MONTANA.

Total population (average per square mile 0.91)		132,159
Number of owners of farms (4.24 per cent of population)		5,603
Number of irrigators (66.14 per cent of farm owners, 2.80 per cent of population)		3,706
Area of state, land surface (145,310 square miles)	acres	92,998,400
Area irrigated in census year	do	350,582
Area of all farms, 46.61 per cent improved	do	1,964,197
Cereals raised in census year, including 13 acres in buckwheat and 14 acres in rye	do	77,162
Barley, average production, 34.50 bushels per acre	do	4,652
Corn, average production, 13.96 bushels per acre	do	1,019
Oats, average production, 29.10 bushels per acre	do	52,768
Wheat, average production, 24.48 bushels per acre	do	18,696
Alfalfa	do	2,522
Total value of all farms, including land, fences, and buildings		$25,512,340
Estimated total value of the farms irrigated in whole or in part		$17,354,000
Estimated value of all farm productions (sold, consumed, or on hand) for 1889		$6,273,415
Estimated value of productions, as above, from farms irrigated in whole or in part		$4,544,000
Average size of irrigated farms	acres	95
Average size of irrigated farms of 160 acres and upward	do	307
Per cent of acreage of irrigated farms of 160 acres and upward to total acreage irrigated		50.37
Average size of irrigated farms under 160 acres	acres	56
Average first cost of water right per acre		$4.63
Average annual cost of water per acre		$0.95
Average first cost per acre of preparation for cultivation		$8.29
Average value of irrigated land, including buildings, etc., in June, 1890, per acre		$49.50
Average annual value of products per acre in 1889		$12.96

GENERAL DESCRIPTION.

In area of land irrigated in 1889, Montana was third, coming after California and Colorado. This was due primarily to the large average size of irrigated farms, 95 acres, for as regards number of irrigators the state is fifth, Utah and Idaho, as well as the states named, having a greater number. As a result of the large average size the value of lands and of products was considerably below the average for the whole western United States, by far the greater part of the crop raised consisting of forage plants. Over one-half of the area of the irrigated lands of the state was in individual holdings of 160 acres or over in size, while the remaining holdings, what may be known as small farms, averaged 56 acres each, in this respect standing next to Nevada, where the irrigated areas were largest. The first cost and value of water rights were relatively low, and also the average first cost of cultivation per acre.

The agricultural development of the state, owing to its arid climate, has been governed directly by the relative position and altitude of the mountain masses and the resulting water supply. By the position of the main ranges, trending in a general northerly and southerly direction, long valleys have been formed following the same general course, as, for example, those of the Missouri below the Three Forks and of Smith river on the east of the Belt range, while other ranges projecting out toward the prairies partially encircle great basin like valleys. The altitude of the mountains determines to a large extent the water supply of the lands at their bases, the effect of altitude being modified, however, by the direction of the prevailing winds. Most of the tilled land, as well as the majority of the population and the bulk of various industries, is found among the mountains in the western half of the state. The broad valleys in which agriculture is practiced are in few cases less than 4,000 feet in altitude, the greater part of the land now under cultivation being at an elevation of from 4,000 to 5,000 feet.

Taking the area of the state as a whole, it has been ascertained that 49 per cent is under 5,000 feet above sea level, 21 per cent from 5,000 to 6,000 feet, 14 per cent from 6,000 to 7,000 feet, 9 per cent from 7,000 to 8,000 feet, and 7 per cent over 8,000. This distribution of altitude must be taken into consideration when discussing the agricultural possibilities of the state, for high mountain masses furnishing perennial streams are as important to future development as low lying valleys with a fertile soil and a genial climate. The great problems to be solved and the doubts as to agricultural possibilities relate mainly to the vast low lying areas not broken by lofty mountains.

Montana is the most northerly state wholly within the arid region, and thus probably, taking all things into consideration, the agricultural land requires as a whole less water than that of any other state, although it may actually receive as much or more. In fact, in the northwestern part of the state crops are often raised without irrigation, the rainfall in ordinary seasons being sufficient for all needs. This extreme corner may be said to lie in the subhumid region. Even here, however, there are years of drought, as 1889 and 1890, when crops were almost a complete failure, and the necessity of irrigation as a means of insurance against loss is apparent. Many of the bottom areas, and even of the benches, when not irrigated yield in favorable years from one-half ton to 1 ton of hay per acre, this quantity, however, being increased several fold where irrigation is practiced. Some of the stock raisers state that hay raised without the artificial application of water, though less in quantity, is much better in quality, as irrigation destroys certain of the valuable native grasses.

In many parts of the state the rainfall is usually sufficient to bring the crops almost to maturity, and often only one watering is required. The grain may be nearly ripe when the dry, hot winds sweep down upon it, parching the vegetation and the soil. If water is not then at hand in abundance all of the past labor will be a complete failure, but with the application of water at this critical period the grain will fill to an abundant harvest. This one watering then is as essential to the success of the crops as are the three or four waterings of the more arid sections, for without it the crops are ruined. Thus, the necessity of irrigation is as great as in states farther to the south, although the quantity of water and the time required in applying it may be less.

FLUCTUATIONS OF WATER SUPPLY.

The quantity of water flowing in some of the larger streams of the state has been measured and computations have been made of the daily fluctuations, the results being given in the descriptions of the counties where the gaugings were made. From these figures the average monthly fluctuations have been computed, showing the changes which take place from month to month. Without water storage or regulation of the annual discharge the value of the river is governed largely by the amount of water which flows during the latter part of the crop season, that is to say, the acreage is limited to a certain extent by the quantity of water available in July and August rather than by the average amount discharged. The percentage of flow for each month is therefore given in the table below in connection with the monthly distribution of rain. Comparison should be made with similar results obtained for rivers in Idaho.

Reducing this matter to the simplest statement, it is seen that in May and June 44.4 per cent of the water was discharged, or nearly one-half the total quantity for the whole year, while in July and August only 13 per cent and 7 per cent, respectively, flowed in the streams. Most of this flood water of May and June comes from melting snow, the spring rises being due rather to increase of temperature than to direct precipitation. The mean annual rainfall for the entire state is about 15 inches, varying greatly, however, with the altitude of the locality, the high summits probably receiving upward of 30 inches of water, mainly in the form of snow, while the lower plains may receive 10 inches a year or even less. This amount of rain, if it were precipitated mainly during the winter or distributed evenly throughout the year, would be of less value than at present for agricultural purposes, but fortunately the greater part falls during the crop season, as shown by the following table, made by the compilation of records from the stations of the signal service located in different parts of the state, most of these being, however, in the valleys. This table gives the average rainfall for all years and stations, the results being shown in inches and in percentages of the whole.

AVERAGE MONTHLY RAINFALL AND RIVER FLOW IN MONTANA.

MONTHS.	RAINFALL.		River flow. (Per cent.)
	Inches.	Per cent.	
The year	14.7	100	100.0
January	1.0	7	3.6
February	0.6	4	3.7
March	0.9	6	3.8
April	1.0	7	6.4
May	2.5	17	21.2
June	2.4	16	23.2
July	1.3	9	13.0
August	1.4	9	7.0
September	1.0	7	4.7
October	1.0	7	5.0
November	0.7	5	4.4
December	0.9	6	4.0

From the preceding table it is seen that the rainfall during May and June was on an average one-third that of the entire year, while that of July and August was a little over one-half that of the previous 2 months, but greater than during any other season of the year, the distribution of the rainfall by months being on the whole favorable for agriculture. The annual distribution of the rain is of more than usual interest in connection with the crops of the census year, for 1889 and 1890 were known as years of drought. Comparing the rainfall as measured for the last decade at several stations in Montana, it is found that for these localities the average is as follows: in 1880 the total depth of rain was 14.5 inches; in 1881, 13.8 inches; 1882, 12.6; 1883, 12.6; 1884, 17.2; 1885, 11.7; 1886, 12.1; 1887, 16.4; 1888, 13.5, and in 1889, 9.5 inches. The most prominent feature about this record is the great rainfall of 1884, a year when there was an unusual abundance of water throughout the west and the rivers were extraordinarily high. On the other hand, is to be seen the deficient rainfall of 1889, when the rivers shrank in many instances far below the level of previous years. These fluctuations in the amount of rainfall year by year are to be found not only in the arid region but throughout the world, but in dry countries they are more noticeable from the fact that all occupations and land values are intimately connected with the supply of water.

DEVELOPMENT OF IRRIGATION.

Montana includes on the east a portion of the Great Plains region and on the west a part of the continental divide, the state extending beyond the main range of the Rockies to the Bitterroot mountains, on the western border. There is thus a wide difference in topography from the serrated peaks and narrow valleys, watered by perennial streams, to the broad expanse of the prairie, whose soil and vegetation are dry and parched during a great part of the year. The progress of settlement has been governed by these topographic features. Following on the hunters and trappers who first explored these regions came the wandering stock men, who settled on the bottom lands in the valleys of the western part of the state. The slow natural transition from pastoral industries to the tilling of the soil was soon broken by discoveries of precious metals among the mountains, and in the rush to the mines agriculture and stock raising became of little relative importance. The necessity, however, of supplies for the mining camps soon encouraged the growth of agriculture and stimulated it to a development far in excess of that which would have taken place in the ordinarily slow growth of a farming community.

The ease with which water could be brought upon the land and the favorable location of mines, furnishing a market for the sale of produce, have caused western Montana, indirectly because of its mountains, to be the most thickly settled and well cultivated part of the state, while the eastern plain or prairie region, with its almost boundless extent of fertile soil and its great rivers, the Missouri and Yellowstone, is still thinly settled. The area irrigated by large canals is comparatively small, and by far the greater part of the irrigation of the state is done by means of small ditches taken from the rivers each to cover one or two ranches. Deducting the acreage covered by the few great canal systems of the state, it has been found that on an average there is an independent ditch for every 225 acres of crops. This figure gives some conception of the difficulties to be encountered in attempting any systematic division of the waters, for in cases of controversy the exact status of each of these little ditches must be ascertained in its relation to the whole water supply and to the claims of all other ditches taking water from the same source.

Throughout Montana, as a rule, the construction of the ditches and irrigating works has been of the most temporary character, although there are a few notable canals well planned and built at great expense. Most of the irrigated area, however, is covered by ditches dug by the farmers without preliminary survey. Many even have been merely plowed out, the water then washing its own channel. The streams are diverted into the head of the ditches usually by temporary obstructions of brush, logs, rocks, and earth, replaced after each freshet. In other cases the bed of the canal is made so low that the water will flow in without diverting dams. In some cases, where the fall of the ground is not sufficiently great to allow of bringing the water out of the river at all times, the so-called high water ditches have been built, receiving water only in times of flood, the bottom of the ditch being above the low water level of the river. In this way a large quantity of water is taken during the spring, and the ground is thoroughly saturated, so that one crop of forage is assured. This irrigation is of the most crude character, but the resources of the irrigators have not been such that they can improve upon it.

METHODS OF IRRIGATING.

The various forage crops are usually flooded; the small grains are irrigated by systems of little furrows, while corn, potatoes, and other vegetables are wet by allowing the water to flow between the hills or beds. In applying the water to the soil it is generally the custom to use a stream flowing at the rate of about 80 to 100 miner's inches, or approximately 2 second-feet. With a less quantity of water a greater time is required in watering the crop, and the stream travels so slowly from point to point that a large part is lost on the way. On the other hand, by attempting to use a much greater amount, the land is badly washed in places or an excess of water is applied. Hay and meadow lands are irrigated from early spring until late in the fall. Wheat, rye, and barley are generally irrigated but once during the season, unless it is unusually dry. Potatoes are irrigated once or twice, and other vegetables may be watered every 10 days or 2 weeks. Oats generally receive two irrigations.

The time required for the irrigation of a field varies with all these details, and perhaps in no one item does individual peculiarity stand out more prominently. One man turns out upon his ground as much water as he can procure and leaves it even for a day or more at a time, while another whose experience has perhaps been different, or whose soil requires special treatment, carefully conducts the water from point to point, and continually opens or closes his small earth dams.

The time of the year during which irrigation is practiced is also accountable for some diversity of method. In general the water is used from the time the rivers begin to rise to the freezing of the water in the fall. In time of flood, however, some of the irrigators turn all the water possible upon the higher lands in order to saturate them and produce an early crop of alfalfa. This is especially the case with those irrigators who have only the right to an excess of water, for it is essential to employ it at the time it is available, and they hope by the aid of fortunate rains to produce an early crop. Many of the older farmers who feel secure in their water rights do not employ irrigation until the appearance of the crop shows it to be absolutely necessary. Others use water throughout the year, flooding meadow lands, and employing it at various times on the different crops. Thus the number of waterings can not be reduced to any definite statement.

Owing to the scarcity of water it is customary in many localities to irrigate only a portion of a farm during any one year. For example, a farmer having 100 acres may use the water only on 50 acres and let the remainder lie fallow, and the next year use the water on the fallow land of the year before. A greater yield per acre is claimed as the result of this alternation. This method introduces some confusion in any statistical investigation, for, on the one hand, the farmer has 100 acres under irrigation, and yet, owing to the scarcity of water, he is not able to irrigate more than half of it in any one year, and perhaps in years of drought, as in 1889, can not produce a crop on more than one-third or one-fourth of the total.

WATER CONTROL.

Up to the present time the control of the water for the greater part of the irrigated area has been in the hands of the irrigators themselves. They have built and now own and manage the means of distributing the water, but there now remain few opportunities for the construction of small ditches. More difficult engineering feats must be attempted, requiring larger capital, and canals must be built by outside aid. The ditches built by corporations are as a rule more expensive than those dug by the farmers, since they usually cover areas more difficult of access. The first cost of water is thus greater, and the annual charge for bringing water to the land must necessarily be larger than that estimated as the present average cost. The charges of water companies range from $1 to $2.50 per year per acre, while the farmers estimate that on an average the annual cost to them is only 95 cents per acre. This charge of the water company is usually a burden to the irrigator, and he is inclined to look upon canal companies in general as extortioners and the rates asked as exorbitant, although as a matter of fact these may not yield a fair interest on the investment.

Some of the larger irrigation schemes have been of a decidedly speculative character, being stocked for a large sum with only a small amount actually paid in or expended on work. A claim is usually filed for all the water in the river, the amount being often in excess of the total discharge of the stream, the object apparently being to sell the franchises of the company at an early stage to other parties or to dispose of the stock. The present condition of irrigation development and of the control of the waters of the state is by no means satisfactory to the farmers, and most of them look forward to improvements in methods of irrigation and in legislation. As the matter now stands, the additional area annually brought under irrigation is rapidly increasing, in spite of the fact that along nearly all the smaller streams the present area under ditch is in excess of the amount that can be successfully watered in such years as 1889 and 1890. On the one hand the older settlers, those who legally should have prior right to the water to the extent of their original appropriation, complain that in spite of their legal rights the later comers are taking water at points farther up the stream, where it can be diverted more easily, and that by this rapid encroachment they themselves are being brought almost to the verge of famine. They can no longer obtain water in times of scarcity, and consequently their lands have little value, and for every new ranch higher up the stream one or more old ranches must suffer.

On the other hand, those who have come into the country at a later date and who have pushed farther up the rivers, who have made for themselves homes and have invested all their capital and labor in irrigating their lands, assert that the owners of prior rights have no consideration for others; that these old settlers will, if they can, take all the water in the stream regardless of others, and often use it carelessly or even waste it, while others are in want; or that during the drought of summer it is useless to let the water run in the bed of the stream beyond their own ditches, as before the slender stream can reach the heads of the ditches farther down the valley the entire amount either sinks or is evaporated, and therefore, since the owners of prior rights can not be benefited, those who can use the water should be allowed to do so.

These complaints form the two extremes, and between them are innumerable cases with every shade of right and wrong involved. The consequence is that during every period of drought there are conflicts arising over the proper distribution of the water. Resort to the ordinary courts of law often yields but little satisfaction, for the

delays appear interminable, and even when a decision is reached, yet not being based upon actual and continuous measurements of the water available and on other engineering details, it is often of little practical value, from the fact than in many instances more water is awarded than actually exists, or new circumstances may have arisen entirely obviating the points passed upon. The great necessity is felt for immediate definite judgments based upon an accurate knowledge of the amount of water available and the demands upon it. Great interest is felt in the practical operations of the Wyoming laws in this matter.

ARTESIAN WELLS.

The principal group of flowing wells in the state are those in the vicinity of Miles city, Custer county. These are from 180 to 600 feet in depth, the largest amount of water being obtained, it is stated, about 170 feet below the surface. Several of the deep wells in this vicinity do not flow, but water is raised to the surface by means of windmills. Flowing wells are also found not far from Albright, 35 miles west of Miles city. The wells discharge from 5 to 200 gallons a minute of water suitable for household purposes and for cattle. Little if any is used for irrigation, as the quantity from most of the wells is very small. In one or two instances it is reported that the flow has diminished since the well was completed. At Billings, in Yellowstone county, a well about 1,000 feet deep has been drilled, but flowing water was not obtained.

At Dillon, in Beaverhead county, a well has been drilled to the depth of 470 feet, penetrating gravel of a thickness of 250 feet, and below this alternations of clay, sand, and gravel. Several of these latter layers were charged with water, and when drilling ceased the water had risen to within 15 feet of the surface of the ground. This well was made in 1886, at a cost of $4,750.

North of Helena, in Lewis and Clarke county, a well was drilled to the depth of 521 feet, at a cost of $3,130, but without success so far as flowing water was concerned. Water is now pumped by means of a windmill, which, it is estimated, will irrigate an acre of ground. Another well, in Helena, was drilled to the depth of 1,000 feet. This well also does not flow, but water was found at 160 feet from the surface. In Cascade county, near Great Falls, are several deep wells. One of these, at a depth of 160 feet, is reported to discharge at the rate of 6 gallons per minute.

CONDITION OF IRRIGATION IN EACH COUNTY.

NUMBER OF IRRIGATORS, AREA IRRIGATED, FARMS, AND CROPS IN EACH COUNTY IN MONTANA IN 1889.

COUNTIES.	Number of irrigators.	Area irrigated in acres.	Average size of irrigated farms in acres.	OWNERS OF FARMS. (a)		IRRIGATORS.		Area of counties in acres.	FARM AREA.		Cereals. (Acres.)	Alfalfa. (Acres.)	AREA IRRIGATED.		
				Total number.	Per cent of population.	Per cent of farm owners.	Per cent of population.		Acres.	Per cent improved.			Per cent of area of county.	Per cent of total farm area.	Per cent of land owned by irrigators.
Total	3,706	350,582	95	5,603	4.24	66.14	2.80	92,998,403	1,964,197	46.61	77,162	2,522	0.38	17.85	23.65
Beaverhead	294	42,606	145	385	8.27	76.36	6.32	2,688,000	181,371	53.45	4,745	557	1.59	23.49	25.59
Cascade	73	4,411	60	211	2.41	34.60	0.83	1,664,000	120,988	21.17	1,709	16	0.27	3.65	15.22
Choteau	39	2,834	73	260	5.48	15.00	0.82	17,459,200	65,060	16.57	616	30	0.02	4.36	11.76
Custer	60	4,302	72	393	7.40	15.27	1.13	17,011,200	78,421	25.70	1,124	134	0.03	5.49	30.25
Dawson	12	194	16	68	3.31	17.65	0.58	17,075,200	10,706	25.70	254	.....	0.00	1.81	12.58
Deerlodge	470	50,948	108	518	3.42	90.73	3.10	3,254,400	195,002	63.78	11,557	88	1.57	26.13	27.32
Fergus	251	30,401	121	443	12.61	56.66	7.14	4,327,680	166,944	42.25	4,659	30	0.70	18.21	24.76
Gallatin	434	46,901	108	587	9.40	73.94	6.95	1,468,800	200,367	63.52	21,171	233	3.19	23.41	27.72
Jefferson	184	15,105	82	203	3.37	90.64	3.05	1,184,000	69,018	55.24	1,051	14	1.28	21.89	21.13
Lewis and Clarke	231	15,441	67	322	1.68	71.74	1.21	1,664,000	101,321	47.07	2,342	98	0.93	15.24	19.05
Madison	345	36,819	107	387	8.25	89.15	7.35	2,720,000	152,430	58.91	8,074	785	1.35	24.15	27.06
Meagher	200	39,324	151	318	6.70	81.76	5.47	4,480,000	225,980	35.20	7,384	26	0.88	17.40	18.26
Missoula	504	22,404	44	757	5.25	66.58	3.49	11,872,000	155,823	54.87	8,029	115	0.19	14.38	29.03
Park	330	19,735	60	453	6.58	72.85	4.80	3,557,120	107,917	31.22	2,229	156	0.55	11.75	14.77
Silverbow	75	5,968	80	83	0.35	90.36	0.32	585,600	21,626	38.58	397	13	1.02	27.60	29.59
Yellowstone	144	13,189	92	215	10.41	66.98	6.97	1,987,200	51,223	69.66	1,751	227	0.66	25.75	34.86

a Includes owned and hired farms, assuming one farmer to each.

BEAVERHEAD COUNTY is in southwestern Montana, partially inclosed by a loop in the continental divide which bounds the county on the north, west, and south. The altitude is great, the lowest part of the county being nearly 5,000 feet above sea level, while the mountain summits rise to heights of from 10,000 to 11,000 feet. The principal crop, indeed the only important one, is hay, which is grown along the streams wherever water can be brought out upon the land. Irrigation is essential, except in the case of a few small areas wet by the annual overflow of the rivers. The early settlers on entering the valleys of this county found good hay produced in abundance by this natural irrigation along the Beaverhead river and tributary streams. Annually, until 1889, this crop has been good, but in that year of unusual drought the natural hay was almost an entire failure.

