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EXCERPTS FROM

Report of

IRRIGATION INVESTIGATIONS IN UTAH

By

U. S. DEPARTMENT OF AGRICULTURE

Office of

EXPERIMENT STATIONS

BULLETIN No. 124

Temp. Exhibit No. _____

Utah Exhibit No. _____

Ident. _____ Adm. _____

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U. S. DEPARTMENT OF AGRICULTURE.

OFFICE OF EXPERIMENT STATIONS—BULLETIN NO. 124.

A. C. TRUE, Director.

REPORT

OF

IRRIGATION INVESTIGATIONS IN UTAH,

UNDER THE DIRECTION OF

ELWOOD MEAD,

CHIEF OF IRRIGATION INVESTIGATIONS,

ASSISTED BY

R. P. TEELE, A. P. STOVER, A. F. DOREMUS, J. D. STANNARD,
FRANK ADAMS, AND G. L. SWENDSEN.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1903.

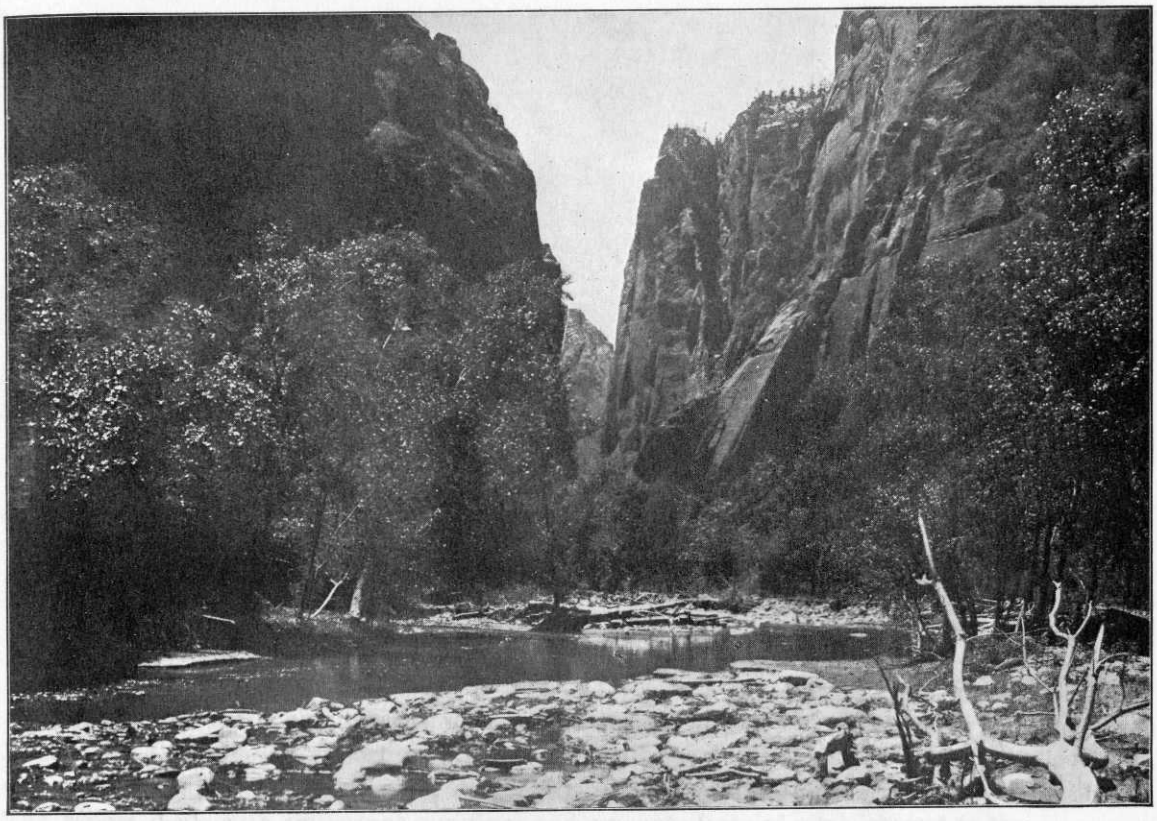

FIG. 1.—ZION CANYON, ZION FORK OF VIRGIN RIVER.

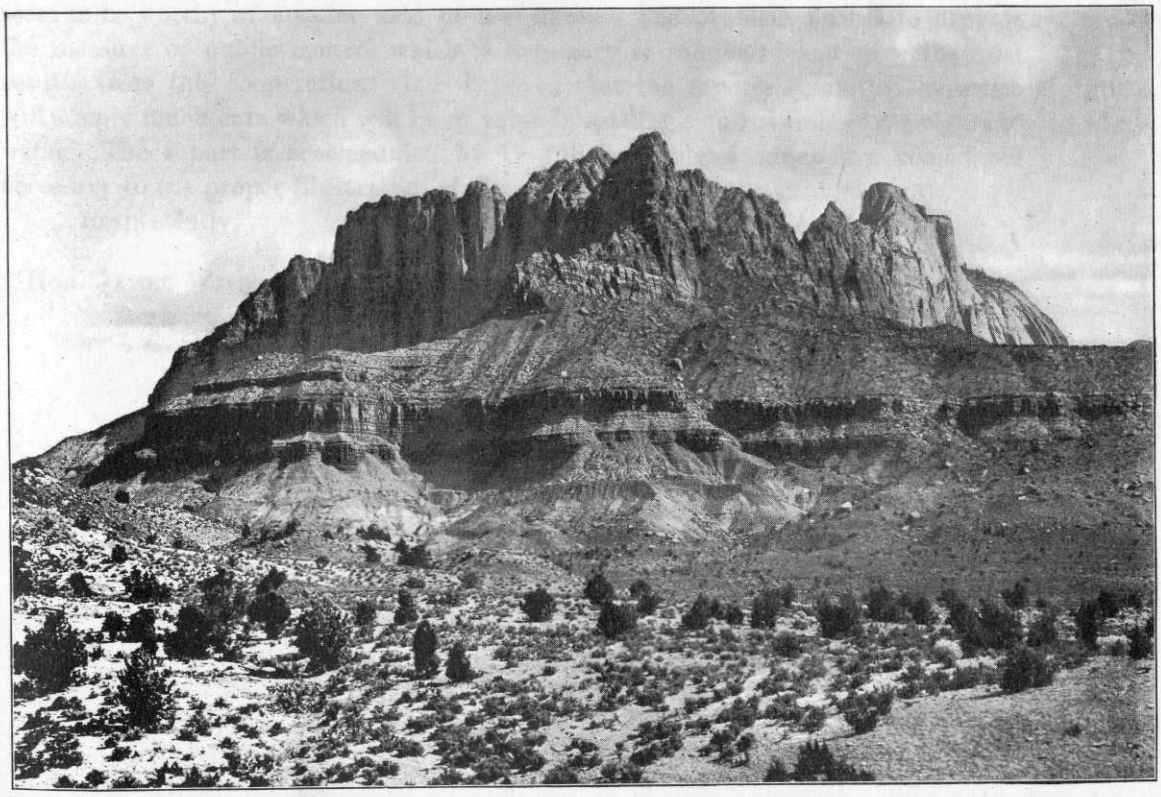

FIG. 2.—STEAMBOAT MOUNTAIN, TYPICAL OF VIRGIN RIVER WATERSHED.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., January 17, 1903.

SIR: I have the honor to transmit herewith and recommend for publication as a bulletin of this Office a report on irrigation conditions in Utah, made under the supervision of Elwood Mead, chief of the irrigation investigations of this Office. The report deals with important questions and presents facts of vital interest to the people of Utah and students of irrigation elsewhere. The farmers of Utah have originated certain methods of cooperative control of quasi-public utilities which seem to be worthy of a wider field of usefulness. The problem now is to provide the measure of public control which is necessary to safeguard and give the best results from this cooperation. It is believed that the reports submitted herewith will supply much data which will be of value in settling controversies over rights to water. The report is accompanied by 19 full-page plates which are considered necessary to the proper illustration of the reports.

Respectfully,

A. C. TRUE,
Director.

Hon. JAMES WILSON,
Secretary of Agriculture.

LETTER OF SUBMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., January 15, 1903.

SIR: I have the honor to submit herewith a report on the laws and customs under which water is diverted, controlled, and used in irrigation in Utah. Following the plan adopted in a similar investigation in California, five typical drainage basins were selected, and the conditions in each of these made the subject of special study. The streams selected were the Weber and Logan rivers in northern Utah, the Jordan River and its tributaries in central Utah, and the Virgin and Sevier rivers in the southern part of the State. Three of these reports were prepared by residents of the State, two of whom have had official as well as personal opportunities for becoming fully informed regarding existing conditions, one being State engineer and the other professor of irrigation engineering in the State agricultural college. The other four reports were prepared by agents of this investigation who have carried on similar studies in other States and were enabled thereby to compare the institutions of Utah with those of neighboring Commonwealths.

The purpose of this report is to present the irrigation situation of Utah in a concrete form; to show the character, extent, and stability of the rights to water thus far established; the problems which confront water users, and the complications which need to be removed in order that each farmer may be protected in his just share of the water supply and litigation and controversy over the division of streams averted. It is hoped that it will be of service to Utah in extending the reclaimed area and in giving greater value to irrigated land and water rights.

Wherever the significance of the facts gathered has been discussed, especial care has been exercised that it should be done with entire candor and fairness. No attempt has been made to outline a system of laws or give details of needed legislation. The gathering of the facts showing the operation of existing laws has been undertaken by this Office because it can best be performed by some agency not affected by local or selfish considerations. But the responsibility for the enactment of laws rests with the people of the State, and it is only expected that this report will be effective through the lesson taught by the facts presented.

The influence of the Mormon Church in shaping and promoting agricultural development has given to the irrigation system of Utah many interesting and unique features. In the early years of settlement there was no provision for acquiring legal titles to either land or water, and without the supervision of the church authorities, acting as arbiters and advisers, there would have been no rule except that of force.

With few exceptions, controversies were settled as they arose, without friction, so that irrigated Utah was for many years a land of homes almost free from incumbrance and of industrial institutions well suited to the arid West. In recent years, however, the lack of clearly defined and legally established titles to water has had many disadvantages and is at present a positive menace to the future of the State. The growing value of water for power purposes, the greater demands of cities and towns for domestic supplies, the lack of unity in religious faith, make it no longer possible to secure a settlement of water-right questions by voluntary agreements or by arbitration under the direction of the authorities of the Mormon Church. The urgent need of Utah is some simple, final method of establishing titles to water and the protection of those titles in times of scarcity. The enactment of laws to insure this has been delayed because of a fear among the farmers of the State that any system of public control will involve a sacrifice of some of their rights, but an analysis of existing conditions does not show this to be well founded. No system of public control can go farther in defining or limiting rights than the courts have gone in the litigation of the past ten years. The question which the irrigators of Utah must decide is whether the present system of adjudicating rights can be improved upon and how these rights are to be protected when established.

The situation on the Jordan River, where rights to the main stream and the streams which flow into Utah Lake have been established independently of each other, is worthy of careful consideration. One lesson seems to be clear, the establishment of rights to water, whether by the courts or by a specially constituted tribunal, should embrace the entire drainage basin of a stream. Legislation which will make this mandatory would do much to simplify the existing water-right situation.

The methods of dividing water from ditches, practiced by the irrigators of Utah, may well be studied by the people of other arid States, while the people of Utah can study with profit the administrative laws of neighboring States.

Respectfully,

ELWOOD MEAD,
Chief of Irrigation Investigations.

Dr. A. C. TRUE, *Director.*

AGRICULTURE UNDER IRRIGATION IN THE BASIN OF VIRGIN RIVER.

By Frank Adams, *Irrigation Assistant.*

THE BASIN OF VIRGIN RIVER.

South of the Great Basin and north of the Colorado River, comprising portions of southwestern Utah, northwestern Arizona, and southeastern Nevada, is an agricultural district perhaps as little known as any in the great Southwest. It is the region irrigated from Virgin River. (Map, Pl. XIV.)

Including the areas drained by all of the tributaries, the basin of Virgin River comprises a region of between nine and ten thousand square miles. Except during the summer cloudbursts the rainfall of much of this area never reaches the river; from some of it, as the upper Meadow Valley Wash, extending northward from the source of Muddy Creek, in Nevada, it never does. Consequently, the area included in the investigation with which this report will deal is considerably less than ten thousand square miles—not over six or seven thousand. This smaller area extends in irregular outline from the headwaters of the Virgin River in the 7,000-foot plateau of northern Kane County, Utah, southerly to its union with the Colorado in southeastern Nevada, approximately 200 miles. It is a typical mountain desert country, with its characteristic stretches of sand and sage brush, its cloudless sky and scorching sun. Much of the area, but that in Utah especially, was the center of volcanic eruptions and tremendous geologic displacements, until what is now the valley of Virgin River became in some sections a succession of faults and folds of intense scientific interest. Through these the stream and its feeders have slowly cut their way in winding courses, leaving the narrow valleys and flood plains which now support the thirty towns and villages of the region.

The upper waters of Virgin River are in two branches, Zion Creek and East Fork or Long Valley Creek, the two joining a short distance above the settlement of Rockville, Utah. These flow for many miles through narrow canyons, below which they widen out enough in places to leave a few acres of tillable land. Below the confluence of Zion Creek and East Fork the valley of the river becomes more open. To the south is Hurricane Ledge, 5,000 and 6,000 feet high, stretching away nearly 100 miles to the Grand Canyon of the Colorado, and forming one of the steps from the lower to the upper areas of the Colorado Basin. On the north, Colob Plateau, 8,000 and 9,000 feet high, forms the watershed from whose snows are fed the spring and summer flows of the Virgin River. West of Colob Plateau is a broken district in which North and La Verkin creeks have their sources, and flow southward to the river. Still to the west the Pine Valley Mountains rise to an elevation of 9,000 feet, to feed Ash Creek on the east and north and Santa Clara Creek on the west and south. Both are tributaries of Virgin River, the former entering it 4 miles below

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Toquerville and the latter 2 miles south of St. George. Southwest of St. George are the Virgin Mountains, 5,000 and 6,000 feet high; west are the Beaverdam Mountains, of about equal elevation. Through the gap between the two ranges, 20 miles southwest of St. George, the Virgin River has cut a canyon which separates this valley and that of the lower river in Arizona and Nevada. Below the canyon the watershed on the south is a continuation of the Virgin Range; on the north the river drains the southern slope of the Mormon Range. Both ranges reach elevations of 9,000 and 10,000 feet.

THE AGRICULTURAL SECTIONS OF THE BASIN.

The irrigable sections of Virgin River Basin are scattered throughout the length of the river and its tributaries, from an elevation of about 1,300 feet at the mouth of the river to one of 6,750 feet on the headwaters. They are either entirely along the stream bottoms or on the contiguous bench lands. The area already devoted to farms is but a small percentage of that which could be farmed were water available for its irrigation. Varying in elevation and exposure, they furnish a diversity of seasons and temperature, and consequently permit the growth of a wide range of products, from the apple and the potato in the higher, colder districts, to cotton and sorghum in the lower valleys. In these lower valleys, particularly in southern Nevada, the climate is such that this range of products could in all probability be widened to include some of the subtropical fruits that thrive in California and southern Arizona. The unwatered irrigable areas are in general of the same character and present the same physical conditions as the watered areas. Of the unwatered areas the bench lands predominate. On the upper reaches of the stream no lands but these remain open, for there the narrow bottoms have been tilled almost since the first settlement in the basin.

CLIMATE.

The rainfall of the valley of Virgin River ranges from 3 to 4 inches at St. Thomas, Nev., 25 miles above the mouth of the river, to 10 inches or slightly more, in parts of Washington and Kane counties, Utah. The most complete records available have been kept by the United States Weather Bureau at St. George, Utah. These records show that for a period of nine years, from 1893 to 1901, the mean annual precipitation was 6.31 inches, and the mean annual temperature 57.6 degrees. The year of greatest rainfall was 1897, when 9.81 inches fell; and of lowest rainfall 1894, when only 3.55 inches fell. During this period the months of least mean precipitation were, in order, June, September, November, and May, and the greatest mean precipitation August, February, January, and March. The lowest monthly mean was 0.1 inch, in June, and the highest, 1.11 inches in August. There has been no year in the nine in which at least one month was not devoid of precipitation. In five months in 1901, four months in 1894, three months in 1898, two months in 1893, 1895, 1897, 1899, and 1901, the total precipitation was not over 0.01 inch; in some of these months there was no precipitation. The greatest fall for one month during the period was 2.98 inches, in July, 1896. The months of lowest mean temperature during these years were, in order, December, January, February, and November,

and of the highest mean temperature, July, August, June, and September. The lowest monthly mean was 36°, in December, and the highest 81.1°, in July. The lowest recorded temperature for the period was 1°, on January 2, 1901, and the highest 115°, on July 29, 1898. For the four years 1898 to 1901, 79 per cent of all the days were clear, 12 per cent were partly cloudy, 9 per cent were cloudy, and only 9 per cent rainy.

From these data it is plain that in the valley of Virgin River the rainfall is light all of the year, but lightest the last of spring and the beginning of summer and in the fall; that the temperature is devoid of low extremes but reaches high extremes in summer; and that most of the days are clear. It is therefore a region well adapted to agriculture by irrigation.

VIRGIN RIVER.

Virgin River is a stream of uncertain flow and shifting bed. In winter and early spring it is fed chiefly by the springs at its source, but in summer the principal supply is from the melting snows and heavy rains in the higher watershed. While there is always water in the river in its upper reaches, it is often dry in the lower end. The flow is torrential, the floods following either a heavy downpour of short duration or warm rains on the snow-covered plateaus of the watershed. The heavy downpours occur usually in July and August, and sometimes cause much damage to the farming lands along the river bottoms. Especially during the floods, but also in all but the seasons of very low water, the river carries in suspension a large percentage of sediment, which not only fills the head gates and ditches along its course, but also makes the impounding of water in the channel of the river impracticable. The river bed is of shifting sand, offering a foundation for none but temporary dams. This sandy bed widens at the lower end of the river to several hundred yards, over which the river spreads in a thin, sluggish sheet, causing a heavy loss of water through seepage and evaporation. During the summer the river is not a continuous stream. No water passes from Long Valley, on East Fork, to the stream below, and the bed is dry in the canyon below St. George. In the lower canyon springs again feed the river, but 40 miles below it once more becomes dry in the early summer—by May 15 in 1902—remaining so, except during a week or ten days after floods, until the cool weather begins in the fall. A number of gaugings of the river were made during the spring and summer of 1902, and a daily record of the depth was kept from March 20 to October 15 at the sulphur springs between La Verkin and Hurricane benches. At that point the river is confined in a rocky channel, but of not entirely even sides. The shifting sand in the bottom prevented using a fixed gauge rod, so that depths were measured daily. The table of daily discharge at this point is given in connection with a discussion of water titles on pages 231, 232.

The measured discharges of the river at various points are given in the following table:

Gaugings of Virgin River, 1902.

Date of gauging.	Place of gauging.	Discharge.
1902.		*Cu. ft. per sec.*
March 7	500 feet above St. George and Washington Field Dam	143.78
March 20	Sulphur Springs, La Verkin Bench	104.05
March 31	Junction of Zion Creek and East Fork (streams gauged separately, Zion Creek having a flow of 45.84 cubic feet per second, and East Fork having a flow of 42.93 cubic feet per second).	88.77
April 3	Sulphur Springs, La Verkin Bench	89.51
April 23	400 yards below lower narrows and 3 miles above Littlefield	111.02
May 19	Sulphur Springs, La Verkin Bench	79.71
June 1	On north and south line in center of sec. 32, T. 42 S., R. 15 W	8.12
June 20	Sulphur Springs, La Verkin Bench	31.69
June 21	Below Virgin City Fields	35.18
June 21	One-fourth mile above head of Upper Farming Land Ditch, Virgin City	42.04
June 23	do	51.18
June 23	Above Rockville South Ditch	49.71
July 2	East Fork, 300 yards above Glendale Dam	7.39

THE SETTLEMENT OF VIRGIN RIVER BASIN.[a]

The spirit of colonization so pronounced with the leaders of the Mormon faith, coupled with a determination to make their new empire self-supporting, led them to push their borders 300 miles to the south within ten years after they first entered Salt Lake Valley. Freighters from Salt Lake to southern California in 1847 had returned with stories of an unused river to the south, passing through green valleys and surrounded by wide expanses of fertile desert land. They told also of the Indians who awaited the uplifting touch of civilization—possible converts to the new faith. Two years later Parley Pratt, one of the leaders, explored the district under commission from the provisional State of Deseret. In 1854 missionaries were sent out, under Jacob Hamblin, to prepare the way for later settlers. Hamblin spent several months among the Indians along the Santa Clara, and gave them their first lessons in irrigation. In the fall of 1854 Hamblin and his associates set to work on a dam across Santa Clara Creek, a few miles above the present town of Santa Clara.

During the next few years increased attention was given to the southern field. In 1856 the first settlement of Santa Clara, about one-half mile above the present Santa Clara, was established by a few farmers. In 1857 Washington was settled, and the first water for irrigation taken from Virgin River. The land watered at that time was from 75 to 100 acres on the right bank of the river. In 1858 an experimental cotton farm was started at Heberville, now Price, a few miles below St. George, and cotton raised at a cost of $3.40 per pound. In 1859 the farm was continued and the cost price reduced to $1.90 per pound, when the settlement was

[a] The data relating to the history and settlement of the Virgin Basin were obtained principally from the records of the court of Washington County, from Mr. James G. Blake, clerk and historian of the Mormon Church at St. George, and from conversations and interviews with pioneer settlers.

temporarily abandoned. The same year a few acres was watered by William Hamblin about one-half mile below the present town of Gunlock. Prior to the settlement of Washington, in 1857, a military post, for protection against the Indians, had been established on the east side of Ash Creek, northwest from what is now known as Kelseys, and called Fort Harmony. There a small stream of water was diverted for irrigation. Later the fort was moved across Ash Creek and known as Old Fort Harmony. A larger field was watered there until the winter of 1861–62, when the settlement was washed away and present Harmony established, and the irrigated acreage still further increased. Next after Harmony, Toquerville was founded, followed by Virgin City, with five or six families. After Virgin City came the old Grafton, which was later washed away and superseded by the present Grafton. After these settlements, and prior to 1861, came in order Rockville, first known as Adventure, Shunesburg, Northup, just above Rockville, and Springdale.

With the breaking out of the civil war in the spring of 1861, the Mormon leaders foresaw a possible cutting off of the American cotton supply, and hence a renewed cause for making their people self-supporting. Accordingly, this year saw redoubled efforts to utilize the waters of the Virgin and its tributaries. Three hundred families started from Salt Lake to this river in the fall of 1861. In November a body of 50 or 60 Swiss people founded Santa Clara on its present site. In December the majority of the 300 families pitched their tents a short distance from where St. George now is, moving in a body to the present site a month later. At the same time the upper river settlements of Toquerville, Virgin City, Grafton, Rockville, Springdale, and Shunesburg were strengthened. Soon after the arrival of these colonists a severe flood undid much of the work of the earlier settlers. The pioneer dam built by Hamblin and the Indians on the Santa Clara was torn out and the settlements of Gunlock, Old Fort Harmony, and Grafton, as well as much of the bottom land along the Virgin River, washed away. The former narrow and somewhat regular channels of both the Virgin and the Santa Clara rivers were torn and widened. In the opinion of many of the old settlers who witnessed the flood, the flow of both streams, as well as of some of the other tributaries, was permanently increased by the opening of springs theretofore closed.

