400
January	1,500	240	537	33,000
February	370	240	310	17,200
March	470	240	356	21,900
April	1,350	450	774	46,100
May	1,890	850	1,460	89,800
June	3,620	1,630	2,250	134,000
July	1,570	260	656	40,300
August	410	250	307	18,900
September	640	305	444	26,400
The year	3,620	240	684	495,000

[a] Discharge interpolated July 12-24, 1908.

Monthly discharge of Provo River near Provo, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1909-10.				
October	470	335	395	24,300
November	530	318	407	24,200
December	570	185	345	21,200
January	1,200	270	435	26,700
February	570	180	341	18,900
March	1,100	335	703	43,200
April	1,450	570	904	53,800
May	1,425	732	992	61,000
June	1,025	225	441	26,200
July	255	180	230	14,100
August	270	180	217	13,300
September	270	210	238	14,200
The year	1,450	180	471	341,000
1910-11.				
October	300	255	271	16,700
November	335	270	299	17,800
December	370	285	311	19,100
January	1,920	270	458	28,200
February	1,000	198	353	19,600
March	975	270	438	26,900
April	620	285	441	26,200
May	810	410	686	42,200
June	1,320	335	899	53,500
July	318	210	275	16,900
August	240	148	167	10,300
September	285	172	189	11,200
The year	1,920	148	399	288,000
1911.				
October	335	240	283	17,400
November	410	255	336	19,900
December	352	270	299	18,400

SOUTH FORK OF PROVO RIVER AT FORKS, UTAH.

LOCATION.—In sec. 26, T. 5 S., R. 3 E., at Vivian Park summer resort, just above Forks, Utah County, a quarter of a mile above confluence of South Fork with Provo River and 12 miles up Provo Canyon, on highway and railroad from Provo to Heber.

DRAINAGE AREA.—30 square miles.

RECORDS AVAILABLE.—November 17, 1911, to September 30, 1920.

GAGE.—Vertical staff nailed to cottonwood tree on right bank June 15, 1913, to September 30, 1920; read by J. F. Carter. Datum raised 2 feet on June 12, 1915. Original gage, vertical staff about 150 feet above mouth of stream, used November 17, 1911, to June 14, 1913.

DISCHARGE MEASUREMENTS.—Made from foot log near gage or by wading.

CHANNEL AND CONTROL.—Bed composed of gravel; shifting. One channel at all stages; banks high and not subject to overflow.

ICE.—Stage-discharge relation not affected by ice.

DIVERSIONS.—Below all diversions.

REGULATION.—None.

ACCURACY.—Stage-discharge relation fairly permanent. May be subject to error at certain periods due to diurnal fluctuation. Records fair.

Monthly discharge of South Fork of Provo River at Forks, Utah.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1911–12.				
November 17–30	35	32	34.6	961
December	35	32	33.5	2,000
January	34	30	32.6	2,000
February	30	28	29.2	1,680
March	30	26	28.9	1,780
April	31	29	30.0	1,790
May	46	30	32.7	2,010
June	74	32	45.2	2,690
July	33	30	30.5	1,880
August	42	33	34.1	2,100
September	42	35	37.6	2,240
The period				21,200
1912–13.				
October	42	38	38.5	2,370
November	38	34	35.6	2,120
December	34	33	33.5	2,060
January	35	32	32.7	2,010
February	32	30	31.9	1,770
March	31	30	30.1	1,850
April	41	32	36.0	2,140
May	39	30	33.9	2,080
June	47	29	35.2	2,090
July	32	28	29.1	1,790
August	30	28	28.3	1,740
September	31	28	28.8	1,710
The year	47	28	32.8	23,700
1913–14.				
October	29	28	28.1	1,730
November	30	28	28.2	1,680
December	30	28	28.1	1,730
January	32	28	28.7	1,760
February	28	24	27.9	1,550
March	34	28	28.7	1,760
April	48	35	43.6	2,590
May	58	46	51.4	3,160
June	52	39	46.6	2,770
July	41	40	40.2	2,470
August	41	40	40.6	2,500
September	43	41	41.9	2,490
The year	58	24	36.2	26,200
1914–15.				
October	44	38	40.2	2,470
November	40	40	40.0	2,380
December	44	34	38.4	2,360
January	38	34	35.5	2,180
February	35	30	33.2	1,840
March	36	33	33.9	2,080
April	42	33	36.1	2,150
May	36	22	30.8	1,890
June	34	23	28.8	1,710
July	36	24	27.6	1,700
August	36	24	30.2	1,860
September	39	31	34.4	2,050
The year	44	22	34.1	24,700
1915–16.				
October	36	31	33.5	2,060
November	36	33	35.1	2,090
December	36	33	34.5	2,120
January	34	31	33.3	2,050
February	30	28	28.5	1,640
March	46	28	32.9	2,020
April	48	34	39.5	2,350
May	50	24	40.7	2,500
June	46	28	38.3	2,280
July	35	29	33.1	2,040
August	37	28	33.8	2,080
September	42	35	37.5	2,230
The year	50	24	35.1	25,500

Monthly discharge of South Fork of Provo River at Forks, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1916–17.				
October	57	40	42.7	2,630
November	42	34	37.4	2,230
December	40	32	34.1	2,100
January	35	32	33.8	2,080
February	34	28	29.7	1,650
March	32	28	28.2	1,730
April	44	29	32.0	1,900
May	72	36	49.5	3,040
June	64	28	45.5	2,710
July	49	20	34.1	2,100
August	38	32	34.7	2,130
September	38	34	34.5	2,050
The year	72	20	36.4	26,400
1917–18.				
October	42	31	37.0	2,280
November	42	36	38.7	2,300
December	39	36	38.0	2,340
January	38	31	35.1	2,160
February	34	31	31.9	1,770
March	38	31	33.7	2,070
April	33	29	31.5	1,870
May	33	22	28.8	1,770
June	--------	22	27.3	1,620
July	36	--------	29.7	1,830
August	38	22	26.6	1,640
September	45	23	30.3	1,800
The year	45	22	32.4	23,400
1918–19.				
October	34	28	30.6	1,880
November	31	26	28.4	1,690
December	28	25	27.2	1,670
January	25	23	24.4	1,500
February	24	23	23.2	1,290
March	29	25	26.3	1,620
April	29	25	25.9	1,540
May	45	26	32.3	1,990
June	37	23	29.1	1,730
July	36	28	32.0	1,970
August	32	23	28.6	1,760
September	35	21	28.2	1,680
The year	45	21	28.1	20,300
1919–20.				
October	34	29	29.4	1,810
November	29	29	29.0	1,730
December	31	27	28.5	1,750
January	26	20	24.9	1,530
February	39	25	25.6	1,470
March	31	25	25.5	1,570
April	33	25	28.0	1,670
May	96	31	60.7	3,730
June	78	32	44.1	2,620
July	34	24	30.2	1,860
August	46	34	38.6	2,370
September	48	35	41.1	2,450
The year	96	20	33.8	24,600

AMERICAN FORK NEAR AMERICAN FORK, UTAH.

LOCATION.—In sec. 30, T. 4 S., R. 3 E., at ranger station 50 feet above mouth of South Fork, 3 miles above Utah Power & Light Co.'s American Fork plant No. 2, 4½ miles above plant No. 1 at mouth of canyon, and 11½ miles from town of American Fork, Utah County.