The Bighole river rises in the western part of the county and flows northerly, then turns to the east and south, forming in the lower part of its course the northeastern boundary of the county. The discharge of the

Bighole on September 8, 1889, at Melrose, was only 60 second-feet. Along this river and its various tributaries are many stock ranches where hay is raised, but in general the altitude is too great for other crops. In irrigating the hay great quantities of water are used. On many ranches it is customary to turn the water on the fields and let it run for two days or more at one place, and then change to another part of the land, the water finding its way to various portions of the field according to the slope of the ground. By watering the bench land at frequent intervals for a period of about three years, good hay land is made without seeding or plowing. Along the Beaverhead river is a succession of valleys, with broad fertile lands, but with an exceedingly scanty water supply. The uppermost and most southern of these valleys, known as Centennial valley, lies in Madison county. It is about 40 miles long by 2 to 3 miles wide. From this valley Redrock creek flows through a short canyon and enters Redrock valley, about 25 miles long and 2.5 miles wide. North of this comes in turn Beaverhead valley. The creek has been gauged at a point near Redrock, and from these measurements computations of the discharge for 1890 have been made, showing an average flow for the year of 148 second-feet, the minimum being 40 second-feet and the maximum 675 second-feet.

On April 10, 1890, when Redrock creek should have been carrying a considerable volume of water, it was almost dry at a point 6 miles above Redrock, while below a number of springs added a small amount to the stream. At the same time the Horse Prairie and Grasshopper creeks were flowing a small volume, sufficient to add appreciably to the discharge of the Beaverhead. The upper valleys of these and other tributaries of the Beaverhead are in general broad, situated at comparatively low elevations, and containing an amount of arable land so great that there is some question whether the whole area can be irrigated even by storing the water, more especially as the water duty in these valleys is very low on account of the open character of the soil.

The principal towns of the county are along the Beaverhead river, which is formed by the junction of Redrock and Horse Prairie creeks. Along the valleys are many ranches, and although but a small proportion of the land is under crop, yet already there is often a general loss from lack of water. On September 9, 1889, this stream, at Dillon, was flowing at the rate of 75 second-feet. There is an ample supply for the present acreage during the spring and early summer, at the time when the crops need little or no irrigation, but later in the season, when the long continued dry weather prevails and the crops are withering, the streams diminish so that there is not sufficient water for all claimants, as may be inferred by the above measurement. At such times the absence of efficient regulation creates endless litigation and consequent poverty and distress among the farmers, many of whom mortgage their farms in order to raise money to defend their water rights, without which their land is valueless. In the higher valleys alfalfa is reported to be unsuccessful, but timothy, redtop, and other grasses, as well as white clover, oats, wheat, and potatoes, are profitably cultivated.

CASCADE COUNTY is comparatively small, lying along the Missouri river a little to the northeast of the center of the state, and including the lower part of the valley of the Sun river. These rivers flow through broad, high plains or "bench lands," into which they have cut comparatively narrow valleys, which, however, widen in places to a breadth of several miles. Southeast of the Missouri river the county extends to the peaks of the Big Belt and Little Belt mountains, and thus contains many streams convenient for irrigating purposes. The greater part of the irrigation in the county is accomplished from these small streams, the use of the waters of the Missouri river not being always practicable or successful. A small amount of land is cultivated by water from this great river, and this area could be increased enormously by the construction of a large, well planned irrigating canal. The lower lands along the Missouri are overflowed usually in June, and some hay is raised by natural irrigation.

On the bottom lands throughout this county there is usually sufficient moisture to cause grain and vegetables to sprout and attain considerable size, but the latter part of July is generally hot and dry, and all crops then require the artificial application of water at least once. Along the foot of the Belt mountains the country is broken, but the small, narrow bottoms are cultivated by taking the water from the springs or small streams. The principal agricultural areas of the county are in Chestnut valley, a broad opening along the southeastern side of the Missouri, extending down to Smith river, and in the valley of Sun river. The amount of water in this latter stream has been measured at a point about 18 miles above the town of Augusta, being thus above irrigating ditches. Gaugings were begun on August 5, 1889, and continued through 1890, the results showing an average discharge of 715 second-feet for 1890, the minimum being 160 second-feet and the maximum 4,085 second-feet from a drainage area of 1,175 square miles.

DISCHARGE OF SUN RIVER ABOVE AUGUSTA, MONTANA.

(Drainage area, 1,175 square miles.)

MONTHS.	DISCHARGE IN SECOND-FEET.			Total for month in acre-feet.	RUN-OFF.		MONTHS.	DISCHARGE IN SECOND-FEET.			Total for month in acre-feet.	RUN-OFF.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.		Maximum.	Minimum	Mean.		Depth in inches.	Second-feet per square mile.
1889.							1890.						
August 5 to 31	221	200	213	13,100	0.21	0.18	January	.....	.....	*a*175	10,760	0.17	0.15
September	260	200	214	12,733	0.20	0.18	February	.....	.....	*a*175	9,712	0.15	0.15
October	200	200	200	12,300	0.20	0.17	March	.....	.....	*a*175	10,760	0.17	0.15
November	200	180	191	11,364	0.18	0.16	April	1,580	160	371	22,074	0.35	0.31
December	.....	.....	175	10,762	0.17	0.15	May	4,085	1,990	2,804	172,446	2.75	2.38
							June	4,000	1,850	2,342	139,349	2.23	1.99
							July	2,440	450	961	59,101	0.94	0.81
							August	480	315	371	22,816	0.36	0.19
							September	365	260	304	18,088	0.29	0.26
							October	480	240	315	19,372	0.31	0.27
							November	390	275	322	19,160	0.31	0.28
							December	340	240	267	16,420	0.26	0.23
							Per annum	4,085	160	715	520,058	8.29	0.60

a Estimated.

There are several large canals in the Sun river valley, of which the two following may be mentioned: the Sun river ditch takes water from the north side of the Sun river 2 miles above the town of the same name. The ditch is 14 miles long by about 8 feet wide, and it cost approximately $14,000. It is owned by an association of ranchmen, who claim to have a supply ample for all their needs. The annual cost of the water is about 25 cents per acre. The Crown Butte canal takes water from the south side of the Sun river and carries it easterly for about 22 miles. The average width is 19 feet, depth 3.5 feet, and discharge about 200 second-feet, and its cost was about $60,000. It is proposed to construct a system of reservoirs sufficient to supply water during times of scarcity. In the Chestnut valley a canal has been built taking water out on the east side of the Missouri, but it is reported that on account of engineering defects this canal is not entirely successful in delivering a sufficient supply of water, although the amount in the river is many times what is required.

CHOTEAU COUNTY embraces an immense area of elevated plains adjoining the British possessions. It extends from the continental divide eastward over the high plains along and across the Missouri river to Dawson county on the east. Numerous streams issue from the high mountains forming the western border of the county and flow in deep channels easterly down the slope of the plains to join the Missouri. The principal of these rivers are the Marias, Teton, and Sun, the last named forming for a portion of its course the southern boundary of the county. The Missouri river flows into the county from Cascade county on the south, and then pursues a general easterly course. This river, as well as it tributaries, has cut deep into the plain, so that the streams now flow at a depth of several hundred feet below the surface of the country, rendering it exceedingly difficult, if not impossible, to take the water from the main streams out upon the bordering bench lands. Milk river flows easterly through the northern part of the county, receiving waters from the hills and the high plains or bench lands near the border between the United States and the British possessions, and finally emptying into the Missouri river in Dawson county. Between Milk river and the Missouri are short ranges of mountains rising 2,000 feet or more above the plains. The streams flowing in all directions from these mountains have already been used to a small extent for irrigation.

The general altitude of the county is from 3,000 to 4,000 feet, the plains rising rapidly on approaching the mountains, and finally reaching an elevation of nearly 5,000 feet. Cattle range over these great tracts of gently rolling land, finding an abundance of summer feed, for in most years there is sufficient rainfall to insure good forage, and occasionally even to mature a crop of cereals. Without irrigation, however, no crop is safe in this county, and attempts at dry farming result in disaster.

The county is very thinly inhabited, the principal towns being along the Missouri river from Great Falls to Fort Benton or on the Sun and Teton rivers. The northern part of the county has until lately been held as an Indian reservation, and this immense body of agricultural land is being rapidly taken up. In the Milk River valley especially the fertile lands now thrown open offer inducements to settlers. This valley is reported to be 3 miles or more in width, and to possess large areas of rich soil. The water supply is probably not sufficient under present circumstances for the irrigation of more than a small percentage of the land, since the drainage basin of the river embraces but a relatively small area of high mountains and furnishes little water after the early spring freshets, the river becoming almost insignificant in size. At times it is a great torrent overflowing the banks, or appears as an inland lake many miles in width.

On the head waters of the Marias river a little irrigation is practiced, and along the Teton river to the south of this nearly every ranch has an irrigating ditch, all the water being claimed. A measurement of the quantity of water in this stream at Choteau, where the area drained is about 900 square miles, showed on August 7, 1889, only 26 second feet. A large irrigating system has been projected and a canal partly constructed to take water from this river, and by the use of various storage basins, notably Benton lake, it is proposed to cover almost incredible areas of rich table lands. Along the Sun river, which separates this county from Lewis and Clarke county and then flows through Cascade county, are several large canals which furnish water to lands lying in these counties, but the unregulated flow of the river is not sufficient to fill all these canals during the latter part of the summer and storage systems are projected.

South of the Missouri river are a number of streams which flow from the Highwood and Little Belt mountains to the south. Along all of these streams irrigation has been developed and as much land brought under irrigation as can be supplied in favorable years. In the drought of 1889 and 1890, when the streams were low, large acreages of crops were destroyed, and the farmers report that the value of the crops lost would have paid for storage systems on many of these streams. Along the Missouri, at various points where the land is too high for irrigation by ditches, it has been proposed to lift water by means of pumps driven by windmillls or other means.

CUSTER COUNTY is in the southeastern corner of Montana, adjacent to the Dakotas and Wyoming. On the northwest it extends across the Yellowstone river and to or even over the divide between the drainage of that stream and of the Missouri river, thus including immense tracts of nearly level plains. The general altitude of the agricultural lands is from 2,200 to 4,000 feet, and the temperature is favorable for maturing the cereals. Stock raising is the principal industry, although the large extent of arable lands and the generally favorable character of the water supply promise a great development of agriculture in the future.

The county as a whole lies in the Great Plains region, the nearest large mountains being the Bighorn range to the southwest in Wyoming, and next to these in importance the Black Hills, which lie to the southeast, mainly in South Dakota. Streams from these mountains enter the county on the southern border, the principal of these being the Tongue, Powder, and Little Missouri rivers. The first named, rising in the high mountains and flowing but a short distance before entering the county, furnishes the best perennial supply of water. A number of canals or ditches have been built, the most notable being the canal above Miles city. The bottom lands along the streams are in general narrow and so irregular that long ditches are almost impracticable. The discharge of Tongue river on October 6, 1889, was 200 second-feet, the area drained being 3,785 square miles.

In the valley of the Rosebud, west of the Tongue river, the summer water supply is not sufficient to fill the ditches already constructed, since this stream does not rise in the high mountains. In the valleys east of the Powder river the water supply is irregular, and is in general insufficient during the latter part of the crop season, for on account of the distance from the mountains much of the water disappears before entering the county from the south. Along the Little Missouri, farther to the east, the supply is even more scanty, this river rising in the Black Hills, the altitude of which is not sufficient to cause the water to flow perennially. This valley is thinly settled, and there may be said to be no irrigation carried on at present, the high banks of the stream and the irregularity of the water supply rendering canal construction expensive and a matter to be entered upon with great care. There are excellent storage facilities, and the large extent of arable land and the possibilities of holding flood water will tempt capitalists to construct efficient irrigating systems.

On both sides of the Yellowstone river in the northern part of the county and along the tributaries entering from the north and south are extensive tracts of fertile land adapted for agriculture in every respect save that of moisture. This land is at present used principally for grazing, since crops can not be raised upon it with any certainty without irrigation. There is an ample supply of water in the Yellowstone river, and at many points the fall of the river is sufficient to allow canals to be taken out, covering long stretches of bottom land. The great expense involved has up to the present time deterred the inhabitants and owners of arable land from building canals. Irrigation is carried on in a very small way by utilizing the little streams entering the valleys from the sides and by damming the ravines and holding rain water for short periods. In the valley of the Rosebud and farther down along the Yellowstone, where ditches are too costly for private enterprise, steam pumps have been tried and are reported to be successful in raising water sufficient for small areas. Work of this character, however, has not been carried on for a length of time sufficient to demonstrate the financial success of agriculture under these conditions.

By the construction of canals from the Yellowstone and Tongue rivers a great part of the low lands along these streams can be reclaimed, but it will not be possible to cover in this way all the fertile lands, since the greater part of these lie too high. Some of this latter land can be irrigated by means of storage systems in the higher rolling or hilly country, and in a few instances small storage reservoirs have already been built. Springs and to a small extent artesian wells are used to irrigate gardens and trees in the lower lands. The Miles City ditch now being constructed is the largest irrigation enterprise in this county. It is to take water from the Tongue river and carry it down on the east side of the stream to within about 2 miles of the Yellowstone, where it turns and follows the general course of that stream. Twenty miles have been built, and the total length of the ditch when completed will be 28 miles. The width is 10 feet, the carrying capacity about 60 second-feet, and the cost reported upward

of $100,000. The water in the Tongue river is to be raised by a permanent dam 320 feet in length to a height 7 feet above low water.

DAWSON COUNTY is in the northeastern corner of Montana, adjoining the Dominion of Canada on the north and the state of North Dakota on the east. The two counties of Custer and Dawson occupy the entire eastern end of the state of Montana, and are similar in many respects, both lying within the Great Plains region, and their surface in a general way being level. The Missouri river, which crosses the county from west to east, and the Yellowstone, which flows through the southeastern corner, as well as the tributaries of both of these streams, have carved channels below the general level of the country, so that the surface of the plain, although at a distance apparently level or but slightly undulating, is in reality often rough and broken.

The soil is very fertile, but there is not sufficient rainfall to support grains and vegetables in all seasons. Occasionally small crops of corn, millet, potatoes, and vegetables are obtained without irrigation, especially in the narrow bottom lands along the perennial streams, but these crops can not be depended upon. The greater part of the arable land lies so high that river water can not be taken out upon it, but there are narrow strips of bottom land, especially along the Yellowstone, as in Custer county, to which canals can be built. This river and the Missouri furnish an ample supply of water at all times, the discharge of each probably not falling below 5,000 second-feet. The small streams generally become dry during the summer.

What little irrigation is done in this county is carried on by water from springs, since it has been found too expensive, with the limited means of the present inhabitants, to take water from the large perennial rivers. A larger acreage could be irrigated by individuals by the construction of small storage reservoirs, but comprehensive irrigation systems can only be entered upon by organizations having ample capital. The principal industry is grazing, the greater part of the grain and other farm produce needed by the inhabitants being brought in from other localities. The settlements are mainly in the eastern end of the county along the Yellowstone, where the altitude is 2,000 feet or upward.

DEERLODGE COUNTY is in western Montana, west of the continental divide, and thus includes a portion of the headwaters of tributaries of Clarke fork of the Columbia. Mining is the principal industry, although agriculture is of rapidly growing importance, as the mining towns furnish good markets for all products. Nothing, however, can be raised without irrigation, and, as in other places where two classes of industry both depend for their success upon the use of water the supply of which is limited, there is often friction between the irrigator and the miner or mill owner. The farmers assert that the powerful corporations needing water for their mills or mines take it in spite of prior rights, or load the streams with débris, filling the ditches or ruining the land, and that it is impossible to secure redress.

The principal agricultural land is in the Deerlodge valley, lying at an altitude of from 4,300 to 5,000 feet, this valley being among the richest and best developed valleys in Montana. It is in all about 40 miles long and from 1 mile to 5 miles wide, having a rich and highly productive soil, but one which contains, especially in the lower lands, considerable alkali, requiring a very careful use of the water to prevent the formation of an alkaline crust upon the surface. Deerlodge creek, which rises in Silverbow county, runs northerly through this valley, and its waters are diverted, especially near the head, by many irrigating ditches. The larger part of the irrigation is done by water from creeks which flow into the Deerlodge valley both from the east and the west. Along each of these streams many ditches are taken out, each ditch supplying water for one or two ranches. In nearly every instance the irrigators state that there is often scarcity of water. They also state that at the head of many of the creeks are small lakes, which probably can be increased in area and capacity, and there are also basins needing only the construction of short dams to be converted into reservoirs. Individuals have already demonstrated the success of storage for irrigation, and there is now a demand for some general system.

Besides the Deerlodge valley, there are several others of importance in agriculture or stock raising. To the west is Flint Creek valley, in which, besides mining, stock raising is an important industry, the most notable crops being those raised for forage. The water is said to be all appropriated, none being available for late settlers, unless possibly by storage. Toward the northern part of the county, on both sides of Nevada creek and the Big Blackfoot, are thousands of acres of good land without water. The water supply of the Big Blackfoot is large, but expensive canals will be required in order to use it to the best advantage. Along these streams and along the Little Blackfoot, which joins Deerlodge creek, are extensive irrigated areas, farming being everywhere successful on account of the markets afforded by mining settlements. The Little Blackfoot valley is over 20 miles long and a mile or more in width, containing extensive areas of fine land, the soil of which is a rich sandy loam, hay, however, being at present the principal crop. The Little Blackfoot river in the latter part of April, 1890, when in flood, was carrying about 150 second-feet.

FERGUS COUNTY lies nearly in the center of Montana, being between the Missouri and Yellowstone rivers, although not bordering upon either of them. The county extends from the plains region on the east, and includes on the west a part of the first ranges of the Rocky mountains. Its location, therefore, is favorable to the development of agriculture by irrigation, since it contains extensive tracts of farming land immediately adjacent to elevated catchment areas. The county is divided into two topographic basins, that of the Judith river on the

northwest and that of the tributaries of the Musselshell on the south and east. The melting snow from the lofty ranges gives rise to many small streams, which finally unite into one or the other of these two drainage systems. The county is comparatively well watered, containing as it does a large number of creeks, each of which can be easily and cheaply used for irrigation. There are thus many small ditches owned by individuals and few, if any, corporations or associations of irrigators.

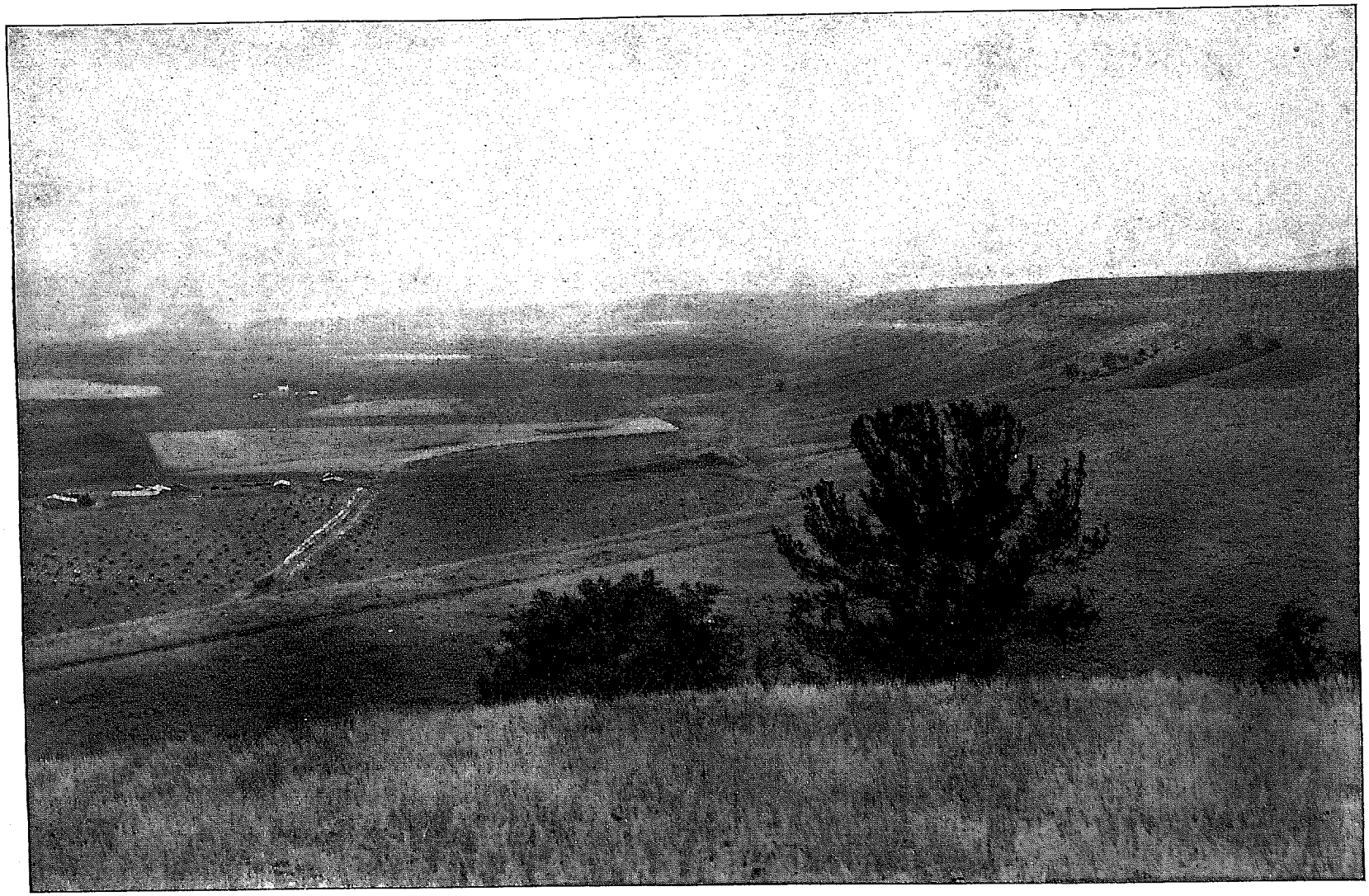
The drainage basin of the Judith river is partially surrounded by high mountains, upon the slopes of which is excellent summer grazing. Ranchmen have taken up a great part of the land along the streams, and have constructed small irrigating ditches for the purpose of raising winter feed. The majority of the farmers had little means and the ditches were built in the cheapest possible manner as temporary expedients. Greater economy of water would be attained by the construction of one well made canal to take the place of a number of these small ditches. Already on many of the tributaries of the Judith river more ditches have been constructed than can be supplied with water during a part of the crop season, and thus the irrigators on the lower parts of these streams have been unable to obtain sufficient water to save their crops. The discharge of the Judith river itself during the summer is very small, from the fact that many of the mountain streams are evaporated from the sandy channels or are entirely used in irrigation.