Notwithstanding this discouraging beginning, a ditch leading from Virgin River was commenced before the settlers had been located a month, and was carrying water 6 miles by the end of 1862. It had a width of 6 feet and a depth of 3 feet and passed through a timbered tunnel 900 feet long. The work of construction was necessarily so hurried that some of it was not lasting. In the first four years and eight months after St. George was founded $26,611.59 was spent in repairing and replacing dams and sections of the ditch, which had thus far watered 420 acres, making a tax of over $63 per acre for water alone. In 1864 the water tax per acre was $10.88; in 1865, $12; in 1866, $9, and in 1867, $9. But for the fact that these taxes were largely paid in labor it would have been impossible for the settlers to meet them. To reduce the burden somewhat, 50 wild-grass lots along the Virgin River, directly south of St. George, were sold at auction, netting $4,306, and this sum placed in the fund for completing and enlarging the tunnel. Nor did these severe conditions give way to better conditions at once. For a number of years after 1867 the annual water tax in the Virgin Field, to which the first ditch led, was $13 per

acre. It was found practically impossible to build a dam in the river that would withstand even the more moderate floods. Rocks and piles sank in the quicksand of the river until hope of building a permanent dam was almost given up. On January 12, 1876, fourteen years after the little band pitched their tents in Virgin Valley, the official returns made to the board of directors of the Virgin Field showed that there were then 34 miles of community canals and ditches on the Virgin River and Santa Clara Creek, which had cost $55,993; that there were 74 miles of private ditches, which had cost $5,820; that the cost of repairing dams and ditches had been $18,150, and that the total cost for irrigation works had been $79,963. In 1877 another attempt at dam building in the river was made about 1¾ miles above the tunnel, at a cost of over $4,000 for the dam and canal leading to it. In 1881 the sum of $3,584 was collected for repairs from 448 acres, a tax of $8 per acre. In 1882 the amount fell to $1,088.62 for the Virgin, Jarvis, and Seep Ditch fields.

These figures but partially tell of the burden that had to be borne in settling the new southern wilderness. The cost of living was excessively high. Common labor cost $3 per day. Flour cost from $15 to $25 per hundred pounds. The price of sugar was $1 per pound; of molasses, $4 per gallon; of common cotton domestic, $1 per yard; of coal oil, $8 per gallon. One hundred dollars a thousand feet was paid for lumber 50 and 75 miles away. A sheep for a pound of tea was a common bargain. Provisions of all kinds were freighted by mule teams from San Bernardino or Los Angeles, Cal., at 16 cents a pound. Traffic in these commodities was practically all by barter, for cash was seldom if ever in circulation. Nor was there other than a local basis for values. Prices of produce to pay for work on dams and ditches were determined in mass meetings of the owners of the land watered. Prices of produce for taxes were fixed by the county court, and it is not uncommon to find entries in the county court records such as that made December 7, 1863, which states that "it was decided that molasses, at $1.75 per gallon, be paid R. L. Lloyd for 72 pounds of cotton, which is hereby appropriated to pay for the probate and county court seals."

The type of institution in the Virgin Valley is essentially cooperative, as it is elsewhere among the Mormons. If the rights of one settlement to water are encroached upon by the farmers elsewhere, the natural method is to stand firm as a local unit until the wrong is righted. If new lands must be brought under ditch to keep the young men at home on the farms, the usual procedure is a joining of forces until the result is accomplished. If water for irrigation is to be distributed, the only way the settlers know is to work together until each man has his rightful share. Thus it is that a forbidding country has been made fruitful where individual effort would have failed.

The early history of these pioneers has been given in some detail because it is the first step in understanding the agricultural conditions of the valley. Without it one can not appreciate the character of farming on Virgin River nor the care with which the necessary improvements in irrigation must be made. The farmer of the Virgin River is the farmer of small means and modest wants. Yet his 5 acres of alfalfa is his fortune. Losing it he loses everything but an opportunity to make a new start in a different country where life is strange to him.

Settlement of both the upper and lower valleys of the river did not follow for several years after the founding of St. George and surrounding towns. About 1866

there was a movement to the valley of Muddy Creek, which is the lower tributary of the Virgin, joining it from the north in southern Nevada, 25 miles above the junction of the Virgin with the Colorado. This movement, known as the Muddy Mission, resulted in the settlement of the towns of St. Thomas, near the end of Muddy Valley, Overton, and St. Joseph, near the upper end of the valley. Ditches were built and irrigation carried on for several years, but through dissatisfaction of the settlers, caused by uncertainty as to whether the valley was part of Nevada or part of Utah, the valley was abandoned early in 1871, and the settlements founded left to ruins. It was not for a number of years that the once cultivated fields received further attention, but they now again support the three towns. The name of St. Joseph has been changed to Logan.

The settlement of the Upper Virgin Valley, known as Long Valley, followed in about 1870. Mount Carmel, lowest in the valley, and Glendale, a few miles above, were organized as precincts June 27, 1871. Orderville, between the two, was started about the same time.

EXTENT AND CONDITIONS OF IRRIGATION IN THE BASIN.

The farms on Virgin River, as elsewhere in Utah, are in community groups surrounding or not far from the settlements from which they are worked. Only in rare instances does a farmer live on his farm, but instead, in the village made up of his neighbor farmers. This compact village type considerably alters agricultural methods and makes the farms less diversified than is common in intensely cultivated farm homes. There is no place in the field for the fruit and vegetables that ordinarily supply so much of the farmer's living. Those products are grown in the village dooryards, where they can have the requisite care and attention. His field is essentially a one-crop field, generally alfalfa, or it may have also wheat or oats. He hauls his product 1, 2, or 4 miles to town, where he stacks it for the winter's feeding.

Agriculturally considered, the Virgin River is naturally in three divisions—that of which St. George is the center and which will be designated in this report as the central division, extending from the narrows above Rockville to the canyon below St. George; that reaching from Littlefield and Beaverdam to the mouth of the river, the lower division; and that of Long Valley, at the head of East Fork, which will be called the upper division. As already shown, these divisions are separated by natural barriers, and, in the distribution of the water of the river, no account is taken in any of the three divisions of the use of water in the other two. This is because in the dry seasons water does not pass down the river from Long Valley to the central division, nor from the central division to the lower division. In discussing the subjects of this report the three divisions will, therefore, be considered separately.

THE CENTRAL DIVISION OF THE BASIN.

The central division of Virgin Basin is the furthest developed and the most important of the three. The largest settlement is at St. George, the county seat of Washington County and the chief city of southern Utah. Next in magnitude are the settlements at La Verkin and Hurricane benches, which are both new. Besides these three, the central division includes Bloomington, Price, and Atkinville, on the Virgin

River below St. George; the valley of Santa Clara Creek, including Santa Clara, the Shebits Indian farm, Gunlock, Magotsa, Pine Valley, and Grass Valley; Washington and Middleton, just above St. George; Harrisburg and Leeds, on Quail Creek; Harmony, Kanarraville, Bellevue, and Toquerville, on Ash and Kanarra creeks; Virgin City, on the river at the mouth of North Creek; Mountain Dell and The Mill, on North Creek; Grafton, Rockville, and Springdale, on the river at the mouth of Zion Creek.

ST. GEORGE.

The agricultural lands farmed from St. George are mainly in five fields—the St. George and Washington Field, 4 miles southeast of town; the Jarvis Field, 2 miles south of town; the field under the Santa Clara Seep Ditch, directly west of the Jarvis Field; and the two St. George Clara fields, on the Santa Clara Creek bottoms, about 2 miles southwest of St. George. The land in these fields is in individual holdings. Except at Atkinville, the water used in their irrigation is distributed by incorporated companies of which the landholders are the shareholders. Title to the water is supposedly vested in the companies and stock in these companies entitles its holders to shares of the water furnished.

ST. GEORGE AND WASHINGTON FIELD.

The largest field is the St. George and Washington Field, which embraces something over 2,000 acres. It is located on a low-lying bench south of the Virgin River and is watered through the St. George and Washington Field Canal, the largest canal now in operation in the basin. The canal heads 10 miles above St. George and follows the south bank of the river for 5 miles, when it turns to the south to reach the field. Its total length is 10 miles, its width an average of 9½ feet, and its depth an average of 3 feet. Just prior to leaving the bank of the river it passes around Schnaubkibe Mountain, where heavy construction work was necessary. About 1 mile below this it divides, one branch turning west to that part of the field called the old field, the larger branch continuing to the main or new field.

The construction and maintenance of this canal and the dam diverting water into it have been a heavy burden on the farmers. The dam and the canal have cost to date for construction and repairs nearly $70,000. Building the dam has been particularly costly and difficult. Experiment after experiment demonstrated the construction of a permanent dam across the sand bottom of the Virgin River to be practically impossible. What was expected to be a successful effort was made some years ago 4 miles below the present dam. At a large expense heavy piles were sunk into the river bed to hold the rock and brush work of the dam, but they proved unable to withstand the summer floods, with the result that when water was most needed and plentiful in the river there was no dam to divert it to the fields. With the washing away of the dam the farmers became satisfied that unless a solid foundation could be found the fields would have to be abandoned. They accordingly sought a new site, which they found where the present dam is located. At that point the river had swung to the left of a stratum of rock which protruded above the river bed. For a number of years some of the farmers held the idea that by damming the channel of the river so as to throw the river to the right over this

stratum, diversion works could be made that would stand. By so doing, full play would be left for the floods, while the dry dam across the original channel would turn the water into the head of the canal. This plan was carried out, and thus far it has proved a success.

The plan of the dam is shown in fig. 1. It is 600 feet long from the spillway to the left bank of the stream, 25 feet high, and 15 feet wide on top, with a slope on the upper face of 2½ to 1 and on the lower face of 2 to 1. Within is a rock core 12 feet wide on the bottom and 4 feet wide on top. At the end of the dam toward the rock stratum is an abutment facing the end of the dam, the ends curving slightly from the stream so as to throw the stream from the dam and over the rock stratum to the right. This abutment is of rock, is 50 feet long, 12 feet high, and 12 feet wide at the upper end and 6 feet wide at the lower end. From the abutment the rock stratum extends 235 feet to what is now the right bank of the river channel. At the abutment this stratum is 90 feet wide, from which it increases to 200 feet at the opposite bank. Through the stratum a short distance toward the center of the stream from the abutment a spillway 6 feet wide and 6 feet deep has been cut in

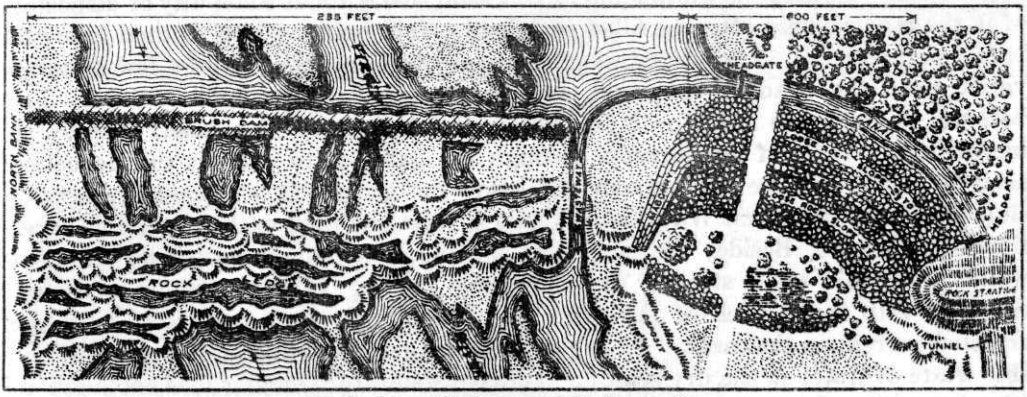

FIG. 1.—Plan of St. George and Washington Dam.

the solid rock, in which is placed a sheet-iron gate 5½ feet wide and 7 feet high to the windlass. To the left of the abutment is the head gate of the canal, which follows the rock dam to the original left bank of the river, where it turns to a higher stratum. By means of the iron gate in the spillway the flow through the head gate into the canal is regulated. Directly above the tunnel through the stratum on the left bank is a second more substantial head gate. The dam has raised the bed of the river 10 feet.

According to careful estimates made on October 1, 1895, by a committee appointed by the county commissioners of Washington County, the area of irrigated and irrigable land under the St. George and Washington Field Canal is 3,510 acres. July 1, 1902, the books of the field company showed a total of 2,175 acres to be drawing water. This was on a basis of 1 acre to each water share, which is the usual basis of figuring. The holdings that were receiving water varied from 1 to 75 acres, averaging a little over 17 acres.

As already stated, the water used for the irrigation of this field is controlled by an incorporated company, the St. George and Washington Canal Company. It was incorporated July 10, 1900. Prior to that date the company was known as the

Washington Field Canal Company, which was incorporated May 11, 1875, and which had at its organization acquired the interests of its shareholders in a dam across Virgin River, and several miles of ditches, valued in all at $12,500. The St. George and Washington Canal Company was organized with a capital stock of $50,000, divided into 4,000 shares. The property of the Washington Field Canal Company which was transferred to the new company consisted of the dam and spillway across Virgin River, valued at $12,000; 10 miles of main canal, valued at $16,000; lateral, waste, and rain ditches, and division gates, valued at $4,000, and other property valued at $1,800, making a total of $33,800.

The water carried in the canal is distributed to the shareholders of the company in proportion to the number of shares held. When it reaches the field it is divided into several streams, their size depending upon the amount of water in the canal, and these streams are given to the different shareholders for periods of time corresponding to their shares, usually one or two hours per share for each watering.

A difficult problem that the St. George and Washington Company, as well as all other irrigators from Virgin River, has to meet is getting rid of the sand deposited in the canal. So large is the amount of this sand that without some way of disposing of it the canals would often be filled with it in a few hours. The method followed is frequent sluicing. Gates for this purpose are placed at intervals of a few hundred yards, near the head of the canal, and at greater distances farther down. The bottoms of the gates are 2 or 3 feet below the bottom of the canal, thereby so increasing the force of the currents through the gates as to cut out the deposited sand for some distance both above and below the gates. It is found necessary to sluice the St. George and Washington Canal at least one hour each day and a longer time on Sundays. Besides the periodical sluicing, when the canal carries sufficient water to permit, small streams are constantly passing through the upper gates, carrying with them much of the sand that has already been precipitated by the arrested current in the canal. As at present managed, the sluicing causes considerable waste of water in the dry season. To have water for sluicing it is necessary to take into a canal more water than is delivered to the field. When the canal is emptied each day and for a longer time on Sunday, allowing the full flow of the canal to pass down the river, the gates of lower canals are not arranged to take advantage of the increased supply and the water which might be utilized is allowed to evaporate or sink in the dry bed of the lower narrows. The extent of this loss is shown in Pl. XV, figs. 1 and 2. Fig. 1 is from a photograph of Virgin River about 2 miles below Atkinville, taken on May 25, 1902. At this point the river was nearly 200 feet wide, but only a few inches deep. Fig. 2 is from a photograph of the river less than 3 miles below, taken the same day. No diversions were made between the two points, yet the entire flow was lost. Such losses are common throughout the basin of the river.

Irrigation in the St. George and Washington Field is accomplished by flooding, and by carrying the water through shallow furrows about 2 feet apart made with a wooden marker. This is the method common in southern Utah. It is the practice to cover the fields once in from ten to fifteen days during the irrigation season, which extends from March to October. Water is applied at irregular intervals, both before and after these dates, some usually reaching the field in every month of the

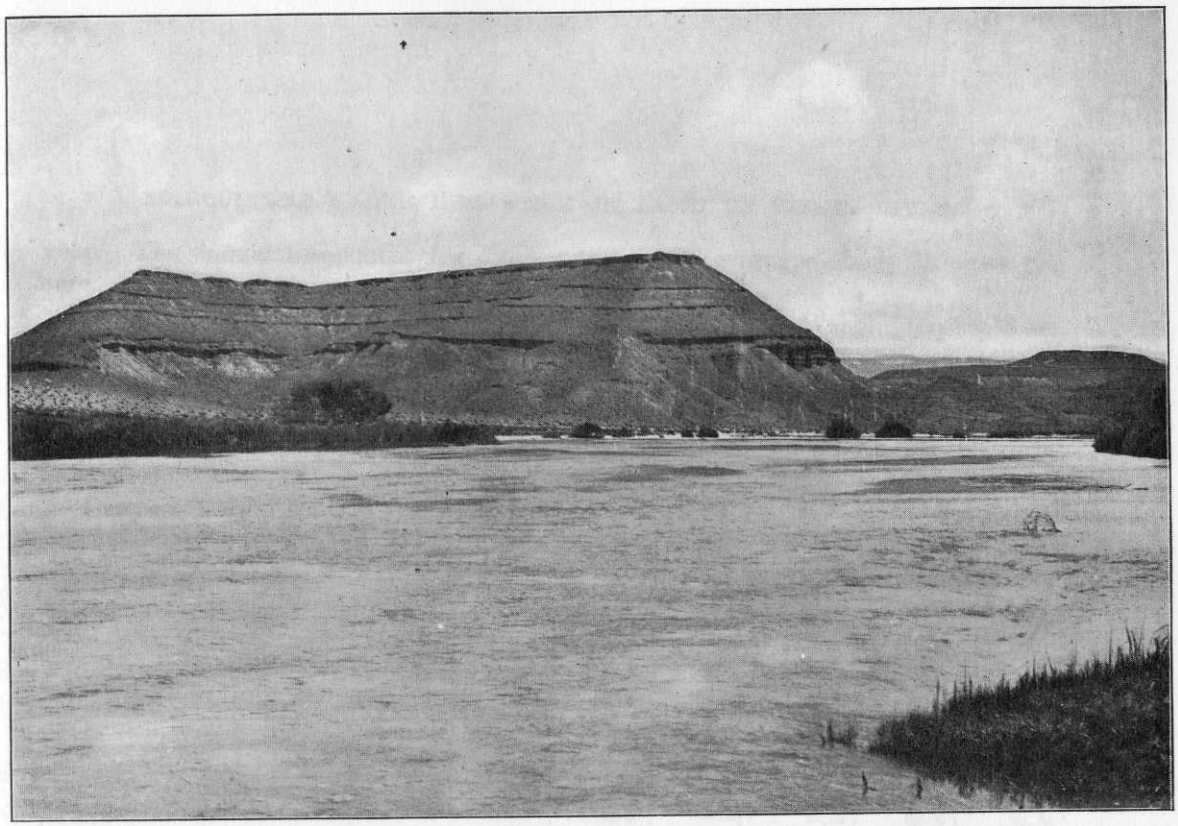

FIG. 1.—VIRGIN RIVER 2 MILES BELOW ATKINVILLE, MAY 25, 1902.

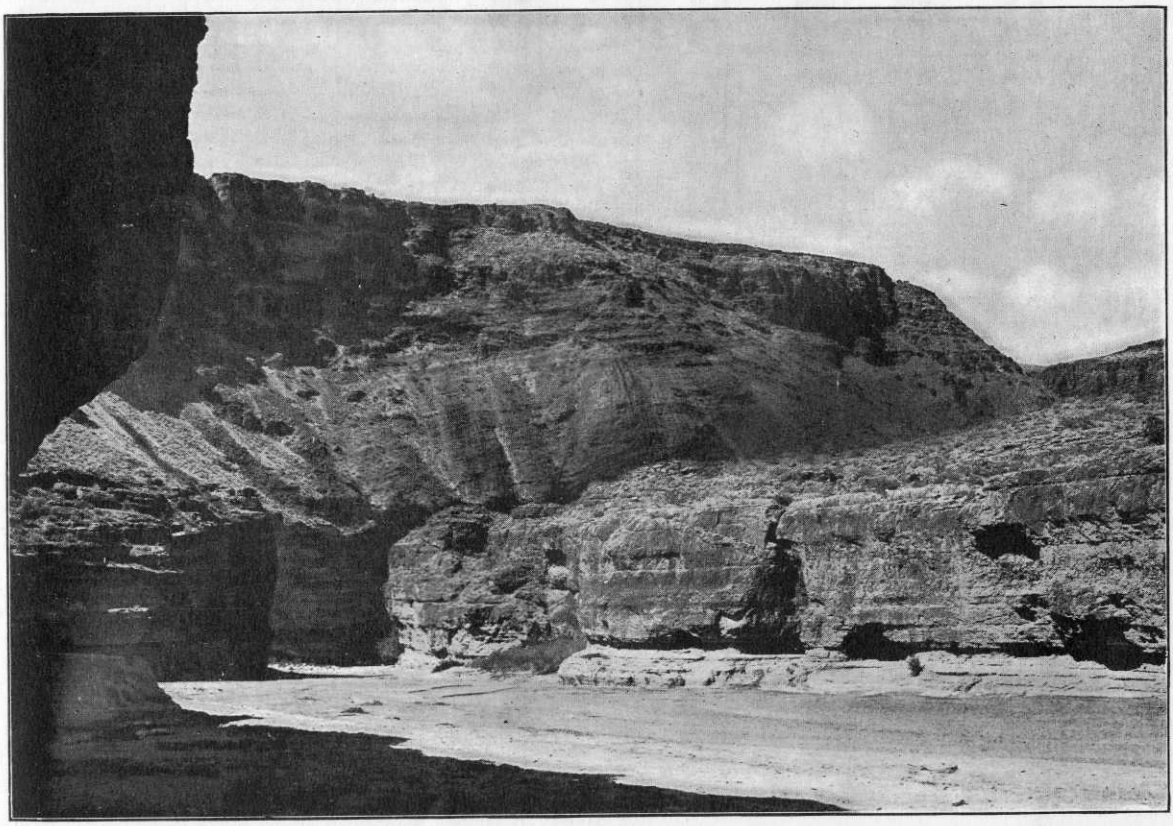

FIG. 2.—DRY BED OF VIRGIN RIVER 5 MILES BELOW ATKINVILLE, MAY 25, 1902.

year. The annual assessment for ditch maintenance averages about 75 cents per acre.

The amount of water used on crops in the St. George and Washington Field has been a subject of much discussion, but prior to 1902 no measurements were made to determine this. Through the aid of Mr. Henry Schlappy, ditch rider, a daily record of the flow of the canal has been kept during the season of 1902. The following table, which gives the daily flow, shows considerable fluctuation from day to day:

Flow of water in St. George and Washington Field Canal during irrigation season of 1902.

Day.	April.	May.	June.	July.	August.	September.	October.
	Acre-feet.	*Acre-feet.*	*Acre-feet.*	*Acre-feet.*	*Acre-feet.*	*Acre-feet.*	*Acre-feet.*
1	.....	.....	78.85	52.56	59.51	22.72	86.78
2	.....	85.12	83.13	40.66	41.16	63.47	92.05
3	.....	102.15	80.55	63.47	31.06	59.51	109.10
4	.....	102.60	75.70	64.46	43.97	52.56	72.20
5	.....	95.96	75.05	66.45	52.57	62.11	77.90
6	.....	29.21	76.48	61.49	47.61	68.43	86.71
7	.....	81.36	69.83	60.50	45.62	66.50	81.36
8	.....	100.15	73.76	59.51	46.58	70.42	68.43
9	.....	92.15	74.10	12.40	102.15	55.80	66.50
10	.....	104.95	63.65	.....	98.02	52.73	70.42
11	.....	97.85	62.11	44.26	64.09	57.00	87.40
12	.....	83.85	98.02	43.14	86.78	58.23	95.05
13	.....	84.93	62.11	39.67	56.34	65.03	94.21
14	.....	95.21	58.23	41.16	41.74	72.20	68.43
15	.....	87.64	38.43	43.14	.....	86.78	70.42
16	.....	75.50	51.24	43.14	.....	69.55	.....
17	100.15	84.48	63.47	59.51	.....	107.10	.....
18	96.21	95.96	65.03	77.36	26.28	100.70	.....
19	100.15	98.07	53.38	89.26	77.36	39.42	.....
20	99.17	104.95	53.56	102.15	74.10	.....	.....
21	102.15	95.96	52.56	19.15	91.24	.....	.....
22	99.17	48.35	53.38	.....	75.70	43.72	.....
23	.....	72.02	53.06	34.30	91.24	96.21	.....
24	.....	96.21	45.60	42.15	77.64	84.20	.....
25	98.76	18.18	45.62	43.14	68.43	77.36	.....
26	96.21	44.62	37.69	54.26	74.10	68.43	.....
27	80.55	77.36	.....	85.12	59.51	71.75	.....
28	91.82	77.36	.....	107.10	94.05	66.94	.....
29	93.23	29.59	35.95	105.15	94.22	82.32	.....
30	98.02	86.78	63.47	80.55	91.24	80.75	.....
31	.....	80.75	.....	59.51	15.20	.....	.....
Total	1,155.59	2,429.27	1,744.01	1,694.72	1,827.51	1,901.94	1,226.96

The canal carried some water both before the record was begun and after it was discontinued, but, as shown by the table, it delivered to the field between March 21 and October 15, 11,979 acre-feet, or sufficient to cover the land watered to a depth of 7.22 feet. From October 15 to November 28, 1.991 acre-feet of water was used, making the total amount applied during the season 13,970 acre-feet, which gives a depth over the 1,660 acres watered of 8.41 feet, and, with the rainfall added, of 8.98 feet.