DRAINAGE AREA.—Approximately 43 square miles.

RECORDS AVAILABLE.—February 15, 1912, to September 30, 1915 (fragmentary).

GAGE.—Inclined staff on left bank 50 feet above mouth of South Fork; read occasionally by forest ranger.

DISCHARGE MEASUREMENTS.—Made from bridge just below mouth of South Fork or by wading.

CHANNEL AND CONTROL.—Bed rocky; permanent except during floods. One channel at all stages. Gage height of zero flow about 1.2 feet.

WINTER FLOW.—Stage-discharge relation not seriously affected by ice. Minimum flow probably during winter.

DIVERSIONS.—Above all diversions.

REGULATION.—None.

Monthly discharge of American Fork near American Fork, Utah.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1912.				
February 15-29			[a] 16	476
March			[a] 20	1,230
April			[a] 30	1,790
May			164	10,100
June			254	15,100
July	162	67	102	6,270
August	120	27	47.9	2,950
September			33.2	1,980
The period				39,900

[a] Estimated.

NOTE.—No discharge record for 1913, 1914, 1915.

SOUTH FORK OF AMERICAN FORK NEAR AMERICAN FORK, UTAH.

LOCATION.—In sec. 30, T. 4 S., R. 3 E., at ranger station 150 feet above confluence with American Fork, 3 miles above Utah Power & Light Co.'s American Fork plant No. 2, 4½ miles above plant No. 1 at mouth of canyon, and 11½ miles from town of American Fork, Utah County.

DRAINAGE AREA.—About 5.8 square miles.

RECORDS AVAILABLE.—February 15, 1912, to September 30, 1915 (fragmentary).

GAGE.—Vertical staff on right bank; read occasionally by forest ranger.

DISCHARGE MEASUREMENTS.—Made from bridge near gage or by wading.

CHANNEL AND CONTROL.—Bed composed of coarse, clean gravel; fairly permanent. One channel at all stages.

WINTER FLOW.—Stage-discharge relation not seriously affected by ice. Flow very low when stream freezes near its source.

DIVERSIONS.—None.

REGULATION.—None.

Monthly discharge of South Fork of American Fork near American Fork, Utah.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1912.				
February 15–29			[a] 1.2	35.7
March			[a] 2.5	154
April			[a] 4.5	268
May			28.2	1,730
June			45.7	2,720
July	33	15	21.4	1,320
August	16	9.3	11.8	726
September			8.68	516
The period				7,470

[a] Estimated.

NOTE.—No discharge record for 1913, 1914, 1915.

LITTLE COTTONWOOD CREEK NEAR SALT LAKE CITY, UTAH.

LOCATION.—One-fourth mile west of SE. ¼ sec. 2, T. 3 S., R. 1 E., and 14 miles southeast of Salt Lake City, at mouth of canyon, one-fourth mile below county bridge, half a mile below Flagstaff smelting works, and 1½ miles above Armstrong Creek.

DRAINAGE AREA.—27.7 square miles.

RECORDS AVAILABLE.—Fall of 1898, to September 30, 1913.

GAGE.—Hub set level with weir crest; depth of water measured with carpenter's rule.

DISCHARGE MEASUREMENTS.—Flow measured by two 15-foot Cippoletti weirs.

ICE.—No ice at the weir.

DIVERSIONS.—The Despain ditches, one on each side of the stream, divert water about 1½ miles above the weir. These ditches irrigate one small farm and their flow is not included in the record. Nearly all the water is used below the station during the irrigating season.

REGULATION.—None.

COOPERATION.—Records are furnished by the city engineer of Salt Lake City.

Monthly discharge of Little Cottonwood Creek near Salt Lake City, Utah.

[Drainage area, 27.7 square miles.]

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1898–99.				
November [a]	15.37	9.22	11.89	708
December	13.93	9.71	11.96	735
January	13.53	10.35	12.12	745
February	13.09	8.50	11.34	630
March	13.92	10.09	12.41	763
April	64.27	13.09	38.95	2,330
May	170.58	44.18	105.32	6,480
The period				12,400
1904.				
August			27.18	1,670
September			17.20	1,020
October			17.47	1,070
November			15.06	896
The period				4,660

[a] Part of month; mean estimated for full month.

Monthly discharge of Little Cottonwood Creek near Salt Lake City, Utah—Contd.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1905–6.				
October	18.55	14.20	16.42	1,010
November [a]	14.21	7.82	11.41	679
December	11.53	8.14	9.76	600
January	11.90	7.09	10.17	625
February	13.51	8.65	11.53	640
March	18.88	9.42	14.05	684
April 1–18	51.81	19.40	27.89	996
The period				5,230
1907.				
January	12.62	9.58	11.49	706
February	16.76	11.07	14.58	810
March	71.19	15.94	29.07	1,790
April 1–12	82.62	37.98	51.10	1,220
The period				4,530
1907–8.				
November	24.13	15.04	18.06	1,070
December	16.76	12.62	14.99	922
January	16.76	11.07	13.29	817
February	17.60	9.24	11.85	682
March	18.54	10.35	15.12	930
April 1–20	110.54	17.60	45.47	1,800
The period				6,220
1908–9.				
December [a]	23.19	5.63	16.93	1,040
January	21.3	9.58	16.9	1,040
February	21.3	14.3	17.5	972
March	24.1	15.0	18.4	1,130
April	88.7	23.2	49.0	2,920
The period				7,100
1909–10.				
October 14–31	27.2	19.4	24.3	868
November	29.2	15.9	22.0	1,310
December	29.2	14.3	22.8	1,400
January	24.1	19.4	21.6	1,330
February	20.4	14.2	17.2	955
March	94.7	18.5	49.6	3,050
April 1–12	110.0	55.0	71.7	1,710
August 4–31	21.3	13.4	16.4	911
September	21.3	13.4	16.7	994
The period				
1910–11.				
October	25.2	15.9	19.9	1,220
November	18.5	13.4	16.5	982
December	16.8	8.2	12.0	738
January	62.9	9.5	13.6	836
February	62.9	15.9	25.8	1,430
March	31.3	15.9	20.6	1,270
August 15–31	21.3	7.52	14.4	486
September	14.2	5.01	8.05	479
The period				
1911–12.				
October	26.1	11.1	17.4	1,070
November	11.1	6.89	8.76	521
December	7.52	4.46	5.74	353
January	13.9	12.9	13.3	818
February	12.8	12.2	12.5	719
March	15.8	12.5	13.6	836
April	39.0	15.8	27.7	1,650
May	268	40.0	141	8,670
June	705	205	422	25,100
July	240	70.0	137	8,420
August	144	32.0	58.2	3,580
September	38.0	21.0	29.2	1,740
The year	705	12.2	73.7	53,500

[a] Part of month; mean estimated for full month.

Monthly discharge of Little Cottonwood Creek near Salt Lake City, Utah—Contd.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1912-13.				
October	55	19	26.0	1,600
November	39	19	26.9	1,600
December	21	16	17.6	1,080
January			14.2	873
February	16.6	12.6	14.2	789
March	16.6	11.9	14.1	867
April	105	16.6	54.6	3,250
May	369	94	191	11,700
June	238	166	204	12,100
July	210	39	138	8,480
August	71	20.9	30.9	1,900
September	35.7	19.1	25.5	1,520
The year	369	11.9	63.3	45,800

COTTONWOOD CREEK NEAR SALT LAKE CITY, UTAH.