Land is still being brought under cultivation by new settlers, although the water rights of the older inhabitants remain unprotected, and apparently a condition of affairs will ensue in which the irrigator at the head waters will be the only one who can be sure of his crops. The snow melts rapidly on the lower summits and flows away in May and June, the streams becoming very small in July and August, so that it will be necessary to store the water which is not needed in the spring for a few weeks only. During years of unusual rainfall crops are raised in the Judith basin without irrigation. For example, in 1887 and 1888 large crops of cereals were raised in a few instances in this manner. In 1889, however, nearly all the crops on unirrigated land were lost, and owing to the scarcity of water in the streams the yield on lands under ditch was in many cases small. In 1890 also the snows were light and the results were disappointing. Many of the ranches were taken up originally after years of abundant rainfall, when the old grass was thick and heavy, and there was every indication that crops could be raised without the artificial application of water. Along the streams which flow east into the Musselshell the conditions are in most respects similar to those prevailing in the Judith basin. Ranches are scattered along the streams, and small ditches have been taken out by the respective owners. There is apparently plenty of water near the foot of the mountains, and at those points grain occasionally matures without irrigation. Farther down the stream, however, there is often not sufficient water for one-half of the ditches constructed.

GALLATIN COUNTY is in southern Montana and covers the drainage basin of the Gallatin river from its head waters in the Yellowstone national park. The county is long and narrow, stretching from the continental divide northerly to the Missouri river, along which it extends for nearly 10 miles. It thus includes in its northern end the Gallatin valley, which at the present time is probably the finest area of agricultural land in the state. This valley, the altitude of which ranges from 4,000 to 5,000 feet, is bounded on the east by the Gallatin and Bridger ranges, from which flow numerous streams to form the East Gallatin river. The main stream, or West Gallatin, traverses the valley, as also does the Madison farther to the west. These, uniting with the Jefferson, which comes in from the southwest, form the Missouri, the junction being known as the Three Forks.

Irrigating ditches and canals are taken from all these streams and also from their tributaries, the water supply being excellent. The smaller streams offer especial facilities for the construction of ditches by individual farmers, so that agriculture has progressed rapidly and successfully along their valleys. In the Gallatin valley itself, and upon the bench lands to the west, the large extent of comparatively level land and the abundant perennial supply of water in the rivers offer inducements for the construction of large irrigating systems. In spite of the magnificent resources of the county, development has not been in all instances satisfactory, from the fact that it has not been governed by efficient and systematic regulations. The first settlers claim that they are being deprived of water by persons who have no legal right to it, but who by their location near the sources of supply are able to readily secure the flow of the stream, while, on the other hand, the owners of secondary rights, who are generally in the majority, accuse the old settlers of taking more than a proper share of the water and employing it in a wasteful manner. Among the foothills in seasons when the ground is kept moist by snow, excellent crops of winter wheat are occasionally raised without irrigation, but crops planted in the spring are not successful in this way, except in the case of some of the old ranches on the lowest grounds along the river, where the soil is kept moist by seepage. The same land has been cultivated year after year without apparent diminution of fertility, although some farmers find that the best results are obtained by letting the fields lie fallow occasionally, as this kills many of the weeds and increases the subsequent crop.

Along the streams which flow into the East Gallatin river are no large canals or corporations selling water, and the ditches are mainly controlled by individuals. In many cases the whole of the water is claimed, and in the drought of 1889 and 1890 large areas of crops were lost. The necessity of reservoiring some of the surplus water was felt and several projects were organized for the purpose of building storage works. The water supply from the West Gallatin, however, was large, and the necessity of water storage along that stream has not been

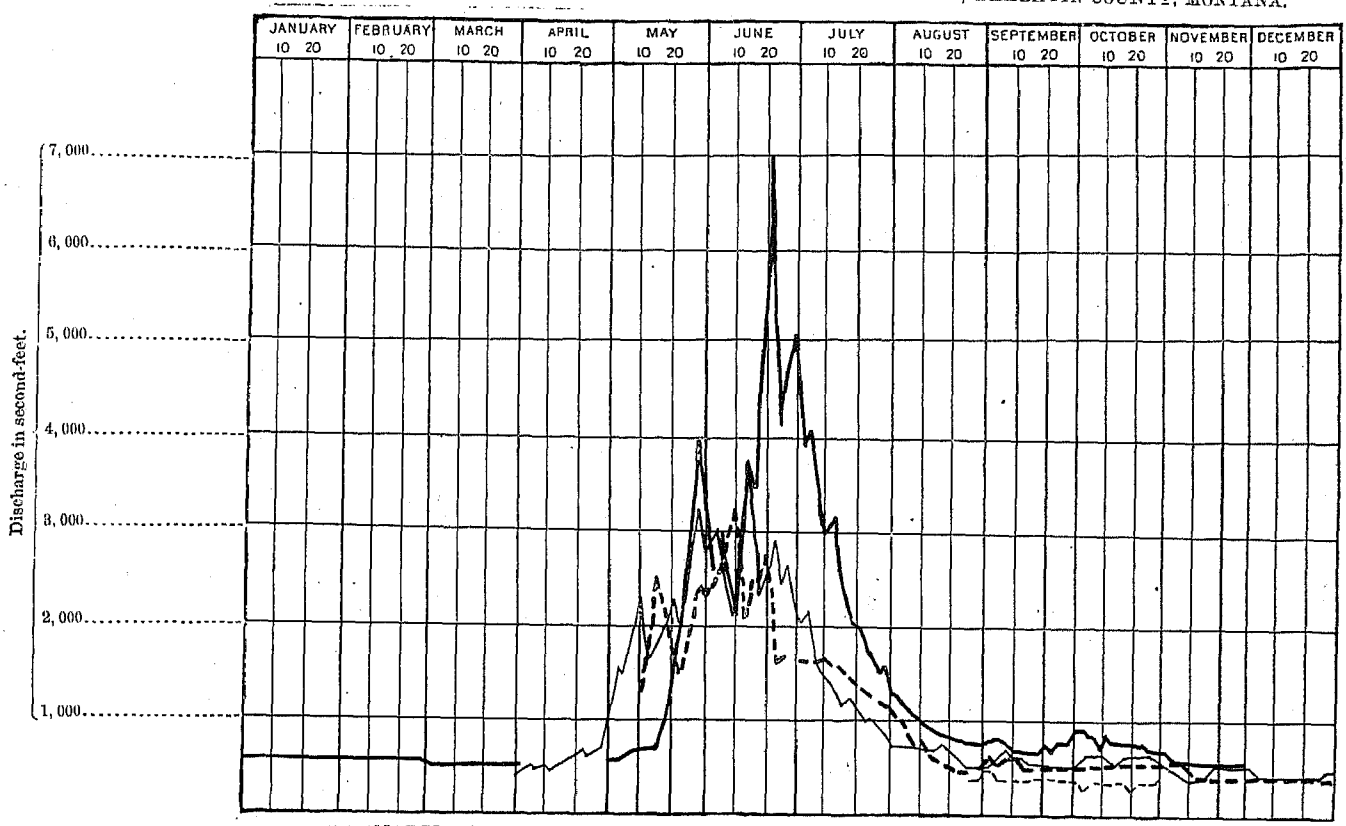


VIEW OF VALLEY AND BENCH LANDS ALONG WEST GALLATIN RIVER, GALLATIN COUNTY, MONTANA.

apparent. Measurements of the discharge of West Gallatin river were made at a point (*a*) in the mouth of the canyon a few hundred feet below Spanish creek, this being about 20 miles southwesterly from Bozeman.

a In the diagram the discharge for 1889 is indicated by the lighter broken line, that for 1890 by the lighter continuous line, that for 1891 by the heavier broken line, and that for 1892 by the heavier continuous line. The results obtained are shown in the table following:

DIAGRAM OF DAILY DISCHARGE OF WEST GALLATIN RIVER BELOW SPANISH CREEK, GALLATIN COUNTY, MONTANA.



DISCHARGE OF WEST GALLATIN RIVER, NEAR BOZEMAN, MONTANA.

(Drainage area, 850 square miles.)

MONTHS.	DISCHARGE IN SECOND-FEET.			RUN-OFF.		MONTHS.	DISCHARGE IN SECOND-FEET.			RUN-OFF.	
	Maximum.	Minimum.	Mean.	Total for month in acre-feet.	Depth in inches.		Maximum.	Minimum.	Mean.	Total for month in acre-feet.	Depth in inches.
1889.						1891.					
August 16 to 31	437	402	426	26,200	0.58	May 6 to 31	2,535	1,390	1,897	116,665	2.57
September	640	402	450	26,775	0.59	June	2,975	1,615	2,516	149,702	3.30
October	437	367	402	24,723	0.54	July	1,760	1,090	1,534	94,341	2.06
November			400	23,800	0.52	August	1,050	570	761	46,801	1.03
December			400	24,600	0.54	September	650	570	583	34,688	0.77
1890.						October	610	570	587	36,100	0.80
January			320	19,680	0.43	November	570	370	501	29,809	0.66
February			320	17,760	0.39	December	500	430	434	26,691	0.59
March 23 to 31	320	320	320	19,680	0.43	Per annum	2,975	370	889	639,022	14.05
April	1,255	280	460	27,370	0.60	1892.					
May	3,195	1,300	2,092	128,658	2.84	January	430	430	430	26,445	0.59
June	3,800	2,060	2,641	157,139	3.47	February	430	400	429	24,667	0.55
July	2,165	890	1,388	85,362	1.88	March 1 to 19	400	400	400	24,600	0.54
August	890	570	761	46,801	1.03	April			*450	26,775	0.59
September	690	570	607	36,112	0.80	May	4,065	465	1,488	91,512	2.02
October	650	570	591	36,346	0.80	June	6,800	2,270	4,163	247,698	5.48
November	570	430	506	30,107	0.66	July	5,170	1,300	2,544	156,456	3.46
December			450	27,675	0.61	August	1,300	810	957	58,855	1.30
Per annum	3,800	280	871	632,690	13.94	September	850	650	734	43,673	0.97
1891.						October	890	650	743	45,694	1.01
January			400	24,600	0.54	November	650	570	589	35,045	0.77
February			400	22,200	0.47	December	570	500	549	33,763	0.74
March			450	27,675	0.61	Per annum	6,800	400	1,123	815,183	18.02
April			500	29,750	0.65						

* Estimated.

A large number of ditches and several canals of notable size depend upon the West Gallatin for their water supply. The more important of these are the works of the Gallatin Canal Company, the West Gallatin Irrigation Company, and the Excelsior Canal Company. The West Gallatin canal heads at a point about 3 miles above Salesville and following the contours, which are exceedingly irregular, gradually leaves the river and finally turns toward the west, covering lands from 10 to 15 miles west of Bozeman. The length is about 24 miles and the width varies from 24 feet on bottom near the head to 14 feet on bottom near the end. Along the course are several flumes and one tunnel through the spur of a hill.

The Gallatin canal heads on the east side of the river at a point about 2 miles below Spanish creek and carries the water out northeasterly toward Bozeman. The length of this canal is about 22 miles, its width 20 feet, and its ordinary carrying capacity from 75 to 100 second-feet and upward. The water is rented at the rate of $2 per miner's inch from June 10 to September 1, and it is estimated on the part of the company that 1 miner's inch will furnish water for 2 acres of small grain. A second canal, to cover some of the lands under this canal, has lately been built by farmers who thought they could secure a cheaper and more efficient supply from a source owned and controlled by themselves. This latter canal is about 12 miles long, 18 feet wide, and was begun in October, 1890, with the intention of using water in the succeeding year.

Along the Madison are many ditches, covering mainly the lower lands. On the very lowest ground along the stream a little hay is cut on land not irrigated. On Willow creek and on the Jefferson bottoms are many ditches, but there is no comprehensive system of irrigation, and in the Willow Creek valley there is reported to be need of more water. In the extreme western end of the county are several canals taking water from the Jefferson river. Of these the Lower and Upper Jefferson ditches may be mentioned, aggregating in all over 30 miles of main, lateral, and distributing ditches.

Water is used from the latter part of April or the early part of May until October. The duty of the water is reported to be very low, one reason being that the ground watered has mainly been newly broken and more water is required than on land irrigated for several years. It is found that after the water has been used for a few years the subsoil becomes more compact and a smaller quantity of water will cover the same area of ground. At the same time the ditches become silted and do not lose so much water by seepage. As it is at present the ditch probably delivers only about two-thirds of the quantity taken in at the head, but after allowing for this loss the irrigated ground during the season is probably covered to an aggregate depth of 24 inches, giving a water duty of 2 acre feet per acre. Between the Gallatin and Madison rivers is an extensive bench land of great fertility, which has afforded for years a most tempting opportunity for irrigation enterprise. The general elevation, however, is great, and the edges of the bench are deeply eroded, so that canal construction is expensive. By the employment of sufficient capital the engineering difficulties have already been to a large degree surmounted, but the greater part of the bench land, which is considered to be equal if not superior to the lower grounds, has not been touched on account of the expense of bringing water upon it.

JEFFERSON COUNTY lies northwest of Gallatin county on the west side of the Missouri river, occupying a comparatively small area between it and the continental divide. On the south the county is bounded by the Jefferson river, one of the three great tributaries of the Missouri. The principal agricultural land is along the Jefferson and Missouri rivers, and in the valleys of the small tributaries which flow into these from the north and west. These lands are from 4,000 to 5,000 feet in altitude, and, especially along the large rivers, they have a climate favorable for the production of vegetables and fruits. Nothing is grown without irrigation, but the main dependence for water is not upon the large rivers, but upon the small mountain streams that flow from the high peaks of the divide. In a few instances water has been taken from the Jefferson and the Missouri, but the ditches are small and cover only the lowest land, much of which is wet by the annual overflow. It is probable that a large canal system could be built, taking water from the Jefferson and carrying it to some of the higher bench lands. Owing to the prevailing drought and the scarcity of feed on the ranges the stock industry has rapidly decreased in value, the cattle having been driven to other parts of the state. Agriculture, wherever water is to be had, is prosperous, largely due on account of the nearness of Helena, Butte, and other mining towns.

LEWIS AND CLARKE COUNTY is north of Jefferson county and lies east of the continental divide, occupying a comparatively narrow strip of country extending from the summits easterly toward and on the south to the Missouri river, which flows in a general northerly direction along the continental divide and from 10 to 30 miles to the east of it. At about the center of the county the stream turns to the northeast, flowing through Cascade county, while the continental divide turns off toward the northwest nearly at right angles to the river, thus rapidly increasing the distance between the mountains and the streams, allowing space for the high plains to sweep around toward the south and rendering the tributaries of the Missouri longer. For example, beginning at the extreme north, in Choteau county, the Marias river is 150 or more miles in length and traverses a great width of the high plains. The Teton, south of this, is shorter, and to the south, in turn, the Sun river, which forms a portion of the northern boundary of the county, is still shorter and traverses a less width of plain, but its length

is far greater than that of the Dearborn, still farther to the south, and the last river of the series. South of this are many important streams, but their course is so brief that they are known as creeks.

This comparatively narrow county, mainly a foothill region, is favorably situated for the development of irrigation. Along the western border are mountains, furnishing water for numerous streams, which, flowing toward the east, are soon lost in the Missouri. Each of these streams as it issues from its canyon is used for irrigation, the water being easily taken out upon the narrow bottom lands by means of small private ditches, the low water supply in general being used to such an extent that there is little, if any, water left in times of scarcity for the wider valleys to the east, nearer the Missouri. Along the Sun river several canals have been built taking water to lands in this county and to those in Cascade and Choteau counties.

Along the Dearborn river are a number of ditches and one notable canal system diverting the waters of the north fork of the river before they leave the canyon. This is done by means of a dam of rock filled crib work bedded on the solid rock. The canal carries water a distance of 4.5 miles to Flat creek, down the channel of which it continues for 20 miles, covering, it is estimated, in this course over 20,000 acres of land, laterals being taken directly from the creek, the topography of the country being peculiarly favorable. Besides these laterals, other canals are taken from Flat creek, and are to be extended to cover the vast areas of arable lands lying in the direction of Great Falls. Suitable storage sites are to be utilized in order to insure permanence of supply. The annual charge for water is reported to be $1 per acre.

Besides the irrigation from these rivers and the creeks farther south, some land is watered by springs which issue among the foothills or in the lower valleys. There is an ample supply of water near the mountains, for here the arable land is limited in extent and the available water is at a maximum. Irrigation, however, is making such rapid development that it seems probable that before long a scarcity must ensue even in the most favored spots. As the ranges are fenced in the stock men are compelled to raise more and more feed for their cattle, thus greatly increasing the area of lands cropped. During the drought of 1889 and 1890 most of the irrigators suffered for lack of water, as the area of land under cultivation in many of the valleys was in excess of the available water. Under this condition of affairs it has often been found practicable to raise crops by securing a thorough saturation of the soil late in the fall or in the early spring, at times when the demand for water is less than in the crop season. The ranchmen living along the foothills south of the Sun river realize that the only way in which the small level areas in this broken and hilly country can be reclaimed is by storing the water of small streams or "dry creeks", as they are usually called, since they do not carry any water in summer. Several instances are reported where small storage reservoirs have been constructed and sufficient water has been saved to irrigate several ranches.

Besides the large valleys along the Sun and Dearborn rivers there is in the southern part of the county a broad, fertile plain known as the Prickly Pear valley. The western side of this area is well cultivated, but there are thousands of acres of good land to the west for which there is at present no water supply. Helena, the capital of the state, is on the southwestern edge of this open country. The irrigating ditches are all small, being owned principally by individuals. Good crops have sometimes been raised here without the application of water. The Missouri river is unfortunately too far below the general level to furnish any water from its abundant supply, but it is possible that some of its tributaries farther to the southwest may be diverted to cover a portion of this area.

The Missouri river has been measured at points within this county, the earliest series of gaugings being at Canyon Ferry, about 18 miles east of Helena. This location, however, was not found favorable and gaugings were continued at a point farther down the river, this being at Craig, about 30 miles north of Helena. Dearborn river was measured August 9, 1889, at Dearborn, where the drainage area is 350 square miles, and the discharge found to be 47 second-feet. A later measurement, on April 15, following, showed 37 second-feet. (*a*)

a The results of the measurements are shown in the following tables:

DISCHARGE OF MISSOURI RIVER AT CANYON FERRY, MONTANA.

(Drainage area, 15,036 square miles.)

MONTHS	DISCHARGE IN SECOND-FEET.			Total for month in acre-feet.	RUN-OFF.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1889.						
September	2,040	1,603	1,873	111,443	0.15	0.12
October	2,516	2,040	2,230	137,145	0.18	0.15
November	2,834	2,230	2,502	148,869	0.20	0.17

MADISON COUNTY is in the southwestern part of Montana, between Beaverhead and Gallatin counties. It extends from the continental divide on the south to the Jefferson river on the north, and includes the greater part of the course of the Madison river as well as a portion of that of the Jefferson. Between the high mountain ranges, which rise to elevations of 10,000 feet or over, are several broad valleys containing a large amount of excellent arable land, and supplied with water from the almost innumerable streams issuing from the different ranges. In these valleys agriculture has progressed rapidly by the aid of irrigation, the mountain streams being well distributed and so located that individual farmers can easily dig ditches and bring the water upon their land. The Madison valley, lying in the western part of the county, is over 30 miles in length and in places 8 miles or over in width. The river of the same name flows northerly through the valley, carrying a considerable amount of water at all seasons of the year. The expense, however, of diverting water from this large river has been so great that individuals have in general been compelled to take water from the side streams, leaving the greater part of the water untouched. The construction of large canals on each side of this river may bring under irrigation enormous areas of the best land in the valley. The water supply of the valley is in general good, and compared with other parts of the county the complaints of scarcity of water are few.

The Madison river has been measured at a point near Red Bluff, the ganging station being below the mouth of Hot Spring creek, at Hayward bridge. (*a*)

DISCHARGE OF MISSOURI RIVER AT CRAIG, MONTANA.

(Drainage area, 17,615 square miles.)

MONTHS.	DISCHARGE IN SECOND-FEET.			Total for month in acre-feet.	RUN-OFF.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1890.						
January			*3,000	184,500	0.20	0.17
February			*3,000	166,500	0.18	0.17
March			*3,000	184,500	0.20	0.17
April 17 to 30	6,100	3,595	4,662	277,389	0.29	0.26
May	12,580	6,900	10,472	644,030	0.68	0.59
June	11,980	8,100	10,674	599,401	0.64	0.57
July	7,850	2,614	5,020	308,730	0.33	0.28
August	2,505	1,960	2,276	136,284	0.15	0.13
September	2,356	1,961	2,232	132,804	0.14	0.13
October	2,722	1,742	2,370	146,308	0.16	0.13
November	3,159	2,723	2,868	170,646	0.18	0.16
December	3,159	1,742	2,762	169,924	0.18	0.16
Per annum	12,580	1,742	4,507	3,121,016	3.33	0.24
1891.						
January	3,523	1,742	2,967	182,470	0.19	0.17
February			3,500	215,250	0.24	0.20
March			4,000	246,000	0.26	0.23
April	9,130	4,576	5,794	344,743	0.37	0.32
May	12,050	7,150	9,015	554,422	0.59	0.51
June	16,355	11,060	13,045	811,877	0.85	0.77
July	12,960	5,890	9,115	560,573	0.60	0.52
August	5,890	2,832	4,415	271,522	0.29	0.25
September	3,704	2,014	3,078	183,141	0.19	0.17
October	3,704	3,159	3,511	215,920	0.23	0.20
November	4,358	3,486	3,802	226,210	0.25	0.22
December			3,290	196,800	0.21	0.18
Per annum	16,355	1,742	5,503	4,008,942	4.27	0.31
1892.						
January			3,000	184,500	0.20	0.17
February			3,000	172,500	0.18	0.17
March			3,200	196,800	0.21	0.18
April	4,140	3,268	3,552	211,344	0.23	0.20
May	18,550	3,486	8,004	492,246	0.52	0.45
June 1 to 25	28,650	13,270	21,027	1,251,106	1.34	1.19

* Estimated.