Through the aid of Mr. James McArthur, water master for the St. George and Washington Field, complete crop return data were gathered for the purpose of showing the money value of the water carried by the canal. A total of 1,660 acres was watered, planted to crops as follows: Alfalfa, 1,342.5 acres; wheat, 194.5 acres; corn, 40.5 acres; oats, 19 acres; sorghum, 17.5 acres; barley, 11.5 acres; fruits, vegetables, etc., 34.5 acres. Alfalfa received an average of 6.9 waterings between April 8 and October 6, and yielded an average of 3.40 tons per acre. Wheat received an average of 3.3 waterings between April 17 and June 25, and yielded an average of 27.46 bushels per acre. Oats received an average of 3.7 waterings between April 20 and June 17, and yielded an average of 35.78 bushels per acre. Barley received an average of 3.2 waterings between April 17 and June 25, and yielded an average of 27.46 bushels per acre. After the alfalfa crop was harvested the meadow furnished pasturage valued at $3,131. The total return from the 1,660 acres was $37,113, or an average per acre of $22.36. The return per acre-foot of water artificially applied was $3.10.

JARVIS FIELD.

The Jarvis Field lies on the right bank of Virgin River, 2 miles southeast of St. George, and is the next field below the St. George and Washington Field. The Jarvis Ditch leaves the river on the right bank through a cut in a rock ledge, has a width of 5 feet, and when full, carries water to a depth of 1.5 feet. May 13, 1902, 30 feet below the lowest sand gate and about 100 feet below the dam, it was carrying 14.84 cubic feet per second, which approximates the usual high-water flow. During 1902 about 200 acres were being irrigated from the ditch.

The Jarvis Ditch was started in 1865, and for the first few years watered between 200 and 300 acres. At one time, about 1874, 500 acres were watered. On June 15, 1880, the Jarvis, Cooper, Bottom, Seep, and Virgin ditches, the latter then known as the Rio Virgin North Canal, were united in the Rio Virgin Canal Company on the theory that the Rio Virgin North Canal, if properly managed, could, in dry seasons, be made to better cover the land formerly covered by the three ditches. This arrangement continued for three years, during which time it was demonstrated that the Rio Virgin North Canal could not cover the three fields. Thereupon the Jarvis and Seep ditches again became separate, and the Rio Virgin North Canal was abandoned.

The annual assessment for care and maintenance of the Jarvis dam and ditch is from $1.50 to $2 per acre.

SANTA CLARA SEEP DITCH.

The Santa Clara Seep Ditch diverts the water that passes the upper dams in Santa Clara Creek or returns to the creek in seepage from the fields above. It heads in Santa Clara Creek near the lower end of the St. George Clara fields, and waters 214 acres on the lower Santa Clara bottoms north of Virgin River and west of the Jarvis Field. This ditch is controlled by the Santa Clara Seep Ditch Company, which was incorporated January 6, 1896, with a capital stock of 244 shares of water right, of the par value of $25 each. The 214 acres watered is owned by 20 irrigators, whose average holdings are 10.7 acres. Each acre receives water from one and one-half to two hours each watering, the waterings occurring every fifteen or

sixteen days. The annual assessment for care and maintenance of the Seep Ditch is from 75 cents to $1 per acre, of which one-fourth is paid in cash and three-fourths in labor. As the water carried by the ditch is limited it is seldom sold apart from the land.

THE ST. GEORGE CLARA FIELDS.

The two St. George Clara fields, excepting the land under the Santa Clara Seep Ditch, are the two lowest fields receiving water from Santa Clara Creek. They cover land on both sides of Santa Clara Creek below the Santa Clara fields and settlement, and above the Santa Clara Seep Ditch. There is supposedly 800 acres in the two fields, embracing 67 holdings, averaging a little less than 12 acres each. The control of the water for irrigation is held by the St. George Clara Field Company, which was incorporated August 22, 1901, with a capital stock of 800 shares, of the par value of $10 each. The fields are watered by the Upper and Lower St. George Clara ditches, heading a short distance apart, directly above the town of Santa Clara. Each acre draws water for from one to three hours each watering, depending on the supply in the creek, the water being distributed by one water master.

For the purpose of ascertaining the approximate duty of water on the Santa Clara bottoms, a record of the flow in the two canals was kept during the season of 1902. There are no flumes in either ditch, so that it was necessary to make the ratings in earth sections. The streams were small at times and hence difficult to measure, but the record is thought to be of value. The record was commenced with the beginning of regular irrigation on March 17, and ended October 15. Owing to the failure of the supply in Santa Clara Creek, neither ditch carried water after June 24. The irrigation season, which ordinarily lasts until fall, was therefore over with the beginning of summer. There was not sufficient water in the creek to fill both ditches even up to June 25, making it necessary to alternate the supply between the two. From March 24 to June 10, as measured at the head, Upper Ditch carried 643.93 acre-feet, and from March 17 to June 24, Lower Ditch carried 684.31 acre-feet, making a total for the two fields of 1,328.24 acre-feet.[a] Although there are 800 acres in the field supposedly watered, the area actually watered was only 485 acres. Spread over this area the 1,328.24 acre-feet covered the land to a depth of 2.74 feet. The rainfall for the season was 0.57 foot, so that the total depth of water received by the land was 3.31 feet.

Careful and complete crop returns were gathered with the help of Erastus B. Snow, of St. George. The principal products grown were alfalfa, 272 acres; wheat, 170 acres; and barley, 35 acres. Alfalfa was irrigated between January 15 and July 26,[b] received

[a] The discharge of each ditch by months was as follows:

Month.	Upper Ditch.	Lower Ditch.
	Acre-feet.	*Acre-feet.*
March	104.02	94.41
April	375.88	185.36
May	109.49	343.35
June	54.54	61.19
Total	643.93	684.31

[b] A few farmers had a little water after June 24.

an average of 2.2 waterings, and yielded an average of 3.62 tons per acre. Wheat was irrigated between January 15 and June 24, received an average of 2.5 waterings, and yielded an average of 22.38 bushels per acre. Barley was irrigated between February 15 and May 20, received an average of 2.5 waterings, and yielded an average of 27.64 bushels per acre. Besides the marketable products, the land produced pasturage worth $429. The total value of crops and pasturage was $10,279, making the average return per acre $21.20. In figuring the returns alfalfa was reckoned at $6 per ton, wheat at 90 cents per bushel, and barley at 75 cents per bushel. For the 1,328.24 acre-feet of water applied in irrigation, the value per acre-foot was therefore $7.73.

The above figures represent the returns from farming the Santa Clara bottoms in a dry year. All irrigators reported a shortage of water, so that it is safe to assume that the returns would be considerably more in years of ample water supply.

LA VERKIN BENCH.

La Verkin Bench is directly north of Virgin River and 3 miles southeast of Toquerville. It comprises a tract of 700 acres of irrigable land, of which 538 acres are under La Verkin Canal, and 150 acres within reach of pumping above the canal. La Verkin Canal takes water from Virgin River 2 miles above the bench, and after following the canyon of the river 1½ miles, tunnels through the cliffs east of the bench 840 feet to La Verkin fields. The canal and tunnel were completed in 1891 at a cost of $25,500. The canal was originally 5 feet wide on the bottom, 7 feet wide on top, and 2 feet deep, with a fall of 1 inch in 10 rods, except at the upper end, where a slightly greater fall was given. Owing to financial difficulties it was found impossible to keep the canal in repair for several years after it was completed, and consequently its capacity is at present somewhat below what it was at first. The head gate has twice washed out and an assessment of $500 had to be collected in 1902 to put in a third one. The canal passes through gypsum beds in a number of places, and in each of these it had to be replaced by wooden flumes, which are in turn being replaced by earth and gravel bottoms. The canal is now rapidly being returned to its former good condition.

This canal is owned and controlled by La Verkin Bench Canal Company, which was incorporated May 5, 1902, with a capital stock of $15,000, divided into 600 shares, each of which is intended to represent a right to water for 1 acre. Since 1902 the company has been in substantial shape. All of the land under the canal has been sold and 400 acres were watered during 1902. The water is distributed on a time basis so as to cover the whole area once in twelve days.

La Verkin Bench has an elevation of 3,200 feet and is adapted to the growth of fruit and vegetables. These are the principal products, although alfalfa and grain will also be grown. The annual assessment for canal maintenance is $1.25 per acre.

HURRICANE BENCH.

The movement that will end in the irrigation of Hurricane Bench, across Virgin River and directly south of La Verkin Bench, is one of the most enterprising connected with the history of Virgin Valley. It embodies the construction by men

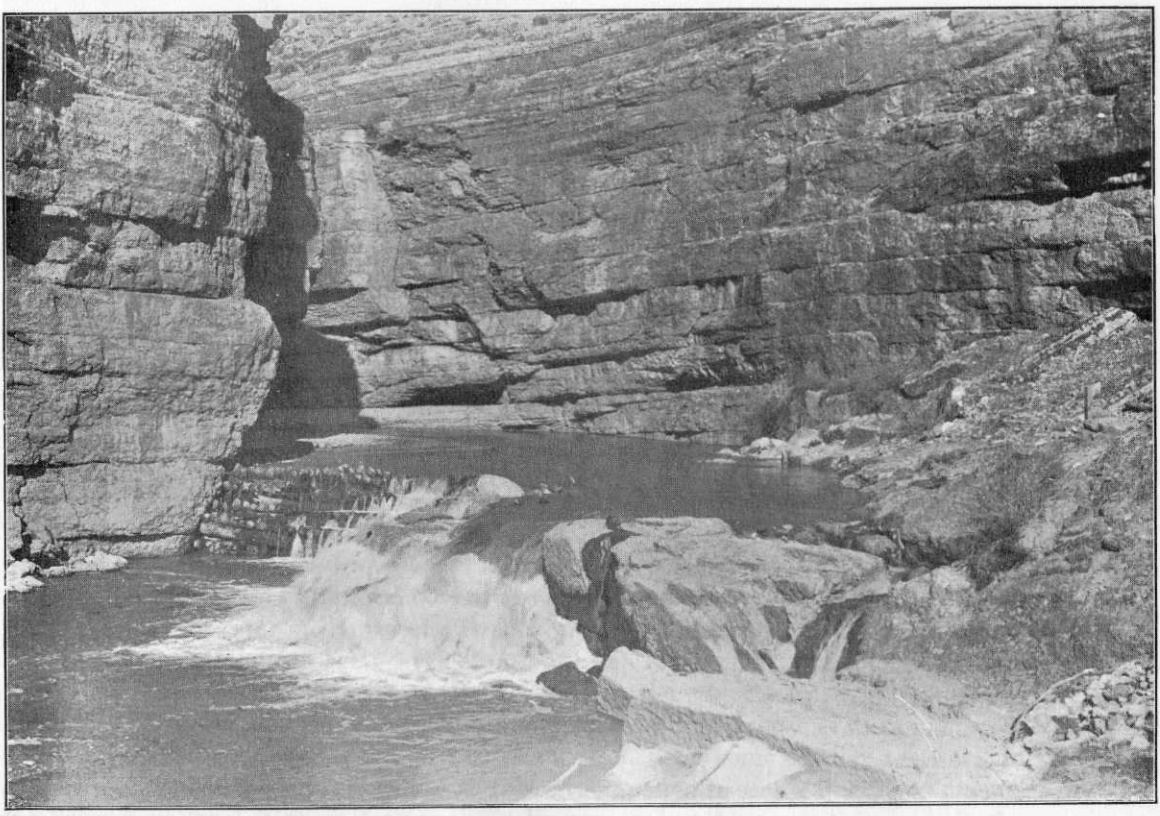

FIG. 1 —HURRICANE DAM IN VIRGIN RIVER.

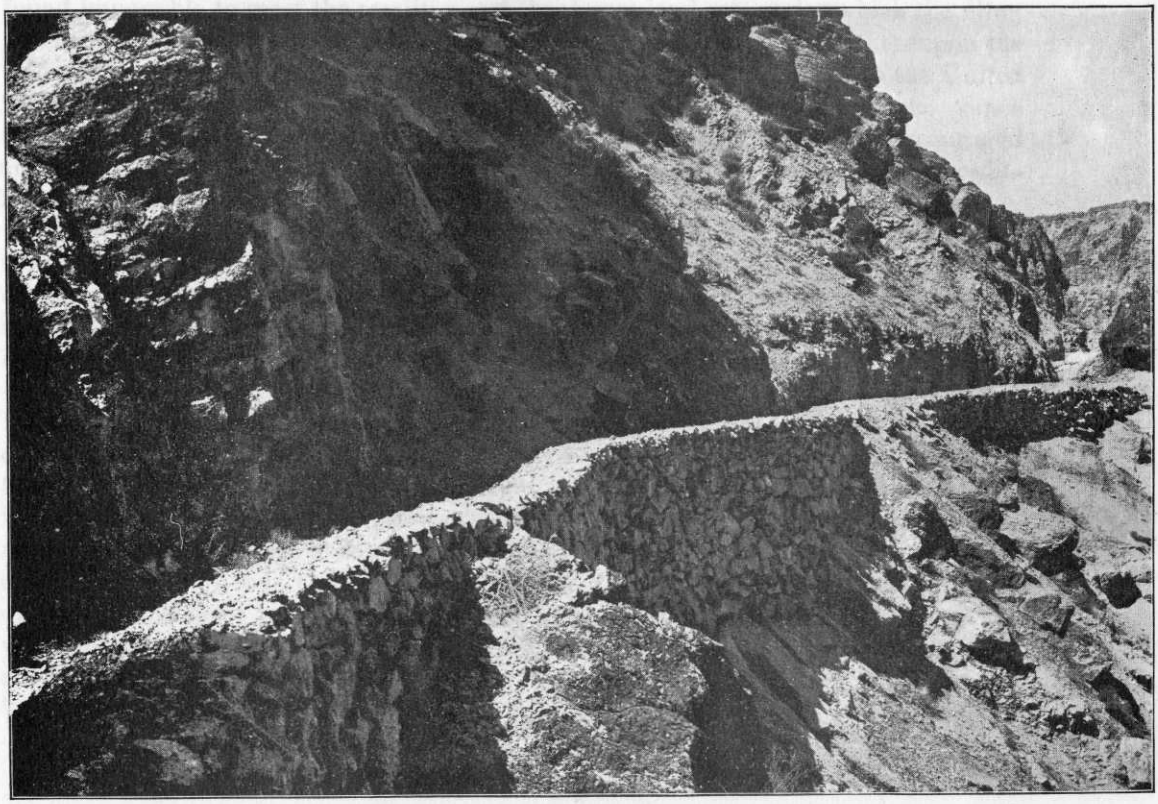

FIG. 2.—SECTION OF HURRICANE DAM.

without other capital than muscle and determination, of 5 miles of canal along the precipitous and rocky cliffs of Virgin River Canyon, directly above La Verkin Bench, and 3 miles of canal whose construction has been less difficult. This work was begun in the winter of 1893–94, after discussion extending over a period of thirty years. If the intention of the builders is carried out, it will be so far completed by the spring of 1903 as to permit of the beginning of irrigation and cultivation on Hurricane Bench. Construction work has been carried on each winter and continued into each summer, as those interested could leave their small farms in the surrounding settlements. On October 1, 1902, $54,000 had been expended, of which about $50,000 was in labor. On that date the total stock subscribed was $64,450. Prior to February 1, 1902, the builders of the canal had received no assistance from any source, but on that date the authorities of the Mormon Church subscribed for $5,000 in stock, which is being paid in cash to those working on the canal. The total cost of the canal is estimated at $65,000, which will make the cost of water on Hurricane Bench fully $50 per acre.

This undertaking has been carried on, not as an investment, but solely to create homes for the sons and daughters of the early settlers in the upper Virgin River towns. The power of these towns to support increased populations was exhausted, and without the new homes which Hurricane Bench or some similar tract would supply the younger generation would have been compelled to seek a livelihood outside the chosen valleys of their fathers. As in any undertaking of this magnitude, discouragements have been encountered from the beginning. Although the land to be watered was not filed on until two years after work on the canal was begun, it was found impossible to meet the conditions of the desert-land act, under which the filing was made, and get water to the land within the required four years; whereupon the land and the first payment of $500 reverted to the Government. Fees to the United States Land Office and to attorneys to the extent of $200 were also lost. Since construction began, from thirty to forty of those interested have become discouraged and have sold their credits for labor for whatever they would bring. These credits have been purchased by the few men of some means connected with the enterprise, who were expected, instead, to hire their shares worked out by those stockholders who needed financial assistance. Losses have also resulted from faulty surveys of the land to be watered. Besides, those who were working out the price of their shares have suffered through frosts in their home settlements, and have consequently been compelled to seek work with a cash rather than a credit income.

As already stated, Hurricane Canal heads in Virgin River 4 miles above La Verkin Bench. Directly at the mouth of a box canyon, whose sides and bottom are of solid rock, a dam of logs and rock has been placed across the river (Pl. XVI, fig. 1). Beginning a short distance from the dam, heavy construction was encountered for 5 miles. The formation passed through is principally conglomerate and lime rock. Gypsum has been encountered in only one short section. Nine tunnels, with a total length of 61 rods, and a number of rods of flume, have carried the canal through or around the most precipitous cliffs. In some cases rock fills (Pl. XVI, fig. 2), whose permanence is at best doubtful, have been substituted for costly excavation, not because they were deemed satisfactory, but because of the limited means of the builders. For the first 4 miles the canal has a grade of one-fourth inch, and below

that one-eighth inch to the rod. It has a bottom width of 8 feet, a top width of 10 feet, and a depth of 4 feet. Its projected length is 6¾ miles.

Those who are building the canal have incorporated the Hurricane Canal Company, with a capital stock of "2,000 shares of primary water right, 1 acre of water right constituting a share of the par value of $40." In 1901, after the filing under the desert-land act lapsed, four stockholders in the company made application to the State land board for the selection of the land by the State and its sale to them. The selection was made and 1,440 acres under the canal purchased in trust for the Hurricane stockholders. It is the intention to purchase 320 acres additional, making 1,760 acres in all. This land will remain in the names of the purchasers until paid for, when it will be deeded to the individual stockholders. The price to be paid the State is $1.25 per acre, of which 25 cents was paid at the time of the selection, the remainder to be paid in ten annual installments. Each share in the company entitles its holder to 1 acre in the tract and water for it. In April, 1902, 1,400 shares had been taken by 75 individuals, in holdings ranging from 15 to 40 acres. The bench will be surveyed into 10-acre holdings and distributed by lot, except the town site, which will contain 4¼-acre blocks. The land in the fields is similar to that of La Verkin Bench, directly north across the Virgin River. It is at present heavily grown with greasewood and black sagebrush. The success with fruits on La Verkin Bench has been an encouragement to the Hurricane shareholders, for it is expected that fruit will be among the chief products grown.

REMAINING SETTLEMENTS IN THE CENTRAL DIVISION.

The remaining settlements in the central division are small, the largest—Washington—having but 500 inhabitants, and the smallest, such as Atkinville and Duncans Retreat, containing but one or two families. They are on Virgin River, extending throughout the length of the central division; on Santa Clara Creek, above the St. George Clara fields; on the benches east of St. George, and on Quail, Ash, Kanarra, La Verkin, and North creeks. Practically all of the water of the tributary creeks is used before it can reach the river. Excepting the Muddy in the lower division, Santa Clara Creek is the principal tributary. It rises in Pine Valley Mountains, in the northern part of Washington County, and flows into Virgin River 2 miles south of St. George. Barring flood water in some years and the water diverted by the Seep Ditch, all of the water in the creek is used above its mouth. Quail Creek, which rises on the southeast side of Pine Valley Mountains, is completely diverted at Harrisburg and Leeds. Ash Creek, also rising in Pine Valley Mountains, is all used in the settlements of Harmony, Bellevue, and Toquerville, each of these settlements in turn having an independent supply. No water of Kanarra Creek, which rises in the mountains east of Kanarraville, passes the town, although the creek is naturally tributary to Ash Creek. La Verkin Creek is a part of the supply of Toquerville. North Creek, excepting in the early spring, when some of the surplus water is diverted by the Virgin City Upper Town Ditch, supports only the two small settlements of Mountain Dell and The Mill. During the season of 1902 the conditions of agriculture and the extent of irrigation in each of these settlements were examined, and some of the principal data gathered in the examination are given below:

BLOOMINGTON.

In this settlement situated on the river below St. George, 190 acres, in average holdings of 12 acres, is watered by the Bloomington Irrigation Company's ditch, taking water from Virgin River, and using also some seepage water from Santa Clara Creek early in the season. The ditch is 2 miles long and the water supply is generally sufficient.

PRICE.

The Price Field Irrigation Company takes water from the Virgin River below St. George, for 184 acres in average holdings of 11.5 acres. The ditch is 3 miles long, and the annual cost of water is from $3 to $10 per acre. The organization controlling the water has recently lapsed.

ATKINVILLE.

At Atkinville on the river valley below Price, William Atkin waters 120 acres through a private ditch 1.5 miles long.

SANTA CLARA.

This settlement is on Santa Clara Creek. The Santa Clara Field Company controls six small ditches which water 455 acres in average holdings of 10.5 acres. Water is distributed by time rotation. The supply is very short, and the cost is from 75 cents to $1 per acre per annum.

GUNLOCK.

Gunlock is also located on the Santa Clara. Nine small ditches distribute water to 105 acres in average holdings of 10 acres. The water supply is short, and costs about 50 cents per acre per annum.

PINE VALLEY.

Pine Valley is near the headwaters of Santa Clara Creek. A generally sufficient supply of water is supplied to 623 acres by seven ditches, at an annual cost of 50 cents per acre. The average size of holdings is 20 acres. In June, 1902, when the Santa Clara was normal, the snow in the Pine Valley Mountains having melted, water was flowing into the valley from all sources as follows:

	Cu. ft. per sec.
Main creek, one-fourth mile above Pine Valley Upper North Ditch	5.25
Spring Branch, 100 yards below spring	2.59
Forsyth and Lloyd canyons	1.00
Total	8.84

A gauging of the stream made below all tributaries and below the fields on the same day showed 2.61 cubic feet per second to be passing out of the valley. Deducting this from the amount entering the valley from all sources gives 6.23 cubic feet per second as being used in the valley. This gave a duty at the beginning of the irrigation season of 1 cubic foot per second to each 100 acres. Only the hardier products can be raised in this valley, on account of the altitude.

SHEBITS INDIAN FARM.

This farm of 80 acres is watered by three ditches from Santa Clara Creek. The water supply is short and the cost is nominal.

MAGOTSA.

Seventy-eight acres in this settlement, located above the junction of Magotsa and Santa Clara creeks, is watered by six ditches from Magotsa Creek and Moody Wash. The water supply is good.

HUNT'S, CHADBURN'S, AND FOSTER'S FARMS.

These farms, containing 46 acres, are on Santa Clara Creek, 15 miles above Gunlock. There are three ditches, with a total length of 1.5 miles.

GRASS VALLEY.

This settlement contains 103 acres on Grass Valley Creek, west of Pine Valley. The holdings average 25.75 acres. There are four ditches having a total length of 3 miles. The supply is generally sufficient.

MIDDLETON.