LOCATION.—In SW. ¼ NE. ¼ sec. 25, T. 2 S., R. 1 E., at mouth of canyon, just below county bridge, 12 miles southeast of Salt Lake City.

DRAINAGE AREA.—48.5 square miles.

RECORDS AVAILABLE.—Fall of 1898 to September 30, 1913.

GAGE.—Vertical graduated glass tube set on lower side of dam.

DISCHARGE MEASUREMENTS.—Made with two 15-foot Cippoletti weirs.

FLOODS.—The maximum discharge record, 835 second-feet, was obtained June 6, 1909.

ICE.—No ice forms at the weir.

DIVERSIONS.—The Butler ditch, entitled to about 2 second-feet during irrigating season, diverts from the left bank about three-fourths mile above the weir. Its flow is not included in discharge record.

REGULATION.—The Utah Light & Railway Co.'s plant one-fourth mile above regulates the flow during low water.

COOPERATION.—Records furnished by the city engineer of Salt Lake City.

The water of the stream is used for irrigation and for municipal supply in Salt Lake City.

Monthly discharge of Cottonwood Creek near Salt Lake City, Utah.

[Drainage area, 48.5 square miles.]

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1898-99.				
November	37.06	26.70	33.19	1,970
December [a]	36.45	16.24	24.52	1,510
January [a]	29.55	21.25	24.04	1,480
February	33.68	9.19	24.29	1,350
March	43.73	24.89	32.12	1,980
April	149.91	35.11	94.91	5,650
May	266.20	67.67	180.68	11,100
June	633.22	211.55	379.37	22,600
July	260.83	97.27	162.11	9,970
August 1-15	109.80	77.32	89.80	2,679
The period				60,300

[a] Part of month; mean estimated for full month.

Monthly discharge of Cottonwood Creek near Salt Lake City, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1899-1900.				
May 14-31	301.04	126.92	219.00	7,820
June	281.74	88.81	170.48	10,100
July	83.75	37.99	58.03	3,570
August [a]	38.53	27.94	33.73	2,070
September	28.40	22.65	25.34	1,510
The period				25,100
1900-1901.				
October	31.07	24.61	27.26	1,680
November	32.81	25.90	29.07	1,730
December	28.94	13.60	25.12	1,540
January	26.08	11.33	22.10	1,360
February	28.15	17.41	23.73	1,320
March	34.60	23.00	29.26	1,800
April	155.97	22.16	69.59	4,140
May	407.32	179.19	269.92	16,600
June	240.97	123.75	171.50	10,200
July	129.30	38.00	71.86	4,420
August	45.61	29.26	39.00	2,400
September	36.93	25.23	29.76	1,770
The year	407.32	11.33	67.6	49,000
1901-2.				
October	33.48	25.89	29.05	1,790
November	31.19	24.85	27.80	1,650
December	34.08	21.78	27.19	1,670
January	27.17	13.63	23.14	1,420
February	28.44	17.23	24.24	1,350
March	27.72	20.41	24.55	1,510
April	142.94	26.96	70.40	4,190
May	369.69	108.93	210.21	12,900
June	309.50	91.74	194.47	11,600
July	92.33	40.87	62.16	3,820
August	38.87	28.44	32.97	2,030
September	30.81	25.17	27.89	1,660
The year	369.69	13.63	63.0	45,600
1902-3.				
October	28.99	21.37	26.32	1,620
November	28.78	21.83	24.84	1,480
December	29.26	16.06	22.80	1,400
January	25.60	15.79	21.30	1,310
February	24.19	13.56	19.50	1,080
March	45.55	18.76	24.12	1,480
April	144.57	30.30	57.66	3,430
May 1-26	266.37	77.21	155.00	7,990
July	74.93	39.14	56.94	3,500
August [a]	53.66	6.09	23.64	1,450
September	13.49	3.29	9.15	544
The period				
1903-4.				
October	14.45	9.98	12.10	240
September 23-30	38.70	30.42	35.90	570
The period				
1904-5.				
October	46.45	30.78	36.95	2,270
November	36.48	26.52	31.77	1,890
December	31.18	21.12	25.58	1,570
January	28.47	22.37	25.77	1,580
February	29.65	17.43	25.07	1,390
March	33.24	25.76	29.18	1,790
April	109.14	32.76	60.20	3,580
May	222.89	70.25	138.32	8,500
June	265.35	109.47	188.12	11,200
July	106.36	38.70	63.82	3,920
August	45.49	27.49	35.95	2,210
September	44.62	25.79	31.69	1,890
The year	222.89	17.43	57.7	41,800

[a] Part of month; mean estimated for full month.

Monthly discharge of Cottonwood Creek near Salt Lake City, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1905–6.				
October	38.15	25.55	32.01	1,970
November	32.80	16.08	28.18	1,680
December	30.75	17.65	26.42	1,620
January	29.73	18.93	25.89	1,590
February	28.23	25.55	26.86	1,490
March	42.93	23.23	31.47	1,940
April	130.29	37.33	73.36	4,370
May	287.82	77.41	205.52	12,600
June [a]			200	11,900
July [b]	216.03	80.24	144.38	8,880
August	114.55	60.44	74.57	4,590
September [a]	89.86	49.61	57.46	3,420
The year			77.5	56,000
1906–7.				
October [a]	50.31	36.63	43.17	2,650
November	43.90	28.34	39.45	2,350
December	54.41	39.03	48.77	3,000
January	50.88	45.12	47.55	2,920
February	82.22	29.73	42.98	2,390
March	146.27	29.48	54.59	3,360
April [b]			85	5,060
May	392.09	102.53	207.52	12,800
June	792.85	216.05	432.01	25,700
July	730.85	149.70	391.43	24,100
August	147.98	70.92	97.60	6,000
September	69.58	49.91	58.03	3,450
The year			129.4	93,800
1907–8.				
October	60.42	41.20	51.59	3,170
November	56.63	37.87	44.46	2,650
December	42.33	35.71	37.01	2,280
January	35.71	28.48	32.83	2,020
February	35.71	27.49	31.10	1,790
March	42.32	26.52	34.07	2,090
April	215.92	32.54	84.55	5,030
May [b]			192.96	11,900
June	519.57	158.42	291.85	17,400
July	268.70	92.05	164.17	10,100
August	89.13	51.71	63.67	3,910
September	87.68	42.33	53.92	3,210
The year			90.2	65,600
1908–9.				
October	66.92	45.77	57.23	3,520
November	60.42	37.87	46.86	2,790
December	38.97	24.6	36.19	2,230
January	46.9	31.5	40.5	2,490
February	43.5	32.5	38.3	2,130
March	52.9	34.6	43.0	2,640
April	171	46.9	98.6	5,870
May	411	136	255	15,700
June	835	162	529	31,550
July	480	118	235	14,400
August	141	79.2	102	6,270
September	139	61.7	90.8	5,400
The year	835	24.6	131.1	94,900

[a] Part of month; mean estimated for full month. [b] Monthly mean estimated.