(*a*) The results of the computations of discharge are shown in the following table:

DISCHARGE OF MADISON RIVER AT RED BLUFF, MONTANA.

(Drainage area, 2,035 square miles.)

MONTHS.	DISCHARGE IN SECOND-FEET.			Total for month in acre-feet.	RUN-OFF.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1890.						
January			1,200	73,800	0.66	0.58
February			1,200	66,600	0.60	0.58
March			1,200	73,800	0.66	0.58
April 8 to 30	2,580	1,370	1,620	96,390	0.87	0.78
May	6,420	3,060	4,823	296,614	2.67	2.32
June	6,260	3,780	4,977	296,131	2.66	2.38
July	3,060	1,715	2,518	154,857	1.39	1.21
August	1,640	1,375	1,535	94,462	0.85	0.74
September	1,580	1,420	1,466	87,250	0.78	0.70
October	1,520	1,420	1,498	92,125	0.83	0.72
November	1,470	1,285	1,380	82,110	0.74	0.66
December	1,520	1,285	1,400	86,100	0.77	0.67
Per annum	6,420	1,200	2,068	1,500,239	13.48	0.99

West of the Madison valley the county extends over the Jefferson and Ruby ranges, thus including the Ruby valley and a portion of the Jefferson valley along the Beaverhead and Bighole rivers as well as along the Jefferson river itself. The supply of water in these valleys is not as good as that in the Madison valley, and there are many statements to the effect that although there was ample water when the valley was first settled, yet with the gradual increase of land under irrigation, especially along the head waters, the irrigators in these lower valleys suffer loss of crops. The Bighole river, having a smaller area of cultivated land along its banks, has a large discharge throughout the year, but the Beaverhead diminishes rapidly during the summer, and in 1889 and 1890 was dry in various places. The Ruby river flows continuously throughout the year, and it is reported that all the ranches depending upon it for water have sufficient for their requirements, but the tributaries occasionally shrink far below the needs of the irrigators, and even become completely dry. On September 4, 1889, the stream at Laurin was discharging at the rate of 90 second-feet, the drainage area at this point being 710 square miles. The Ruby valley ditch may be given as an example of irrigation development. This ditch is 8 miles long, 9 feet wide, and 1.5 feet deep, and cost about $5,000. It takes water from the Ruby river by a temporary brush dam about 2 miles above Laurin and carries it down the east side of the valley. The water, as is usually the case, is divided equally among the partners owning the ditch.

The lowest bottom land in these valleys is generally devoted to raising hay, dependence being placed upon the annual overflow of the river. Other bottom lands a little above the reach of the river water are also irrigated for hay, while the bench lands, wherever the water can be brought upon them, are generally sown with alfalfa and grain. The irrigated area is rapidly increasing, settlers pushing up into the higher parts of the valley, while at the same time the older farmers are tilling new fields and gradually enlarging the old ditches. Water is used in general very freely, the quantity varying largely with the character of the soil, the season, and the experience of the irrigator.

Irrigation does not usually begin until the crops are well advanced, but in 1890 the season was so dry that in many places it was necessary to irrigate in order to plow the land, and water had to be applied throughout the season instead of but once or twice, as is usually the case. It sometimes happens that in wet seasons no irrigation is necessary for the first crop of alfalfa. The experience of the farmer counts for a great deal, and even in a dry season losses could often be avoided by the exercise of greater skill and judgment. For example, some of the crops failed because of delay in irrigation, while others were saved by the thorough soaking given to the ground at the time water was plentiful. The presence or absence of alkaline salts, especially on the lowest ground, is a matter of great importance. There are several places in this county where before ditches were made there was no sign of alkali, but upon irrigation the salt rapidly developed upon the surface, requiring years of patience before the farmers could wash it out. In this county are many excellent sites for reservoirs in which the flood water of the spring could be held. The site most frequently mentioned is that at Redrock lake, in the southern end of the county near the continental divide. The water from this lake flows easterly into Beaverhead county, and along its course down Redrock creek and Beaverhead river there is urgent demand for it, since during the late summer the creek is often dry.

MEAGHER COUNTY is near the center of the state, and includes the area from the Missouri river on the west to the summits of the Little Belt and Snowy mountains on the east. There are three independent drainage basins in this county, namely, the head waters of the Smith river, which rises in the center of the county and flows

DISCHARGE OF MADISON RIVER AT RED BLUFF, MONTANA—Continued.

MONTHS.	DISCHARGE IN SECOND-FEET.			Total for month in acre-feet.	RUN-OFF.		MONTHS.	DISCHARGE IN SECOND-FEET.			Total for month in acre-feet.	RUN-OFF.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.		Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1891.							1892.						
January	1,580	1,240	1,406	80,469	0.78	0.67	January	1,375	1,240	1,305	80,257	0.72	0.63
February	1,580	1,265	1,436	70,008	0.72	0.69	February	1,640	1,330	1,504	86,480	0.78	0.72
March	1,790	1,470	1,631	100,306	0.90	0.78	March	1,640	1,330	1,488	91,512	0.82	0.71
April	1,960	1,640	1,774	105,530	0.95	0.85	April	1,420	1,240	1,295	77,052	0.69	0.62
May	4,260	1,790	3,389	208,423	1.88	1.62	May	2,580	1,330	1,454	89,421	0.81	0.70
June	4,620	3,780	4,167	247,936	2.20	2.00	June	5,940	2,820	4,200	291,550	2.62	2.35
July	3,660	1,155	2,045	125,767	1.13	0.98	July	5,940	1,700	3,225	198,337	1.78	1.55
August	1,640	1,200	1,420	87,383	0.80	0.68	August	1,885	1,285	1,519	93,418	0.84	0.73
September	1,375	1,240	1,309	77,885	0.70	0.63	September	1,420	1,330	1,360	80,920	0.73	0.65
October	1,470	1,240	1,351	83,080	0.75	0.65	October	1,420	1,285	1,327	81,610	0.74	0.64
November	1,470	1,285	1,403	83,300	0.75	0.67	November	1,420	1,330	1,424	84,728	0.76	0.68
December	1,240	1,070	1,137	69,925	0.63	0.55	December	1,420	1,240	1,324	81,426	0.73	0.64
Per annum	4,620	1,070	1,872	1,356,208	12.19	0.90	Per annum	5,940	1,240	1,844	1,336,711	12.02	0.89

northerly through Cascade county into the Missouri; those of the Musselshell, which flows in a general easterly direction, and, third, the so-called Missouri valley on the west. Each of these divisions is bounded by high mountains, and thus the water supply is large, each stream supplying many ditches, owned as a rule by individual ranchmen.

The Musselshell and Smith rivers rise on opposite sides of the Elk mountains, being separated on the north by a comparatively low pass. Agriculture has developed along the narrow valleys to such an extent that most of the available water is used, although a far larger acreage could be covered by a more systematic and economical distribution of the water. In the valley of the Musselshell the greater part of the bottom land is covered by private ditches, and is used to the extent of the water supply. At Martindale on August 17, 1889, the north fork of the Musselshell was discharging 15 second-feet and the south fork 10 second-feet. The higher bench lands are broken, but there are large areas that with a more abundant water supply could be brought under irrigation. On Smith river there is ample water in the higher valleys, but the land below is not so well supplied. The amount of water in the river itself, especially where it enters Cascade county, is usually very small, owing to the diversions made farther up the stream, so that irrigators in Cascade county are interested in securing water conservation, being often in controversy with their neighbors.

The Missouri valley contains the principal agricultural land of the county. The Missouri river leaves a canyon above Toston, the valley widening to a breadth of from 1 mile to 8 miles and extending in all a distance of about 25 miles. Along this course the river has in places cut bottoms from 1 mile to 2 miles in width, above which is the bench land, which in turn gradually disappears into the foothills of the Big Belt mountains to the east. From these mountains come many streams, each of which has eroded a deep and wide notch or coulee into the bench, in many cases forming bottoms of a width sufficient for cultivation. In these the water flows in abundance during the spring and early summer, but it declines or even disappears in July and August. Most of the irrigation is done by means of water from these creeks, for the Missouri river, although carrying a great quantity of water, is relatively at too low a level for the irrigation of much of the best land. It is possible that in the future a large canal may be taken from this river at a point in the canyon above Toston and carried out around the eastern edge of the valley, bringing an enormous acreage under irrigation. If this were done, the waters of the numerous side streams, if properly held in reservoirs, would be available for the lands lying above the level of such a canal. As it now is, throughout the county and in fact the entire state the waters of the creeks are often claimed by the farmers occupying the lower grounds far away from the mountains.

MISSOULA COUNTY lies in the extreme western end of the state beyond the main divide of the Rocky mountains, and contains the greater part of the drainage area of Clarke fork of the Columbia river. On its northeastern corner the county extends over the continental divide and includes a long, narrow area on the head waters of the Marias river, which flows into the Missouri. The northwestern part is traversed by the Kootenai, a tributary of the Columbia. In the northern end of the county there is usually sufficient rainfall for agricultural purposes, and irrigation has been practiced only to a small extent. In the southern valleys, however, its necessity and benefits have long been recognized. The principal areas of tilled land are in the southern part of the county in the valley along the Bitterroot river, which flows northward into the Missoula, the chief tributary of Clarke fork of the Columbia. The Bitterroot valley is over 50 miles in length and from 4 to 12 miles in width, with a large extent of arable land on both sides of the river. The land lying on the left or western side of the stream is well watered by the numerous creeks that flow from the Bitterroot range, which forms the boundary between Montana and Idaho, but on the eastern side the supply is less abundant.

The tilled land in the Bitterroot valley is mainly irrigated in a somewhat primitive manner by small ditches constructed by individual ranchmen or by a partnership of neighboring irrigators. These ditches lead from the mountain streams, and in a few cases, mainly on the east side, from the Bitterroot river itself. The irrigated land is on the bottoms along the streams, the bench lands back from the river being, as a rule, still untouched. By the construction of a large canal taking water from the Bitterroot near the head of the valley and following down near the foothills a very large area of bottom land, and perhaps some of the level lands, could be brought under irrigation. The altitude of the lands of this valley is from 3,200 to 4,000 feet, and the valley being sheltered by high ranges of mountains the climate is mild, being perhaps the most favorable in Montana for the cultivation of fruit. The agricultural land also possesses the advantage of having a ready market for produce at the mining towns in the adjoining counties. The water supply being in general ample large quantities are usually employed and the water duty is correspondingly low. Much of the lower land is gravelly and conducts the water away readily, so that a strong flow of water is necessary in order to irrigate successfully. By the application of plenty of water, however, the apparently worthless gravel bars along the Bitterroot river have been made to yield as high as 5 tons of alfalfa to the acre. During the spring floods the lower lands are in part submerged or saturated by seepage from the river, so that forage crops are successful without any further watering.

One of the largest irrigating canals in this valley is the Republican ditch, which takes water from the Bitterroot about 11 miles above Corvallis and a short distance below the mouth of Weeping Child creek, carrying it down on the east side of the valley to Hamilton and Corvallis, crossing Skalkaho creek on the way. The

total length of the main ditch is reported to be 14 miles, its width 12 feet, narrowing to 6 feet at the end, and its cost $16,000. A number of other canals, some of large size, have been projected, the valley offering apparently an excellent opportunity for investment on account of a large area of arable land and the facilities for obtaining water by the expenditure of a reasonable amount of capital. Several storage schemes have also been discussed, as there are excellent opportunities for holding the excess water of the spring in lakes or basins at the head of many of the small creeks whose summer supply is insufficient for the land now under ditch.

In the upper course of the Bitterroot above the main valley are a number of ranches, but here the arable land is limited and the water supply so great as to be in excess of all demands. On Rock creek, east of the Bitterroot valley, similar conditions prevail. There grazing is the principal industry, as there is little farming land, and the altitude is too great for many crops. Northwesterly from the Bitterroot valley down along the Missoula river are several open valleys, but in these irrigation is practiced only to a small extent on account of the expense of diverting water from the main stream. Crops can often be raised without the application of water, but during the drought of the past few years nearly everything has failed. The same conditions prevail farther down the river on Clarke fork of the Columbia, which is formed by the junction of the Missoula and Flathead rivers. For example, at Horse Plains are extensive areas on which good crops are occasionally raised, but the expense of taking water from the river is too great for the ranchmen. Some of the low-lying land along Clarke fork is wet by the annual overflow of the river, this being known among the inhabitants as subirrigation, and from the results following this occurrence the farmers are led to believe in the great benefit to be derived from a thorough system of irrigation.

The Flathead Indian reservation occupies a large part of the center of this county, including the lower part of Flathead lake and also the lands along the river draining the lake. Irrigation is practiced to a small extent by the Indians through the influence of the Jesuits, who have established missions among them. North of Flathead lake and beyond the reservation is an extensive area of excellent agricultural land along Ashley, Stillwater, and Clearwater creeks and Flathead river. Here crops of all kinds, wheat, oats, vegetables, and fruits, have been raised without irrigation, this method of agriculture, however being practiced to a small extent. In the droughts of 1889 and 1890, moreover, the crops were small in amount, in some cases being entirely lost, so that the farmers had their attention forcibly called to the advantages of a good water supply. Irrigation can probably be cheaply developed, as the rivers and tributaries carry a large amount of water throughout the year.

PARK COUNTY is in southern Montana, north of the Yellowstone national park, and receives a great part of the drainage of that elevated, mountainous region. The county itself contains many high mountain ranges, and is thus well watered, the available supply being in many cases in excess of the land to be irrigated. In the southern part of the county are the Beartooth and Snowy mountains, rising to heights of over 10,000 feet, being continuations of the great Absaroka range, from which comes the abundant water supply of the valleys to the south, in Bighorn county, Wyoming. The Yellowstone river, flowing northerly from the national park, passes through the wonderful canyons for which the river is famed and enters the county at its southern border. Here the canyon walls begin to retreat, leaving a narrow strip of lowland which in places widens out to a breadth of half a mile or more. About 25 miles beyond the county line the valley opens still wider, and the river for 35 miles is bordered by open land from 1 mile to 2 miles or more in width. Along this portion of the stream are several towns, depending mainly upon stock raising and agriculture. North of this open country the river plunges through what is known as the Lower canyon, emerging again into a comparatively wide valley, at the head of which is Livingston. Beyond this point the stream continues with rapid fall through narrow valleys, and is bounded usually by high bench lands, the remnants of the plain into which the river has cut its broad channel. The quantity of water in the Yellowstone has been measured at Horr, about 4 miles below Cinnabar, being thus above points of diversion. (*a*)

a The results are shown in the following table. In the diagram the discharge for 1889 is indicated by the lighter broken line, that for 1890 by the lighter continuous line, that for 1891 by the heavier broken line, and that for 1892 by the heavier continuous line.

DISCHARGE OF YELLOWSTONE RIVER AT HORR, MONTANA.

(Drainage area, 2,700 square miles.)

MONTHS.	DISCHARGE IN SECOND-FEET.			Total for month in acre-feet.	RUN-OFF.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1889.						
August 12 to 31.	1,853	1,411	1,660	102,090	0.71	0.62
September.....	1,653	1,126	1,270	75,565	0.52	0.47
October.....	1,126	841	976	60,024	0.42	0.36
November.....	841	651	743	44,208	0.31	0.27
December.....	.....	.....	*650	39,975	0.28	0.24

* Estimated.

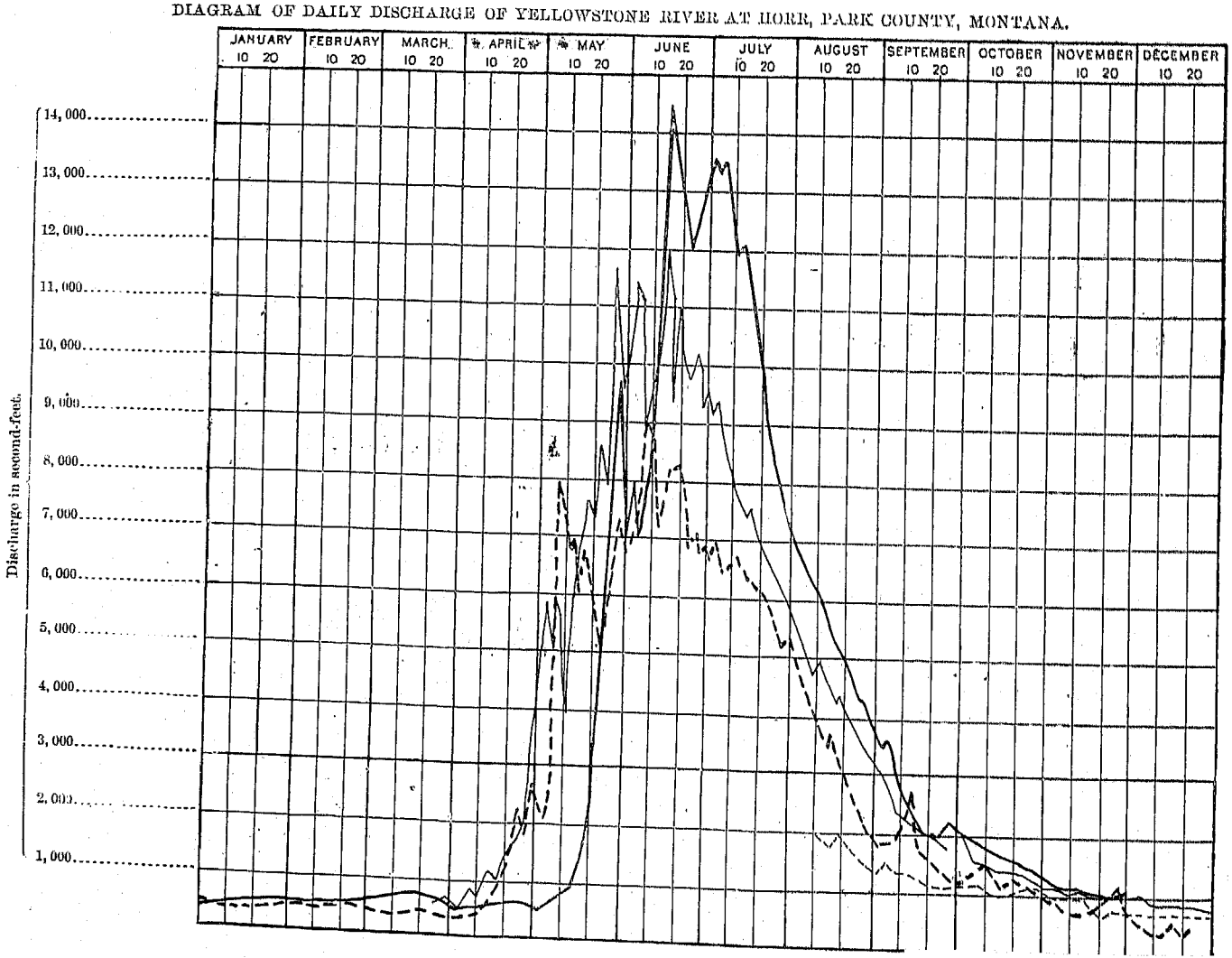
The agricultural lands along the Yellowstone and its larger tributaries receive their water from the smaller streams which issue from the high mountains on both sides. In general the water supply on the east side is better

DISCHARGE OF YELLOWSTONE RIVER AT HORR, MONTANA—Continued.

MONTHS.	DISCHARGE IN SECOND-FEET.			Total for month in acre-feet.	RUN-OFF.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1890.						
January			*550	33,825	0.23	0.20
February			*550	30,525	0.21	0.20
March 23 to 31	620	560	585	35,977	0.25	0.22
April	4,495	510	1,417	84,311	0.59	0.53
May	11,915	5,090	7,522	462,603	3.21	2.79
June	11,915	8,720	10,086	600,117	4.17	3.74
July	9,410	5,760	7,682	472,443	3.28	2.84
August	5,600	3,145	4,375	269,005	1.87	1.62
September	3,145	1,670	2,276	135,422	0.94	0.84
October	1,920	1,160	1,473	90,589	0.63	0.55
November	1,160	850	970	57,715	0.40	0.36
December	815	590	695	42,742	0.30	0.26
Per annum	11,915	510	3,181	2,315,334	16.08	1.18
1891.						
January	590	470	488	30,012	0.21	0.18
February			*500	27,750	0.19	0.18
March	360	285	316	19,434	0.13	0.12
April	2,720	360	1,082	64,370	0.45	0.40
May	7,480	1,855	5,227	321,460	2.24	1.93
June	8,975	6,685	7,592	451,724	3.13	2.81
July	7,110	5,090	6,135	377,302	2.62	2.27
August	4,020	2,060	3,442	211,683	1.47	1.28
September	2,625	1,250	1,641	97,630	0.68	0.61
October	1,610	1,080	1,264	77,736	0.54	0.47
November	1,080	680	801	53,014	0.37	0.33
December	745	360	475	29,212	0.21	0.18
Per annum	8,975	285	2,421	1,761,345	12.24	0.90
1892.						
January			*500	30,750	0.21	0.19
February	650	470	570	32,775	0.23	0.21
March	780	620	713	43,840	0.30	0.26
April	780	590	664	39,508	0.27	0.25
May	10,200	710	3,544	217,950	1.51	1.31
June	15,200	6,520	11,201	666,460	4.63	4.15
July	15,500	6,770	10,180	626,070	4.35	3.78
August	6,770	3,400	4,931	303,257	2.10	1.82
September	3,485	1,020	2,808	167,076	1.16	1.04
October	1,020	1,200	1,555	95,632	0.66	0.58
November	1,200	745	952	56,644	0.39	0.35
December			*800	49,200	0.34	0.30
Per annum	15,500	470	3,202	2,320,177	16.15	1.19

* Estimated.