Middleton, 2 miles east of St. George, gets water from Middleton Springs, for 35 acres, in holdings of 8.75 acres. There is no organization, and the annual cost of water is about 15 cents per acre.

WASHINGTON.

Washington is 5 miles east of St. George. The water supply comes from springs and Mill Creek, and is controlled by the town council of Washington and the Mill Creek Water Company. Water is distributed to 325 acres, by rotation. There are six ditches, having a total length of 4.5 miles. The water supply is generally sufficient.

HARRISBURG AND LEEDS.

These settlements are on Quail Creek. The Leeds Water Company controls the water to irrigate 30 acres at Harrisburg and 230 acres at Leeds. Three ditches, having a total length of 7 miles, furnish a generally sufficient supply of water. June 18, 1902, Quail Creek was carrying 4.97 cubic feet per second at Silver Reef above the division of the water to Harrisburg and Leeds.

ANDERSONS.

The Anderson Ditch waters from 1 to 150 acres from a spring, the area depending on the water supply, which is short. Fifty acres of orchard and vineyard received no water from January 1, 1900, to June 1, 1901, but were kept alive and thrifty by intensive cultivation.

HARMONY.

Harmony is located on the headwaters of North Ash Creek, and gets its water from that stream and springs. Nine ditches, with a total length of 5.5 miles, supply water to 305 acres in average holdings of 16 acres, at an annual cost of 50 to 75 cents per acre. On June 19, 1902, the following gaugings were made of Ash Creek, Lawson Spring, and Harmony Town Ditch, leading from Comanche Spring:

	Cu. ft. per sec.
North Ash Creek, 100 feet above upper dam below Harmony	1.04
Lawson Spring Ditch, 200 yards below spring	.65
Harmony Town Ditch, at edge of F. Prince's field	.49
Total	2.18

When these gaugings were made, Lawson Spring and Comanche Spring were normal. The main stream was approximately one-third of its flow April 15, 1902, when irrigation began, and twice the midsummer flow. The lowest duty of the water is therefore approximately 1 cubic foot per second to each 70 acres, and the highest duty 1 cubic foot per second to each 180 acres at Harmony.

KANARRAVILLE.

The Kanarra Field Reservior and Irrigation Company supplies water from Kanarra Creek to 350 acres, the average holdings being 12 acres. The water supply is very short. Water is delivered by time rotation, each acre receiving water two and one-half to four hours once in eight days. On June 19, 1902, Kanarra Creek was carrying 1.72 cubic feet per second, which was said to be the lowest flow for ten years, from one-fifth to one-tenth of the usual spring flow, and one-half of the usual summer flow. Because of the shortage, but 175 acres were being watered.

BELLEVUE.

Bellevue is located at the junction of South Ash and Ash creeks. The area irrigated is 75 acres in average holdings of 19 acres. On June 20, 1902, South Ash Creek was carrying 2.22 cubic feet per second, which was one-half the spring flow and twice the flow about August 1.

TOQUERVILLE.

This settlement is on Ash Creek. Three hundred and fifty acres in average holdings of 6.5 acres are watered from Ash Creek and La Verkin Creek by six ditches, having a total length of 3 miles. The

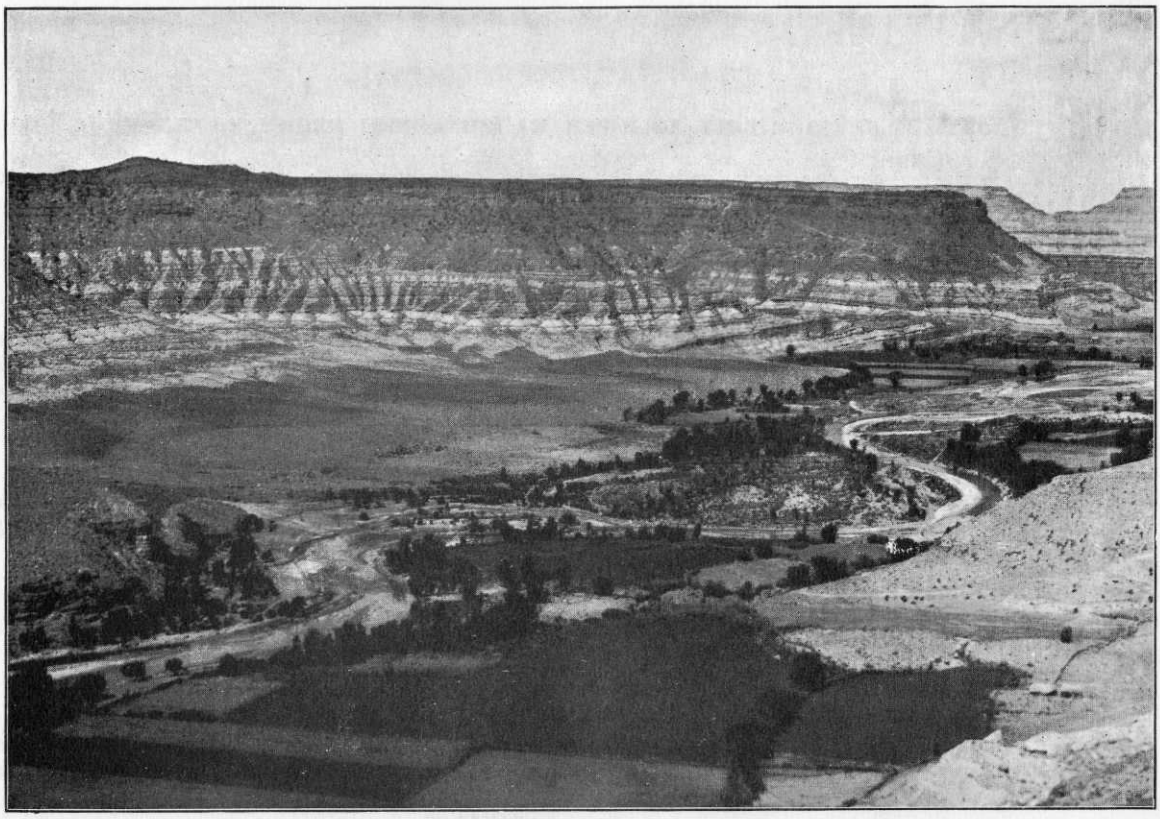

FIG. 1.—VALLEY OF VIRGIN RIVER BETWEEN ROCKVILLE AND GRAFTON

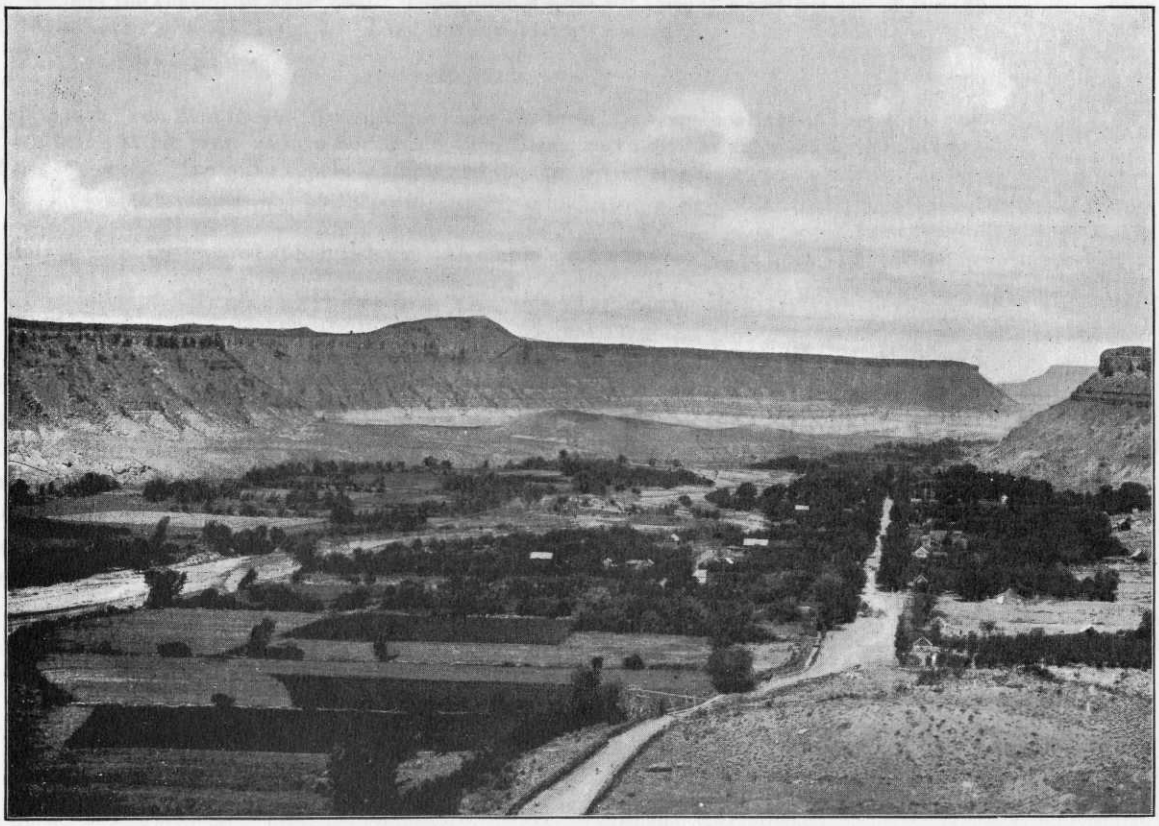

FIG. 2.—VALLEY OF VIRGIN RIVER, SHOWING ROCKVILLE TOWN AND FARMING LANDS.

Toquerville Irrigation Company controls the town and east side ditches. Each acre receives water two and one-half to four hours every eight days. The west side and La Verkin Creek ditches are not organized. The annual cost of water in the settlement is about $1 per acre.

VIRGIN CITY.

This settlement is on the Upper Virgin River. Six ditches supply water to 227 acres in average holdings of 7 acres, the annual cost being $4.25 per acre. The supply is ample, but the cost is large, owing to the sand filling the ditches. The water users are not organized, but the principal ditches have each a secretary and a water master.

MOUNTAIN DELL AND THE MILL.

These settlements are on North Creek. One hundred and thirty acres in average holdings of 12 acres are watered by twelve ditches at a merely nominal expense. The water supply is short in June and July.

DUNCANS RETREAT.

Four acres are watered at this place on the Upper Virgin River. The water supply is ample and the cost is merely nominal.

GRAFTON.

This settlement takes water from the river through two ditches. (Pl. XVII, fig. 1.) An area of 154 acres in average holdings of 8.5 acres is watered at a cost of from $1 to $3 per acre per annum. Each acre receives an irrigating stream from two to four hours every eight or ten days. There is no formal organization, but each ditch has a water master and a secretary.

ROCKVILLE.

Rockville is the only settlement on Virgin River in which a strict time-rotation system of distribution is not followed. As there is abundant water in the river at Rockville, no strict regulation is exercised over the amount of water used. Three ditches serve 293 acres at a cost per acre of from $1 to $2.50 per year. (Pl. XVII, fig. 2.) Land holdings average 9 acres.

SPRINGDALE.

Springdale is on Zion Creek. Two ditches water 160 acres in average holdings of 8 acres, the cost per acre being $1 per year. Above Springdale, Zion Creek, seven ditches water 135 acres in average holdings of 8 acres. The water supply is ample and the cost is very small.

SHUNESBURG.

Only 35 acres are watered at Shunesburg. An ample water supply is taken from Virgin River.

CROP RETURNS FOR THE CENTRAL DIVISION.

The data covering the crop returns in the St. George and Washington and the St. George Clara fields have already been given (see page 218). In addition an effort was made to learn the yield and value of crops in the other settlements of the central division of the basin. It was impracticable to gather detailed reports of actual yields in these settlements, but, instead, estimates were obtained from several of the leading farmers in each settlement. Although each farmer consulted was asked for a conservative estimate, it is natural for the figures given to more nearly represent good than average years.

The following summary contains averages of the estimates obtained in each settlement, and also shows the principal crops grown:

Summary of crop returns in settlements of central division of Virgin River Basin.

Settlements.	Principal products grown.	Average yield per acre.	Return per acre.	Average return per acre for settlement.
Bloomington and Price	Alfalfa	4 tons	$24.00	$23.25
	Wheat	25 bushels	22.50	
Santa Clara	Alfalfa	5 tons	30.00	31.58
	Wheat	25–30 bushels	24.75	
	Barley	50 bushels	40.00	
Gunlock	Alfalfa	5 tons	35.00	35.00
Pine Valley	Alfalfa	2 tons	18.00	31.60
	Wheat	20 bushels	18.00	
	Oats	38 bushels	30.40	
	Potatoes	150 bushels	60.00	
Grass Valley	Alfalfa	2 tons	20.00	28.12
	Wheat	25 bushels	22.50	
	Oats	40 bushels	30.00	
	Potatoes	100 bushels	40.00	
Harrisburg and Leeds	Alfalfa	5 tons	30.00	30.00
	Wine grapes	200 gallons	a 100.00	
Harmony	Alfalfa	4 tons	28.00	30.30
	Wheat	25 bushels	22.50	
	Oats	40 bushels	28.00	
	Barley	do	28.00	
	Potatoes	100 bushels	45.00	
Kanarraville	Alfalfa	4 tons	32.00	39.40
	Wheat	25 bushels	22.50	
	Barley	50 bushels	37.50	
	Oats	40 bushels	30.00	
	Potatoes	150 bushels	75.00	
Bellevue	Alfalfa	4 tons	32.00	32.00
Toquerville	Alfalfa	3½ tons	17.50	32.50
	Wine grapes		50.00	
	Sorghum	100 gallons	30.00	
Virgin City	Alfalfa	2 tons	10.00	22.50
	Sorghum	100 gallons	35.00	
Grafton	Alfalfa	3 tons	15.00	26.50
	Sorghum	125 gallons	37.50	
	Wheat	30 bushels	27.00	
Rockville	Alfalfa	4 tons	20.00	28.33
	Wheat	35 bushels	30.00	
	Sorghum	100 gallons	35.00	
Springdale	Alfalfa	3 tons	18.00	20.25
	Wheat	25 bushels	22.50	
Mean				29.38

[a] Acreage small and not counted in average.

The above summary shows the mean annual return per acre for the settlements in the basin, outside of the St. George and Washington and the St. George Clara fields, to be $29.38. Although believed to fairly represent the returns from farming in the basin, this mean is not necessarily accurate, because the average returns for each settlement would be larger or smaller according to the acreage planted to the

different products. In most of the settlements farm produce does not yield a cash return, and consequently the prices used in figuring the returns are based on the market values in the vicinity. Such produce as fruits, vegetables, and sorghum are usually peddled in the adjoining counties as far north as the Sevier Valley, and in the mining camps around St. George, and in Lincoln County, Nev. Until recent years the peddling was mostly by barter, a gallon of molasses or wine going for a bushel of wheat, and fruits and vegetables being exchanged for household provisions. When wheat came to have a cash value in the northern settlements and molasses came to be imported from outside States, the purchasing power of the latter became so diminished that the settlers along the Virgin River found it more profitable to raise wheat than sorghum, and consequently the area now devoted to sorghum is small.

LAND AND WATER VALUES IN THE CENTRAL DIVISION.

Land and water values vary in the different settlements of the central division of the basin, according to the scarcity or abundance of either one. In the upper settlements on Virgin River—Virgin City, Grafton, Rockville, Springdale—water is so abundant as to have no cash value, but land is so scarce as to be in demand, although not at a high figure. In the St. George and Washington Field land and water together change hands constantly at from $25 to $50 per acre, of which $12 to $15 represents the price of the water. On the lower Santa Clara Creek bottoms the two are seldom separated, but together bring from $50 to $100 per acre. In the smaller settlements land and water together are considered worth from $25 to $60 per acre, with little changing hands.

WATER TITLES IN THE CENTRAL DIVISION.

Water titles in the central division of the basin of Virgin River have, except on Santa Clara Creek, received no serious consideration. This is because, until recently, development had not reached the point that made it necessary. On some of the tributaries of the Virgin River, and on some sections of the main stream, agreements between the farmers, based on continued usage, and awards by the county selectmen sitting as water commissioners under the law of 1880, have settled common opinion as to what the rights are and in many cases furnished a basis for finally establishing them. Establishing rights through litigation has not been generally followed. The founding of the southern settlements by a people of one faith enabled the settlers to divide the water as a rule satisfactorily. Their practical sense told them how much land the small streams would water, and this land was straightway tilled, yet this knowledge did not prevent their allowing another 50 or 100 acres to be taken up under the same stream by another of their faith who wished to cast his lot with them. So the watered areas were gradually widened and the available water for each acre lessened, until some of the smaller springs and tributaries came to support populations that severely taxed them. Misunderstandings there were, of course; but the net result was for contentment and progress. If individuals could not reach an agreement the Mormon Church authorities could. When the Territorial legislature constituted the county selectmen guardians of the streams, the farmers appeared before them for certificates of water as they did for range and milling privileges, and

the county court appointed water masters as it did tax collectors. When the judges of the districts north began to hold the awards of the county selectmen invalid, the farmers on Virgin River were too far away to know it, and to this day many of them will draw their "water" from their vest pocket with assurance of absolute possession and ownership. When, in 1865, the law authorizing irrigation districts was passed, one was straightway formed embracing the valley of the Santa Clara, and efforts were made to form them at Washington and Springdale. When the districts failed, the practice common in the north of protecting rights by incorporating the irrigation interests in the different settlements was taken up, and this is the stage being passed through to-day.

It has already been stated that because the water in the river does not pass in the dry season from one division to another, water titles in each of the three agricultural divisions of the Virgin Basin are practically independent of water titles in the other two. This fact makes it desirable to follow the plan used in discussing agricultural conditions and to consider water titles in the three divisions separately.

To make the discussion clear, it will be repeated here that what is called the central division of Virgin River is that between the narrows in Zion Creek and East Fork canyons, above the towns of Rockville, Springdale, and Shunesburg, and the narrows in the river below St. George. It embraces St. George, Bloomington, Price, and Atkinville, on the river below St. George; the valley of Santa Clara Creek, including Santa Clara, Shebits Indian Farm, Gunlock, Magotsa, Pine Valley, and Grass Valley; Washington and Middleton; Harrisburg and Leeds, on Quail Creek; Kanarraville, Harmony, Bellevue, and Toquerville, on Ash and Kanarra creeks; La Verkin; the proposed Hurricane settlement; Virgin City, North Creek, Grafton, Rockville, and Springdale. Excepting Zion Creek, none of the tributaries discharges water into Virgin River during the dry season and only small amounts during the remainder of the year. They have consequently always been considered independent of the Virgin, and they will be so considered in this discussion and taken up separately.

ON VIRGIN RIVER.

The settlements on Virgin River in the central division, beginning with those highest on the stream, are: Springdale, Shunesburg, Rockville, Grafton, Virgin City, Hurricane Bench, La Verkin Bench, St. George, Bloomington, Price, and Atkinville. The canals and ditches furnishing water to these settlements, arranged in order, commencing at the head of the stream, follow:

Summary of canals and ditches taking water from Virgin River in central division.

No.	Name of canal or ditch.	Location.	Area watered.
			Acres.
1	Zion Ditch	Above Springdale	41
2	Flanigan Ditch	do	7
3	Reusch Ditch	do	7
4	Windows Ditch	do	40
5	Crawford Ditch	do	40
6	Flanigan Ditch	do	120
7	Springdale Upper Ditch	Springdale	96

Summary of canals and ditches taking water from Virgin River in central division.—Continued.

No.	Name of canal or ditch.	Location.	Area watered.
			Acres.
8	Springdale Lower Ditch	Springdale	64
9	Shunesburg West Ditch	Shunesburg	15
10	Shunesburg East Ditch	do	7
11	Shunes Creek Ditch	do	7
12	South Creek Ditch	do	6
13	Rockville Town Ditch	Rockville	235
14	Rockville South Ditch	do	52
15	Dalton Ditch	do	6
16	Grafton Town Ditch	Grafton	70
17	Grafton Lower Ditch	do	84
18	Duncan Ditch	Above Virgin City	4
19	Upper Farming Land Ditch	Virgin City	52
20	Farming Land Ditch	do	91
21	Virgin City Upper Town Ditch	do	32
22	Virgin City Lower Town Ditch	do	44
23	Lee & Spendlove Ditch	do	10
24	Wright and Isom Ditch	do	7.5
25	Hurricane Canal	Hurricane Bench	.....
26	La Verkin Canal	La Verkin Bench	400
27	D. Spillsbury Ditch	Above mouth of Ash Creek	8
28	L. Savage Ditch	do	6
29	Pollock Ditch	Above St. George and Washington Dam	55
30	Prince & Wilkinson Ditch	do	55
31	St. George and Washington Canal	Above St. George	2,175
32	Jarvis Ditch	do	200
33	Bloomington Ditch	Bloomington	190
34	Price Ditch	Price	184.5
35	Atkinville Ditch	Below Price	120
	Total		4,531

The above summary includes every ditch, however small, taking water from Virgin River in the central division of the stream, including Zion Creek, during the irrigation season of 1902. It shows thirty-five ditches, watering a total of 4,531 acres. It would seem that before so many ditches could have been built some orderly and lasting system of acquiring water rights would have been established, if not on demand of the public, then at least on demand of individuals using water. Yet of the thirty-five ditches not one has been decreed a right to the water it diverts, nor has one a right whose title is in the least certain. There is not even the usual dependence on posting notices and filing claims. Although the laws of Utah provide[a] that those desiring to appropriate water shall, within twenty days after making the appropriation, file a notice of the appropriation with the clerk of the county in which the appropriation is made, the records of Washington County show but few claims to water from Virgin River. Those which are on file are given in the following summary:

Claims to water from Virgin River on file in Washington County.

February 13, 1878, Mat Magney and George Buckner. They claimed all the water of Virgin River from and above secs. 25 and 26, T. 41 S., R. 13 W. for irrigation.

[a] Revised Statutes of Utah, 1898, par. 1269.

January 12, 1899, Thomas Judd and E. V. Hardy claimed 1,500 miner's inches, for irrigation, on La Verkin Bench.

January 9, 1890, Washington Field Canal Company claimed 3,500 inches, for irrigation, to be used through the Washington Field Canal.

January 15, 1890, Thomas Judd claimed all the water of Virgin River not claimed by La Verkin Fruit and Nursery Company, for milling and mining. A similar notice by the same parties was filed October 18, 1900.

April 24, 1894, Thomas Judd and R. G. McQuarrie claimed all of Sulphur Springs in Virgin River, for bathing purposes.

There is nothing in the county record to show that any of the claims enumerated above have ever been made good by actual appropriation and use. By an examination of the stream it was learned that there have been appropriations under the claims filed for La Verkin Bench, the Washington Canal, and for bathing purposes only.

Many of the ditches included in the summary on pages 228, 229 were awarded water by the county selectmen. These awards were usually made to the individuals under the ditches rather than to the ditches. The awards were mostly made during the first ten years after the law authorizing such awards was passed, yet authority to make awards was considered to be vested in the county commissioners until 1895, when the application of Hurricane Canal Company for a primary right to 4,000 inches from Virgin River was considered and refused on the grounds that the awards already made exhausted the stream in low water. While these awards in no sense established title, they have some value as evidence regarding the time and amount of early appropriations. Therefore the records of the county commissioners' courts were searched for a list of them. The records found were very incomplete. Nine awards to Virgin River were entered. Of these, one dated August 7, 1881, gave D. McMullin a primary right for 15 acres and a secondary right for 15 acres; one dated August 7, 1881, gave D. and G. McMullin a primary right for 9 acres and a secondary right for 9 acres; one dated August 7, 1881, gave W. Laney a primary right for 7 acres and a secondary right for 2 acres; two dated March 7, 1882, gave A. J. Workman a primary right for 4½ acres; one dated March 7, 1882, gave W. D. Johnston a primary right for 1 acre; one dated June 2, 1891, gave Bloomington Irrigation Company a primary right to 275 inches; one dated June 2, 1891, gave Price Irrigation Company a primary right to 1,200 inches, and one dated August 8, 1893, gave the Washington Field Canal Company a primary right to 3,500 inches. The records at Kanab show also that rights were given to Levi Savage for 20 acres at Toquerville; to the Virgin City Farming Land Ditch for 132.5 acres; to Virgin City Parker Ditch for 10 acres; to Virgin City Lower Ditch for 50 acres; to Grafton Ditch for 125.5 acres, and to Rockville Ditch for 280 acres. The awards shown by the record are not all that were made, a number of other individuals in the upper settlements holding certificates to small amounts, showing either that all awards were not entered or that some of the records have been lost. The record is, therefore, so incomplete as to have but little value when it comes time to settle the rights on the central division of the river.