Monthly discharge of Cottonwood Creek near Salt Lake City, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1909–10.				
October	90.6	49.3	69.8	4,290
November	84.8	50.5	66.5	3,960
December	79.2	48.1	62.7	3,860
January	66.9	50.5	56.1	3,450
February	55.4	43.5	47.8	2,650
March	150	49.3	92.7	5,700
April	343	99.5	181	10,800
May	387	182	285	17,500
June	390	125	235	14,000
July	120	69.6	88.1	5,420
August	82	51.7	62.9	3,870
September	55.4	46.9	51.2	3,050
The year	390	43.5	108.5	78,600
1910–11.				
October	69.6	46.9	53.0	3,260
November	49.3	36.8	44.7	2,660
December	49.3	36.8	42.7	2,590
January	79.2	31.5	40.2	2,470
February	70.9	32.5	42.5	2,360
March	60.4	32.5	47.3	2,910
April	93.5	52.9	69.9	4,160
May	238	82.0	169	10,400
June	387	173	283	16,800
July	160	66.9	101	6,210
August	69.6	37.9	49.5	3,040
September	46.9	31.5	36.5	2,170
The year	387	31.5	81.6	59,000
1911–12.				
October	50.5	29.5	38.4	2,360
November	34.6	20.9	29.3	1,740
December	26.5	21.8	25.1	1,540
January	29	20	24.7	1,520
February	26	20	24.0	1,380
March	38	22	27.3	1,680
April	90	36	63.2	3,760
May	475	68	219	13,500
June	730	267	419	24,900
July	238	72	123	7,560
August	88	59	69.3	4,260
September	62	42	51.1	3,040
The year	730	20	92.8	67,200
1912–13.				
October	55	19	26.0	1,600
November	39	19	26.9	1,600
December	21	16	17.6	1,080
January			14.2	873
February	16.6	12.6	14.2	789
March	16.6	11.9	14.1	867
April	105	16.6	54.6	3,250
May	369	94	191	11,700
June	238	166	204	12,100
July	210	39	138	8,480
August	71	20.9	30.9	1,900
September	35.7	19.1	25.5	1,520
The year	369	11.9	63.3	45,800

MILL CREEK NEAR SALT LAKE CITY, UTAH.

LOCATION.—Near mouth of canyon, at weir in creek in SW. ¼ NW. ¼ sec. 31, T. 1 S., R. 2 E., and at weir in power-plant tailrace in SE. ¼ NE. ¼ sec. 36, T. 1 S., R. 1 E., 8 miles southeast of Salt Lake City.

DRAINAGE AREA.—21.3 square miles.

RECORDS AVAILABLE.—Fall of 1898 to September 30, 1913.

GAGE.—Depth of water measured with a carpenter's rule from a hub set level with crest in creek and by a hook gage in tailrace.

DISCHARGE MEASUREMENTS.—Computed flow over a 12.5-foot Cippoletti weir in the main stream and a 5-foot rectangular weir in the tailrace of the power plant.

FLOODS.—On June 17 and 18, 1909, the discharge of the creek was 112 second-feet.

ICE.—No ice forms at the weir.

DIVERSIONS.—Most of the water is used for irrigation below the station during the summer. Records include flow in the power plant tailrace, thus giving total run-off from the drainage area.

REGULATION.—None.

COOPERATION.—Records furnished by the city engineer of Salt Lake City.

Monthly discharge of Mill Creek near Salt Lake City, Utah.

[Drainage area, 21.3 square miles.]

Month.	Discharge in second-feet.			
	Maximum.	Minimum.	Mean.	Run-off in acre-feet.
1898–99.				
November a	15.25	10.08	12.94	770
December	13.69	2.85	10.40	640
January	12.74	7.92	11.65	716
February	12.38	3.18	10.27	570
March	14.64	11.64	12.22	751
April a	24.52	12.38	21.06	1,250
May	45.93	23.08	34.83	2,140
June	66.01	34.15	50.35	3,000
July	35.63	19.80	25.68	1,580
August	19.80	16.70	17.87	1,100
September	16.70	14.88	15.67	933
The period				13,400
1899–1900.				
October	18.35	11.66	14.60	898
November	14.43	13.13	13.52	804
December	13.13	2.35	11.43	703
January	13.04	8.09	12.05	741
February	11.33	8.09	10.39	577
March	13.04	10.49	11.84	728
April	13.95	11.74	12.60	750
May	30.79	13.95	21.63	1,330
June	22.92	13.04	16.18	963
July	13.95	8.86	10.46	643
August	10.49	8.83	9.48	583
September	8.86	8.09	8.56	509
The year	30.79	2.35	12.7	9,230
1900–1901.				
October	8.86	8.49	8.56	526
November	9.66	8.49	8.74	520
December	8.49	1.41	7.13	438
January	8.86	1.41	7.17	441
February	8.86	3.71	8.11	450
March	8.86	8.09	8.37	515
April	12.16	8.49	9.94	591
May	47.43	14.88	29.41	1,810
June	28.49	15.33	19.82	1,180
July	15.33	14.88	15.16	932
August	14.88	12.16	12.53	770
September	12.16	11.33	11.58	689
The year	47.43	1.41	12.2	8,860

a Part of month; mean estimated for full month.

Monthly discharge of Mill Creek near Salt Lake City, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1901-2.				
October	12.16	11.33	11.62	715
November	12.16	11.33	11.36	676
December	13.04	3.99	10.20	627
January	13.04	3.70	9.33	574
February	11.33	3.70	8.88	493
March	9.66	9.66	9.66	594
April	15.33	9.66	12.77	760
May	39.46	15.33	23.62	1,450
June	36.95	16.79	21.70	1,290
July	16.79	11.33	13.72	844
August	11.33	9.28	11.00	676
September	9.66	9.28	9.33	555
The year	39.46	3.70	12.8	9,250
1902-3.				
October	9.66	9.66	9.66	594
November	9.66	5.26	8.54	508
December	9.66	1.86	6.96	428
January	9.66	3.99	7.84	482
February	9.66	2.87	6.48	360
March	9.66	5.58	8.46	520
April	11.74	9.28	10.21	607
May	25.07	11.74	17.50	1,080
June	34.44	16.79	25.95	1,540
July	16.79	14.88	15.15	932
August	14.88	11.74	12.85	790
September	11.74	11.33	11.58	689
The year	34.44	1.86	11.8	8,530
1903-4.				
October	11.33	11.33	11.33	697
November	11.74	5.58	11.02	656
December	11.33	3.40	9.07	558
January	13.04	6.64	9.85	606
February	13.04	3.71	9.87	568
March	13.04	9.28	11.20	689
April	25.07	11.33	18.92	1,130
May	58.81	25.07	41.42	2,550
June	55.87	29.66	40.86	2,430
July	29.66	20.79	25.74	1,580
August	16.79	13.04	14.89	916
Septemer	15.81	13.04	14.95	890
The year	58.81	3.40	18.3	13,300
1904-5.				
October	13.95	13.04	13.66	840
November	13.04	11.33	12.36	736
December	11.33	1.02	8.63	531
January	8.86	8.86	8.86	545
February	9.66	1.86	7.87	437
March	11.74	8.49	10.23	629
April	16.79	11.33	12.26	730
May	38.46	16.79	23.06	1,420
June	36.95	20.79	26.51	1,580
July	16.79	14.88	15.37	945
August	14.88	10.89	12.66	778
September	13.04	10.89	11.86	706
The year	38.46	1.02	13.6	9,880
1905-6.				
October	13.04	11.33	11.61	714
November	11.33	8.49	10.13	603
December	11.33	1.21	7.18	441
January	11.33	3.13	8.69	534
February	9.66	9.28	9.44	524
March	9.66	5.26	9.52	585
April	20.79	9.66	15.22	906
May	55.87	16.28	31.29	1,920
June	58.81	24.54	36.89	2,200
July	25.07	11.74	18.97	1,170
August	27.33	12.62	15.53	955
September	15.33	13.04	14.00	833
The year	58.81	1.21	15.7	11,400