DIAGRAM OF DAILY DISCHARGE OF YELLOWSTONE RIVER AT HORR, PARK COUNTY, MONTANA.



than that on the left or western bank, from the fact that on the former side the mountains are higher and are often covered with snow throughout the summer. In the valleys close to the mountains an occasional crop can be raised without irrigation. For example, fall wheat in a favorable season has been successful without the artificial application of water. A few ditches have been taken from the river to cover the lower lands, but the expense of maintaining them is often great. They have, however, plenty of water at all times, which is more than can be said of some of the other ditches.

In the larger valleys the water has already been filed upon to such an extent that the amount claimed far exceeds the total discharge of the streams, and the farmers fear that the ditches now under construction can not obtain sufficient water without taking what is now used or demanded by prior appropriators. The Yellowstone river itself carries more than enough water to irrigate all the agricultural land along its course, but unfortunately the level of the water in the river is too low to cover much of the best land, or the expense of building canals has been found upon survey to be so great as to be prohibitory for single individuals or even associations of irrigators, and thus attention has been confined to the smaller streams, leaving untouched vast tracts of fertile land to which in the future the river water may be brought.

The soil on the benches, while in general of excellent character, is occasionally very thin, appearing on the surface to be composed wholly of gravel. One case is cited on good authority in which the general level of the soil on the first thorough saturation was reduced from 1 foot to 1.5 feet or more, the underlying gravel beds being apparently consolidated by the excessive amount of water. In other cases the gravel was so open at first that large irrigating streams disappeared into the ground as though running into a sieve. In time, however, this open land becomes silted, and water can be used to advantage.

The ditches from the mountain streams are usually owned by individuals or by associations of ranchmen acting together and distributing the water equally or according to some agreement among themselves. Between the owners of the different ditches along the same stream, however, especially in cases where the water supply is short, there is little or no agreement. During the drought of 1889 and 1890 the necessity of efficient water supervision was appreciated more than before, and many complaints are made as to the defects of present methods, or rather lack of method, of distributing water to the ditches. All crops usually require two irrigations during the season, and at the time of the second application the water supply is, as a rule, running short, although plentiful in the preceding months; especially is this the case along Shields river, Medicine Bow and Sweetgrass creeks. In the southern part of the county, however, and especially in the southeastern part near the coal mines, where the valleys are narrow and the mountains high, it is probable that all the tillable land can be brought under irrigation by the present water supply.

SILVERBOW COUNTY is in southwestern Montana, lying across the continental divide, so that the snows falling upon the high peaks within this area furnish water to both the Columbia river and the Missouri. This is a mining county, agriculture being a comparatively unimportant industry, for the altitude is from 5,500 feet upward, and the climate is too severe for any but the hardier grains and forage crops. The city of Butte is in this county, as are several other mining towns of importance, and these furnish a ready market for agricultural products. The principal bodies of cultivated land are along the Bighole river, which forms for some distance the southwestern boundary of the county, or in the valley of the Silverbow, near Butte, in the northern end of the county. The ditches are mainly small and owned by individuals, the topography of the country being such that the irrigating ditches are quickly and cheaply made. There is ample water in the Bighole river for all the land along its banks, but in order to utilize this fully it will be necessary to construct one or more large canals. At present the water is taken out only upon the lowest land along the river and its tributaries, leaving the higher bench lands untouched, although these latter contain agricultural land as good if not better than that now utilized.

On Silverbow creek, one of the tributaries of the Deerlodge river, the water supply is not so abundant, and the irrigators state that as the timber is cut in the mountains the amount of water apparently diminishes year by year, or at least that which flows during the summer. Already several small reservoirs have been built by individuals, and others are projected. There are sites suitable for the construction of storage works, where water can be held for use upon the land along the Deerlodge valley. In some of the irrigating ditches below the mining region trouble is occasionally experienced on account of the débris or tailings from the mills, concentrators, and placer mines in the mountains. This fine material is in time of flood washed down in great quantities, and if then carried into the ditches it silts them up rapidly.

YELLOWSTONE COUNTY is a little southeast of the center of the state of Montana, lying in a southwestern prolongation of the Great Plains region, which covers the whole of eastern Montana. The surface is level or gently undulating, the general elevation being from 3,000 to a little over 4,000 feet. The county embraces that part of the plain which is south of the Musselshell river, the Yellowstone river forming its southern boundary. These rivers have carved narrow valleys through the plains, so that their bottom lands are bounded by steep bluffs 100 or more feet in height, and an observer traveling along the river courses finds them bounded by bench lands, whose nearly level surface appears to be so high above the river as to render the introduction of water upon them of doubtful practicability. The edges of these benches are in places cut by small tributaries of the Yellowstone and Musselshell or by coulees.

The principal industry is the raising of cattle and sheep, since the bench land, though dry, affords excellent grazing. Agriculture is practiced by the ranchmen, who irrigate the lower lands along the streams. The land on the benches, though apparently not so rich as that in the bottoms, would, nevertheless, be very productive, with the introduction of water. Before this can be done it will be necessary to make extensive surveys in order to determine whether it will be feasible to bring the water of the Yellowstone out upon this land. There is no question as to the supply of water in this magnificent stream or as to the possibility of bringing the water upon a portion of these high plains, but regarding the expense involved and the engineering difficulties to be encountered, as well as the acreage that can be profitably irrigated, there is much yet to be learned.

Along the Musselshell the land is rich, but the difficulty and uncertainty of obtaining water are great. The river was dry in 1890, and is always liable to be low or even to stop flowing during the latter part of the summer. On the other hand, the floods are destructive, and dams placed in the river for diverting the water have been washed out. The river is bounded by bluffs or banks so high that individual effort is rarely successful in taking out ditches, and the lands along the bottom are in general too small to repay the cost of a large canal.

There is one canal nearly 40 miles in length taking water from the Yellowstone and carrying it to Billings, thus covering a long strip of the lower land. Besides this canal, which is owned by a corporation, there are several of smaller size owned and controlled by farmers, and also a larger number of small private ditches irrigating one or two ranches. The annual cost of water from the larger canal is reported to be $2 a year per miner's inch. This quantity is commonly said to water an acre, although in fact it often covers more, and cases are reported where 40 to 50 miner's inches have raised crops successfully on 160 acres. On the other hand, where the farmer must conduct a small quantity of water in his laterals for some miles before using it, he states that it is difficult to irrigate at the rate of 1 acre per miner's inch on account of loss in transit by evaporation and seepage. Complaint is frequently made that at the rate of $2 per miner's inch the annual water dues become a burden too heavy for the ordinary farmer.

The development of irrigation is reported to have been retarded by the fact that the smaller owners can not afford to build extensive ditches, and the owners of large tracts of land, including some of the best land in the county, are holding these for speculative purposes. Most of the farmers migrated from the east, and on coming into the country either knew nothing about irrigation or believed it to be unnecessary, and it is only within a comparatively few years that the inhabitants have begun to appreciate the necessity and the possibilities of this method of agriculture. The difficulties in the way of taking ditches from the Yellowstone have prevented an extensive development of systems of small private ditches, which are so common in localities where the streams are small and easily controlled. High water ditches, that is, those receiving water in times of flood only, are, however, largely used. In a few instances the attempt has been made to raise water from the river by mechanical means, for instance, by the ancient Egyptian *noria* or undershot water wheel, which elevates the water by means of buckets placed on the rim of the wheel. The liability of much of this country to be visited by sudden local storms renders it necessary to locate and construct the ditches with extreme care, and to place flumes and other structures in such a manner that they will be exposed as little as possible to the torrents of rain which accompany these storms. The most notable canals in the county are briefly described below.

The Minnesota and Montana Land and Improvement Company's canal, mentioned above, takes water from the Yellowstone river at a point on the north bank about 35 miles above Billings. The total length of the canal is estimated to be 39 miles; its width, 24 feet; its ordinary capacity, approximately, 100 second-feet, and its cost, about $125,000. There is no dam across the river, the timber headgates being set in masonry, and the river banks on both sides protected by rock. This corporation sells water for the season, from May 1 to October 1, at the rate of $2 per miner's inch, measured under a 6-inch pressure. For example, the water flowing throughout the season from a box 12 inches wide, with the gate raised 1 inch from the bottom, is considered to be 12 miner's inches. It is claimed by the company that 40 inches will usually irrigate 160 acres. Farther down the river, on the north side and in succession, are the ditches known as the Italian Company's, the Mill, Clarke Fork, and the Yellowstone and Canyon Creek.

The Yellowstone and Canyon Creek canal heads about 16 miles below the canal above described and conducts the waters of the river for about 13 miles to the vicinity of Billings. The canal is 11 feet wide, carries ordinarily about 30 second-feet, and its total cost was $10,000. It is owned by about 20 stockholders, each taking an amount proportionate to the number of shares owned by him, measurement being made under a 4-inch pressure. The annual assessment for maintaining the canal is about 50 cents per acre, a portion of which can be worked out by the shareholder at the rate of $2.50 per day.

NEVADA.

Total population (average per square mile, 0.42)		45,761
Number of owners of farms (2.79 per cent of population)		1,277
Number of irrigators (91.39 per cent of farm owners, 2.55 per cent of population)		1,167
Area of state, land surface (109,740 square miles)	acres	70,233,600
Area irrigated in census year	do	224,403
Area of all farms, 43.52 per cent improved	do	1,661,416
Cereals raised in census year, including 54 acres in rye	do	15,530
Barley, average production, 29.35 bushels per acre	do	8,081
Corn, average production, 23.87 bushels per acre	do	274
Oats, average production, 28.40 bushels per acre	do	3,490
Wheat, average production, 22.44 bushels per acre	do	3,631
Alfalfa	do	49,215
Total value of all farms, including land, fences, and buildings		$12,339,410
Estimated total value of the farms irrigated in whole or in part		$9,200,000
Estimated value of all farm productions (sold, consumed, or on hand) for 1889		$2,705,660
Estimated value of productions, as above, from farms irrigated in whole or in part		$2,899,000
Average size of irrigated farms	acres	192
Average size of irrigated farms of 160 acres and upward	do	513
Per cent of acreage of irrigated farms of 160 acres and upward to total acreage irrigated		78.69
Average size of irrigated farms under 160 acres	acres	58
Average first cost of water right per acre		$7.58
Average annual cost of water per acre		$0.84
Average first cost per acre of preparation for cultivation		$10.57
Average value of irrigated land, including buildings, etc., in June, 1890, per acre		$41.00
Average annual value of products per acre in 1889		$12.92

GENERAL DESCRIPTION.

One of the most notable facts concerning irrigation in Nevada is the large average size of farms, 192 acres, this being nearly three times the average for the whole western United States. This is exhibited on the diagrams in the first part of the report, which also bring out clearly the undue proportion of large irrigated holdings, namely, those containing 160 acres and upward, these forming 78.69 per cent of the total area irrigated. The small holdings, those under 160 acres in size, are in the average larger than in any of the other states and territories. This condition of affairs is due mainly to the fact that the broad, nearly level, valley lands at the foot of high mountains are easily flooded during the spring, in some places almost wholly by nature, and thus the forage crops are easily produced. Probably over 90 per cent of the land irrigated in 1889 was covered with the native grasses and other hay producing plants. The average value of products per acre was low, exceeding only New Mexico and Wyoming, and the average value of irrigated land per acre was correspondingly small.

The general condition of agriculture is somewhat peculiar, since, taking the state as a whole, tilling the soil is an adjunct to stock raising. Owing to the enormous area of the state and its small and scattered supply of water, largely from springs, the ranches or farms, excepting on the extreme western border, are at a considerable distance from each other and at still greater distances from market. Transportation is expensive, and only sufficient produce is raised to supply home or local demands. In the broad, barren valleys of the state or among the rugged hills, wherever a spring occurs, some ranchman has bought or taken up 40 acres or more, sufficient to cover the source of the water, and, owning this, he can practically control thousands or hundreds of thousands of acres of grazing lands.

The state of Nevada lies almost wholly within the Great Basin region, the only exceptions being in the northeastern corner, where the state lines include a small portion of the Snake River basin, and the southeastern corner, in the Colorado River basin on the south. The Great Basin extends on the east beyond Nevada, including nearly one-half of the territory of Utah, as well as small portions of Idaho and Wyoming, but since Nevada includes so large a part of this area a general description of the basin is essential in order to give the principal topographic features of the state. The Great Basin, as the name implies, comprises a vast area within whose rim

are no streams contributing water to the ocean. All of the precipitation falling within the irregular lines bounding it must at some time be evaporated and again return to the atmosphere. In its round of life, however, the raindrop which has fallen within the basin may join other drops, becoming a rill and later forming part of a creek or large river, and then an infinitely small portion of some great lake, but from this lake it can only escape to join the ocean by taking on the form of aqueous vapor and floating away with the wind.

The Great Basin is bounded on its eastern and western sides by two great mountain masses, the Wasatch, in Utah, on the east, and the Sierra Nevada, in California, on the west. To the north and south of these ranges the boundaries of the basin are less distinctly marked, and the exact location becomes in places a little uncertain, as the line must be drawn along high plateaus or over broken country whose drainage is not well defined. These two great mountain areas, rising to heights of over 10,000 feet, by their superior altitude and consequent effect upon precipitation, give rise to many rivers, a few of which flow toward the Great Basin. Both were formed by the rising of great blocks of the earth's crust, these blocks being tilted, the uplifted edge forming the mountain crests. In each case the blocks tilt away from the Great Basin at a gentle angle and present toward it the steep, apparently vertical faces, so that the streams, which have deeply carved these great blocks, flow away down the long slope, draining comparatively large areas, while those flowing from the steeper face turn toward the Great Basin, descend with great rapidity, and have a comparatively small, though very steep, catchment area.

In the case of the streams of the eastern side of the basin in Utah the water supply is enormously increased from the fact that the rivers draining the gently sloping side of the Wasatch mountains do not flow away from the Great Basin, but turning abruptly pass through narrow, deep canyons and come out on the plains at the foot of the steep slopes. Thus it is that Utah enjoys such an unexampled water supply in spite of its otherwise unfavorable position. On the western side of the basin in Nevada, although many of the characteristics are similar to those on the opposite edge in Utah, yet this favorable circumstance is not found except to a very slight extent. The streams which rise on the far side of the Wasatch range westerly from the Great Basin continue to flow in that direction and finally enter the San Joaquin and Sacramento, so that Nevada receives only the drainage from the steeper slopes. A possible exception may be noted in the case of the Truckee river, which rises behind the Tahoe range and comes around the northern end of that range into the Great Basin. In many respects this is a counterpart of the Bear river of the northeastern side of the Great Basin, with its regulating lake and sinuous course, but in every way it is of far less size and less importance to agriculture. In short, the great streams of the eastern edge of the basin are but feebly represented on the western side.

The Great Basin as a whole rises gradually from south to north, the upper edge being at a general elevation of nearly 5,000 feet. It is higher in the center than on the eastern and western edges at the foot of the uplifted mountain blocks. Thus it is that the water collects in these depressions on each edge, forming on the west a number of small saline lakes, each fed by its own river, and on the east, with the greater water supply, a single great salt lake covering the place comparable to that of the smaller lakes on the other side. In consequence of the higher center of the basin, the greater portion of the drainage forming the Humboldt river flows from the center westerly toward the edge and there aids in the formation of the small lakes.

An almost innumerable array of smaller mountain ranges, trending north and south, fills the Great Basin and diversifies its surface by their bare and rugged peaks. Streams issue from some of these, but after a short course down the mountain sides and along a narrow valley they disappear into small saline lakes or sinks in the broader valleys between the ranges. Over hundreds or even thousands of square miles of lower mountains and desert plains there may not be a drop of water to be found during a great part of the year, and the unwary traveler is in danger of perishing from thirst. For months or even years rain does not fall on some of these vast plains, and the heat of summer renders the higher animal life almost impossible.

The climate within the interior basin has not always been as arid as at present, for within comparatively late geological time there have been fluctuations sufficient on the one hand to produce great lakes of fresh water, and on the other extreme to completely dry these, the ever-changing conditions again bringing about the abundant rainfall necessary to fill the ancient basins. The shores and beaches of these ancient lakes (*a*) form conspicuous features of the landscape of the present country, and the fine materials deposited upon their bottoms are now the level plains whose soil, when moistened, yields abundant crops.

Four rivers of notable size are formed by the drainage from the steep eastern face of the Sierra Nevadas. These are the Truckee on the north, the Carson, Walker, and Owens on the south. The first three of these flow westerly into the Great Basin and finally lose their waters in the saline lakes, the Truckee into Pyramid and Winnemucca lakes, the Carson into Carson sink, and the Walker into Walker lake. The fourth river, Owens, clings closely to the foot of the mountains and flows in a general southerly direction along the base. The Sierra Nevadas have a general northwesterly and southeasterly trend, while the state lines which bound this side of Nevada have courses which form small angles with this direction, and for this reason have a peculiar influence upon the water supply within this state.

a These ancient lakes, Bonneville on the east and Lahontan on the west, their extent and fluctuations, have been described in monographs of the United States Geological Survey.

The western boundary of Nevada coming from the north runs toward the Sierra Nevadas and crosses the eastern slope diagonally, ascending gradually toward the higher summits. When it reaches Lake Tahoe it turns abruptly to a southeasterly course and descends again diagonally down the mountain slopes to the plains beyond. Within this broad angle included by the state lines where they ascend and descend the Sierra Nevadas is included the most important portion of the state agriculturally and also as regards mining industries and population. The state lines on this side by their peculiar position, in both instances diagonal to the general course of the mountains, cut the drainage basins of the Truckee, Carson, and Walker, leaving the head waters and upper valleys in California and the lower fertile plains in Nevada. The fourth stream of this series, Owens river, lying along the mountains, is by the southeasterly direction of the state line left wholly in California.

These three rivers, the Truckee, Carson, and Walker, together with the Humboldt, which flows from the center of the basin toward the western edge, comprise practically the water supply of the state. There are other small streams and many springs, but none of these are of importance save to small localities or to individuals. The development of the agricultural resources of the state, therefore, depends upon the careful conservation of the waters of these rivers, and their utilization to the greatest possible extent. This fact has long been recognized, and steps, though somewhat halting, have been taken toward the investigation of the water supply and the best means of increasing the utilization of it. In all projects, however, Nevada as a state is hampered by the fact that her principal streams derive the greater part of their water from catchment areas lying within the state of California.

STORAGE RESERVOIRS.

There are many excellent localities for the construction of storage reservoirs upon the head waters of the Carson and Truckee, by which the excess waters of the early spring floods could be held for use later in the season. Surveys have been made of a number of the more important of these, and they have been reserved, at least such portions of them as belong to the United States, for reservoir purposes. The reservoir which has attracted the greatest amount of popular attention is lake Tahoe, and it has been urged that by holding its waters back by means of a suitable dam enormous quantities can be retained for the irrigation of thousands of acres. There is however, a question of water supply of the lake involved in this project which is seldom taken into account. The drainage area tributary to the lake of 506 square miles is, in proportion to the open water surface, which amounts to 192 square miles, exceedingly small, and it is doubtful whether in every year the lake can be raised to a height sufficient to furnish water to the amount anticipated. In this respect lake Tahoe is comparable to Bear lake and Utah lake on the eastern side of the Great Basin, namely, in being too large for economical water storage. The expense, however, of holding water within the lake would be very small, since the outlet can be readily controlled. One obstacle to the use of this lake as a storage reservoir for the dry lands of Nevada is that the lake is principally in California, as is also the natural outlet and a large part of the course of the Truckee river, which flows from it. The outlet is now under the charge of lumbermen, who use the water from the lake at certain seasons of the year to carry logs to the sawmills below.

In addition to the reservoir sites occupied in part by lakes, and to which public attention has been especially drawn, there are a number of localities scattered through the mountains at the head waters of the streams, many of which are suitable for holding water. These are mainly valleys, in some cases formerly occupied by glaciers and later by small lakes which in course of time have cut an outlet through the lower rims. A comparatively small expenditure of labor and capital will close the outlets, and by this means bodies of water of considerable size can be held. As previously mentioned these localities are mainly in California, while the lands to be benefited are far down the stream upon the deserts of Nevada, and there is uncertainty as to the requisite co-operation on the part of California in forwarding such enterprises. Another drawback is that these localities are in general owned and occupied as dairy farms, and a large price is put upon them whenever the matter of water storage is discussed.

FLUCTUATIONS OF WATER SUPPLY.

There is usually ample water for these storage reservoirs, which can be filled in April, May, or June during the height of the floods or during the winter months. The distribution of water in the streams throughout the year is perhaps best shown by the table on the following page, which gives the percentage of discharge month by month. With this is placed the percentage of rainfall for immediate comparison. The actual quantities of water in many of the important streams are given in tabular form under the descriptions of the counties on the following pages.

MONTHLY PERCENTAGE OF RIVER FLOW AND RAINFALL.