After the law of 1901 authorizing the county commissioners to appoint water commissioners was passed, that section of the river designated in this report as the central division was constituted water division No. 1, in Washington County,

and a water commissioner was appointed. How this water commissioner was to distribute the water of Virgin River to 35 ditches when not one of them, or not one of the individual irrigators under them, had an established title to water is not clear, yet that was the task set him. Fortunately the irrigators from Virgin River are endowed with a propensity to peace, and are fairly well agreed as to their own and their neighbors' rights. The commissioner has rarely, if ever, been called upon to make any division, and consequently the need for a definite basis of division has not been strongly felt.

Within a short time an increased demand for water from the river will make a definite settlement of rights, if not absolutely necessary, then at least highly desirable. The stage has already been reached when the irrigators wish to know and have tangible evidence of what their rights are. The establishment of these rights is not a difficult task, yet it will require care and thoroughness in its accomplishment. The problem that is now giving the most concern is whether there will be sufficient water in the river to cover the land under the new Hurricane Canal without causing a shortage in the lower canals. The Hurricane farmers claim only a secondary right, yet they have spent so much time and effort on their enterprise that failure in the water supply would be serious. During the progress of the canal the theory has been held that water diverted to Hurricane Bench at the season the supply in the river is ample will seep back to the river at the season the river is lowest, thus being a benefit rather than an injury. While such a result has followed diversions on many streams, as for instance the Sevier (see page 268), there seems little reason for believing that it will follow to any great extent in the case of the Hurricane enterprise. The Hurricane land is bench land of volcanic origin with no clearly defined dip toward the river. The character of the subsoil of the bench is unknown. The land to be watered is from one-half to 3 miles from the river. It is doubtful, therefore, whether the water diverted to the bench will return to the river in time to be of any value to the irrigators below. Even if the theory of the Hurricane farmers proves incorrect, it would seem that, if handled wisely, there is ample water in Virgin River to meet all present needs and also to supply those of Hurricane Bench. To determine if this is the fact, a daily record of the flow of the river was kept during the season of 1902 at La Verkin Sulphur Springs (see page 209). This record, computed in acre-feet, is given in the following table of discharges:

Estimated discharge of Virgin River at La Verkin Sulphur Springs during irrigation season of 1902.

Day.	March.	April.	May.	June.	July.	August.	September.	October.
	Acre-feet.	*Acre-feet.*	*Acre-feet.*	*Acre-feet.*	*Acre-feet.*	*Acre-feet.*	*Acre-feet.*	*Acre-feet.*
1		213.21	223.13	121.98	50.58	528.25	478	301.50
2		241.97	358.20	82.08	50.58	509.74	459.20	267.80
3		223.13	418.50	108.14	45.12	519.06	459.20	199.35
4		223.13	320.32	103.14	62.83	519.06	437.85	180
5		223.13	301.48	82.08	62.83	497.45	478	166.50
6		241.97	261.31	62.83	50.58	497.45	478	141.80
7		282.63	241.97	62.83	56.53	538.10	487.93	141.80
8		377.50	261.31	62.83	50.58	556.88	459.20	122
9		301.48	241.97	112.66	62.83	578.45	469.10	122
10		320.32	223.13	62.83	39.01	578.45	478	141.80
11		301.48	182.47	67.93	50.58	556.88	478	133.90

Estimated discharge of Virgin River at La Verkin Sulphur Springs during irrigation season of 1902—Cont'd.

Day.	March.	April.	May.	June.	July.	August.	September.	October.
	Acre-feet.	*Acre-feet.*	*Acre-feet.*	*Acre-feet.*	*Acre-feet.*	*Acre-feet.*	*Acre-feet.*	*Acre-feet.*
12	.....	459.17	223.13	72.64	50.58	578.45	478	166.50
13	.....	377.50	223.13	62.83	45.12	588.07	459.20	133.90
14	.....	327.66	135.52	50.58	39.01	776	459.20	151.75
15	.....	349.09	135.52	62.83	50.58	835.01	519.06	141.80
16	.....	358.50	131.90	59.94	50.58	716.01	538.10	.....
17	.....	377.50	135.52	56.53	62.83	657	459.20	.....
18	.....	459.16	168.09	56.53	62.83	578.45	418.50	.....
19	.....	399.14	168.09	39.01	62.83	556.88	459.20	.....
20	206.37	578.42	168.09	45.12	50.58	578.45	478	.....
21	292.26	320.32	168.09	50.58	62.83	519.06	478	.....
22	241.97	301.48	153.71	62.83	50.58	478	478	.....
23	223.13	327.66	153.71	56.53	21.50	377.50	418.50	.....
24	261.31	320.32	153.71	56.53	39.01	399.17	339.15	.....
25	241.97	339.15	153.71	45.12	103.14	418.50	301.48	.....
26	261.31	358.20	182.47	39.01	Flood.	519.06	301.48	.....
27	282.63	339.15	103.14	39.01	734.90	497.45	320.32	.....
28	282.63	339.15	135.52	50.58	657	657	339.15	.....
29	261.31	358.20	163.29	50.58	657	616.58	339.15	.....
30	213.21	358.20	172.95	72.64	657	556.84	339.15	.....
31	213.21	.....	163.29	.....	592.64	519.06	.....	.....
Total	2,981 31	9,997.92	6,226.37	1,953.75	4,632.59	17,302.31	13,085.32	2,512.40

The year of 1902 has been one of the driest on record, yet 58,692 acre-feet passed Virgin City to the ditches below between March 20 and October 15. This was sufficient to cover all of the irrigated land under the ditches below Virgin City as well as the 2,000 acres on La Verkin and Hurricane benches, which have as yet received no water, to a depth of 10.87 feet. As shown in discussing the climate of Virgin Valley and the character of the river channel, a large loss through evaporation and seepage must be counted on. It would seem conservative to estimate that two-fifths of the stream could be saved. This would cover the irrigable land under ditch not yet irrigated to a depth of 4.35 feet, which is certainly sufficient to produce crops even in Virgin Basin. Sufficient water to meet all needs can not be saved, however, without more economical use of water than is made now. Seepage losses in canals will have to be lessened, more of the water used for sluicing will have to be saved, and a higher duty of water when applied to the land will have to be reached. A striking example of extravagant use is presented by St. George and Washington Field. Enough water was used on that field during the season of 1902 to cover the land irrigated to a depth of 8.41 feet, nearly double the amount that should be necessary (see page 217). That it was far in excess of the needs of the land is shown by the fact, reported by the president of the company, that 200 acres in the field have been rendered useless and 300 acres additional very much injured by the rise of alkali in the land, due to overirrigation on the higher lands of the field and seepage from the near by canal and laterals. Out of the 119 farmers watering land in the field in 1902, 56 reported damage by alkali, their crops being cut down from one-eighth to three-fourths. There is no excuse for wasting water where it is as valuable and where its loss means so much as in Virgin River Basin.

From Virgin City up, the farmers on the river have thus far been practically independent of those below. There land, and not water, determines values. A shortage in the Virgin River at these settlements has never been known, and on only one or two occasions have complaints of excessive use in these settlements been made by those below. On those occasions committees of lower settlers have made the request that for a few days the entire flow of the river be allowed to pass to the canals and ditches farther down. Such requests have always been granted, yet it is an interesting fact that there is on record no occasion on which the shortage that was the reason for such a request has not been removed by the coming of a flood almost before the complaining committees had returned. Because the upper settlements have thus far been independent is no reason for their remaining so. They should be allowed to lessen the flow of the river only so far as is necessary for the irrigation of their land. Although much of the excess water used in the upper settlements returns to the river, it is still true that a large percentage is lost by evaporation in the frequent and wasteful floodings. A series of measurements of the effect of the upper diversions on the flow of the river was made in the summer of 1902. The flow of Virgin River both above and below Virgin City and Rockville, and also of the ditches at both settlements, was measured, with the results given in the following summaries:

Measurements of Virgin River at Virgin City, June 21, 1902.

[Cubic feet per second.]

Discharge above all ditches		42.05
Discharge below all ditches		38.18
Net decrease from diversions		3.87
Diversions:		
Lee and Spendlove Ditch	1.59	
Wright and Isom Ditch	.20	
Lower Town Ditch	1.49	
Farmingland Ditch	8.15	
Upper Farmingland Ditch	2.38	
		13.81
Gain in section due to return seepage		9.94

Measurements of Virgin River at Rockville, June 23, 1902.

[Cubic feet per second.]

Discharge above all ditches		49.76
Discharge below all ditches		51.18
Net increase in section		1.42
Diversions:		
Duncan Ditch	2.37	
Grafton Town Ditch	6.48	
Rockville South Ditch	5.73	
Dalton Ditch	.50	
		15.08
Gain in section due to return seepage		16.50

It is recognized that a single series of measurements is not conclusive, but these summaries show that the flow of the river was not appreciably affected by the diversions being made on June 21 and June 23. With diversions at Virgin City amounting to 13.81 cubic feet per second, there was but 3.87 cubic feet per second less water flowing away from the settlement than was flowing to it, showing that 9.94 cubic feet per second of the 13.81 cubic feet per second diverted returned to the river before the settlement was passed. With diversions at Rockville amounting to 15.08 cubic feet per second, there was 1.42 cubic feet per second more water leaving Rockville than was flowing to it, showing that while only 15.08 cubic feet per second was diverted, the gain by return seepage was 16.50 cubic feet per second. This is explained by the fact that larger diversions than those made on the days of measurement are usual and had been made a few days prior to the date of the gaugings shown in the tables. The largest ditch at Rockville—the Rockville Town Ditch, with a capacity of 10.82 cubic feet per second—and the largest ditch at Grafton—the Grafton Lower Ditch, with a capacity of 14.15 cubic feet per second—were empty on the day the gaugings were made.

When a move is made to settle water titles on Virgin River, besides determining to what extent Hurricane, La Verkin, St. George and Washington, and other canals and ditches are independent of those above, the respective rights of the irrigators in each section will have to be considered. To determine the area irrigated and the requirements of the land in the upper settlements, and the dates of use, would be a comparatively simple task, but to reach a just conclusion as to the division of water between Hurricane, La Verkin, and St. George and Washington canals would be more difficult. While the St. George and Washington Canal has been using water more systematically than La Verkin Canal, certain conditions have been met under La Verkin Canal that affect its standing. Chief of these have been the difficulties in ditch maintenance mentioned in connection with this canal earlier in this report. The question of whether reasonable diligence has been exercised by the builders of this canal would have to be considered. In determining the rights of Hurricane Canal, the question of priority would not arise, but only that of how far wasteful use elsewhere on the stream should be allowed to the injury of Hurricane Canal. The fact of wasteful use in St. George and Washington Field is clear. It should be the duty of some official, presumably the county water commissioner, to see that the wasteful use is stopped. While other fields are suffering as the Hurricane Field will when the canal is completed, no irrigator should be allowed water in excess of his needs.

After the Hurricane Canal is completed and a definite basis of dividing the water of Virgin River is established, the work of division would be greatly facilitated by a knowledge of the flow of Virgin River above Hurricane Canal. If the division is to be entirely satisfactory, this knowledge will be essential, because it is impossible to divide accurately a stream whose volume is not known. In the box canyon directly above the Hurricane Dam is a desirable section of the river for keeping such a record. An automatic register at that point would keep the record in a satisfactory and comparatively inexpensive manner, and it is to be hoped that either the owners of the different canals or the county of Washington, through the water commissioner of water district No. 1, will see their way clear to install it.

ON SANTA CLARA CREEK.

The distribution of the water of Santa Clara Creek has so far presented more difficulties than has the distribution of water in any section of Virgin River Basin. The only irrigation district successfully organized and operated in the Virgin Valley under the law of January 20, 1865, and the only litigation over water rights occurring in the central division of the basin have been in connection with this stream. Yet in spite of the difficulties met, conditions are more nearly settled on this stream than anywhere else in the basin, save in Long Valley, on the headwaters of East Fork

The cause of trouble on the Santa Clara has been twofold—the lack of any definite understanding as to what area the creek could be made to water, and unbusinesslike methods in administering the various organizations that have from time to time been charged with its control. The desire to live and let live, so prevalent with the Mormon settlers, resulted in gradual encroachments on the water supply, until in dry seasons it is insufficient. As shown in the record of discharges of the two St. George Clara ditches during 1902, the entire flow of the creek was exhausted in June. From the end of the irrigation season of 1901 to the end of the season of 1902 the only water that passed the ditches into Virgin River was that which seeped from the irrigated lands along the stream too far down to be again used. In outlining the history of the valley of Santa Clara Creek it was shown that Santa Clara was the first town to be established, that Gunlock followed Santa Clara, and that Pine Valley came last. When the missionaries were first sent south by the church authorities, the idea of making Pine Valley an agricultural settlement was not considered, and it was thought that the lower settlements on Santa Clara Creek would have an ample water supply. Pine Valley was intended primarily as a milling center, and the records of the old Washington County court have frequent reference to milling privileges allowed different settlers. Thus on September 1, 1856, the control of the water, timber, and grass in Pine Valley was granted to C. W. Dalton and others for mill purposes, and, in addition, water to irrigate 2 acres of land; and on the same day springs in Grass Valley were awarded the same parties for irrigation, "so long as their operations continue to subserve the interests of the settlement." December 3, 1867, Robert Gardiner was given a right to unite the water of Pine Valley and Hawley Springs to run a sawmill. It was not until 1866 that water came to be used to any extent for irrigation in Pine Valley. There is no record of any grant being made for such a purpose, but the early settlers remember distinctly how people from St. George gradually began irrigating the narrow bottoms in the valley, each thinking that his small diversion would work no injury to those below. The church authorities, wishing to find homes for as many as possible, urged that there was land and water for all. The natural result was that by the early seventies the irrigators began to realize that some way to retard further appropriations must be found and some agreement reached as to the division of the water.

When the city of St. George was incorporated January 17, 1862, the city council was given control of the water of Santa Clara Creek, with the provision that such control should not be exercised "to the injury of any rights already acquired by actual settlers thereon." During the controversy among the irrigators in the differ-

ent settlements there was uncertainty as to what authority the city council really had. No one knew what the rights "already acquired by actual settlers" were. September 23, 1871, a motion was made in the city council praying that the county court hold a special session for the purpose of adjudicating the rights acquired prior to the granting of the St. George charter. Instead of such an adjudication, on January 20, 1872, the uncertainty was temporarily cleared up by a compromise suggested by two of the church authorities acting on behalf of the people of Santa Clara and the city council of St. George. On the same day it was voted to form under the law of January 20, 1865,[a] the Santa Clara irrigation district, extending between certain ditches, and from the Threemile Place on Santa Clara Creek to the west side of Main street in St. George. During the next year the controversy continued, culminating in charges being filed with the church authorities against certain of the water users. Diversions above had so increased that water was scarce for domestic purposes in Santa Clara settlement. It was not until August 4, 1873, that a public election was held to decide on levying a special tax of $3.50 per acre on the land within the proposed district. The tax was carried and the district declared organized according to law. With the formation of the Santa Clara irrigation district it was supposed that the controversy would end, but it did not. August 9, 1873, it was suggested that a committee be appointed before whom every right on the stream should be proved, but no action was taken on the suggestion. October 3, 1875, a general meeting was called at the instance of the lower settlers on the creek, who could not get water for the planting of fall wheat. It was then decided to petition the church authorities to determine the rights on the stream. The petition was granted and on February 5, 1876, an agreement was submitted to the irrigators, as holders of "acquired possessory rights by use and appropriation of all of the waters of the Santa Clara River for agricultural and other purposes." By this agreement they bound themselves to abide by the decision of three referees who should "fully and finally adjust and have duly recorded" every claim to the water of Santa Clara Creek for the "present benefit and future security" of the settlers. There is nothing in the records to show the outcome of this agreement, but a similar agreement was drawn up and signed March 13, 1878. August 31, 1878, the board of arbitration appointed by the later agreement rendered a lengthy report, containing the following provisions:

(1) That the limits of the Santa Clara Creek irrigation district be extended so as to include the whole of Santa Clara Creek, the extension to be accomplished by petitioning the county court.

(2) That of this district, Pine Valley should form the first subdistrict; from the Eightmile Springs to the Warm Springs should form the second subdistrict; from Magotsa corral to the lower

[a] An act was passed by Territorial legislature and approved January 20, 1865, providing for the incorporation of irrigation companies. Under this act county courts were authorized to organize irrigation districts, upon petition of a majority of the citizens, in localities requiring more water for irrigation and in which there should be unclaimed streams that could be made to supply this need. The act provided further that after the organization of such a district the citizens of the district might organize an irrigation company to locate and construct canals and assume management and control of the irrigation works of the district, for such purpose being empowered to levy and collect taxes assessed against all the property in the district, or only the lands to be benefited. The act required that the board of trustees of the company should make annual reports of the progress and condition of the company to the county court. (Compiled Laws of Utah, 1876, Chap. III, secs. 505–528.)

end of the Truman farm should form the third subdistrict; from the upper end of Jackson farm to the lower end of Conger farm should form the fourth subdistrict; from the upper end of Fivemile Place to the head of the St. George Clara Field ditches should form the fifth subdistrict; from the head of St. George Clara West Ditch to the mouth of Santa Clara Creek, on the west side should form the sixth subdistrict; and from the head of St. George Clara East Ditch to Tonaquint Wall on the east side of Santa Clara Creek should form the seventh subdistrict.

(3) That in each of the subdistricts there should be an under water master, to be appointed by and be under the immediate supervision and control of the general water master of the district.

(4) That the first subdistrict should be entitled to water from Santa Clara Creek to irrigate 623 acres, to be divided pro rata; provided, that after notice from the general water master, all of the water of Santa Clara Creek should be allowed to flow out of Pine Valley to the settlements below for six out of each fourteen days.

(5) That William Empey should be entitled to the use of Earl Spring for irrigation.

(6) That the second subdistrict should be entitled to water pro rata with the rest of the district to irrigate 46 acres. (Individual holdings follow).

(7) That the third subdistrict should be allowed water pro rata with the rest of the district to irrigate 119 acres. (Individual holdings follow.)

(8) That the fourth subdistrict should be entitled water pro rata with the rest of the district to irrigate 40 acres. (Individual holdings follow).

(9) That the fifth subdistrict should be entitled to water pro rata with the rest of the district to irrigate 475.5 acres, provided that the citizens of Santa Clara town have sufficient water in the town ditch for household use and to irrigate the gardens in the town at low stages of water.

(10) That the sixth and seventh subdistricts should be entitled to water pro rata with the rest of the district to irrigate 800 acres.

The report of this board of arbitration was thorough and conclusive and was so accepted by the irrigators along the Santa Clara. Extending the boundaries of the district so as to include the whole creek placed the creek under the control of one authority, which was the first step in a settlement. Even before the report of the board of arbitration was rendered, namely, on January 15, 1877, a committee had been appointed to ask the county court for such an extension. October 2, 1878, it was ordered by the county court that the extension asked for be granted, and that the number of trustees be increased from 5 to 8.

The organization of the Santa Clara irrigation district has been given in detail because it has been the cause of most of the disagreement on Santa Clara Creek. For a number of years, aside from slight misunderstandings, it controlled affairs with entire satisfaction. Then doubt began to arise in the minds of the people of Gunlock and Pine Valley as to whether the affairs of the district were being administered fairly. October 14, 1880, the people of Gunlock claimed that no water was being run through the Gunlock Town Ditch for culinary and garden purposes, whereupon the directors of the district ordered that water be allowed for culinary purposes but not for garden purposes. The dissatisfaction caused by the refusal of the directors to grant water for garden purposes was increased by the directors on June 13, 1881, granting 100 inches to the settlement of Santa Clara for garden and culinary purposes, and on March 19, 1883, a petition was presented to the directors protesting against their grant to Santa Clara. The ill-feeling between the settlements continued and became aggravated as the years passed. The people of Gunlock and Pine Valley became suspicious of the water users in the lower subdistricts, and a sentiment grew that the taxes levied by the directors of the district should be resisted. Although both Gunlock and Pine Valley had representatives on the

directorate of the district, certain actions of the directors were considered arbitrary and their legality questioned. Unfortunately for the peace of the communities, some person removed from the record book of the district a number of pages covering the actions of the board from February 17, 1878, to June 15, 1879, and also from March 19, 1883, to June 8, 1883. The discovery of this fact still further aggravated the trouble, and when, on December 27, 1898, stockholders representing 675 shares in the district voted a tax of 15 cents per share on all shares in the district, ordering that if the tax was not paid by April 15, 1899, the delinquent shares be advertised and sold, the upper settlers concluded that resistance was their only course. It was decided in Pine Valley and Gunlock that the directors had no authority to levy a tax, and that as a tax it would not be paid. The settlers in Gunlock and Pine Valley were willing to bear their share of the district expenses but they split hairs over the word tax. March 25, 1899, at the meeting of the directors following that at which the delinquent shares were ordered sold, an attempt was made to disapprove the minutes of the former meeting, the division again being squarely between the representatives of the upper and the lower settlements. The drift of affairs being apparent, the sale of shares on which the tax was delinquent was postponed one month to give time for a friendly injunction suit to test the legality of the district organization. A committee of attorneys was appointed to examine the records and consult authorities. The report of the committee was to the effect that the district organization was fatally defective in that it did not give the names of the original stockholders of the district, and because the records did not show that the district had been extended so as to include the entire stream. Thereupon the sale of shares on which the tax was delinquent was postponed indefinitely.

Although the records of the county court and of the district were not sufficiently complete to stand a test of law, they were sufficiently complete to show conclusively that the district had been extended. The ordering of the extension by the county court on October 2, 1878, may not have been disclosed by the search of the attorneys, but it was, nevertheless, on the books as it is to-day,[a] and also on the books of the clerk and historian of the Mormon Church at St. George. Annual reports of the district required by the law authorizing irrigation districts[b] were filed with the county court and accepted December 31, 1879; May 1, 1880; December 5, 1881, and March 5, 1883, but, with the exception of the report for December 31, 1879, they are missing from the county files. No mention is made of the reports for the other years. The unbusinesslike manner in which the records were kept was therefore good ground for doubting the legality of the district.

After the report of the attorneys was received, opinion was divided as to whether the district should be dissolved or its organization perfected. After a year of discussion it was allowed to lapse, the last meeting of the directors being held December 15, 1900.

With the dissolution of the Santa Clara irrigation district the problem of controlling the water of Santa Clara Creek was at the same stage as when the church authorities were petitioned for a settlement, on October 3, 1875, with the exception that new complications had arisen through the gradual extension of the irrigated

[a] Book B, Minutes of the Court of Washington County, Utah. [b] See note, page 236.

areas, bringing additional reasons for determining the rights of the irrigators. Meantime, the movement toward incorporation of irrigation interests had gained ground in Utah, and to incorporate the interests along the Santa Clara was the next move. Accordingly, on August 21, 1901, the Santa Clara Field Company, comprising subdistrict 5 in the old district, and on August 22, 1902, the St. George Clara Field Company, comprising subdistricts 6 and 7 in the old district, were incorporated. During 1902, through the instrumentality of the church authorities, the interests at Gunlock were placed in like shape, and on October 15, 1902, the incorporation of the interests at Pine Valley was being effected.

LITIGATION.