Monthly discharge of Mill Creek near Salt Lake City, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1906-7.				
October	13.04	13.04	13.04	802
November	13.04	3.99	11.41	679
December	11.74	11.33	11.71	720
January	11.74	6.64	11.13	684
February	20.79	11.33	14.16	786
March	34.44	14.88	19.12	1,180
April	44.70	16.79	32.58	1,940
May	64.77	36.95	47.66	2,930
June	71.72	42.08	57.94	3,450
July	49.55	27.33	34.38	2,110
August	29.66	22.92	25.70	1,580
September	27.33	19.72	22.71	1,350
The year	71.72	3.99	25.2	18,200
1907-8.				
October	20.30	16.28	18.72	1,150
November	16.79	16.28	16.60	988
December	16.79	12.62	14.96	920
January	13.78	12.62	12.93	795
February	13.95	6.98	12.88	741
March	14.88	12.68	13.63	838
April	17.73	12.68	15.29	910
May	50.22	17.73	29.63	1,820
June	64.77	39.46	46.22	2,750
July	39.46	27.33	30.66	1,890
August	25.07	20.79	22.90	1,410
September	20.79	18.73	19.42	1,160
The year	64.77	6.98	21.2	15,400
1908-9.				
October	18.73	16.28	17.07	1,050
November	16.79	11.33	15.93	948
December	16.79	3.99	12.98	798
January	18.7	8.09	14.7	904
February	20.8	14.9	16.6	922
March	22.9	16.3	19.3	1,190
April	39.5	22.9	29.4	1,750
May	83.8	32.0	50.8	3,120
June	112.	64.8	81.1	4,830
July	83.8	25.1	36.6	2,250
August	29.7	25.1	28.1	1,730
September	27.3	22.9	24.9	1,480
The year	112	3.99	29.0	21,000
1909-10.				
October	22.9	20.3	20.8	1,280
November	25.1	18.7	19.5	1,160
December	20.8	6.64	16.3	1,000
January	16.8	8.1	15.4	947
February	15.3	14.9	15.1	839
March	25.1	14.9	21.5	1,320
April	42.1	22.9	33.0	1,960
May	44.8	32.0	38.4	2,360
June	44.8	27.3	31.0	1,840
July	27.3	20.8	22.1	1,360
August	18.7	16.8	18.3	1,130
September	16.8	15.3	16.2	964
The year	44.8	6.64	22.3	16,200
1910-11.				
October	15.3	14.9	15.1	928
November	15.3	14.9	15.2	904
December	16.8	13.0	15.2	935
January	11.33	3.99	5.52	339
February	7.04	3.42	5.21	289
March	9.03	7.04	7.44	457
April	11.48	8.73	10.1	601
May	35.76	11.48	23.3	1,430
June	40.72	16.67	28.1	1,670
July	16.67	11.04	12.9	793
August	11.05	7.48	8.76	538
September	7.76	6.64	7.03	418
The year	40.72	3.42	12.9	9,300

Monthly discharge of Mill Creek near Salt Lake City, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1911-12.				
October	7.76	6.45	7.08	435
November	6.87	4.68	5.67	337
December	6.64	5.03	5.69	349
January	12.4	10.3	11.0	676
February	10.9	9.0	9.58	551
March	14.8	9.2	10.9	670
April	30.9	16.6	23.8	1,420
May	121	25.0	44.5	2,740
June	92	32.0	59.4	3,530
July	34	19.0	24.4	1,500
August	24	17.0	20.6	1,270
September	18.4	16.1	17.2	1,020
The year	121	4.68	20.0	14,500
1912-13.				
October	25.0	17.4	19.8	1,220
November	21.3	15.6	17.3	1,030
December	18.6	1.4	15.6	959
January	17.9	6.9	13.2	812
February	13.0	11.6	12.7	705
March	32	11.3	13.9	855
April	70	29	44.6	2,650
May		40	68.9	4,240
June	80	26	39.1	2,330
July	30	17.9	22.6	1,390
August	20	15.1	16.7	1,030
September	16.8	13.6	14.5	863
The year		6.9	25.0	18,100

PARLEYS CREEK NEAR SALT LAKE CITY, UTAH.

Location.—In northwest corner of sec. 25, T. 1 S., R. 1 E., at mouth of canyon just above intakes of city waterworks, 6 miles southeast of Salt Lake City.

Drainage area.—50.1 square miles.

Records available.—Fall of 1898 to September 30, 1913.

Gage.—Hook.

Discharge measurements.—Determined by means of two 10-foot Cippolett weirs.

Floods.—On June 6 and 7, 1909, there was a maximum flow of 274 second-feet.

Ice.—No ice forms at the weir.

Diversions.—Part of the city water supply is taken from this creek and surplus water is used for irrigation during the summer season. The Parley's surplus ditch diverts from the left bank about 1 mile above the weir, and its flow is included in the records of daily discharge.

Regulation.—None.

Cooperation.—Records furnished by the city engineer of Salt Lake City.

Monthly discharge of Parleys Creek near Salt Lake City, Utah.

[Drainage area, 50.1 square miles.]

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1898.				
August [a]	11.66	7.18	9.26	569
September	11.78	7.44	8.90	530
The period				1,100
1898-99.				
October	14.74	8.53	10.32	634
November	13.77	6.69	9.44	562
December	13.69	2.90	8.30	510
January	13.39	6.43	8.91	548
February	11.30	4.00	8.21	456
March [a]	50.10		12.45	766
April	216.00	48.30	146.66	8,730
May	220.00	113.00	174.81	10,800
June	227.50	125.60	108.72	6,470
July	120.80	30.68	58.40	3,590
August	28.44	14.66	20.86	1,280
September	16.24	12.71	14.33	853
The year	227.50	2.90	48.5	35,200
1899-1900.				
October	21.55	14.44	16.43	1,010
November	18.90	12.99	14.27	849
December	14.79	4.21	11.30	695
January	15.65	8.11	11.91	732
February	11.90	8.81	10.45	579
March	20.14	10.74	16.43	1,010
April [a]	31.20	14.88	20.32	1,210
May [a]	38.98	22.30	29.39	1,810
June	24.13	9.68	15.84	943
July	13.56	6.19	9.46	582
August	10.41	6.19	7.25	446
September	10.02	4.37	6.97	415
The year	38.98	4.21	14.2	10,300
1900-1901.				
October	12.17	7.34	8.93	549
November	12.08	5.39	7.75	461
December	9.01	2.92	7.35	452
January	10.00	4.11	7.73	475
February	16.20	4.76	9.00	500
March	17.34	9.34	11.13	684
April	90.32	11.02	38.17	2,270
May	109.49	43.16	86.71	5,330
June	47.75	18.05	28.49	1,700
July	20.15	9.94	13.85	852
August	23.82	5.85	12.23	752
September	12.90	7.26	8.44	502
The year	109.49	2.92	20.1	14,500
1901-2.				
October	9.94	8.12	8.59	528
November	11.39	7.51	8.19	487
December	13.30	3.01	7.67	472
January	9.33	2.15	7.08	435
February	9.27	3.35	7.34	408
March	10.57	5.05	7.39	454
April	85.71	6.68	33.38	1,990
May	95.26	33.46	58.47	3,600
June	73.83	18.26	33.64	2,000
July	16.85	10.37	13.38	822
August	13.26	5.52	10.57	650
September	8.84	7.02	7.59	452
The year	95.26	2.15	17.0	12,300

[a] Part of month; mean estimated for full month.