MONTHS.	Average run-off. (Per cent.)	Average rainfall. (Per cent.)
January	2.7	15.8
February	2.8	13.0
March	4.6	10.2
April	10.2	9.6
May	24.7	9.0
June	22.8	5.8
July	15.3	2.5
August	5.3	1.8
September	3.3	2.5
October	3.0	6.8
November	2.6	9.0
December	2.7	14.0

The above percentages of run-off relate strictly to the discharge of the Carson river for 1890, but it may be assumed that the Truckee and Walker follow about this general order. It is probable that the distribution of water in the Humboldt varies somewhat from this, a greater proportion flowing in March and less in June, the flow during fall and winter also being somewhat smaller. From an inspection of the table it appears that nearly one-half of the total amount of the water carried by the river comes in May and June, the amount falling off rapidly, so that by the end of July the rivers are below the average for the year. The distribution of the rain throughout the year has been taken from the records of the signal service obtained at 13 stations in the state where observations have been carried on for a period of at least 18 years. The average annual rainfall recorded at all of these stations was a little over 6.10 inches. Taking the months from November to March, inclusive, 62.00 per cent of the total rainfall for the year fell, this amounting to 3.78 inches. In the 7 months from April to October the average precipitation for all these stations was only 2.32 inches. It should be noted, however, that the localities where these measurements of precipitation were made are mainly in the Great Basin, away from the mountains, and at altitudes of from 4,000 to 6,000 feet.

It is evident from a consideration of these figures that farming without irrigation is practically impossible, except possibly on low grounds wet by seepage. Not only is the amount of rain exceedingly small but the distribution throughout the year is not favorable to the needs of agriculture, since such a large proportion falls during the winter. The average rainfall, 6.10 inches, above noted, does not by any means represent the rainfall in the Sierra Nevadas. As examples of precipitation at localities among the mountains may be given Boca, Cal., at an altitude of over 5,550 feet, with a mean annual rainfall for over 18 years of 15 inches; also Truckee, Cal., at an altitude of 5,820 feet, and rainfall of 27 inches. Still higher in the mountains, at Summit, Cal., where the altitude is 6,765 feet, the mean annual rainfall for 17 years was over 42 inches. It is from this abundant precipitation, mainly in the form of snow on the high mountains, that the rivers receive their supply. At rare intervals heavy storms may occur out in the basin, but these are of comparatively little value to agriculture, and in fact may be injurious. The rains falling upon the perfectly level lands in the center of some of the valleys sometimes convert them into broad lakes, the water standing to a depth of a few inches for several hours or days until evaporated.

In the employment of waters in irrigation it has been found here, as in other localities, that the irrigation of the higher land on the edge of a valley helps to water the lower ground, and that less water is required on the latter, and in some cases forage crops can be successfully raised by seepage alone from higher land. When water is first applied to the soil it often sinks in so rapidly that even with a large stream it seems impossible to saturate even an acre. Gradually, however, the water level is raised in the surrounding lands, and in the course of months or years the ground water of the vicinity has come so near the surface that a comparatively small amount of water suffices for a season's irrigation. The rise of the ground water is attested by the fact that wells previously sunk in dry earth to depths of 60 to 100 feet without reaching water are in some cases filled to within a few feet of the surface.

WELLS.

The waters from wells and springs have an exceptional value in Nevada on account of the general scarcity of surface waters. Taking the state as a whole, there are a large number of springs the waters of which in many cases are warm or hot and often too heavily charged with mineral matter to be useful for agriculture. There are a few shallow flowing wells in the state, notably in the vicinity of Carson. A number of deep holes have been drilled in different parts of the state, but without success so far as flowing wells are concerned. It is reported that a well was sunk by the railroad company at White Plains, Churchill county, west of the Humboldt and Carson sinks, to a depth of 2,345 feet, but without reaching water. Another well at Lovelocks, Humboldt county, north of Humboldt sink, was put down to a depth of 1,000 feet, but without success.

On the lower lands in Ormsby county are a number of small flowing wells from 100 to 150 feet in depth, delivering a quantity of water ranging from 2 to 25 gallons per minute each. Other small flowing wells have been found in Carson valley in Douglas county, in Washoe valley in Washoe county, on the low lands of Churchill county, near Battle mountain and Austin in Lander county, and also in Eureka and White Pine counties. In general it may be said that these wells vary in depth from 50 to 300 feet, are from 2 to 6 inches in diameter, and cost from $1 to $6 per foot according to depth and the success of the driller. The amount of water delivered is very small, almost insignificant in comparison to that carried by a small irrigating ditch, but is valuable for watering stock and for domestic purposes.

These wells are in many respects similar to those of Utah along the edge of Utah lake and Great Salt lake. It appears probable that in all of these valleys in which irrigation has been carried on for a number of years the waters have permeated the unconsolidated deposits of sand and gravel. These being interstratified with beds of clay and dipping slightly toward the center of the basin give rise to conditions favorable for small flowing wells in the lower portions of each valley. When a pipe is driven down through these alternating beds and penetrating the clay layers enters the gravel or sand, the water tends to rise to the surface and overflow if the top of the pipe is below the general level of the valley.

The probabilities of obtaining large artesian wells in the valleys of Nevada do not seem from present knowledge at all favorable, both because the deep wells drilled within the past few years have been in general dry, and because the large number and wide distribution of springs indicate a dislocation of strata unfavorable to the production of artesian wells. Exploration in this regard is being carried on occasionally, and it is possible that flowing waters of considerable local value, especially for supply of cattle, may be obtained.

IRRIGATING DITCHES.

The irrigating ditches of Nevada for convenience have been arranged in two groups, the first consisting of those having an average width of less than 5 feet and the second those of a width of 5 feet and over. The average cost per running mile of the smaller ditches has been found to be approximately $200 and of the larger $1,150 per mile, including in this the cost of headworks, flumes, and other structures. The average width of these larger ditches is about 8 feet, and there are comparatively few averaging over 10 feet in width, so few in fact that a separate class of this dimension has not been made as in the case of other states.

The average area irrigated by each ditch is 530 acres, excluding from this computation a number of larger ditches reported to irrigate tracts of unusually great size. For comparison with this, it should be noted that in Idaho the ditches irrigate on an average 385 acres and in Montana 225 acres, excluding in these cases a few of the large canals. This large acreage to each irrigating ditch is due not to better construction but rather to the fact that throughout a great part of the state irrigation is still in the first steps of development, not having advanced beyond the simple and wasteful methods of flooding the ground. Not only is a great portion of the water wasted but the results obtained are often of less value than would have been the case in the employment of better methods of irrigation, for by the use of too great an amount of water some of the most valuable species of native grasses are drowned out, coarse swamp grasses taking their places. The employment of too much water by one man not only diminishes the supply for other persons, but may injure the property of the user.

In the construction of these irrigating ditches little, if any, outside capital has been employed, but they have been dug by the irrigators, acting individually or in co-operation. The ownership is almost wholly within the hands of the farmers, and the administration of the water, if the general lack of system can be called such, is wholly within the control of the men who are directly benefited. Owing to the multiplicity of ditches deriving water from the same stream and the many separate interests involved, there constantly arise conflicts between irrigators as to the distribution of water, especially during the seasons when the supply is scanty.

CONDITION OF IRRIGATION IN EACH COUNTY.

NUMBER OF IRRIGATORS, AREA IRRIGATED, FARMS, AND CROPS IN EACH COUNTY IN NEVADA IN 1889.

COUNTIES.	Number of irrigators.	Area irrigated in acres.	Average size of irrigated farms in acres.	OWNERS OF FARMS. (a)		IRRIGATORS.		Area of counties in acres.	FARM AREA.		Cereals. (Acres.)	Alfalfa. (Acres.)	AREA IRRIGATED.			Average value of products per acre.
				Total number.	Per cent of population.	Per cent of farm owners.	Per cent of population.		Acres.	Per cent improved.			Per cent of area of county.	Per cent of total farm area.	Per cent of land owned by irrigators.	
Total	1,167	224,403	192	1,277	2.79	91.39	2.55	70,233,600	1,661,416	43.52	15,530	49,215	0.32	13.51	14.13	$12.02
Churchill	43	9,686	225	43	6.12	100.00	6.12	3,105,280	52,780	81.06	449	3,643	0.31	18.36	18.36	10.33
Douglas	26	4,250	163	38	2.45	68.42	1.68	570,880	22,502	61.42	1,429	822	0.74	18.89	22.78	9.68
Elko	250	56,305	225	262	5.47	95.42	5.21	11,297,280	538,527	48.55	5,709	3,911	0.50	10.46	10.78	8.49
Esmeralda	29	4,527	156	30	1.40	96.67	1.35	5,465,600	19,060	56.35	481	1,895	0.08	23.75	23.95	12.34
Eureka	38	6,344	167	41	1.25	92.68	1.16	2,656,000	143,390	8.89	2	2,633	0.24	4.42	4e45	10.10
Humboldt	116	56,680	489	147	4.28	78.91	3.38	10,611,200	418,815	45.01	8	5,938	0.53	13.53	13.85	14.44
Lander	52	7,857	151	59	2.60	88.14	2.29	3,389,440	71,129	24.22	913	623	0.23	11.05	13.52	10.45
Lincoln	95	4,400	46	98	3.97	96.94	3.85	11,315,200	18,805	54.78	971	410	0.04	23.40	24.48	13.04
Lyon	87	17,777	204	87	4.38	100.00	4.38	808,960	49,445	54.91	1,142	10,816	2.20	35.95	35.95	13.03
Nye	82	8,366	102	98	7.60	83.67	6.36	10,821,120	36,425	49.93	771	706	0.08	22.97	23.09	13.81
Ormsby	26	1,497	58	29	0.59	89.66	0.53	92,160	8,002	62.20	301	1,175	1.62	18.71	20.25	31.55
Storey	1	120	120	1	0.01	100.00	0.01	172,800	320	37.50	15	105	0.07	37.50	37.50	.....
Washoe	221	28,631	130	235	3.65	94.04	3.43	3,596,800	153,591	32.15	1,575	13,788	0.80	18.04	20.45	18.85
White Pine	161	17,961	178	109	6.33	92.66	5.87	6,330,880	128,625	51.06	1,074	2,750	0.28	13.96	16.07	12.33

a Includes owned and hired farms, assuming one farmer to each.

CHURCHILL COUNTY is in western Nevada, east of the row of small counties along the foot of the Sierra Nevadas. It contains on the extreme west a portion of Winnemucca lake, into which the Truckee flows, and on the north a part of Humboldt lake at the lower end of the Humboldt river. The most important bodies of water are Carson lake, near the southwesterly side of the county, and Carson sink, to the north of this, occupying evidently the lowest portion of this part of the Great Basin, since the drainage of the Truckee, Humboldt, and Carson finds the last resting place and ultimately disappears by evaporation. Carson river, entering the county from the west, flows in a general easterly direction, meanders through the nearly level bottom lands, and dividing into several channels discharges into Carson lake to the south or into the sink toward the north. In the broad valley in the vicinity of these lakes there are probably over 100,000 acres of rich land, the greater portion of which is lying idle for lack of water. The general altitude of this low land is under 4,200 feet and the climate is favorable for the production of large crops. The lands at present tilled form an insignificant part of that which could be brought under cultivation if water could be secured. By the construction of reservoirs at the well known sites along the Carson above this valley, ample water could be obtained for the irrigation of a portion at least of this desert area.

The present agricultural lands are along the Carson river and its various channels. Water is taken from the river and its sloughs by over 50 ditches, each leading to one or more ranches. The lower lands near the lakes have mainly an adobe soil, which, though fertile, is not as rich as that of the desert lands farther back from the river, but can be brought under cultivation at small expense. The water for irrigation is allowed to run on wild grass until the quantity is equal to that which would cover the surface to a depth of from 3 to 4 inches, the stream flowing steadily for 8 or 10 days, after which the water is turned off for a week or more, and then allowed to run upon the field again. Large areas of grass are thus brought under irrigation at small expense and with little labor, and great quantities of water are used at times when it is plentiful.

There are thousands of acres of good land in this county lying back from Carson river at an elevation slightly too great to admit of bringing water upon them except by the construction of long and expensive canals. In one case at least water is raised by means of a pump driven by an engine. This is said to deliver water at the rate of 100 miner's inches, irrigating 1 acre in 2 hours. The cost of the pump and engine is reported to have been $1,200. The fuel used is sage brush.

DOUGLAS COUNTY is the most southerly of those on the west side of Nevada and occupies the broad angle made by the change in direction of the line between this state and California. It extends easterly from Tahoe lake nearly to the Walker river, including in its southern extremity a portion of the West Walker. The east and west forks of the Carson flow from California northerly into this county and unite in the Carson valley, whose bottom lands have an altitude of from 4,700 to 5,000 feet. The agricultural land of the county is within this valley, mainly on the western side, water being taken from the east and west forks, and also from the small creeks which come down from the Tahoe mountains. On the east side of the Carson valley are broad deserts, whose fertile lands could be rendered highly productive by the use of waters obtained by storing the floods of Carson river. These lands are owned largely by a few individuals, some of whom have discussed the feasibility of attempting the construction of reservoirs. Examinations conducted by the United States Geological Survey and by private

enterprise have furnished data by which the cost of these improvements can be computed, and a large amount of information is available as to water supply and storage capacity, sufficient to show the feasibility of such schemes. The extension of agriculture in this county by use of stored waters rests upon the questions of water control and of securing sufficient capital to construct the systems. The information at hand carries the matter beyond the preliminary stages, and is sufficient to justify organization for definite ends. In the lower part of Carson valley is a locality suitable in many ways for the construction of a reservoir to hold waters for use upon the lands below Dayton in Storey county. In short, there is no lack of localities favorable for water conservation, the obstacles being of a financial or legal character rather than those offered by nature.

The quantity of water in the East and West Carson rivers has been measured at points (*a*) above the valley, the gauging station on the East Carson being at the Rodenbah ranch, about 14 miles from Genoa and 22 miles from Carson, and that on the west fork of the river being about one-half mile above the town of Woodford, Alpine county, California, which is 20 miles from Genoa and 32 miles from Carson.

The main Carson was measured on June 10, 1889, below the junction of the east and west forks. The discharge at that time was only 527 second-feet, a great part of the water being diverted by irrigation ditches at points above. In 1890 a station was established at the lower end of the Carson valley, near Empire, thus giving the discharge as shown above available for the valleys farther down below Dayton, in Lyon county.

a The results are given in the following tables:

DISCHARGE OF EAST CARSON RIVER AT RODENBAH, NEVADA.

(Drainage area, 414 square miles.)

MONTHS.	DISCHARGE IN SECOND-FEET.			Total for month in acre-feet	RUN-OFF.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1890.						
April 7 to 30	1,565	752	1,026	61,047	2.76	2.48
May 4 to 31	4,260	1,315	2,654	163,221	7.38	6.41
June	3,900	1,745	2,430	144,585	6.55	5.87
July	2,780	750	1,789	110,024	4.98	4.32
August	875	437	597	36,715	1.66	1.44
September	437	400	415	24,692	1.12	1.00
October	390	385	386	23,740	1.07	0.93
November	385	380	384	22,848	1.04	0.93
December	400	375	379	23,308	1.06	0.92
1891.						
January	395	385	388	23,862	1.08	0.94
February	715	377	402	22,311	1.01	0.97
March	1,650	390	783	48,154	2.18	1.89
April	590	410	452	26,894	1.22	1.09
May	1,884	1,010	1,445	88,867	4.02	3.49
June	1,884	565	1,328	79,016	3.58	3.12
July	1,190	445	618	38,007	1.72	1.50
August	447	390	408	25,092	1.14	0.99
September	400	385	388	23,086	1.04	0.93
October	385	385	385	23,677	1.08	0.93
November	385	385	385	22,907	1.05	0.93
December	480	385	438	26,937	1.19	1.06
Per annum	1,884	377	619	448,810	20.31	1.50
1892.						
January	405	375	390	23,985	1.08	0.94
February	400	290	388	22,310	1.00	0.94
March	445	400	422	25,953	1.17	1.02
April	535	400	478	28,441	1.29	1.15
May	2,590	480	1,226	75,400	3.41	2.96
June	1,790	715	1,158	68,782	3.11	2.81
July	715	420	506	31,119	1.40	1.22
August	420	410	413	25,399	1.15	1.00
September	420	410	414	24,633	1.12	1.00
October	420	410	416	25,584	1.16	1.01
November	535	400	414	24,633	1.12	1.00
December	5,540	400	1,097	67,465	3.06	2.65
Per annum	5,540	290	610	443,704	20.07	1.47

DISCHARGE OF WEST CARSON RIVER AT WOODFORD, CALIFORNIA.

(Drainage area, 70 square miles.)

MONTHS.	DISCHARGE IN SECOND-FEET.			Total for month in acre-feet.	RUN-OFF.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1890.						
April 9 to 30	448	145	284	16,898	4.56	4.06
May	924	318	657	40,405	10.83	9.40
June	1,284	448	614	36,533	9.79	8.77
July	606	252	380	23,370	6.27	5.43
August	240	90	135	8,302	2.23	1.93
September	86	70	75	4,462	1.09	1.07
October	78	54	67	4,120	1.10	0.96
November	58	46	49	2,915	0.78	0.70
December	58	42	53	3,259	0.87	0.76
1891.						
January	62	46	52	3,198	0.86	0.74
February	58	42	48	2,664	0.71	0.69
March	68	50	61	3,758	1.01	0.87
April	384	62	127	7,556	2.02	1.82
May	740	300	534	32,820	8.79	7.62
June	456	260	338	20,111	5.38	4.83
July	280	82	130	7,995	2.14	1.86
August	78	50	65	3,997	1.07	0.93
September	50	34	41	2,439	0.65	0.60
October	54	42	48	2,952	0.80	0.69
November	50	38	43	2,558	0.69	0.61
December	54	42	47	2,800	0.77	0.67
Per annum	740	34	128	92,938	24.89	1.83
1892.						
January	46	42	45	2,767	0.74	0.64
February	54	38	46	2,645	0.69	0.66
March	74	54	65	3,997	1.07	0.93

DISCHARGE OF MAIN CARSON RIVER AND FLUME, NEAR EMPIRE, NEVADA.

(Drainage area, 894 square miles.)

1890.						
April 16 to 30	2,307	1,337	1,565	93,117	1.95	1.75
May	6,278	1,751	3,475	213,712	4.48	3.89
June	4,276	2,311	3,143	187,008	3.92	3.52
July	3,115	1,491	2,159	132,550	2.79	2.41
August	1,421	215	756	46,494	0.98	0.85
September	215	131	144	8,568	0.18	0.16

ELKO COUNTY is in the northeastern corner of Nevada, adjoining Idaho on the north and Utah on the east. The greater part of the county is on the head waters of the Humboldt river, containing the catchment areas of the north, east, and south forks, which unite to form that stream. On the extreme north it also contains the head waters of Salmon creek and Bruneau river, which flow north into the Snake, and the east and south forks of the Owyhee flowing northwesterly into Idaho and Oregon. The northern part of the county consists of a great plateau 7,000 feet and upward in elevation, little known except perhaps to prospectors and to a few cattle men. In the southern part of the county, however, the topography is similar to that of the rest of the state, namely, high mountain ranges trending in a north and south direction with long, narrow valleys between them. From some of these mountains, as, for example, the Ruby and Humboldt ranges, a large amount of water flows in the various streams during the spring and early summer, thus rendering possible the cultivation of land along the base of the mountains. The agricultural land of the county is scattered, being in small patches where a stream comes out from the canyons upon nearly level land. Cattle raising is the chief industry, and irrigation is carried on mainly for the purpose of obtaining hay for winter feed, and to a less extent for pasturage for the stock, for which as a rule the larger part of the feed is found in the higher valleys among the mountains. A comparatively small amount of grain is also raised, as well as some vegetables for home use. The acreage in small grains has diminished during the past few years, owing to the lack of markets and to the high freight rates. As a rule the lands formerly used for grain have been planted to alfalfa or other forage crops and are being converted into hay lands.

The crop area as a whole has diminished owing to the droughts of 1888 and succeeding years and the unusually severe winter of 1889–1890, during which a great part of the cattle perished, in a few cases as high as 90 per cent. The expense of transportation is so great that with the decline of mining industries farming has hardly held its ground, and considerable hardship has been experienced by the greatly scattered agricultural population. The water supply as a rule is in ordinary seasons ample for present needs, except perhaps during the latter part of the year. The ranches being some distance apart and in most cases each upon its own mountain stream or group of springs, there is little complaint of interference of water rights.

In many localities the storage of spring water is necessary to insure a constant water supply and an increase of cultivated area. There are a number of excellent reservoir sites in the county, especially on the south fork of the Humboldt, where there is an abundance of water from the Ruby mountains; also on Bishop creek and on the head waters of Mary river and north fork of Humboldt, as well as on Susie and Maggie creeks. There is apparently ample water to fill reservoirs each year, and if built they will be of value not only to this county but also to lands in Eureka, Lander, and Humboldt counties along the course of the river. In one instance at least storage reservoirs have been constructed, and they are reported to be a financial success to the owners.

There are a great number of valleys in this county, on the edge of each of which are ranches utilizing nearly all of the available water. The principal groups of ranches are those in the vicinity of Tuscarora, on the head waters of the south fork of the Owyhee, and of the streams flowing southerly into the Humboldt; also along the east fork of the Humboldt from Wells westerly, along the western side of Ruby and Clover valleys, and on the south fork of the Humboldt. The methods of irrigation practiced in all these localities are of the simplest and least expensive kind. The streams diminish greatly in size or become dry in July, and therefore as much water as possible must be used early in the season. The irrigating ditches are plowed out to a size sufficient to bring water out of the stream bed, in which it is prevented from flowing by rough dams. The higher "sage brush" lands in general are planted to alfalfa, and the lower to grasses, timothy and redtop doing well on the bottom lands. By the irrigation of the alfalfa on the higher, more porous soil, the lower grounds usually become thoroughly wet and almost swampy in places. It is thus a matter of difficulty to make careful comparisons of cost and values of this kind of irrigation with those where the methods are more highly developed, for here, where thousands of acres are wet by simple diversion of a stream upon the higher edge of nearly level land, it becomes almost impossible to obtain with any exactness the crop area actually irrigated, since the distance the water penetrates and consequent area covered vary greatly with the season and character of the soil.