One case affecting Santa Clara Creek and one case affecting its tributary, Grass Valley Creek, have been tried in the district court at St. George, and a third case affecting the rights of the entire stream is contemplated. This last case is to follow the incorporation of the irrigators interested in each of the settlements on the creek, and if the present plans of the church authorities are carried out will be brought in the United States court at Salt Lake City. The United States court is selected because the Government's interests at Shebits Indian farm, between Santa Clara and Gunlock, are affected. October 15, 1902, the advisability of the United States court's trying the case was under consideration by the United States district attorney. If the case is tried, the aim and purpose will be to finally settle every right on the stream.

State of Utah v. *Royal Hunt.*—The case affecting the Santa Clara was the case of the State of Utah *v.* Royal Hunt, and had reference to springs feeding Santa Clara Creek on the farm of the defendant. In the apportionment of water under the Santa Clara irrigation district regulations these springs were considered part of the creek and were subject to the control of the general district water master. During the period of controversy over the legality of the irrigation district the defendant in the suit concluded that he need not continue subject to the orders of the general water master, and they were consequently ignored and water taken from the springs at a time it had not been allotted. It occurred to the county officials that the alleged infringement on the rights of the other settlers could best be corrected through criminal proceedings against Hunt, and on August 1, 1900, the county water commissioner in water district No. 2, comprising Santa Clara Creek, swore to a complaint before the justice of the peace in St. George charging Hunt with "willfully and unlawfully turning from and using a part of the water running in the Santa Clara Creek at a time said water had been duly distributed to the people living in Santa Clara settlement for irrigating purposes, thereby changing the flow of said waters without being duly authorized to make such change." The case went to trial before the justice of the peace August 6, 1900, and on the following day the court rendered judgment finding the defendant guilty and ordering him to pay a fine of $7.50 and costs amounting to $61.05. Appeal was taken to the district court. After several continuances the case came up for trial before Judge W. M. McCarty, of the sixth district, who was invited to hear it in lieu of the presiding judge of the district. The State filed an amended complaint, alleging that the defendant, Hunt, had diverted the water of Santa Clara Creek at a time said water "had been duly and regularly distributed to the

owners thereof by Alexander Fullerton, the water master appointed by the owners of the water of Santa Clara Creek and its tributaries, thereby changing the flow of said waters without being duly authorized or having the right to make such change and use, contrary to the customs, usage, and the manner of distribution of the said waters for the past twenty years * * * and against the peace and dignity of the State." May 20, 1901, the court ordered the discharge of the defendant. The decision of the court came as a great shock to the water users prosecuting the case, who believed implicitly in the authority of the Santa Clara irrigation district over the water of Santa Clara Creek. It left no doubt whatever of the chaotic condition of water titles on the stream and showed the necessity for some speedy settlement. In his decision Judge McCarty stated that the evidence in the case did not show conclusively that the right to control the water in question had ever been surrendered to the irrigation district, and that it was questionable but that a court of equity would, on the evidence as it stood, allot to the defendant, Hunt, the stream in question. He stated, further, that the district water master had absolutely no right under the evidence to designate to the individuals within the subdistricts the amount of water they should take, that being the province of water masters of the subdistricts.

George M. Burgess v. J. A. Gardner and R. J. Gardner.—On August 12, 1899, a complaint was filed in the district court against John A. Gardner and Royal J. Gardner by George M. Burgess, alleging (1) that the plaintiff was the owner of a certain tract of land in Grass Valley and had a right to water to irrigate that land; (2) that the selectmen of Washington County, acting as water commissioners, had decided that James Rencher was entitled to a primary right to one half of the water of Rencher Canyon and that John A. Gardner was entitled to the other half; (3) that the said water commissioners had given secondary rights to the water of Grass Valley to John A. Gardner for 25 acres, to George M. Burgess for 80 acres, to H. Burgess for 37 acres, to B. Burgess for 15 acres, to R. Gardner for 5 acres, to E. Whipple for 16 acres, to R. L. Lloyd for 15 acres, and to L. Brown for 7 acres; (4) that since July 18, 1881, the plaintiff, George M. Burgess, had acquired, by purchase and appropriation, a complete title to five-sixths of the secondary rights to the water of Grass Valley, and that he had used them until the spring of 1898, when the defendants diverted the water of Rencher Canyon at different places and used it on land that had not been previously irrigated or cultivated, thus unlawfully depriving the plaintiff of his secondary rights; (5) that part of the land for which John A. Gardner had been granted a primary right by the county water commissioners was meadow adjacent to the main stream, from which the water applied in irrigation seeped back to the stream and flowed on to the land below holding a secondary right, and that the lands on which the primary rights had been used since 1898 were so situated that no water found its way back from them into the main creek. August 27, 1899, the defendants filed a demurrer to the complaint, alleging that it could not be ascertained from the complaint whether the plaintiff relied on an original appropriation, upon an award of certain alleged water commissioners, or upon a right acquired by purchase or by adverse use, and, further, that the complaint did not allege an appropriation of any water or the use of any water for any useful purpose. October 19, 1899, Judge E. V. Higgins sustained the demurrer. The decision on the demurrer covered the

ground of the complaint so thoroughly and touched on so many points of interest that the following quotation is given:

It is the contention of the plaintiff that while the defendant may ordinarily change the place of use of their water, yet where the circumstances show, as in this case, that an injury to a third party will result thereby, it can not be permitted. This is true if the injury complained of is a legal injury, such an injury as would create a cause of action against the wrongdoer. Is then the injury complained of in this case a legal injury? We think not.

It is settled beyond controversy that the owner of the soil is likewise the owner of percolating water contained in such soil, and that he assumes the same right to control it as he does the soil. If this is true then the defendants in this case would have a right to prevent entirely the escape of any percolating water within the soil owned by them from without the boundaries of such soil so owned by them and to collect and apply the same to some beneficial use. Had the defendants in this instance done this the plaintiff would not, by reason of such act on their part, have had legal cause for complaint. Allowing this seepage water to flow from their land for a long period of time, however, was no promise or guaranty on their part that they would always allow it to so flow, or that they would perpetually maintain on such tract the source of such flow, nor can such act on their part in permitting the creation and flow of seepage water be urged in estoppel of their right to use the water in such a manner that thereafter there will be no seepage.

If the plaintiff by virtue of his appropriation acquired any right it is one of definiteness and certainty. He acquired a right to have the same amount of seepage water flow correspondingly during the same season of each and every year. This means that the defendants would be held not only to use the same amount of water on the same tract each year, but further, that they must so use it that the seepage flow shall not be diminished in quantity.

It means that should any crop other than meadow require or absorb more water and thereby decrease in amount the seepage flow, the defendants would be liable to the plaintiff for whatever of damage might result to him by reason of such diminution.

A statement of these propositions shows of itself the falsity of plaintiff's contention.

Under our statute the owner of water can treat it either as personal property or as realty, and in view of this right it will hardly be claimed that the defendants in this case would not have the right to sell their water to a third person, who would equally have the right to use the same for some beneficial purpose; it might be for irrigation or for the purpose of supplying some village or city with water for domestic use. And if defendants' grantee would have this right, surely the grantor would have an equal right, for the grantor can convey no greater right than he himself possesses.

The decision on the demurrer was so clearly against the plaintiff that no further action was taken beyond filing an amended complaint.

CLAIMS TO WATER FROM SANTA CLARA CREEK.

A number of claims to water from Santa Clara Creek have been recorded with the clerk of Washington County. These do not give any clew to the extent of appropriations, yet a summary of them is inserted below as making a part of the record of water titles on the stream.

January 2, 1896, W. L. Dykes and Joseph Lippman claimed the surplus and unappropriated water flowing in Pine Valley Narrows, and all that could be stored by dam or reservoir at that place, for irrigation in the Santa Clara Valley. January 4, 1896, the same parties filed a claim for the unappropriated water in Grass Valley Narrows, and all that could be stored at that point for irrigation in the Santa Clara Valley; and on the same day they filed another claim similar to their first one on Pine Valley Creek.

April 11, 1896, the Utah and Pacific Improvement Company claimed all the water flowing in Santa Clara Creek, about 1 mile below Foster's ranch, for irrigation on lands which are described in the notice.

August 16, 1898, A. E. Miller and George F. Whitehead claimed all the water flowing southerly from Fivemile Place, amounting to 50,000 miner's inches, for irrigation on the Santa Clara Bench and elsewhere.

A glance at the above claims will show the utter valuelessness and the failure of the law authorizing them to establish or systematize rights to water. Not a single actual appropriator of water from Santa Clara Creek appears on the list. One claim calls for 50,000 miner's inches, which is about fifty times as much water as the creek carried at its normal high flow during the spring of 1902.

AWARDS OF SANTA CLARA CREEK BY COUNTY SELECTMEN.

The county selectmen of Washington County, sitting as water commissioners, made a number of awards to the water of Santa Clara Creek. Because of the value of these records to show the date and amount of use, the following summary of them is given:

Summary of awards of water of Santa Clara Creek and tributaries by selectmen of Washington County, Utah.

Date of award.	To whom awarded.	Amount of award.
July 18, 1881	T. J. Jeffrey	All of Hawley and Carr springs, in Pine Valley.
Do	James Rencher	Primary right to one-half in Rencher Canyon and all of springs, for 60 acres.
Do	J. A. Gardner	Primary right to one-half in Rencher Canyon, for 60 acres.
Do	J. and T. H. Gardner	All in Hawley Canyon, Grass Valley.
Do	John A. Gardner	Secondary right for 25 acres in Grass Valley.
Do	George M. Burgess	Secondary right for 80 acres in Grass Valley.
Do	R. Gardner	Secondary right for 8 acres in Grass Valley.
Do	R. L. Lloyd	Secondary right for 15 acres in Grass Valley.
Do	H. Burgess	Secondary right for 37 acres in Grass Valley.
Do	B. H. Burgess	Secondary right for 15 acres in Grass Valley.
Do	Eli Whipple	Secondary right for 16 acres in Grass Valley.
Do	L. Brown	Secondary right for 7 acres in Grass Valley.
June 3, 1884	Eli Whipple	Primary right to all in Pine Valley for milling purposes.
Do	Santa Clara irrigation district	Primary right to all of Santa Clara Creek from source to mouth.

SUMMARY FOR SANTA CLARA CREEK.

The foregoing discussion has shown that even on a small stream such as Santa Clara Creek, if the settlement of water titles is left until all of the water becomes appropriated, instead of having each right established for all time with the first use of the water, misunderstanding and contention are sure to result. While the controversies over titles have been in progress, the difficulties of distribution have been annoying. Even with no accepted basis of division between the settlements, the general district water master continued to exercise authority so long as the district remained in existence. Soon after the lapsing of the district a water commissioner was appointed for Santa Clara Creek by the commissioners of Washington County, under the law of 1901. In the absence of a legal basis of division this commissioner has had to work more or less on sufferance and to make the divisions according to former custom and mutual agreements. Until the season of 1902 there was not a single measuring device in the creek or in any of the ditches, so that the water commissioner has been compelled to guess as to the flow of the stream and of the ditches in making the division. Acting under authority of the law of 1901, the water commissioner now in office, Mr. Brigham Jarvis, of St. George, has made an effort to have measuring flumes placed in each ditch, and has been measuring the

water in the stream and ditches over a portable Cippoletti weir with more accuracy and satisfaction than the water of Santa Clara Creek has ever before been measured.

There will be difficulties of distribution on this stream even with a definite legal basis. The loss from the stream by seepage and evaporation and the daily fluctuation in the flow are both considerable, and will have to be taken into account. Before they can be taken into account their extent will have to be ascertained by careful measurement. The flow of the creek at its source in Pine Valley; at the farms of Hunt, Foster, and Chadburn, 15 miles below; above Gunlock, and above Santa Clara settlement should be known to the water commissioner at all stages of the irrigation season if he is to divide the water justly and satisfactorily, and this flow can be obtained only with the proper measuring devices. During the spring and summer of 1902 a number of measurements were made, mostly above the Threemile Place ditches, 3 miles above Santa Clara. These measurements are given in the summary below. From the last of June to October 15 the stream carried no water below Santa Clara Town Ditch.

Gaugings of Santa Clara Creek during 1902.

Date of gauging.	Place of gauging.	Discharge.
1902.		*Cu. ft. per sec.*
March 8	200 feet above upper Threemile ditches	9.98
April 11	do	19.30
May 8	do	12.37
May 28	do	7.91
June 8	One-fourth mile above upper Pine Valley ditches	5.25
Do	Spring Branch, in Pine Valley, 100 yards below head	2.59
Do	Lower end of Pine Valley fields and above narrows	2.61
June 9	50 feet below junction with Magotsa Creek	7.96
Do	200 feet above upper Threemile ditches	4.58

If the move being made to adjudicate all of the rights to Santa Clara Creek in one suit, to be brought in the United States court at Salt Lake City, is successful, conditions will be greatly improved over what they are at present. It must not be expected that such a suit will be final. The time will come when there will be appropriators of the surplus flood water, and the relation of the rights to such water to those settled in the proposed suit will need to be determined. If water is ever stored on Santa Clara Creek, and it seems probable that it will be, the relation of the rights to the stored flow will need to be settled by some method not yet contemplated.

WASHINGTON AND MIDDLETON.

The subject of water titles at Washington and Middleton has given but little concern to the irrigators in these settlements. The water in Middleton is conceded to be the property of a few farmers. August 7, 1881, Middleton Springs were granted to five appropriators by the county selectmen. Notices of appropriation are on file with the clerk of Washington County in which A. F. Macdonald, jr., claims, under date of July 13, 1897, all the water in Lime Kiln Gulch, immediately west of Middleton, amounting to 12 "inches," to be used for irrigating 25 acres; Sheridan Andrus and Henry Schlappy, jr., claim, under date of July 6, 1897, all the

water in the same gulch northwest of Middleton, amounting to 1 cubic foot per second, to be used for irrigating 20 acres; and Sheridan Andrus and Henry Schlappy, jr., claim, on August 9, 1897, the water to be obtained by tunneling three-fourths of a mile northwesterly from Middleton, amounting to 2 cubic feet per second, to be used for irrigating 20 acres. In Washington the control has been vested in the city council since the city was incorporated February 18, 1870, section 10 of the incorporating act containing the provision that "the city council shall * * * have control of the water and water courses leading to the city, provided that such control shall not be exercised to the injury of any rights already acquired by actual settlers thereon." Mill Creek, which furnishes water to the fields below town, is not under the control of the city, but instead, is under the control of the Mill Creek Water Company. Although this company is loosely organized, the interests are so small as to have caused but little friction.

HARRISBURG AND LEEDS.

The water of Quail Creek, on which Harrisburg and Leeds are located has been used extensively for mining operations at Silver Reef, as well as for irrigation at Harrisburg and Leeds. An effort has therefore been made to keep title to the water clear, and although it has never been in court, nearly all transfers made have been recorded. June 26, 1873, the users from Quail Creek agreed to have all rights determined by a board of arbitration, and on March 4, 1874, the decision of the board of arbitration was rendered. Among the provisions of this decision were the following:

(1) When all the water of Quail Creek shall measure 120 inches or less, in the head gates, at the point of division of water between Harrisburg and Leeds, the primary claims, consisting of 162 acres, shall draw 67.5 per cent, and the secondary claims, consisting of 118.75 acres, shall draw 32.5 per cent of the water in said creek.

(2) When all the water of said creek shall measure from 120 to 150 inches, the primary and secondary claims shall draw equal shares of water per acre.

(3) All water in said creek over 150 inches shall be deemed surplus, and shall be equally divided by the water masters to *all* claims of water included in the several classes of claims as hereinafter set forth, according to the acreage of said claims.

(4) All sales of water rights hereafter shall be made by transfer and record.

This decision was satisfactory to those concerned and has been the basis for all titles since then. During the past few years there has been some disagreement over the title to the water for 18.5 acres at one time owned by the Christy Mining Company, due to a failure to record certain transactions. Although some rights at Harrisburg and Leeds are nominally primary and some secondary, all have been treated alike in distribution for some time, although assessed differently for ditch maintenance.

CLAIMS TO WATER FROM QUAIL CREEK.

A number of claims to the water of Quail Creek and its tributary springs have been filed from time to time with the clerk of Washington County, of which the following is a summary:

May 8, 1890, Thomas P. Gillespie claimed all the water between the head of Leeds Ditch and a point in Quail Creek 4,000 feet in a northwestly direction, for mining and milling.

May 8, 1890, David McMullen and others claimed all the water of Quail Creek not used by Harrisburg and Leeds for irrigation in the Harrisburg Old Field.

January 6, 1891, James N. Louder claimed 200 inches, or all the surplus not diverted by Harrisburg and Leeds Ditch, for mining, milling, and manufacturing at the Bonanza mill site.

January 7, 1891, Thomas Judd claimed all the water of Quail Creek at the head of Leeds Ditch, for operating the Barber Mill.

January 13, 1891, M. E. Paris claimed 200 inches for mining, milling, and manufacturing at the Magdalena mining claim.

January 23, 1891, John S. Ferris claimed all the water at the junction of Cottonwood and Harrisburg creeks, for mining, milling, and manufacturing at the Ferris mill site.

January 25, 1893, August Kuhn claimed all of Grassy Spring in Grapevine Wash, near Leeds, for agriculture. January 16, 1894, the same party filed another notice, claiming the water of Grassy Spring for irrigation.

May 20, 1901, E. C. Olsen claimed all the water in Three Pine Creek, 3 miles northwest from Heath ranch, for irrigation and domestic purposes.

June 4, 1901, W. J. Custer claimed all the water in Three Pine Creek for ranch purposes.

November 25, 1901, Brundage Mining and Reduction Company claimed 500 miner's inches from Quail Creek, for mining, milling, manufacturing, and other purposes above the Leeds Dam. On January 20, 1902, the same company claimed 50 cubic feet per second for mining, milling, and domestic purposes, in the Harrisburg mining district.

AWARDS OF QUAIL CREEK BY COUNTY SELECTMEN.

There have been a number of awards to Quail Creek and tributary springs by the county selectmen sitting as water commissioners, of which the following is a summary:

July 20, 1881, J. H. Leigh was given primary right to Leigh Springs for 24 acres.

July 20, 1881, I. S. McMullin was given primary right to springs one-half mile above McMullins field, near Leeds, for 32 acres.

August 6, 1881, Barber & Walker Silver Mining Company was given primary rights for 12 acres.

August 6, 1881, the Leeds Mining Company received a right for 14.75 acres.

August 8, 1893, W. D. Sullivan received a primary right for 8 acres, and a secondary right for 35 acres from the spring rising in Leeds field.

August 8, 1893, Hiram Leary received a certificate for primary right for 8 acres, and a secondary right for 5 acres from water rising in Leeds field.

ON ASH AND KANARRA CREEKS.

There has been little difficulty over water titles in the settlements on Ash and Kanarra creeks. On Kanarra Creek there has been no question about the ownership of the water until recently, and on Ash Creek, while there have been a few unimportant disagreements, titles are quite well settled, although not established according to law.

KANARRAVILLE.

For over twenty years, according to the old settlers, the water of Kanarra Creek has been used in Kanarraville and fields under an allotment made in 1881, by which the water of the creek was divided into $244\frac{51}{60}$ shares by the selectmen of Kane County. During the intervening time complete harmony has prevailed in the distribution of water. In 1902, to make titles more secure, the Kanarraville Field Reservoir and Irrigation Company was incorporated and all individual rights merged into it. These individual rights were "conveyed and warranted" to the corporation in return for capital stock. No sooner had the organization been accomplished than W. T. Stapley,

one of the individual users at Kanarraville, on May 10, 1902, posted a notice at the post-office in Kanarraville claiming 5 cubic feet per second of the water of the two main springs at the head of Kanarra Creek for domestic purposes and for irrigating 160 acres of land. This notice caused consternation among the water users of Kanarraville. In making the claim it was Stapley's idea to develop the springs and take the benefit of the increased flow. It was clear to the irrigators of Kanarraville that if Stapley succeeded in making good his claim, the main supply of the newly organized company would be taken away, and they were consequently apprehensive of the outcome. Because the springs fluctuate, they believed that they would find it difficult to establish any definite flow for them. The fact of continued use of the water by the Kanarraville people seems so easy of proof that there is little apparent cause for concern. Stapley's action is but an instance of the trouble that can be caused water users if some definite basis of rights is not established and enforced before opportunity is given for complications to arise.

HARMONY, BELLEVUE, AND TOQUERVILLE.

Because the flow of Ash Creek is so limited as to be entirely used, the three settlements on this creek, Harmony, Bellevue, and Toquerville, are independent in the matter of water titles. The springs at the headwaters are used without question by the farmers at Harmony. The basis of title at Harmony is a grant of the springs at the head of Ash Creek and of Kanarra Creek made by the county court to the old settlement on February 23, 1856, and the further award by the selectmen of Kane County of 183 shares and additional independent shares in the Harmony Springs. The settlers of Bellevue have uncontested control of South Ash Creek and of Ash Creek south of the narrows below what is known locally as the Black Ridge. This control is based on an award of water for 100 acres by the selectmen of Kane County.

At Toquerville there have been some misunderstandings over titles, due entirely to a lack of any record. December 26, 1859, it was ordered by the county court of Washington County "that the citizens of Toquerville have power and control of the waters of Ash Creek for farming, irrigation, and machinery purposes." Over twenty years later the selectmen of Kane County awarded the water of Ash Creek and Toquerville Springs to be used for 197 acres on the east side of Ash Creek, and 83.5 acres on the west side of Ash Creek, with secondary rights for 42 acres below Toquerville. These awards and continued use furnish the only basis of title the Toquerville farmers have. During recent years there has been some controversy as to what proportion of the water of the creek and springs the users on the west side of the creek are entitled to. It is claimed by some that at a meeting of the water users it was agreed that the west side should have one-third of the supply and by others that only one-fourth was voted. A lawsuit to settle the difficulty has been threatened a number of times. The only reference to the grant on the records of the Toquerville Irrigation Company is the testimony given at a meeting of all the users on May 4, 1896. At that meeting it was stated by one of the irrigators on the west side that one-third of the supply had been granted his side. The man who had been water master for many years gave equally positive testimony that only one-fourth had been granted. Two others supported the testimony of the

water master by written statements and a third testified that he had been present with the water master and a representative of the west side in 1883 when the division between the two sides was made, and that in that division one-fourth was turned into the west ditch and the remainder into the east ditch. In 1901 a committee was appointed to arbitrate the difficulty. The report of this committee was a compromise and was never agreed to by more than five or six of those interested, so that the matter is still unsettled. There is no record on the books of the Toquerville Irrigation Company of the award made by the selectmen of Kane County, sitting as water commissioners, by which the west side was given water for 83.5 acres and the east side for 197 acres. Although of no legal force, this award states the accepted division at the time it was made, which was before the controversy arose. As this award gave to the west side between the one-third and the one-fourth contended for, it is probable that it would have been accepted as the division that was once agreed to had the existence of the record been known by the parties to the controversy. That the record of the award is on the Kane County books at Kanab, 75 miles away, instead of on the Washington County records, is the probable reason for its never having been found.

CLAIMS TO WATER FROM ASH CREEK.

A number of claims to Ash Creek and tributary springs have been filed with the clerk of Washington County. There is no evidence in the county records of appropriations having been made in accordance with the claims. The following summary gives the principal facts concerning the claims:

July 14, 1896, D. Hammond and J. Duffin claimed all of Sawyer Springs and all of Ash Creek one-half mile northwest from Kelsey's ranch, amounting to 1,500 miner's inches, for domestic and all ordinary uses, including irrigation, manufacturing, mining, and all other useful purposes, for use on lands in Washington County, described in the notice.

May 29, 1897, William H. Ivins claimed all the water in Ash Creek below New Harmony Fields except that used on Kelsey's ranch, for irrigating 160 acres of land.

August 19, 1897, William H. Ivins claimed all of Sawyer Springs for irrigating 160 acres of land.

September 30, 1897, W. A. Brinhurst claimed sufficient water to reclaim 160 acres, which is described in the notice.

AWARDS TO WATER OF ASH AND KANARRA CREEKS BY WASHINGTON COUNTY SELECTMEN.