Monthly discharge of Parleys Creek near Salt Lake City, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1902-3.				
October	7.91	7.20	7.52	462
November	9.27	4.85	7.33	436
December	9.78	2.89	6.73	414
January	15.27	4.35	7.84	482
February	8.00	3.35	6.69	372
March	24.59	6.01	12.15	747
April	88.12	13.29	29.83	1,780
May	124.03	51.48	73.80	4,540
June	133.73	20.45	55.30	3,290
July	36.71	13.70	16.33	1,000
August	14.35	8.06	11.12	684
September	9.97	7.72	8.73	519
The year	133.73	2.89	20.3	14,700
1903-4.				
October	11.38	8.45	9.73	598
November	13.06	2.41	8.67	516
December	8.28	2.06	5.93	365
January	9.21	4.82	7.08	435
February	18.07	4.20	10.29	592
March	39.29	9.36	19.60	1,210
April	207.29	69.75	123.18	7,330
May	208.52	88.12	168.46	10,400
June	137.50	28.48	52.63	3,130
July	41.08	19.47	26.09	1,600
August	20.20	11.79	15.99	983
September	13.05	9.40	11.36	676
The year	208.52	2.06	38.3	27,800
1904-5.				
October	13.69	11.78	12.88	793
November	11.79	8.82	10.27	611
December	10.78	2.55	8.25	507
January	10.15	6.48	9.00	553
February	12.24	1.87	8.76	487
March	10.17	6.90	9.28	571
April	38.66	8.64	18.94	1,130
May	56.65	22.88	36.97	2,270
June	28.18	14.79	21.41	1,270
July	15.70	10.18	12.49	768
August	13.72	6.65	8.23	506
September	11.37	5.84	6.72	400
The year	56.65	1.87	13.6	9,870
1905-6.				
October	7.51	5.30	6.79	418
November	7.51	5.16	6.58	392
December	8.29	2.75	5.86	360
January	11.83	3.94	7.51	462
February	9.60	6.20	7.71	428
March	27.32	4.58	12.82	788
April [a]	38.87	21.46	48.49	2,890
May	145.85	70.93	106.94	6,570
June	122.03	38.66	68.98	4,100
July	38.74	17.78	24.58	1,510
August [a]	30.93	14.14	17.25	1,060
September [a]	14.79	9.78	11.68	695
The year	145.85	2.75	27.2	19,700

[a] Part of month; mean estimated for full month.

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Monthly discharge of Parleys Creek near Salt Lake City, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1906-7.				
October	10.26	9.10	9.70	596
November	12.79	3.34	9.12	543
December	14.99	5.00	10.06	618
January	10.62	3.18	8.14	501
February, 7 days	32.06	8.63	23.12	321
March				
April	211.79	123.22	162.76	9,690
May	203.64	85.22	146.89	9,030
June 1-16	163.52	116.03	139.01	4,410
July				
August				
September				
The year				
1907-8.				
October				
November	15.77	10.54	13.43	799
December [a]	13.65	9.28	11.23	691
January	15.77	6.95	11.16	686
February	13.94	5.14	10.15	584
March	22.39	5.58	13.59	836
April	41.14	1[illegible].15	27.24	1,620
May	81.10	1[illegible].99	49.14	3,020
June	81.31	49.09	74.14	4,410
July	49.09	25.25	34.44	2,120
August	29.74	16.40	22.07	1,360
September	28.98	11.62	15.26	908
The period				17,000
1908-9.				
October	20.33	13.94	17.11	1,050
November	17.68	5.14	13.59	809
December	17.68	3.16	12.41	763
January	36.9	10.5	24.5	1,510
February	25.3	15.8	21.5	1,190
March	64.3	23.1	38.7	2,380
April	228	63.3	130	7,740
May	262	143	209	12,900
June	274	68.4	166	9,880
July	64.3	28.2	42.5	2,610
August	39.4	17.6	26.5	1,630
September	24.5	17.7	19.6	1,170
The year	274	3.16	60.2	43,600
1909-10.				
October	19.7	16.4	18.6	1,140
November	50.9	17.0	21.0	1,250
December	22.4	7.92	17.6	1,080
January	32.1	12.2	18.6	1,140
February	19.7	7.4	15.4	855
March	115	19.6	71.9	4,420
April				
May				
June	47.3	26.0	32.9	1,960
July	27.5	19.0	22.7	1,400
August	19.0	13.4	15.7	965
September	13.2	11.1	12.2	726
1910-11.				
October	19.6	12.2	13.7	842
November	12.8	8.4	11.5	684
December	12.8	5.6	9.7	599
January	26.0	4.31	10.9	670
February	22.4	4.31	10.8	600
March	22.4	9.98	16.4	1,010
April	53.7	18.3	27.3	1,620
May	45.5	24.5	32.8	2,020
June	27.5	17.0	22.6	1,340
July	21.7	12.9	16.3	1,000
August	12.8	8.42	9.7	596
September	10.5	7.43	8.01	477
The year	53.7	4.31	15.8	11,500

[a] Part of month; mean estimated for full month

Monthly discharge of Parleys Creek near Salt Lake City, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1911–12.				
October	12.8	7.9	10.1	621
November	9.4	4.3	7.89	469
December	12.8	4.6	8.39	516
January	10.6	5.0	8.27	508
February	24.5	2.5	8.82	507
March	20.3	7.4	11.7	719
April	108	17.7	49.5	2,950
May	226	49.1	139	8,550
June	189	55.0	121	7,200
July	76	28.0	38.2	2,350
August	34	18.3	23.1	1,420
September	21.7	15.8	17.4	1,040
The year	226	2.5	36.9	26,800
1912–13.				
October	18.3	14.5	15.8	972
November	19.6	11.1	15.2	904
December	13.4	5.6	10.1	621
January	13.4	4.3	10.5	646
February	12.8	5.1	9.99	555
March	34	4.7	13.2	812
April	139	52	95.3	5,670
May	108	56	82.7	5,080
June	54	27	36.2	2,150
July	36	21	24.6	1,510
August	23	14.5	17.5	1,080
September	17	13	14.2	845
The year	139	4.3	28.8	20,800

EMIGRATION CREEK NEAR SALT LAKE CITY, UTAH.

LOCATION.—In SW. ¼ NW. ¼ sec. 11, T. 1 S., R. 1 E., half a mile below mouth of canyon and below Wagener's old brewery and 4 miles southeast of Salt Lake City. Weir in pipe line is half a mile east of Wagener's old brewery, in a tank house.