ESMERALDA COUNTY is in western Nevada lying along the state line adjacent to California, and having a general northwesterly and southeasterly direction. The northern half of the county is traversed by a narrow gauge railroad connecting with the Central Pacific at Reno and running south to Owens lake in Inyo county, California. The East Walker river rises in the Sierra Nevadas north of Mono lake in California, and flowing easterly and northerly, crosses the state line into Esmeralda county, and continues northerly into Lyon county, where it joins the West Walker. The main stream flows first north, then east, then southeast, returning into Esmeralda county, and emptying into Walker lake, whose waters escape only by evaporation. The portion of the East Walker which is included within the county lines and the streams immediately tributary to it furnish the greater part of the water supply available for agriculture. A number of small streams, however, issue from the mountains to the east of the East Walker river and furnish a small supply of water for the broad valley to the south of Walker lake.

The situation of this county in the valleys below the main range of the Sierra Nevadas adds to the difficulties of developing agriculture. The best reservoir sites are in another state, being on the head waters of the East

Walker in Mono county, California. There the waste water of the spring could be held to advantage for use upon the fertile valleys of Esmeralda and Lyon counties were it not for complications arising from state lines.

The unregulated water supply is so uncertain that the development of the resources without water storage is impossible. In 1889 the Walker river was dry in Mason valley, owing partially perhaps to diversions of water in Mono county, California. Several of the smaller tributaries of the East Walker, which rise within the borders of the county, can be wholly controlled, and small reservoirs can be constructed upon them, thus obviating any interstate complications, and there are probably other sites suitable for water storage on the small streams entering the larger valleys, so that many thousand acres can be redeemed even if the better sites in California are not utilized.

As a rule, owing to its scarcity water is used a little more economically in this county than in localities farther north. Irrigation is usually by means of small furrows about 30 inches apart, or by the check system, small ridges of earth being thrown up to hold the water to a given depth over each part of the field. Along the streams there are a few small meadows where clover, wire grass, and the native redtop receive sufficient moisture to grow, but these are of little importance in comparison with the irrigated forage crop. A great part of the lower ground is impregnated with various mineral salts, often requiring one to three years' irrigation before these are washed out. In some of the valleys the concentration of these salts, borax especially, is so great that they become a source of revenue.

EUREKA COUNTY is a little east of the center of Nevada, and comprises a narrow strip extending in a north and south direction, its northern end being crossed by the Humboldt river, along which are a number of ranches. It lies south and west of Elko county, to which it is similar in many respects, a description of the irrigation in that county applying to the condition of affairs in this. It has an advantage over some of the other counties of the state in being traversed by a north and south line of railway, which connects with the Central Pacific at Palisade and extends southerly to Eureka and to the mines at Ruby Hill. This railroad was built for the purpose of transporting mineral products and lumber, and is of less importance to agriculture, on account of the high rates for freight. It carries a comparatively large tonnage of hides and wool. Away from the vicinity of the Humboldt and of Trout and Pine creeks the water supply of the county is very scanty, and the prospects are not encouraging as to future development of agriculture by irrigation.

HUMBOLDT COUNTY is in northwestern Nevada adjoining Oregon, and separated from California only by the comparatively narrow Washoe county. It contains the lower course of the Humboldt river and the greater part of the sink where the waters of this river disappear by evaporation. The surface of the county consists of alternations of short mountain ranges rising to heights of 7,000 or 8,000 feet above sea level, some of the peaks reaching altitudes of over 9,000 feet. Lying between these ranges are nearly level valleys, the soil of which has been deposited from ancient lakes, or has been made by the action of wind and rain in bringing particles from the mountain masses. Among the mountains are many springs, which sometimes unite to form small streams. These brooks and creeks are swollen during the spring by the melting snow, and their waters flow out upon the desert valley land, but during many months of the year their beds and channels become dry, except high among the canyons.

The Humboldt is a river of entirely different character from the streams issuing from the Sierra Nevadas, so that direct comparisons can not be made. In many respects it is more like the Owyhee and the Malheur of eastern Oregon, which rise directly north of the Humboldt and flow in a general northerly and easterly direction into the Snake. Series of gaugings have not been made on the Humboldt, but two measurements are given by Russell in his monograph on lake Lahontan. These measurements were made below the mouth of the Little Humboldt, where the total drainage area was 10,600 square miles, that of the Little Humboldt alone being 1,650 square miles. The discharge on September 10, 1881, when the river was at the lowest stage of the year, was 48 second-feet, and on July 17, 1882, it was 750 second-feet. At this latter time the height of the river had fallen 3 feet from the maximum of the year and was declining rapidly, the discharge two weeks later being nearly one-half the amount given. A still later measurement of the river during a June flood showed a discharge of over 2,000 second feet. Humboldt lake, into which this river discharges, is reported to have been dry in 1879, but following this time of drought came high water which raised the lake until in 1882 it stood at a higher level than immediately before the drought. The amount of water in this lake, as in the case of all the other sinks of rivers, gives evidence as to the quantity which might be held by storage at points higher on the stream, and without further discussion it is evident that great areas can be brought under cultivation by thus storing the water and preventing the waste by evaporation as the water finds its way down the long sandy channel of the stream.

The principal streams of the county, besides the Humboldt, are King, Quinn, and Little Humboldt rivers. Quinn river rises in the valley between Disaster peak on the west and the Santa Rosa mountains on the east. It flows southerly through this valley, its channel turning westerly around the northern end of Jackson mountains to Blackrock desert on the western side of the county. During the time of melting snow a considerable amount of water flows down the channel to the desert, whose surface is so level that the water spreads out into a large lake of many miles in extent, but having a depth of only a few inches. This lake dries again in a few weeks, leaving the desert perfectly arid for the rest of the year.

King river rises in the valley to the west of the head waters of Quinn river, and flows southerly, its channel joining that of Quinn river above Blackrock desert. In floodtime, therefore, it contributes its share toward converting the desert into a lake. The Little Humboldt receives its water from the east side of the Santa Rosa mountains, south of the head waters of the Little Owyhee river, a portion of the Columbia drainage. The waters tributary to this stream seldom reach the main channel, although at times of unusual flood the Little Humboldt flows south to the Humboldt, joining it above Winnemucca. It may be said of the streams of this county that for the brief flood time of spring there is an excess of water which spreads out and fills the low valleys, while for the rest of the year not a drop of water is to be had except from an occasional spring in the mountains.

The Humboldt river itself is the only exception to this rule as to complete drought during the greater part of the year, for water has flowed continuously in its channel down to the Humboldt sink for 30 years at least, except in 1889. During this year of unusual scarcity the water was entirely used by the ranchmen along the upper courses of the river, little, if any, reaching the lower meadows. For this reason thousands of acres of hay land which had been cropped continuously for some years did not yield sufficient to repay the trouble of cutting. This condition may be regarded as unusual, but as it has occurred once the probabilities are that it will happen again, especially as the tendencies are toward greater and greater diversion of the water of the tributaries of the Humboldt.

The irrigators along the lower course of the river are anxious to secure some system of storing the excess water of the spring, for they fear that they will be deprived of their supply more frequently in future. The irrigators having ranches from Winnemucca down to the Big Meadows, where the soil is especially fertile, as a general thing, have first right to the water, but in spite of this fact they are not able to secure the amount to which they are probably entitled by prior appropriation. Lawsuits have been tried in the hope of compelling irrigators higher on the stream to turn down the water, but this, as is generally the case, has been of little real benefit. It seems practically impossible, in spite of laws or regulations, to compel one man to deliberately destroy his own property by turning away water in order to benefit individuals 100 miles away.

The principal body of irrigated land is along the Humboldt river and down toward the sink. Much of this rich land is very low, and it is hardly necessary to dig ditches to bring water upon it, for the annual rise of the river produces a natural irrigation, or in many cases water is raised and diverted by a dam across the river, causing large areas to be overflowed. Later in the season much of this ground is wet from beneath by seepage through the subsoil. Thus it is exceedingly difficult, if not impossible, to distinguish between the crops raised by irrigation, as the term is commonly employed, from those raised by the perfectly natural methods of overflow and seepage. The greater part of the land of the county is irrigated for hay, the acreage of cereals and vegetables being almost insignificant. The size of the ranches is very great, each containing several hundreds or even thousands of acres. On the irrigated land the heaviest of the hay only is cut and the cattle are turned in to graze upon what is left.

In Paradise valley on the Little Humboldt are large ranches irrigating hay crops principally, and there are at least 20 ditches taking water from Martin creek, the principal tributary of the Little Humboldt. This stream rises among peaks of the Santa Rosa mountains, whose heights are upward of 8,000 feet, and therefore it receives a comparatively large amount of water. On the head waters of Quinn river there is some irrigation for the purpose of raising feed for cattle and for small patches of grain and gardens. All the natural supply of this river has long since been appropriated. Besides these localities are several places, as in Pleasant valley south of Winnemucca, where irrigation is carried on near the foot of the mountains.

LANDER COUNTY is nearly in the center of Nevada, lying southeast of Humboldt county. Like Eureka county it extends in a general north and south direction and is traversed by a railroad running from Battle mountain on the Central Pacific to Austin, the headquarters for the mining and stock raising trade of that part of the state. Humboldt river crosses the northern end of the county and Reese river flows from the south, in time of flood contributing to the Humboldt. During the latter part of the summer and in the fall the river channel is dry at some distance above the junction of these two streams. There are thousands of acres of fertile land along Reese river, for which there is no apparent supply of water. From the head waters downward the stream in times of low water disappears in the sandy channel, water reappearing at various points where springs rise in the bed or sides. Cattle ranches are scattered throughout the county wherever there is water to be found for the stock and all of the streams are utilized in most seasons to their full extent for flooding the hay crops. In Smith Creek valley and also in Reese valley near Battle mountain are flowing wells of a depth of from 150 to 750 feet. The water from these wells is used for stock and the excess is allowed to flow out upon the ground, watering one or two acres of grass or occasionally small gardens. Along the Humboldt river are places, as in Eureka and Humboldt counties, where by the spring overflow of the river crops of hay are raised.

LINCOLN COUNTY is in the southeastern corner of Nevada, adjoining Utah, Arizona, and California. It extends from the Colorado river northerly half the length of the state, embracing on the south a great portion of the lowest part of the state, areas of considerable size near the Colorado river being below an altitude of 2,000 feet. The annual rainfall is very small, being from 8 inches down to less than 1 inch. The average for over 5

years at Pioche, where the altitude is about 6,200 feet, has been 6.5 inches. The southern and lower portions of the county are thus exceptionally dry, and the climate is semitropical in character, so that wherever water can be obtained the more valuable fruits can be raised, as well as cotton and sugar cane.

The principal agricultural settlements are along the Pahranagat valley; also along Muddy river, which flows into the Virgin, and on the Virgin river. The water supply of the Pahranagat valley is derived from a number of large springs which rise at intervals along the mountains. The most northerly of these is known as Hiko spring. About 5 miles south of this are Crystal springs, and farther south is Ash spring. The farming land lies in a narrow belt about 30 miles long and less than a mile in width. The springs deliver a nearly constant supply of warm water, which flows down the valley and forms a lake at the southern end. The lowest land was formerly a marsh, and requires draining followed by irrigation. In fact, the farmers on the lowest ground complain that for a large part of the year their land is under water, while the rest of the year they may suffer from drought. Above the low bottom land is a broad bench, furnishing excellent grazing for cattle during certain seasons of the year. If the water of the springs could be conducted out upon a portion of this bench by means of well built canals a larger area of better land could be brought under cultivation. With the present lack of markets and the impossibility of transporting the produce, it is doubtful whether such projects would repay their cost. At present the principal occupation is stock raising, and only sufficient of the small grains, vegetables, and fruits is produced to supply local consumption.

Along Muddy river, in the vicinity of Moapa and Overton, are a number of ranches, on each of which a small amount of grain is raised. On Virgin river the farms in the vicinity of Bunkerville are in many ways similar to those in Washington county, Utah. The bed of the river is constantly changing, rendering irrigation difficult and expensive, and the occasional heavy summer storms not only destroy crops but even wash away portions of the agricultural land. The climate is so favorable that the most valuable crops can be raised with success, and 5 cuttings of alfalfa can often be obtained. In this hot climate water must be used with great care on account of the presence of alkaline salts in the soil. In many cases the water can not be applied directly to the surface, for on evaporating it leaves a thin crust through which the young plant can not penetrate. The water is applied by means of small ditches or furrows at intervals of 30 or 40 feet, covering the field, the water saturating horizontally the intervening space but not wetting the surface.

LYON COUNTY is in western Nevada, a portion of it lying between Douglas and Esmeralda counties, the greater part, however, being to the east of the cities of Carson and Virginia. It is in general form somewhat the shape of a four-pointed star, one narrow projection running northward to the Central Pacific railroad, another westward up the Carson river to the quartz mills, the third eastward along a portion of the lower Walker river and out upon the desert south of Carson lake, and the fourth projecting southwesterly up the main Walker and the West Walker for a portion of its course, and then leaving the river continuing in a narrow strip to the state line of California. It thus includes Smith valley on the lower part of the West Walker river, Mason valley on the main Walker, and Churchill valley on the Carson.

The principal agricultural areas are in Mason valley, where the East and West Walker rivers unite. Here the altitude is a little under 4,500 feet, and the climate is highly favorable for fruits, as well as for various crops. In Mason and Smith valleys large areas are irrigated for alfalfa, two to three cuttings per year being obtained, and in many cases the cattle find pasturage on these same fields in early spring or late fall after the crop season. There being little or no market for this alfalfa it is fed for dairy purposes or for raising beef cattle. The lack of transportation facilities retards the development of these valleys. The land at present under cultivation is in area almost insignificant with that which might be cultivated by a better supply of water. The amount from the Walker river is nearly all utilized during the latter part of the crop season, and in years of drought there is scarcity for the land now cultivated, as in 1889, when there was large loss, particularly in the second crop of alfalfa. As in the case of the Truckee and Carson rivers, water storage seems to be the main hope of the irrigators, although apparently there is no present prospect of realizing any of the schemes, as the best storage sites are across the line in California. Water for use in Smith valley might possibly be held by a reservoir on or near West Walker river in the lower end of Antelope valley, and in the same way that for Mason valley in the lower end of Smith valley.

The ranches are mainly in the hands of a few persons owning large acreages, and the tendency seems to be to increase the average size of irrigated crop per farm rather than to diminish it. It is almost impossible for a settler to take out a new ditch to supply his land, and the expense of buying rights in an old ditch is too great for a poor man. A large amount of land is held for stock raising or for speculative purposes, so that the population increases very slowly. Along the Carson river in Churchill valley are a few irrigated areas, the principal crop being alfalfa. For these low, level lands there is often an excess of water in the latter part of May or early in June, followed by a drought later in the season. Storage could probably be provided for this flood water by utilizing some of the reservoir sites higher up the stream, in particular that in the lower end of Carson valley in Douglas county. The quartz mills along the river from Empire to Dayton, up stream from these agricultural lands, have first claims to the water, and the efforts of these mill owners to secure an ample supply during periods of drought will be of benefit to the agricultural land below, since the water after being used for power is returned to the river. There is,

however, a conflict of interest between the irrigators in the Carson valley above the mills and the irrigators farther down, the development of agriculture in the upper valley tending to decrease the supply for the lower.

Examples of the ditches of this county may be given. The Weston and Campbell ditch, taking water from the main Walker river and carrying it northerly toward Wabuska, is 8 miles long, averages 8 feet wide, and is owned by private parties sharing the water among themselves. The Dayton Ditch Company takes water from the Carson 1.5 miles above Dayton, carrying it out on the south side for a distance of 5 miles, covering land in the vicinity of Dayton. The average width is 6 feet and it cost about $10,000. There are three reservoirs on this ditch, each holding an amount of water equivalent to that usually flowing during 12 hours in the ditch. By this means the water flowing during the night is held for use on the next day. The Hougham and Howard ditch takes water from the Carson river about 16 miles below Dayton and carries it out on the north side for a distance of about 5 miles. The average width is 8 feet and it cost probably $5,000. The water is taken from the river by a permanent dam 6 feet in height, raising the water so that it flows into the ditch. The water in the river at this point has never completely failed, although failure has been reported both above and below.

NYE COUNTY is in south central Nevada, extending from the head waters of streams tributary to the Humboldt southerly to the California line. It embraces a great area of rough mountain ranges and nearly level barren valleys, whose only perennial water supply is from an occasional spring of cold or hot water often charged with mineral matter. In April and May, when the snow melts upon the high ranges, streams are formed which rush down the sides and out upon the valleys, forming short lived lakes or marshes. During these months vegetation springs up and affords excellent pasturage for live stock. Wherever water can be had for cattle to drink there the hardy ranchman has taken up his abode. If there is sufficient water for irrigation, various forage crops are raised for hay for winter feed; also small areas are planted to wheat, barley, oats, and vegetables. Among the mountain ranges are large deposits of mineral wealth, but the difficulty of transportation renders these almost valueless at present.

The principal crop areas are in the northern end of the county, where the altitude is greater and the water supply more abundant. On the head waters of Reese river, which flows northerly through Lander county, there are 20 or more ranches from the source of the river down to Austin. The water in this stream usually begins to fail about the middle of June, and is short at the time when most needed, in July. The altitude of this valley is from 6,000 to 7,000 feet. The seasons vary from one year to another, and irrigation sometimes begins in early April, or in other years on the first of May. The water supply for this valley, as well as for that lower in Lander county, could be improved materially by storage, but it is questionable whether with the present value of products this would be profitable.

In Big Smoky valley, to the east of Reese river, there is a small amount of irrigation from springs and from the creeks which flow in the early part of the year. The seasons, however, are short, and the valley is cold and subject to frosts. In the eastern end of the county, on Duckwater creek and White river, are a few ranches, the altitude here being a little less than in Big Smoky valley. In the southern end of the county is the great Ralston desert, south of this the Amargosa desert, and southeast of this Pahrimp valley, where there are a number of ranches. The altitude of this valley is less than 4,000 feet, and it has a comparatively good water supply in a few localities by the drainage from Charleston peak, which rises to an altitude of over 8,000 feet. The ditches of this county are all small, being taken mainly from springs or from the fluctuating mountain torrents. The Gooding ditch may be given as an example, taking water from the west side of the Reese river. The total length is 2.5 miles, width 3 feet, cost about $250, and area irrigated nearly 200 acres.

ORMSBY COUNTY includes a small area on the western side of Nevada, extending easterly in a narrow belt from lake Tahoe on the west across the Tahoe range and Eagle valley to Pinenut mountains. It is the smallest county of the state, comprising only 144 square miles, the greater part of this being mountainous. It includes the state capital at Carson, and in population ranks third in the state. The agricultural land of the county is mainly on the west side of Eagle valley at an altitude of 4,600 to 5,000 feet. The water supply is derived from streams flowing easterly from the Tahoe range, the principal of which are those in Ash and King canyons, and also Clear creek. A number of small farms are cultivated by the use of several of the cold or warm springs which occur in the valley. The Carson river flows through the eastern part of the county mainly in canyons, and its waters are not used to any considerable extent in this county. A large increase of agricultural area can be rendered possible only by the construction of storage reservoirs mainly to the west of Eagle valley. By providing efficient storage the lands in Eagle valley, especially those on the eastern side, now unutilized and worth from $1.25 to $5 per acre, would be worth from $25 to $50 per acre. There are a number of sites suitable for water storage, but the expense of construction, doubts as to permanence of title to the stored water, and questions as to financial success, as well as the general lack of co-operation among the land owners, have retarded developments in this line. In general it may be said that those irrigators having a supply of water sufficient for present needs do not fully appreciate the necessity of increasing the water supply, while the farmers who do not have ample water are often too poor to materially aid such projects.

STOREY COUNTY comprises a small triangular shaped area of mountainous country lying south of the Truckee river and east of the Washoe range. It is wholly a mining region, agriculture and stock raising having little or no importance in comparison with the mineral wealth. The population of the county is concentrated at Virginia, the population of that place, namely, 8,806, being nearly one-fifth that of the entire state.

WASHOE COUNTY extends in a long, narrow strip along the western edge of Nevada from Oregon nearly to Carson, the capital of the state. The principal part of the tilled land, as well as the population, is in the extreme lower end of the county in the vicinity of Reno on the Truckee river. The greater portion of the county north of this point is composed of irregular mountain areas surrounded by nearly level plains made by the sediment deposited from the waters of the ancient lake Lahontan. The soil is rich in many places, but the water supply is scanty and wholly insufficient for the needs of an agricultural population. The county also contains Pyramid lake, one of the two bodies of saline water into which the Truckee empties. The land under cultivation is principally in the vicinity of Reno, on the Truckee meadows, extending southerly up Steamboat valley. Water is derived from the Truckee river and from the small streams which flow easterly from the Tahoe range. The lower lands are wet partially by direct irrigation from ditches, but also in an indirect manner by seepage and by overflow during the spring floods.

In Lemon and Spanish Springs valleys, lying north and northeast of Reno, are thousands of acres of fertile land unutilized for lack of water. It is possible to bring under cultivation a large portion of this rich land by a system of storage of the waters of the Truckee river and by high line canals leading from the river or from these storage works. The expense, however, will be very great, and it is not probable that enterprises will be inaugurated for many years, as much of the land belongs to individuals who can not co-operate in a project requiring enormous capital, and also because many of the necessary storage sites are within the state of California, and are owned by persons who hold them at large prices. The amount of land under irrigation, however, can be greatly increased, first, by a more careful utilization of the amount available from the Truckee, and, second, by making use of smaller storage sites within the state of Nevada, particularly those near the base of the mountains.