There were other awards made to Ash and Kanarra creeks by the county selectmen in addition to those already mentioned. A complete summary of all the awards to the creeks and tributaries is as follows:

March 8, 1891, the farmers of Toquerville received a certificate for undivided primary rights for 197 acres on the east side of Ash Creek, and secondary rights for 83.5 acres on the west side of Ash Creek, from Ash Creek and Toquerville Springs, and secondary right for 42 acres from Ash Creek, below Toquerville.

March 8, 1881, the farmers of Harmony were given a certificate of primary right to Harmony Springs for 183 acres, besides additional independent rights.

March 8, 1881, the farmers of Kanarraville were given a certificate of primary rights for 244.85 acres from Kanarra Creek.

March 8, 1881, the farmers of Bellevue were given a certificate of primary rights for 100 acres from South Ash Creek and North Ash Creek, below the narrows of Black Ridge.

August 12, 1892, A. Gregerson was given a certificate of primary right to Peter Leap Creek, flowing into North Ash Creek, 2 miles above Bellevue.

June 4, 1894, J. F. Pace received a certificate of primary rights and surplus waters at the mouth of Harmony Canyon.

ON LA VERKIN CREEK.

The only use of La Verkin Creek is made 1 mile east of Toquerville. The watered area is small and the only difficulties over water rights have been due to enlargements of the watered area since the selectmen of Kane County in early days divided the creek into 30 shares primary right and 20 shares secondary right. One claim to water is on file for this creek, that of H. J. Jackson, filed November 5, 1898, for sufficient of the unappropriated water of the creek to irrigate the SW. ¼ of the SE. ¼ sec. 14, T. 42 S., R. 13 W.

MISCELLANEOUS CLAIMS TO WATER IN THE CENTRAL DIVISION.

Besides the awards and claims to water in the central division of Virgin River Basin already mentioned, a number are on record which should be considered. They are given in the summary following:

October 10, 1890, the city of St. George claimed 125 miner's inches, more or less, of Cottonwood Creek, for manufacturing, irrigation, and domestic purposes.

April 15, 1896, the city of St. George claimed all the water of Cottonwood Creek 2 miles northwest from Prince's farm, amounting to 1,500 miner's inches, for domestic and all ordinary uses, including irrigation, manufacturing, mining, and other useful purposes, on lands which are described in the notice, and "any other place."

November 25, 1892, S. G. Higgins and F. R. Bentley claimed all of Goat Spring, 3 miles west of Blake & Carter's place, for ranching, grazing, and other purposes.

June 3, 1896, Alowise Bauer, jr., claimed all of the water in Cottonwood Spring, on the west side of Cottonwood Bench, amounting to 8 inches, for domestic and all ordinary uses, including irrigation, mining, and other useful purposes, to be used on lands described in the notice, and "any other place."

June 9, 1896, W. and W. B. J. Carter claimed all of Carters Spring, e S a Clara Field, amounting to 4 inches, more or less, to be used for domestic, irrigation, and other purposes, on any land.

August 10, 1896, W. Hamilton claimed all of the North Valley Springs, in Pine Valley Mountains, amounting to 3 miner's inches, for domestic, irrigation, stock, and other purposes.

August 10, 1896, M. E. Paris claimed all of the West Valley Springs, in Pine Valley Mountains, amounting to 4 miner's inches, for domestic, irrigation, stock, and other purposes.

March 27, 1899, James Andrus claimed all of Meeks Springs, for domestic and culinary purposes, at his residence in St. George.

May 10, 1901, J. L. Bunting claimed the seepage water flowing down Maple, Main, Locust, and Washington streets, in St. George, for irrigating 20 acres.

August 24, 1902, I. H. Langston and W. Reusch claimed all of Birch Creek, 3 miles northeast of Springdale, in Zion Canyon, for culinary, irrigation, and other purposes.

THE LOWER DIVISION OF THE BASIN.

From the narrows below St. George to the junction of the Virgin River with the Colorado is the lower agricultural division of the basin. In this division are the settlements of Littlefield, on Virgin River, in Arizona; Mesquite and Bunkerville, on Virgin River, in Nevada; and St. Thomas, Overton, and Logan, on Muddy Creek, in Nevada.

LITTLEFIELD.

Although on the banks of Virgin River, the settlement of Littlefield does not take its water from the river, but from two springs,[a] one-half mile above the settle-

[a] April 23, 1902, the south spring was discharging 3.76 cubic feet per second when the ditch was heavily grown with water grass. On the same day the north spring was discharging 1.30 cubic feet per second.

ment. Two ditches water 105 acres, in holdings averaging 21 acres, which are planted to products used exclusively in local consumption. The irrigation season extends from February 1 to October 15. There is no organization in control of the water.

Above Littlefield, on Beaverdam Creek, a small tributary of Virgin River from the north, 31 acres are farmed in three holdings; and on the river above Beaverdam Creek, 30 additional acres are watered.

MESQUITE.

Mesquite was first settled in 1882, abandoned after two or three years, and again settled in 1894. It is on the right bank of Virgin River, 10 miles below Littlefield. The water is controlled by the Mesquite Irrigation Company, which was organized October 28, 1898, but not incorporated. The officers of the company are a secretary and a water master. The water is not distributed according to any definite plan, because the supply in the river is usually ample. Each acre draws a stream three hours each watering. The Mesquite Ditch, in Arizona, leaves the Virgin River 3½ miles above town, where a brush dam is maintained. The ditch covers 1,100 acres, all of which has been purchased from the State and will eventually be irrigated. By some alteration it can be made to cover 600 acres additional.

Above Mesquite, on Virgin River, three small ditches, aggregating 2½ miles in length, water 225 acres.

BUNKERVILLE.

At Bunkerville, on the left bank of the Virgin River, 5 miles below Mesquite, 587 acres are irrigated in holdings averaging 18 acres. There is but one canal, which heads in the river 3 miles above town. It is 3½ miles long, 6 feet wide, and 3 feet deep. When in average condition, according to a gauging made April 22, 1902, it carries 19.62 cubic feet per second, which, distributed over the 587 acres watered, gives a duty of 1 cubic foot per second to each 30 acres. The dam at the head of the canal was first built in 1878, but has washed out fully twenty times since then, each time incurring a loss of $100 to $200. It diverts the entire river in the dry season, but much of the water seeps back to the river before reaching the Bunkerville fields.

Irrigation at Bunkerville is controlled by the Bunkerville Irrigation Company, which is not incorporated. According to the by-laws the capital stock consists of "$3 per acre," which may be increased in case additional ditches become necessary. The principal officers are a secretary and a water master. In distributing the water carried by the canal it is divided into six streams, and during the dry months of July and August each acre draws one of these streams for three hours each watering. The rest of the year no limit is placed on the amount used. Irrigation is commenced in March and continues until late fall.

Until 1900 Bunkerville was the center of cotton raising on the Virgin River, but owing to the closing of the cotton mill at St. George the growth of this product has been discontinued. The principal producing years were from 1882 to 1884. At that time the cotton goods used in the Virgin River settlements had either to be manufactured in St. George or shipped from Salt Lake City, much of the distance by team. This made the price of cotton goods high, building up the industry on the

Formerly cotton was raised at St. Thomas, 500 pounds of lint to the acre being the average yield for the medium class soil. None has been raised for two years. It is considered a profitable crop at 8 to 10 cents per pound.

Water at St. Thomas is valued at $20 to $25 per acre. Unimproved land under ditch, with a chance to get water, can be purchased for $5 per acre. The cost of ditch maintenance is nominal.

OVERTON.

There are six ditches at Overton, aggregating 11 miles in length, and watering 776.5 acres in holdings of 30 acres. The largest is Overton Ditch, which waters 271.5 acres. This ditch divides one-half mile above Overton into Perkins Ditch and Overton Town Ditch. April 18, 1902, Perkins Ditch, measured 50 feet below the division box, was carrying 4.05 cubic feet per second, and Town Ditch, measured 150 feet below the division box, was carrying 7.79 cubic feet per second, a total of 11.84 cubic feet per second, which, distributed over the 271.5 acres, gave a duty at that season of 1 cubic foot per second to each 23 acres. The next largest ditch is Stringtown Ditch, which waters 138 acres in the settlement of Stringtown, directly across Muddy Creek from Overton.

Although all of the ditches at Overton are subject to the Muddy Valley Irrigation Company, no uniform system of management or distribution is followed. A water master distributes water on a basis of the whole of Town Ditch to each acre under it for one hour each week, and the whole of Perkins Ditch to each acre under it for two hours each week. Regular distribution is followed from April 1 to September 1 only; at other times each user takes what water he desires at times convenient to him.

Land at Overton is valued at $2.50 to $10 per acre, the latter being comparatively choice and having some improvements. Although capitalized at $1 per acre, water usually sells for $10 per acre.

LOGAN.

At Logan, 4 miles above Overton, five ditches, aggregating 5 miles in length, water 421 acres in holdings averaging 35 acres. The largest ditch is the St. Joe Ditch, which waters 217 acres north and east of Logan. When gauged April 17, 1902, 100 feet below the head, it was carrying 6.5 cubic feet per second, giving a duty on the 217 acres watered of 1 cubic foot per second to each 33 acres. The next largest is Logan Ranch Ditch, which waters 80 acres. April 20, when the head gate was badly choked with aquatic growth, the ditch was carrying 2.83 cubic feet per second, or 1 cubic foot per second to each 28 acres.

No regular system of distribution is followed on any of the ditches and there is no local organization in charge.

Above Logan and in the neighborhood of Moapa Indian Reservation 350 acres are watered from a number of small ditches.

RIOVILLE.

At Rioville, where Virgin River joins the Colorado, Daniel Bonelli irrigates 100 acres from Virgin River through a ditch 1¾ miles long, which heads on the right bank of the river. During the summer months, when the flow in the river is very

low, the Bonelli Ditch takes the entire flow of the river. This flow rises a short distance above the head of the ditch.

WATER TITLES IN THE LOWER DIVISION.

The only portion of the lower division of Virgin River Basin in which any attention whatever has been given to water titles is on Muddy Creek. At the three settlements of Littlefield, Mesquite, and Bunkerville the supply of water is considerably in excess of present needs, and water is had for the taking. Only one notice of appropriation from Virgin River in the division has been filed. The filing was made in the office of the clerk of Mohave County, at Kingman, Ariz. The claimants were Brigham Jarvis, W. J. B. Carter, and Arthur F. Miles, and the amount claimed 2,000 "inches" from Virgin River in the narrows above Littlefield "for mining, milling, and other beneficial purposes" on Paymaster mill site. The notice was filed April 5, 1902.

MUDDY CREEK.

When Muddy Valley was first settled by the Mormon missionaries in the sixties no attention was paid to water titles. Some ditches were built in the settlements of St. Thomas, Overton, and St. Joseph, but no shortage of water was felt. With the exodus of the Mormons in 1871 and the resettlement of the valley, the first move to establish water titles was made. This was merely in the form of an official county survey on February 1 and 2, 1872, of a ditch 6 miles long. This survey was made at the instance of Daniel Bonelli, and on February 2, 1872, Bonelli filed with the clerk of Lincoln County, Nev., at Pioche, a claim for "an undivided one-fourth of a certain water ditch and 400 inches of the water running and which may run through said ditch, for agricultural purposes," and also "an undivided one-half of a certain ditch in said Muddy Valley, known as Old Farm Ditch, and one-half of the water running and which may run therein, for agricultural purposes."

This is not only the first but the only record of water rights on Muddy Creek, and the conflicting claims to the water this record refers to have furnished ground for the only contest and litigation over water rights there has been in the valley.

When the ditch referred to in the recorded survey was built, Daniel Bonelli owned a one-fourth interest, as stated in his recorded claim. For several years after the ditch was built Bonelli farmed some of the land under it, but in 1879 he moved away, whereupon his land was worked by tenants. In 1894 the interest of Daniel Bonelli in the ditch and the water it carried was turned over to his son, B. F. Bonelli. During these years the owners and their grantors of the remaining three-fourths interest in the ditch had had a slight misunderstanding with Bonelli, and also with the users of water from Muddy Creek in the upper settlements of Overton and Logan. With a view to clearing away these misunderstandings a union of all irrigation interests in the valley by incorporating the Muddy Valley Irrigation Company was proposed. A few irrigators from the creek, among them Bonelli, refused to join interests in this way, but nevertheless, on August 24, 1895, the company was incorporated. The difficulties with Bonelli were not overcome by the formation of this company, but continued to give trouble and culminated in a suit in which Bonelli was the plaintiff and the other irrigators in the valley were the defendants.

The complaint in the suit, which was entitled B. F. Bonelli *v.* T. J. Jones et al., was filed September 8, 1899, with the clerk of Lincoln County, Nev., at Pioche. Among other things it alleged (1) ownership by the plaintiff since February 12, 1872, of 400 inches, miner's measurement, of the water of Muddy Creek flowing in the St. Thomas ditches, and (2) that during and since 1896 the defendants, without right and notwithstanding the protests of the plaintiff, had diverted said water to the injury of the plaintiff. The complaint prayed for $2,000 damage and an injunction restraining the defendants from diverting the water in question. The answer of the defendants was that the plaintiff had not at any time appropriated or put to beneficial use water in excess of sufficient to irrigate 10 acres. The case went to trial November 8, 1899. Daniel Bonelli testified (1) that from 1872 to and including 1876, 57.5 acres of land had been irrigated and that 2.5 to 3 "inches" of water per acre were required for its proper irrigation; (2) that he rented his land after 1879 and could not tell what quantity of water was used; (3) that he stated to the other users from the ditch that they were using water belonging to him, but that no direct understanding was reached regarding this, and (4) that he had always claimed 400 inches or one-fourth of the ditch. B. F. Bonelli testified (1) that he took charge of the property in question as owner in 1893, and that he received a deed in 1894; (2) that in 1894 and 1896 his tenant irrigated 10 acres of vineyard requiring 25 or 30 inches of water; (3) that in 1897 20 acres were watered; (4) that in 1896 the other irrigators from the ditch objected to his having water for more than 10 acres, claiming that only 10 acres had been irrigated for a number of years, but that in reply he stated that he was entitled to 400 inches of water, and that when the water supply was reduced to 400 inches the others were using his water, and (5) that since 1896 all of the others denied his right to water for more than 10 acres. One of the defendants testified that the ditch was measured when full and in average condition and was carrying 240 miner's inches under a 6-inch pressure, and that for the five or six years last past the ditch had carried not over 75 or 80 inches during July and August.

On November 10, 1899, the court ordered that judgment be entered in favor of the plaintiff for 60 inches of water under a 6-inch pressure, which was one-fourth of the largest amount the evidence showed the ditch to have carried. December 17, 1900, the case went into court for a modification of judgment and the court ordered "that if written consent to a modification of the judgment so far as to limit and restrict the right and use of the plaintiff to 45 square inches of the water running under a 6-inch pressure between noon of the 1st day of July of each year and noon of the 1st day of February of the following year, is filed on behalf of the plaintiff within sixty days, then the motion for a new trial shall be deemed denied but otherwise shall be granted."

February 13, 1901, the written consent provided for was filed for the plaintiff on consideration that no further proceedings should be taken by the defendants. Meantime an appeal was taken to the supreme court of Nevada from the court's decision on the motion for a new trial, and on June 27, 1901, the case was returned to the lower court for retrial. In October, 1902, a new trial had not been held, and there was a probability of the difficulty being settled outside of court.

Summary for Muddy Creek.—The whole cause of the disagreement which culminated in this litigation was a lack of an understanding in the beginning as to the

respective rights of the builders of the original ditch. In making the survey for the ditch the county surveyor estimated that Muddy Creek was carrying 2,000 "inches," and it was on this estimate that Bonelli claimed 400 "inches" as his one-fourth share. Evidently Bonelli filed his claim to 400 "inches" in perfectly good faith with his coowners in the ditch, and in the absence of any conception of what an "inch" of water was, it was natural that he should hold to the original estimate of the county surveyor. The case is simply another instance of the confusion sure to follow leaving the establishment of titles to so valuable a commodity as water to the haphazard methods of individual appropriators having no exact knowledge of measurement and no adequate conception of the value of clear, indisputable title. Had some efficient public supervision of the appropriations from Muddy Creek been exercised when water was first used, the disputed questions would never have appeared in court. The lessons of the case should show the farmers of this division of Virgin River Basin the necessity for putting water titles into shape before there is any occasion for disagreement. The fact that nothing has yet been done toward establishing titles at the settlements of Littlefield, Mesquite, and Bunkerville is sufficient proof that there is still ample opportunity for profiting by the past experiences on the Muddy.

THE UPPER DIVISION OF THE BASIN.

The upper agricultural division of Virgin River is principally Long Valley, on the East Fork. There are in addition several small areas irrigated on the headwaters and upper tributaries of Zion Creek, principally on North Fork. Long Valley is a narrow valley with an elevation of from 4,000 to 5,000 feet, the main section being 7 or 8 miles long. In this section are the three settlements of Mount Carmel, Orderville, and Glendale. At the head of East Fork, 12 miles from the valley proper, is Ranche.

East of Long Valley, but a few miles from the headwaters of Virgin River, flowing to the south and west, and Sevier River, flowing to the north, Kanab Creek rises and takes its way southward into the heart of the Grand Canyon of the Colorado. Since about 1870 the water of this creek has been used in irrigation, and there are to-day three settlements on its banks supported entirely from its waters. Chief of these settlements is Kanab, the county seat of Kane County, Utah, which is 4 miles north of the boundary line between Utah and Arizona. Just below the line, in Arizona, is Fredonia. At the headwaters is Upper Kanab. Although Kanab Creek is no part of the water system of Virgin Basin, it is so closely related geographically and economically to the upper division, that a brief description of irrigation in its basin is included in the discussion of irrigation in that division.

Agricultural conditions are practically the same in Mount Carmel, Orderville, and Glendale. Irrigation begins in March—sometimes as early as February—and continues until the late fall. Frosts occur until the middle of June, and are expected again by September 10. The products grown are alfalfa, wheat, oats, potatoes, and corn, with some hardy fruits and vegetables. Land with water is worth an average of $50 per acre. Water alone is held at an average of $20 per acre. In the valley there are approximately 600 acres of additional irrigable land, all of which is in private ownership. On the bench above there is an additional quarter section.

The water supply in Long Valley is limited, there being, in the opinion of many of the farmers, but about one-half enough to irrigate the land now claiming a water right. July 2, 1902, East Fork, measured 300 yards above Glendale Dam, was carrying but 7.40 cubic feet per second. The total area watered in the three settlements is 1,104 acres, or approximately 150 acres to each cubic foot per second in the stream in the middle of the irrigation season. After May 1 water seldom flows down the stream out of Long Valley to the settlements below.

MOUNT CARMEL.

Mount Carmel is the lowest settlement in the valley. Two main ditches and one smaller one that collects the seepage water from the other two, aggregating 6 miles in length, water 422 acres. Water is distributed two and one-half hours to each acre every fourteen days. The annual assessment for ditch maintenance averages 50 cents per acre for the three ditches. The water at Mount Carmel is controlled by the Mount Carmel Irrigation Company, which was incorporated February 28, 1896, with a capital stock of $4,048.33, divided into 404.83 shares. Each share represents a water right for 1 acre of land.

ORDERVILLE.

At Orderville there is but one ditch, which is 2.5 miles long and waters 265.5 acres. The control of the water is in the Orderville Irrigation Company which was incorporated March 3, 1896, with a capital stock of $2,980, divided into 298 shares. The ditch assessment averages 60 cents per acre per year.

GLENDALE.

There are two ditches at Glendale—the Glendale East Ditch, 4 miles long, and watering 231 acres, and the Glendale West Ditch, 4 miles long, and watering 203 acres. Water is distributed four hours to the acre under the east ditch and three hours to the acre under the west ditch. The water is controlled by the Glendale Irrigation Company, which was incorporated March 2, 1885, with a capital stock of $4,340, divided into 434 shares, each of which represents a right to water for 1 acre. The annual assessment for ditch maintenance averages 55 cents per acre.

RANCHE.

Above Glendale, and extending to Ranche, a series of eight small ditches irrigates 140 acres in holdings averaging 15 acres. The valley of the East Fork is very narrow and the irrigated areas much scattered. Considerable wild hay is grown, and also some alfalfa and small grain. Potatoes and hardy vegetables are the other products.

WATER TITLES IN THE UPPER DIVISION.

Water titles in Long Valley have, after some years of confusion, become quite well settled through a decree of the district court quieting title to the whole of East Fork from Ranche to and including Mount Carmel. This decree was rendered April 18, 1900, by Judge W. M. McCarty, in the case of the Mount Carmel Irrigation Company et al. *v.* L. J. Hopkins et al. Chamberlains Lake and Lydias Fork of East

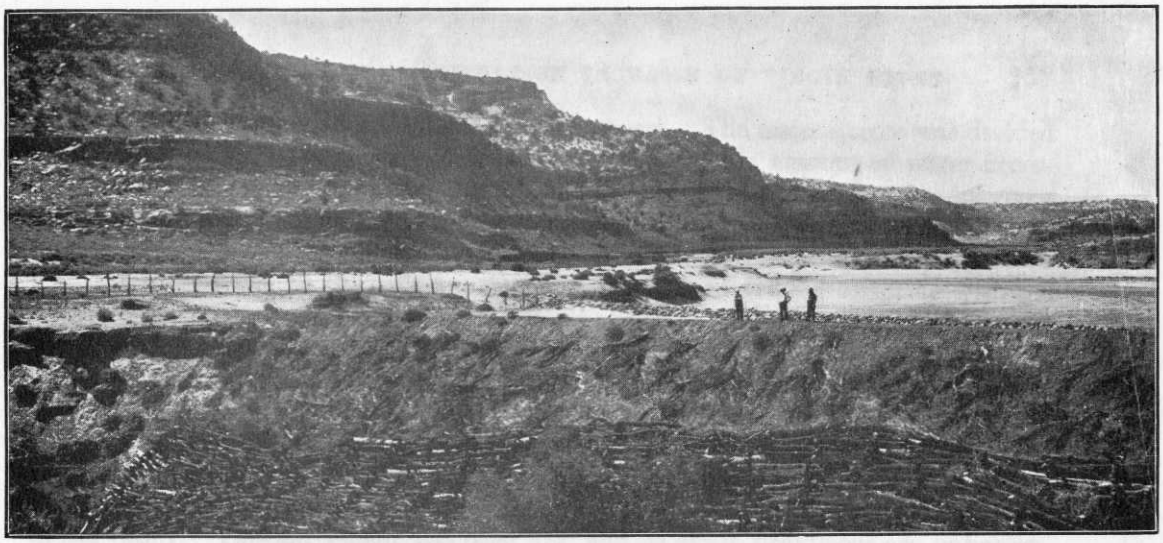

FIG. 1.—DAM IN KANAB CREEK AT HEAD OF KANAB DITCH.

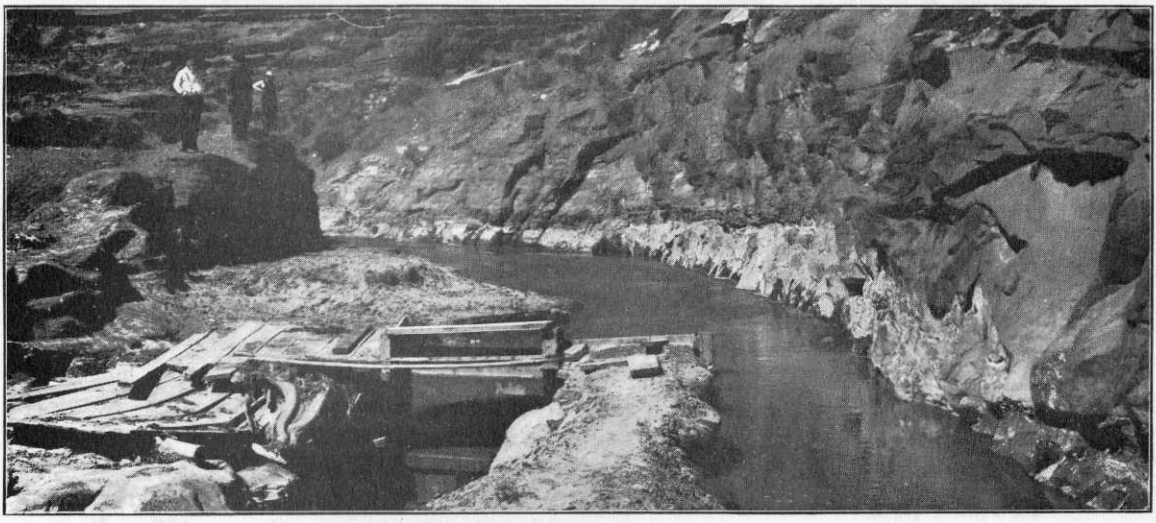

FIG. 2.—ROCK LEDGE AT HEAD OF KANAB DITCH.