DRAINAGE AREA.—29 square miles.

RECORDS AVAILABLE.—Fall of 1898 to September 30, 1913.

GAGE.—Graduated copper plates used as staff gages in pipe line and in creek.

DISCHARGE MEASUREMENTS.—Computed from flow over two Cippoletti weirs, 2.5 and 5 feet long, in creek, and a 2-foot rectangular weir in pipe line from spring just inside mouth of canyon.

FLOODS.—There was a maximum discharge of probably 45 second-feet in April, 1913.

DIVERSIONS.—The city has obtained a small part of its water supply by developing a spring a short distance up the canyon and by keeping the water out of the creek by means of a pipe line. This water is included in the total run-off record.

REGULATION.—None.

COOPERATION.—Records furnished by the city engineer of Salt Lake City.

Monthly discharge of Emigration Creek near Salt Lake City, Utah.

[Drainage area, 29.0 square miles.]

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1900.				
June	3.46	1.27	2.41	143
July	1.57	.51	.91	56.0
August	.57	.50	.54	33.2
September	.61	.48	.52	30.9
The period				263.1
1900–1901.				
October	1.26	.48	.68	41.8
November	2.76	.73	1.29	76.8
December	1.40	.66	.87	53.5
January	.70	.57	.66	40.6
February	8.56	.68	1.68	93.3
March	5.57	1.38	3.73	229
April	13.72	4.14	8.27	492
May [a]	21.97	7.05	12.44	765
June	7.05	2.97	4.87	290
July	2.76	.84	1.84	113
August	3.02	.76	1.13	69.5
September	3.13	.61	.82	48.8
The year	21.97	.48	3.20	2,310
1901–2.				
October	1.52	.82	1.01	62.1
November	1.45	.97	1.20	71.4
December	1.75	.50	.94	57.8
January	.60	.60	.60	36.9
February	1.29	.60	.87	48.3
March	2.35	.70	1.46	89.8
April	19.33	2.20	9.69	577
May	17.13	7.10	9.92	610
June	8.03	2.93	4.87	290
July	3.12	.94	2.05	126
August	1.37	.57	.78	48.0
September	.60	.50	.52	30.9
The year	19.33	.50	2.83	2,050
1902–3.				
October	.80	.61	.69	42.4
November	1.79	.70	1.10	65.5
December	1.37	.73	.95	58.4
January	6.26	.66	1.07	65.8
February	.85	.53	.64	35.5
March	11.72	.73	3.05	188
April	12.77	3.72	8.04	478
May	19.33	5.50	9.48	583
June	18.07	3.99	8.62	513
July	3.99	1.56	2.79	172
August	1.72	.60	.98	60.3
September	1.11	.60	.83	49.4
The year	19.33	.53	3.19	2,310
1903–4.				
October	2.04	1.11	1.23	75.6
November	3.15	.99	1.29	76.8
December	.84	.61	.68	41.8
January	.87	.73	.86	52.9
February	3.72	.87	1.72	98.9
March	24.21	1.01	6.82	419
April				
May				
June				
July				
August [a]	1.88	1.41	1.77	109
September	1.41	1.11	1.16	69.0

[a] Part of month; mean estimated for full month.

Monthly discharge of Emigration Creek near Salt Lake City, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1904-5.				
October	2.40	1.11	1.55	95.3
November	1.51	1.27	1.43	85.1
December	3.13	.77	.82	50.4
January	1.08	.77	.93	57.2
February [a]	1.34	.91	1.11	61.6
March	2.66	1.54	1.96	121
April	7.29	2.26	5.13	305
May	12.19	5.74	9.22	567
June	7.07	1.95	4.53	270
July	2.33	.50	1.32	81.2
August	.50	.39	.43	26.4
September	.60	.43	.44	26.2
The year	12.19	.29	2.41	1,750
1905-6.				
October	.53	.53	.53	32.6
November	.76	.53	.65	38.7
December	.67	.64	.64	39.4
January	.64	.64	.64	39.4
February	.64	.64	.64	35.5
March	15.47	.64	4.24	261.0
April	18.07	11.09	15.02	894.0
May	17.48	12.17	14.50	892.0
June	14.02	4.28	10.59	630.0
July	6.88	2.97	4.50	277.0
August [a]	3.78	1.72	2.30	141.0
September	3.15	1.41	1.87	111.0
The year	18.07	.53	4.68	3,390
1906-7.				
October	1.56	1.11	1.45	89.2
November	2.40	1.11	1.58	94.0
December	4.40	1.11	1.85	114
January [a]	2.28	1.11	1.60	98.4
May 24-31	18.75	5.01	10.40	165
June [a]	19.44	5.01	7.54	449
July [a]	5.23	4.57	5.55	341
August [a]	7.62	6.39	6.77	416
1907-8.[b]				
November [a]	2.76	1.72	2.13	127
December [a]	3.99	1.56	2.72	167
Fenuary	1.88	1.25	1.59	97.8
Jabruary	3.15	1.41	1.52	87.4
March	3.99	1.56	2.98	183
April	8.93	3.56	5.72	340
May	8.93	5.80	8.80	541
June	12.47	2.97	7.60	452
July	8.93	2.40	6.39	393
August	8.93	3.99	6.16	379
September	6.80	3.15	4.90	292
The period				3,050
1908.[b]				
October	6.80	4.85	5.76	354
November	5.80	4.85	5.58	332
December	4.85	2.43	3.64	224
The period				910
1911.				
January			2.51	154
February			2.26	126
March			4.19	258
April			7.08	421
May			4.31	265
June			2.90	173
July			1.44	88
August			.63	39
September			.44	26
The period				1,550

[a] Part of month; mean estimated for full month.
[b] All months incomplete during calendar year 1908. Means estimated for full months.

Monthly discharge of Emigration Creek near Salt Lake City, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1911–12.				
October			0.60	37
November			.56	33
December			.50	31
January			1.88	116
February			2.12	122
March			2.64	162
April				
May 8–31			35.8	1,700
June			16.9	1,010
July			8.91	548
August			6.89	424
September			6.26	372

CITY CREEK NEAR SALT LAKE CITY, UTAH.

LOCATION.—In southeast corner SE. ¼ sec. 16, T. 1 N., R. 1 E., 4 miles northeast of Salt Lake City, 4 miles above mouth of canyon, and just above highest point of diversion into city water system.

DRAINAGE AREA.—19.2 square miles.

RECORDS AVAILABLE.—Fall of 1898 to September 30, 1913.

GAGE.—Hook.

DISCHARGE MEASUREMENTS.—Computed by means of two 5-foot Cippoletti weirs.

FLOODS.—There was a maximum discharge of 132 second-feet in May, 1907.

ICE.—No ice forms at the weirs.

DIVERSIONS.—All the water is diverted below the weirs for city water supply except during the spring floods, when the surplus water wastes through the streets of Salt Lake City to Jordan River.

REGULATION.—None.

COOPERATION.—Records are furnished by the city engineer of Salt Lake City.

Monthly discharge of City Creek near Salt Lake City, Utah.

[Drainage area, 19.2 square miles.]

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1898–99.				
December 19–31	5.84	5.27	5.42	140
January	5.54	5.12	5.24	322
February	6.03	3.15	5.18	288
March	10.63	5.14	6.63	408
April	30.38	8.91	22.71	1,350
May	60.66	20.74	41.24	2,540
June	121.96	48.48	78.50	4,670
July	48.26	17.63	28.76	1,770
August	15.69	11.99	13.15	809
September	12.77	9.93	11.28	671
The period				13,000

Monthly discharge of City Creek near Salt Lake City, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1899–1900.				
October	10.91	9.43	10.13	623
November	11.27	8.67	9.19	547
December	8.73	7.76	8.33	512
January	10.04	7.75	8.01	493
February	8.06	7.06	7.44	413
March [a]	11.00	7.79	9.29	571
April	14.49	8.86	10.95	652
May	31.30	14.45	23.91	1,470
June	24.32	11.50	16.06	956
July	11.90	7.74	9.84	605
August	8.93	6.75	7.52	462
September	7.20	6.16	6.49	386
The year	31.30	6.16	10.6	7,690
1900–1901.				
October	7.05	6.31	6.51	400
November	7.12	5.81	6.44	383
December	6.24	5.39	5.73	352
January	5.67	5.26	5.37	330
February	6.60	4.99	5.58	310
March	7.27	6.09	6.82	419
April	18.05	6.67	11.00	655
May	72.01	20.36	51.12	3,140
June	35.97	15.65	23.26	1,380
July	15.45	9.83	12.64	777
August	10.51	7.35	9.19	565
September	8.05	6.46	6.98	415
The year	72.01	4.99	12.6	9,130
1901–2.				
October	9.58	6.53	7.32	450
November	7.42	6.53	6.94	413
December	6.82	5.95	6.37	392
January	6.83	4.27	5.83	358
February	5.95	3.61	5.49	305
March	6.17	5.53	5.75	354
April	23.20	5.95	13.36	795
May	58.18	19.88	38.67	2,380
June	57.58	16.63	29.40	1,750
July	17.24	10.68	13.57	834
August	10.33	7.50	9.22	567
September	7.73	6.67	7.11	423
The year	58.18	3.61	12.5	9,020
1902–3.				
October	6.82	6.67	6.74	414
November	6.53	6.09	5.28	314
December	6.53	5.53	5.90	363
January	6.82	5.81	6.06	373
February	10.87	4.32	6.14	341
March	10.50	5.53	6.56	403
April	16.04	7.58	10.16	605
May	42.88	12.62	26.33	1,620
June	63.09	21.00	39.96	2,380
July	21.00	13.08	16.13	992
August	14.85	10.16	11.62	714
September	10.16	8.52	9.16	545
The year	63.09	4.32	12.5	9,060

[a] Part of month; mean estimated for full month.

Monthly discharge of City Creek near Salt Lake City, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1903-4.				
October	11.05	8.36	9.44	580
November	8.36	6.97	7.86	468
December	6.97	6.67	6.81	419
January	6.67	5.95	6.24	384
February	7.89	5.95	6.62	381
March	11.02	7.27	8.42	518
April	28.75	11.02	21.59	1,280
May	70.06	28.75	55.62	3,420
June	56.97	26.62	39.15	2,330
July	26.50	16.24	19.74	1,210
August	15.26	11.46	13.36	821
September	11.38	9.39	10.38	618
The year	70.06	5.95	17.1	12,400
1904-5.				
October	9.34	8.72	9.09	559
November	8.72	8.20	8.47	504
December	9.18	7.66	8.04	494
January	8.28	7.43	7.65	470
February	9.58	6.68	7.52	418
March	9.00	7.58	7.94	488
April	18.26	8.68	12.53	746
May	44.81	19.09	30.16	1,850
June	36.61	17.75	26.78	1,590
July	17.64	12.44	14.64	900
August	12.35	9.74	10.64	654
September	10.13	8.27	9.13	543
The year	44.81	6.68	12.7	9,220
1905-6.				
October	8.82	8.22	8.40	516
November	8.17	7.63	7.84	467
December	8.28	7.58	7.82	481
January	8.36	7.50	7.77	478
February	8.76	7.50	7.84	435
March	15.07	8.05	10.64	654
April	32.91	13.27	22.46	1,340
May	68.78	26.27	50.61	3,110
June	59.09	32.92	49.45	2,940
July	26.62	18.78	24.09	1,480
August [a]	19.09	13.27	15.31	941
September	13.74	11.02	12.11	721
The year	68.78	7.50	18.7	13,600
1906-7.				
October	10.85	10.42	10.63	654
November	10.68	9.49	10.17	605
December	9.49	9.08	9.41	579
January	9.49	8.60	8.94	550
February	19.51	9.16	15.28	849
March	37.27	14.68	20.12	1,240
April	59.70	20.79	40.01	2,390
May	132.09	43.29	70.22	4,320
June	110.61	56.97	80.47	4,790
July	56.97	28.03	41.09	2,530
August	26.85	19.30	22.25	1,370
September	18.78	13.17	15.67	932
The year	132.09	8.60	28.7	20,800

[a] Part of month; mean estimated for full month.

Monthly discharge of City Creek near Salt Lake City, Utah—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1907–8.				
October	13.17	11.46	12.27	754
November	11.72	6.40	10.33	614
December	10.85	9.91	10.15	624
January	10.08	8.68	9.51	585
February	9.66	8.84	9.25	532
March	12.44	9.25	10.39	639
April	21.11	9.49	15.32	912
May	64.34	18.46	37.18	2,290
June	80.63	47.34	64.42	3,830
July	46.77	22.31	31.27	1,920
August	22.53	16.24	18.99	1,170
September	16.44	13.72	14.66	872
The year	80.63	6.40	20.3	14,700
1908–9.				
October	15.46	12.62	13.24	814
November	12.62	9.00	9.98	594
December	9.41	8.20	8.86	545
January	14.90	8.04	10.60	652
February	11.00	8.84	9.70	539
March	18.70	9.00	13.60	836
April	48.80	17.80	31.50	1,870
May	108.00	42.90	71.80	4,410
June [b]				
The period				10,300
1911.				
May	33.2	22.5	28.4	1,750
June	28.0	15.6	21.9	1,300
July	15.5	10.3	12.5	769
August	10.3	7.58	8.73	537
September	7.42	6.52	7.03	418
The period				4,770
1911–12.				
October	6.97	6.09	6.43	395
November	6.38	5.53	5.94	353
December	5.53	5.26	5.42	333
January	5.3	5.0	5.26	323
February	5.7	5.0	5.26	303
March	9.2	4.7	5.91	363
April	19.3	8.5	13.7	815
May	79.6	16.0	45.2	2,780
June	92.4	31.9	61.9	3,680
July	30.7	16.6	21.8	1,340
August	16.4	11.2	13.6	836
September	11.2	8.8	9.96	593
The year	92.4	5.0	16.7	12,100
1912–13.				
October	9.2	7.9	8.45	520
November	7.9	7.0	7.56	450
December	7.0	6.4	6.70	412
January	6.4	4.6	5.99	368
February	6.1	5.8	5.99	333
March	10.4	5.8	6.93	426
April	38	14.9	23.7	1,410
May	56	33	41.7	2,560
June	37	18.2	23.5	1,400
July	17.6	11.9	14.3	879
August	11.9	8.8	10.1	621
September	9.2	7.6	8.20	488
The year	56	4.6	13.6	9,870

[b] The weir was out of order after June 4, 1909.

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