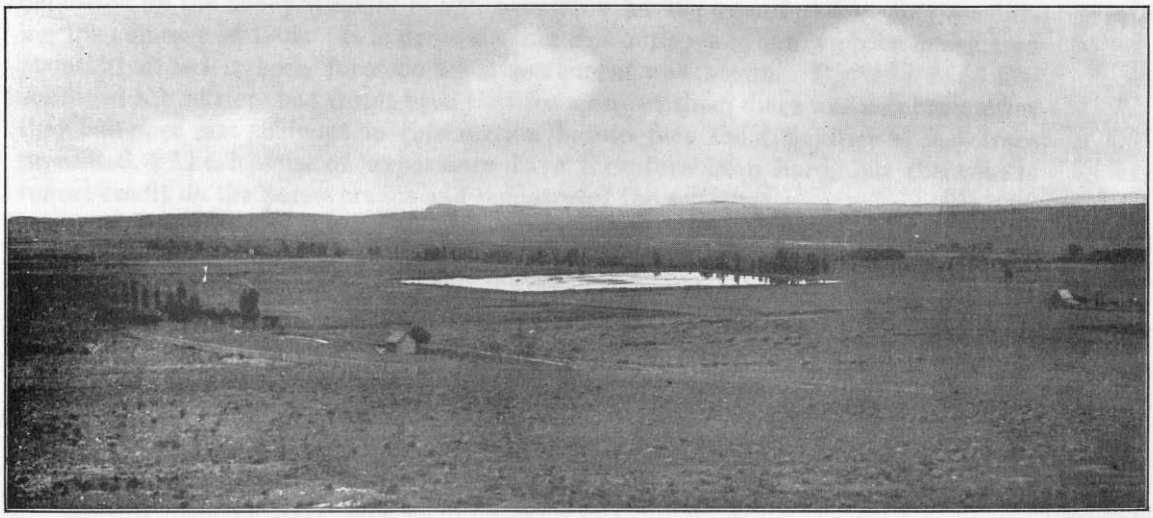

FIG. 3.—DISTRIBUTING RESERVOIR NO. 1, KANAB IRRIGATION COMPANY.

Fork were awarded in addition to the entire stream. The main stream was divided into 1,201⅓ shares, each share supposedly representing the amount of water necessary for the irrigation of 1 acre. The Mount Carmel Irrigation Company was given 404⅔ shares, the Glendale Irrigation Company 434 shares, the Orderville Irrigation Company 265½ shares, and the remainder went to a number of individuals. Each of the parties to the suit was perpetually enjoined from interfering with the rights of the others. A water commissioner was appointed by the court to carry out the provisions of the decree. There has since been appointed a county water commissioner, who exercises general supervision over the distribution of the water in the valley.

Prior to this decree, several attempts had been made to settle water titles in the valley. Conditions had been acute since settlement because of the shortage of water. March 16, 1878, articles of agreement regarding titles were drawn up by the farmers in the valley. This agreement has been lost, and its exact provisions are unknown, but whatever it was, it did not prove satisfactory, and the matter of a settlement was taken up by the Mormon Church authorities at Kanab, by whom a decision apportioning the water in question was rendered April 2, 1879. This decision stated the area entitled to water as 1,162½ acres and apportioned the water ratably over that area. Instructions were given as to the means to be employed in dividing the water. This award did not give satisfaction, and other agreements followed, which were set aside by order of court February 9, 1897, in case of G. D. MacDonald et al. *v.* Jedidiah Adair et al. The setting aside of the agreements by order of the court was the opening wedge for the adjudication of the entire East Fork in the later suit of Mount Carmel Irrigation Company et al. *v.* L. J. Hopkins et al.

KANAB CREEK.

Kanab Creek is a small stream whose flow is comparatively constant, with the exception of summer floods. The irrigable land under it reaches many thousands of acres, and is far beyond the capacity of the creek to irrigate. Not over 1,200 acres are now watered in the three settlements of Kanab, Fredonia, and Upper Kanab, and this area can not be appreciably increased without storage. The burden of building irrigation works on Kanab Creek has been a heavy one. At Kanab alone, where no more than 750 acres is watered, $70,000 has been expended on dams and ditches. Of this amount, a large part has been expended in removing from the ditches the sand deposited by the heavy summer floods, over $700 having gone for that purpose during the summer of 1902. It is probable that this outlay would have been considered prohibitive had it been foreseen when settlement was begun. It would have discouraged the settlers had it not been that for many of them there was no choice after they had once cast their lot in this section but to face the difficulties as they were presented. The lessons of experience have therefore been hard, but the results reflect credit on the perseverance and industry of the settlers.

KANAB.

The only ditch taking water from the creek at Kanab, which is also the principal ditch on the stream, heads 2½ miles above town, at the Kanab Dam (Pl. XVIII, fig. 1), and follows the east bank to and past town to a small reservoir (Pl. XVIII, fig. 2).

From this reservoir two laterals are taken out, one on the west side 3 miles long, leading to the main fields, and the other on the east side one-half mile long. The head of the ditch has been cut through the sandstone banks of the canyon at the east side of the dam (Pl. XVIII, fig. 3). The construction of the dam at the head of the ditch presented difficulties similar to those encountered on Virgin River (see page 214), namely, finding a solid foundation in the sandy bottoms of the stream, and they have been likewise overcome by throwing the channel of the stream over a rock ledge. The present dam at Kanab is also the successor of numerous less substantial ones. It is 300 feet long, 64 feet high, and has a bottom width of 300 feet. The rock spillway at the east end is 20 feet wide and 200 feet long, and has been cut out of the rock bank of the canyon.

When measured on June 30, 1902, 50 feet below the head gate, Kanab Ditch was carrying 4 cubic feet per second. This was the entire flow of the creek, and was said by the owners of the ditch to be the normal flow for most of the irrigating season. This is the amount of water available for irrigating the 750 acres farmed in Kanab settlement, which is but 1 cubic foot per second for each 187.5 acres. It is also the amount of water $70,000 has been spent to control and a dam 300 feet long and 64 feet high built to divert. The right to this water is vested in the Kanab Irrigation Company, which was incorporated December 13, 1881. This company was at an early date awarded the water of Kanab Creek between Upper Kanab and the gap in the canyon below the Kanab fields by the selectmen of Kane County, sitting as water commissioners, and shares of stock in the company in proportion to their respective rights in the water as established by past usage have been issued to the individual stockholders.

Because of its extreme scarcity the water at Kanab is carefully husbanded. To avoid night irrigation two small reservoirs, one of which is shown in Pl. XVIII, fig. 3, are used for storing the night flow of the ditch. The lower reservoir, which has a capacity of approximately 60 acre-feet, is generally filled several times from the higher water in spring. The two laterals leading from the upper reservoir carry approximately 4 cubic feet per second each, that amount being considered an irrigation stream. For each share in the company one of these streams is delivered to the irrigators for four minutes each watering, and from five to seven shares are required to water each acre. Shares sell at from $8 to $9, making the cost of water from $40 to $60 per acre. The principal crop grown is alfalfa. As sufficient for local needs is not raised, the price of this product, as well as of most other products consumed at Kanab, is determined by the cost of hauling the same product from the valley of Sevier River, 100 miles north.

UPPER KANAB AND FREDONIA.

The use of water at Upper Kanab and Fredonia is small. At Upper Kanab 127 acres are watered, the water being divided into 7 parts, 2 of which cover 50 acres, 1 covers 17 acres, 1 covers 20 acres, and 3 cover 40 acres. The title is based on the awards of the county selectmen. At Fredonia 300 acres are watered. The water there is controlled by the Consolidated Irrigation and Manufacturing Company, which was incorporated February 23, 1889, with a capital stock of $1,800, divided into "336 shares of dams, reservoirs, and ditches, together with the water of Kanab Creek" below the Fredonia Field Dam.

WATER TRANSFERS.

With comparatively few exceptions, transfers of water in the basin of Virgin River are not recorded. Often they are accomplished by mere verbal agreements. In the incorporated companies they are entered on the books of the company at the verbal or written request of the grantor. The principal incorporated companies have not issued certificates of stock, and hence the grantee has no other evidence of title than a debit account against him on the books of the secretary for the assessments on the transferred stock. In many instances others than the original entrymen on land and the original appropriators of water are, and have been for twenty years, farming land with deed to neither land nor water; in other instances the only record of transfer is in the time book of the water master. The few exceptions to these conditions refer chiefly to the water of Quail Creek, although there are several recorded transfers to Virgin River water. More regard has been given transfers on Quail Creek because of the use made of its water for mining purposes. The deeds to water are based on the original agreement and arbitration by which the water was divided among the people of Leeds, Harrisburg, and Silver Reef. When incorporated water companies have been formed to control water formerly controlled by individuals, it is the practice for a joint deed to be executed to the company by the individual irrigators. This is not done in every case, and even when such a deed is executed it is not always recorded. These deeds lack definiteness, because in practically no case has the grantor a definite title to convey. A deed to one of the incorporated companies of Long Valley conveys "the right, title, and interest to as many acres of water right in the East Fork of Virgin River as will correspond to the number of shares set opposite" the names of the subscribers to stock in the company, but nowhere in the deed is reference made to the amount of water one acre of water right represents. The articles of agreement of the Orderville Irrigation Company contain no reference to transfers other than the number of shares of water right subscribed by each of the stockholders in the company. The deed conveying individual water rights to the Kanarraville Field Reservoir and Irrigation Company provides that the "owners and possessors of certain water rights in what is known as Kanarra Creek * * * convey and warrant to said company" all their "respective rights to the use of the waters of the said Kanarra Creek, with the number of hours or shares and the value thereof" set opposite the names of the subscribers.

Although not all entered in one book, the water transfers that are recorded in Washington County, Utah, are accessible through an abstract of real-estate transfers, water filings, adjudications of county water commissioners, water transfers, etc. This abstract shows all essential facts of record. The water transfers are segregated by streams or springs and are in chronological order. If a deed conveys both land and water, reference to the water only is made under the stream or spring to which it applies, the reference to the land being entered elsewhere.

The laws of Utah relating to the conveyance of water rights[a] contain the following provision:

A right to the use of water appurtenant to land shall pass to the grantee of such land, and in cases where such right has been exercised in irrigating different parcels of land at different times such right

[a] Revised Statutes of Utah, 1898, par. 1281.

shall pass to the grantee of any parcel of land on which such right was exercised next preceding the time of the execution of any conveyance thereof; subject, however, in all cases, to payment by the grantee of any such conveyance of all amounts unpaid on any assessment then due upon any such right: *Provided*, That any such right to the use of water, or any part thereof, may be reserved by the grantor in any such conveyance, or may be treated as personal property, and separately conveyed.

It is this provision of the law that must, in a measure, be held to account for the incomplete records of water transfers in the basin of Virgin River. So long as water can be transferred apart from land, and the recording of water transfers is not made compulsory, so long will the records of transfer remain uncertain and incomplete. It is, of course, natural that written transfers should not always be made and recorded when the titles are as uncertain as on the Virgin River; but titles will some day be made certain, and when they are, it will be a wise step to provide for a complete and orderly record of transfers.

While it is conceded that irrigation water should, as a general rule, be appurtenant to and inseparable from the land on which it is used, there is a question whether there ought not to be some exceptions to this rule in some of the upper settlements. In Virgin City, Grafton, and Rockville considerable land that was at one time farmed under a water right equal with that of the land now farmed has been washed away by floods, leaving its owners no other alternative than taking up new land. For some of the land that washed away water certificates had been issued by the county selectmen sitting as water commissioners. Although these certificates do not carry title, they are evidence of use at the time they were issued. The question therefore arises, Have the early appropriators whose land has washed away any rights superior to those of later appropriators? This question has been asked by some of the builders of the Hurricane Canal (see page 234), and it has been proposed that the rights acquired for land that has washed away shall be transferred to the land under the new canal. While such action would be a departure from the approved principle of attaching water inseparably to land, it is at least an open question whether under the circumstances, providing no undue injury were worked the other appropriators, it would not be equitable. Reasonable diligence in making the second appropriation would need to be insisted upon if the present State laws of appropriation were enforced, but this would be a question of fact easily determinable. There seems little question that the matter should be considered when water titles are cleared up on Virgin River.

RANGE CONDITIONS.

Of the 6,000 or 7,000 square miles in the basin, the larger portion is a public range, and from the cattle and sheep that graze on this range is derived practically the only cash income of many of the farmers. In few instances are the cattle and sheep owned by others than the irrigators of the many small farms in the basin. In 1900, according to the first annual report of the Utah State board of statistics, there were in Washington County 2,864 head of cattle assessed at $46,274, and 59,544 head of sheep assessed at $148,869; and in Kane County 2,468 head of cattle assessed at $39,595, and 28,825 head of sheep assessed at $72,062. In 1902, according to the county assessors, there were in Washington County approximately 7,000 head of cattle and 15,000 head of sheep, and in Kane County approximately 3,000 head of cattle and 40,000 head of sheep. Although these figures show a light stocking of the

range in proportion to area, the range is maintaining practically its limit because of the recent droughts. The droughts of 1894 and thereabouts were a great blow to the stock interests, many farmers being left by them with only enough stock to start a new herd. Before the drought the range between Virgin River and Kanab and in the neighborhood of Kanab supported 40,000 head of cattle and 150,000 head of sheep, but there are now not more than half that number in the entire basin. It was therefore natural that the stringent range conditions would occasion the usual rivalry between the owners of cattle and the owners of sheep. The resulting contest for control of the ranges has not ended seriously, but this control is now being effected in those localities where the farmers are most dependent upon stock by the owners of cattle purchasing or leasing from the State all of the range lands fronting on streams or containing other supplies of stock water. Much of the range has only low browse for feed, and as on such a range sheep invariably drive out cattle, the owners of cattle have been compelled in self-protection to take the steps they have. Although controlling the water of a range is an effective method of controlling the range, the agricultural interests of the basin would have been better served if the control of the water could have remained with the public, and some plan of controlling the range near the small irrigated farms in the interest of the holders of these farms worked out. Where a range is essential to the success of irrigated agriculture, as it is in some sections of Virgin Basin, there is little justice in allowing transient herds from other localities to consume the local range and curtail, as they do in some of the Virgin River settlements, the only cash income of the irrigators. The owners of both cattle and sheep in Kane County have combined to protect themselves against transient herds by purchasing practically all of the 40-acre tracts containing water in their county. The only way sheep men now have of getting into the county is by reservoiring water on the desert from the summer rains, thus obtaining a supply which will last until the winter snows.

The owners of cattle controlling the range between Kanab and Hurricane Ledge have been compelled to require that each one have in his name sufficient unfenced water to supply his stock, and as the water is greatly limited, many owners of cattle are suffering.

Besides the difficulties attending the use of the range by the cattle and sheep is the presence on the range between Kanab and Hurricane Ledge, and around Kanab, of some 5,000 head of wild horses, which the stockmen claim do more damage to the range than either cattle or sheep. These wild horses are degenerate stock of practically no commercial value, and an effort is now being made to rid the range of the trespassers by annual wild-horse drives.

LAND CONDITIONS.

On the map of Virgin River Basin, given at the beginning of this report (Pl. XIV), are shown in different colors the areas of irrigated land and the approved individual entries and State selections. The remainder of the basin, excepting a few small areas in the mountains too small to be shown, is in State selections not yet approved, or is unentered public land. The total irrigated area in the basin is approximately 13,700 acres, the total of approved individual entries and State selections 76,000 acres, and the

total of State selections not yet approved, 14,000 acres. Outside of the barren lands and lands adapted only to grazing are large areas of fertile irrigable land. Although this land is not classified in detail by either the State or National Governments, an endeavor was made through personal examination and the assistance of Mr. Isaac C. Macfarlane, county surveyor of Washington County, Utah, who is familiar with conditions in practically the entire basin, to determine its approximate area and location. Only that land was classed as irrigable that could by any reasonable means be watered from the streams of the basin were their flow increased. Beginning with the head of Virgin River in Long Valley, and including all tributaries to the mouth of the river, these lands are classified by location and area in the following summary:

Nonwatered irrigable lands in basin of Virgin River.

	Acres.
East Fork of Virgin River, in Long Valley	800
Northwest of Virgin City	200
Hurricane Bench, in addition to 2,000 acres under Hurricane Canal	2,000
Below Bench Lake on Hurricane Bench	2,500
Kanarra Creek	4,000
Ash Creek, at Harmony	4,000
Ash Creek, above Kelseys	320
Ash Creek, above Bellevue	320
Ash Creek, at Bellevue	640
Ash Creek, at Toquerville	250
La Verkin Creek	50
Quail Creek, east of Leeds and Silver Reef	640
Quail Creek, between Harrisburg and Silver Reef	500
Cottonwood Creek, near Harrisburg	1,600
Washington and Middleton	3,500
In wash below St. George and Washington Field	1,000
South and west of St. George	1,440
Santa Clara Creek, in Grass Valley	1,000
Santa Clara Creek, in Pine Valley	100
Santa Clara Creek, above Diamond Valley	2,500
Santa Clara Creek, below Gunlock	200
Santa Clara Creek, above Santa Clara	2,500
Between Bloomington and Santa Clara Creek	200
Bloomington and Price benches	800
Between lower narrows on Virgin River and Beaverdam	2,100
Mesquite	1,500
Bunkerville	400
Virgin River, between Bunkerville and Muddy Creek	7,000
Muddy Creek	13,000
Virgin River, below Muddy Creek	7,300
Total	61,760

From the above summary and the figures given to show the extent to which the public lands of the basin have been entered or selected, the following generalizations are apparent: That of the 4,500,000 acres in Virgin Basin, only 1.7 per cent are in State or private ownership, only 1.7 per cent are irrigable, and only three-tenths of 1 per cent are irrigated. The question then presents itself, Is there any way for the irrigated area to be increased?

STORAGE POSSIBILITIES.

It was not the province of this investigation to consider in detail either the storage possibilities on Virgin River or the possibilities of reclaiming an additional area of public land. Nevertheless, an endeavor was made to learn in general something of both problems, by determining the opportunities for storage that are offered in the basin.

Except at the headwaters it will probably never be practicable to store any considerable volume of water in the channel of Virgin River. This is because of the very large percentage of sediment carried in suspension by that stream. While no sediment determinations were made on the river it is probable that the percentage carried nearly equals that of some of the streams of Texas and New Mexico, and that consequently but few years would pass after the construction of a reservoir in the river channel before it would be filled by the deposited silt[a] and its usefulness ended. The formation of the watershed of the river is largely shale and sandstone, and consequently the erosion in flood times is heavy. The action of the sediment carried into the river in filling canals has already been discussed (see page 216), and it is sufficient to say here that before any reservoirs are built in the channel of the river some definite method of disposing of the deposited sediment, by sluicing or settling basins or some other means, should be worked out. At the headwaters of the river, on Big Creek, is a site for a reservoir which, if properly utilized, could be made to store a considerable quantity of water. The construction of such a reservoir has been considered as a way to insure an ample water supply under the new Hurricane Canal. In Zion Canyon, below the narrows, excellent opportunities for constructing dams are presented, but the problem of sediment would be serious there also, although probably not so serious as lower on the river.

On three of the tributaries of Virgin River reservoirs might be built that would aid greatly in obtaining a stable water supply. These tributaries are Ash Creek, Santa Clara Creek, and Muddy Creek. The possible site on Ash Creek is near Kelseys, and the water that could be stored at a reasonable expense would be of much value to the farmers of Bellevue and Toquerville. The site on Santa Clara Creek is in Pine Valley. A dam in the narrows immediately below Pine Valley settlement would spread water over a surface of 200 to 300 acres, and would impound water sufficient both to relieve the farmers already suffering for water in the lower valley of the creek and to reclaim some of the remaining irrigable land along the stream. To this site there are two main objections. One is that some of the land that would be submerged is occupied by the town of Pine Valley; the other is that the run-off from the Pine Valley Mountains above the dam would not always be sufficient to fill the reservoir when once built. During the past year practically all of the water of Santa Clara Creek has been utilized in irrigation, but still the farms have greatly suffered. Even if the lands that would be submerged in Pine Valley could be purchased, the reservoir would still have to be planned to hold sufficient water to supplement the present flow for at least two seasons. If this were not done,

[a] For a discussion of the silt problem in connection with reservoirs, see Progress Reports on Silt Determinations, by J. C. Nagle, in U. S. Dept. Agr., Office of Experiment Stations Buls. 104 and 119.

an increase in the watered area would not be justified because of the likelihood of a repetition of such dry seasons as the two past years have brought. There are two possible sites on Muddy Creek in the narrows above Logan. A dam 500 feet long and 40 feet high, 5 miles above Logan, would back the water 3 miles up the channel of the creek, and the water surface thus formed would be 80 rods wide in places. Three miles above this site is a site for a second reservoir of equal, if not greater, capacity. A reservoir on the upper site would cover several small holdings of private land, which could undoubtedly be purchased by the builders of the reservoir.

It would be of advantage to property interests and a great aid to agriculture in the basin of Virgin River if careful and detailed examination could be made of the reservoiring possibilities of the basin and some move made to build reservoirs wherever practicable. The value of small reservoirs as an insurance against drought has been clearly demonstrated elsewhere in Utah and in Colorado.[7] Before any reservoirs are built the relation of the rights to the water already used and to that to be stored should be clearly defined in order to avoid the uncertainty and confusion sure to result if this is not done.

FINAL SUMMARY.

Because each subject dealt with in this report has been summarized as presented, a detailed and comprehensive final summary is not necessary. It is sufficient to state, in conclusion, a few general facts disclosed by the investigation.

The basin of Virgin River covers a rough area of between 6,000 and 7,000 square miles, extending over portions of Utah, Arizona, and Nevada, on which the annual rainfall is generally under 10 inches. It is watered by Virgin River and tributaries, of which Santa Clara and Muddy creeks are agriculturally the most important. With this water supply but 13,700 acres, or three-tenths of 1 per cent of the total area in the basin, is irrigated. In addition to this irrigated area, but 61,700 acres, or 1.4 per cent of the total area in the basin, could be irrigated if by some means the water sources of the basin could be increased. The possibilities for increasing the irrigated area by more careful use of water are considerable throughout almost the entire basin, but more particularly in the central division of the basin, of which St. George is the center. The possibilities for increasing the area through storage in a large way are not great, because of the heavy percentage of silt carried in Virgin River, yet the present available supply of water can be valuably increased by small supplemental reservoirs, particularly on the headwaters of the river and on Santa Clara and Muddy creeks. Nowhere in the basin are water-title conditions acute; their determination and final settlement, excepting in Long Valley, at the headwaters of East Fork, and on Santa Clara and Muddy creeks, has received no serious consideration whatever. That conditions are not acute does not mean that they are satisfactory. On the contrary, there is need for their settlement if development is to be either satisfactorily maintained or extended. The accomplishment of such a settlement presents no serious difficulties, but would readily follow a larger knowledge of the flow of the streams of the basin and an accurate knowledge

[7] See article on "Some typical reservoirs in the Rocky Mountain States," by Elwood Mead, in Yearbook of the Department of Agriculture, 1901, p. 415.