The irrigators in this county look toward lake Tahoe as the great reservoir site, and believe that future development will rest largely upon the utilization of this lake; but from the reasons previously given, namely, the relatively great area of the lake and small drainage to it, as well as the fact that the outlet lies in California and is controlled in the interests of lumber men, it seems highly improbable that the county will receive as much benefit from this lake as from smaller projects. Water storage has been begun in a small way by making use of Washoe lake. A stone dam has been built across the outlet and Galena creek diverted by a ditch about 6 miles in length, so that the surplus water of that creek can be turned into the lake. The cost of this enterprise has been a little over $11,000. The principal obstacle was in the fact that the land around the lake is owned by private parties, each of whom was injured to a greater or less extent by raising the surface of the lake. Other storage schemes for holding waters among the foothills have not as yet been attempted on any extended scale.

On the hills and lower mountains is a natural grass most excellent for grazing, furnishing pasturage for large numbers of sheep and cattle. In many of the valleys in which water is too scarce for irrigation the small amount available is sufficient for stock ranging upon the hills. In many places wells have been successfully put down, as, for example, in Lemon valley, where windmills are used for raising water for cattle. Large quantities of alfalfa are cut for winter feed for the stock, two and sometimes three crops being had in a season. It is irrigated three or four times, while the wheat is usually irrigated four times, potatoes five times, and garden vegetables even more frequently.

Measurements of the amount of water in the Truckee river and its tributaries have been made at various points, mainly in the vicinity of Boca, California, and in the vicinity of Reno. This river may be considered as beginning at Lake Tahoe, whose drainage it receives. The outflow from the lake into the river on July 4, 1889, was 136 second-feet. The amount declined rapidly until on August 8 the outflow was 75 second-feet and on August 18 only 49 second-feet.

The first tributary of importance below the lake is the creek draining Donner lake and Cold Creek valleys, entering the Truckee from the north or left hand side. On June 28, 1889, the discharge of Cold creek alone was 11 second-feet, and on July 3 the united discharge of Cold creek and Donner creek was 18 second-feet, a nearly equal amount coming from each valley. On July 6 this total had declined to 10 second-feet, falling off rapidly until in August it was less than 2 second-feet. The total drainage area of both creeks is about 30 square miles.

The next tributary of the Truckee is Prosser creek, which drains Twin valley, flowing into the Truckee a short distance above Boca, Cal., and having a total drainage area at this point of 56 square miles. The discharge during April, 1889, averaged 100 second-feet; in May, 259 second-feet; June, 110 second-feet; July, 17 second-feet; August, 3 second-feet, and September, 2 second-feet, the stream during these latter months being nearly dry. In 1890 the average discharge during April was 340 second-feet; during the latter part of May, 817 second-feet; during June, 580 second-feet; July, 382 second-feet, and August, 102 second-feet, the average from April to August being in the two years, respectively, 98 second-feet and 444 second-feet. The discharge of the Little Truckee, flowing into the Truckee at Boca, Cal., is given in the table on the following page.

DISCHARGE OF LITTLE TRUCKEE RIVER, NEAR BOCA, CALIFORNIA.

(Drainage area, 179 square miles.)

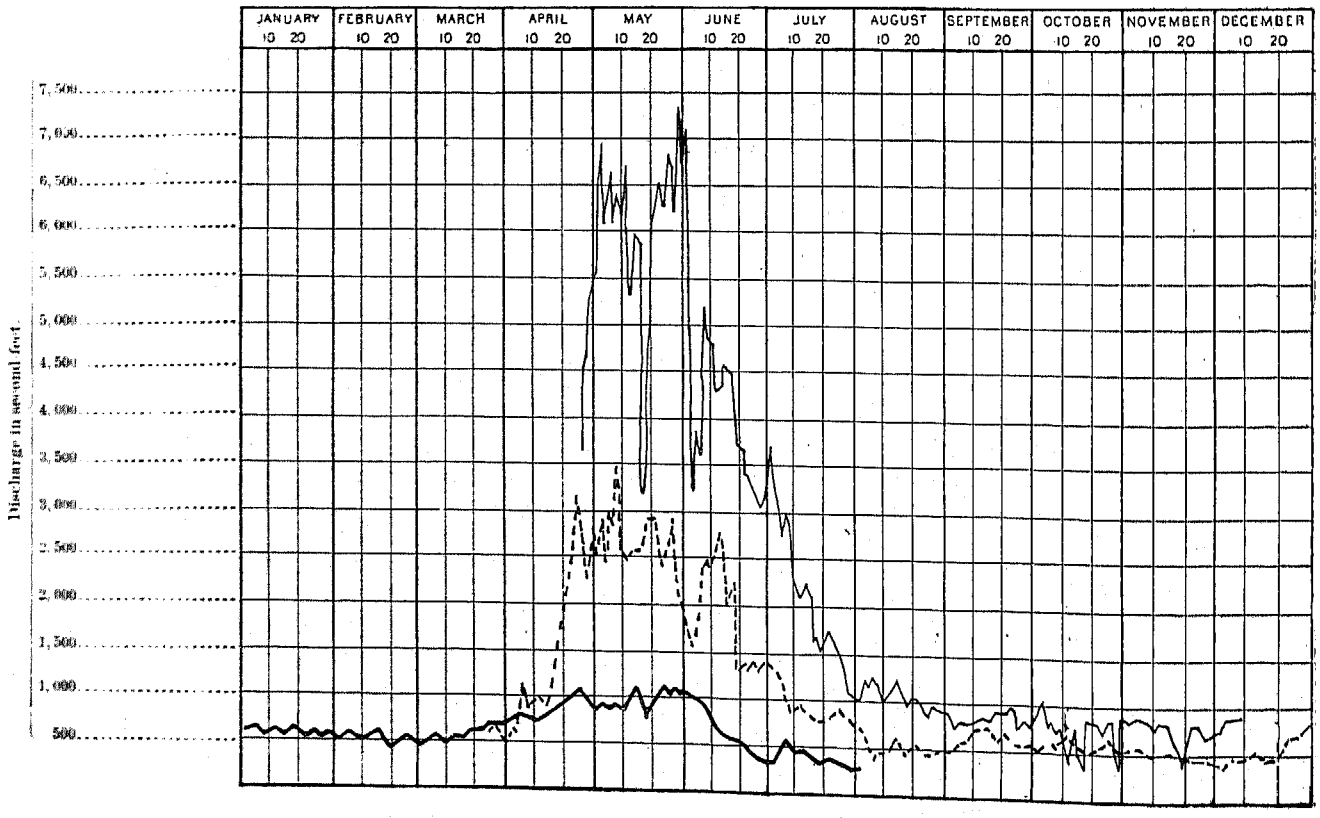
MONTHS.	DISCHARGE IN SECOND-FEET.			Total for month in acre-feet.	RUN-OFF.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1890.						
April 2 to 30	2,646	276	958	57,066	5.90	5.86
May	2,867	1,000	1,998	122,914	12.85	11.15
June	1,840	1,005	1,491	89,438	9.36	8.33
July	1,330	295	749	45,975	4.81	4.18
August	390	110	200	12,300	1.28	1.12
September	150	87	97	5,771	0.60	0.54
October	108	70	86	5,289	0.55	0.48

The Truckee river itself was measured near Essex, Nev., during the summer of 1889, giving the following discharges: for May an average of 2,314 second-feet; June, 771 second-feet; July, 278 second-feet, and August, 200 second-feet. The drainage area is 991 square miles. During the following year measurements were made higher up the stream at a point below Boca, Cal., where the drainage area was 902 square miles. Here the discharges were during the last week in March 637 second-feet, averaging in April 2,751 second-feet, and ranging during this month from 580 second-feet to 5,716 second-feet. In May the average was 5,275 second-feet, reaching the maximum of the year of 7,172 second-feet; in June the average was 4,291 second-feet; in July, 1,870 second-feet; August, 736 second-feet; September, 513 second-feet, and October, 555 second-feet.

The discharge of the Truckee was also measured during 1890 at Vista, 8 miles below Reno, the drainage area being 1,519 square miles. This point is below the Truckee meadows and above the lower canyon of the river, thus giving the discharge available for use upon the plains in the vicinity of Wadsworth. In general the discharge here is less than at Boca or points above Reno, from the fact that a large part of the water is diverted for use upon lands in the vicinity of Reno and south of it in Warm Spring valley. (*a*)

a In the following diagram the discharge for 1890 is indicated by the lighter continuous line, that for 1891 by the broken line, and that for 1892 by the heavier continuous line. The gaugings are for 1890, 1891 and 1892.

DIAGRAM OF DAILY DISCHARGE OF TRUCKEE RIVER AT VISTA, WASHOE COUNTY, NEVADA.



There are a number of large irrigating ditches in the vicinity of Reno, each taking water from the Truckee and carrying it north or south of the river in nearly parallel courses. The waters of the higher ditches tend to pass by seepage toward the lower, and they probably increase the amount in the lower ditches to a small extent. Taking the principal ditches in order, those on the north side are the Highland, Orr, Sullivan, and North Truckee, and on the south side the Steamboat, Last Chance, Lake, South Side, and Cochran.

The Highland ditch heads about 9 miles above Reno, is 15 miles long, 9 feet wide on top, and 6 feet wide on bottom, with an average depth of 3 feet. Its capacity is estimated to be 32 second-feet, irrigating 1,200 acres. The Orr ditch heads about 4.5 miles west of Reno, and flows in a general northeasterly direction through a portion of the town, the total length being about 9 miles. The top width is 12 feet, bottom width 8 feet, depth 4 feet, capacity estimated to be 77 second-feet, irrigating 2,600 acres. There are two extensions of this ditch, the Orr Eastern ditch and the Orr and Hayden ditch. It is estimated that the land under this ditch requires about 1 miner's inch of water to the acre, a greater amount being used upon new land. Water is delivered to the distributing ditches through measuring boxes, the amount being apportioned according to the estimated number of miner's inches. The pressure is usually taken as being 6 inches, measured above the center of the opening, namely, in the case of a box 10 inches wide, if the gate is raised vertically 2 inches, the water should stand 6 inches above the center of this opening, or 7 inches from the bottom of the box, in order to deliver 20 miner's inches. The ownership is divided into 248 shares, at an estimated value of $200 per share, each share entitling the owner to 10 miner's inches. Many of the shareholders do not own land, but rent the water to other persons.

The Sullivan ditch begins in the town of Reno, and carries water northeasterly about 4.5 miles. The width is about 7 feet, and cost, approximately, $6,500. The ditch is owned by private parties, who divide the water proportionally among themselves. The North Truckee ditch heads about 2.5 miles east of Reno, and runs northeasterly for about 10 miles. The width is 9 feet, and cost, approximately, $5,000. The ditch is owned by farmers who have formed a corporation.

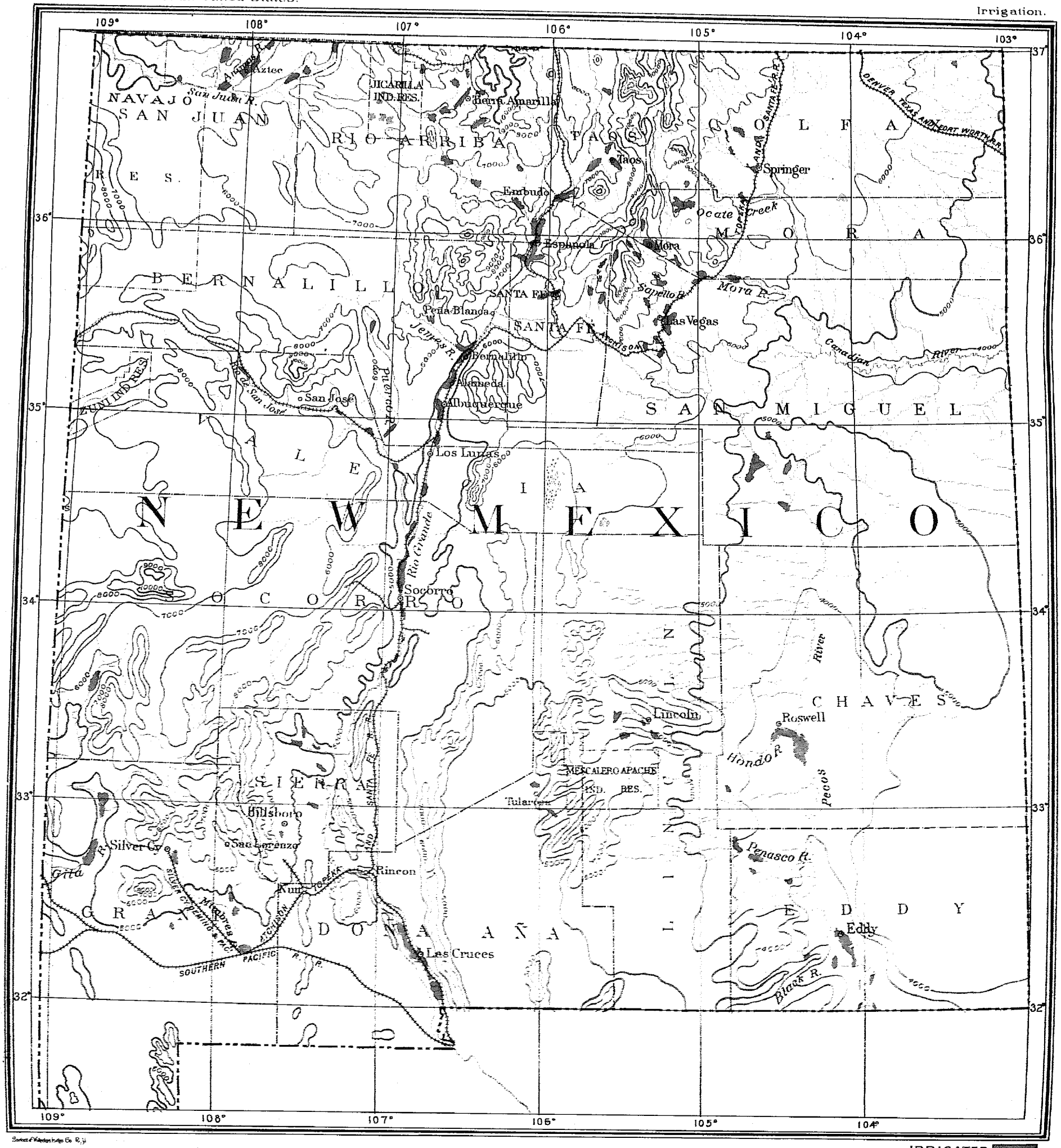
The Steamboat ditch takes water from the south side of the Truckee 15 miles above Reno, and carries it along the river and southerly toward Steamboat valley, a distance in all of over 30 miles. Its capacity is reported to be 65 second-feet. The South Side Irrigating canal heads about 3 miles west of Reno, and carries the water in a general easterly and southerly direction for a distance of 9 miles. The width is 6 feet, and cost about $15,000. The ditch is owned by irrigators, and the water is divided according to the number of shares owned by each individual, one share entitling the owner to approximately enough water to irrigate an acre. The Cochran ditch heads in Reno, and carries the water southerly for about 8 miles. The width is 6 feet, and the ditch cost about $7,000. The first cost of water right is estimated to have been from $5 to $25 per acre, and the annual cost about 25 cents per acre. These statements will serve to give a general idea of the size and cost of the ditches of this county. The laws of the state require that each ditch owner shall file a sworn statement giving a description of the ditch, its dimensions, capacity, grade, land irrigated, and other information from which data can be obtained as to the extent of appropriation of water. The statements regarding the capacity of the ditches are, however, open to question, being in general largely in excess of the amount of water actually carried.

DISCHARGE OF TRUCKEE RIVER AT VISTA, NEVADA.

(Drainage area, 1,519 square miles.)

MONTHS.	DISCHARGE IN SECOND-FEET.			Total for month in acre-feet.	RUN-OFF.		MONTHS.	DISCHARGE IN SECOND-FEET.			Total for month in acre-feet.	RUN-OFF.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.		Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1890.							1891.						
April 26 to 30	5,610	3,730	4,496	267,512	3.30	2.96	July	1,345	730	945	57,928	0.71	0.62
May	7,510	3,200	5,990	368,385	4.55	3.94	August	690	390	485	29,730	0.37	0.32
June	6,710	3,115	4,162	247,639	3.06	2.74	September	670	430	558	33,201	0.41	0.37
July	3,730	1,185	2,198	135,177	1.67	1.45	October	630	510	561	34,389	0.42	0.37
August	1,152	750	952	58,548	0.72	0.63	November	550	430	503	29,928	0.34	0.30
September 21 to 30	825	570	682	40,579	0.50	0.45	December	730	370	508	31,242	0.35	0.30
October	1,030	490	742	45,633	0.56	0.49	Per annum	3,285	370	980	709,530	8.69	0.63
November	825	400	765	45,517	0.56	0.50							
December			750	46,125	0.57	0.49	1892.						
1891.							January	755	450	593	36,469	0.45	0.39
January			700	43,050	0.54	0.46	February 1 to 20	630	430	505	29,037	0.36	0.33
February			650	36,075	0.44	0.43	March	850	550	723	44,464	0.55	0.48
March			650	39,975	0.56	0.43	April	1,630	775	854	50,813	0.63	0.56
April	3,115	570	1,523	90,618	1.12	1.00	May	1,120	590	937	57,625	0.71	0.62
May	3,285	1,990	2,765	170,047	2.10	1.79	June	1,060	370	628	37,366	0.46	0.41
June	2,730	1,280	1,905	113,347	1.39	1.25	July	530	210	328	20,172	0.25	0.22

WHITE PINE COUNTY is on the eastern side of Nevada, adjoining Juab and Millard counties, Utah. The valleys are at an elevation of 6,000 to 7,000 feet, and the climate in many of them is too cool and frosty for agricultural success every year. The water supply is very limited, and wherever a spring is to be found its waters are employed to their full extent for the irrigation of alfalfa and grass, and to a less extent for produce for home consumption. The population is scattered in the numerous valleys; in Steptoe valley, for example, the ranches are from 1 to 10 miles apart, each being near some small creek flowing from the mountains. The tilled areas are mainly in the vicinity of Cold creek in the northwestern corner of the county, in Newark valley near Eureka, near Cherry creek or Schellbourne in the northern end of Steptoe valley, and all along down toward Taylor in the southern end of the valley. South of Cherry creek are the Campbell ditches, taking water from Warm springs. The total length is 6.5 miles, average width 3 feet, cost $2,000, and area irrigated about 1,200 acres, most of this being hay. This is a fair example of the small ditches owned by the various ranchmen depending upon springs for water supply.



MAP OF NEW MEXICO SHOWING AREAS IRRIGATED IN 1889.

IRRIGATED

NEW MEXICO.

Total population (average per square mile, 1.25)		153,593
Number of owners of farms (2.90 per cent of population)		4,458
Number of irrigators (69.20 per cent of farm owners, 2.01 per cent of population)		3,085
Area of territory, land surface (122,460 square miles)	acres	78,374,400
Area irrigated in census year	do	91,745
Area of all farms, 33.39 per cent improved	do	787,892
Cereals raised in census year, including 81 acres in buckwheat and 69 acres in rye	do	61,340
Barley, average production, 23.60 bushels per acre	do	1,484
Corn, average production, 20.45 bushels per acre	do	28,539
Oats, average production, 20.81 bushels per acre	do	9,314
Wheat, average production, 15.72 bushels per acre	do	21,853
Alfalfa	do	12,134
Total value of all farms, including land, fences, and buildings		$8,140,800
Estimated total value of the farms irrigated in whole or in part		$4,677,000
Estimated value of all farm productions (sold, consumed, or on hand) for 1889		$1,784,820
Estimated value of productions, as above, from farms irrigated in whole or in part		$1,174,000
Average size of irrigated farms	acres	30
Average size of irrigated farms of 160 acres and upward	do	312
Per cent of acreage of irrigated farms of 160 acres and upward to total acreage irrigated		21.45
Average size of irrigated farms under 160 acres	acres	24
Average first cost of water right per acre		$5.58
Average annual cost of water per acre		$1.54
Average first cost per acre of preparation for cultivation		$11.71
Average value of irrigated land, including buildings, etc., in June, 1890, per acre		$50.98
Average annual value of products per acre in 1889		$12.80

New Mexico in many respects can be contrasted with Nevada, both in the character of its population and in the methods and results of irrigation. One of the most striking features was the small average size of irrigated farms, 30 acres, these being less than one-sixth the size of the average in Nevada. In this respect New Mexico was surpassed only by Utah, where the irrigated areas averaged 27 acres each. There were very few large irrigated holdings, and these in the aggregate formed only 21.45 per cent of the total area irrigated, this being less than one-half the average for the United States. The average value of products in 1889 was, however, not as high as might be expected, being next to Wyoming, the lowest in the list. The average small farmer, especially of Spanish and Indian descent, has shown little energy or skill, and as a consequence the returns have been small. In cost and value of water rights the territory occupied an intermediate position. The facts concerning these were obtained mainly from modern ditches, the older irrigating works having been built for so many years that it was impossible to obtain even an approximation of their cost.

GENERAL DESCRIPTION.

New Mexico can be divided into three great geographical divisions. On the east are the broad plains, which, extending nearly one-third of the way across the territory, gradually rise to form the plateau which is the base of the Rocky mountains. The rivers which issue upon the plains from the mountain ranges in the northern part of the territory flow eastward and finally unite in the Canadian, a tributary of the Arkansas. South of this drainage, however, the rivers, after flowing eastward a short distance, unite and flow southward into the Pecos, a tributary of the Rio Grande. On the western side of the mountain ranges is the long, narrow valley of the Rio Grande, which traverses the territory from north to south, being confined for a great portion of its way by lofty mountain ranges. In the central and southern parts of the territory, cut off by high mountains from the Great Plains region and the narrow Rio Grande valley, are elevated table lands, perfectly arid, excepting at the edge adjoining the foot of the higher mountains, from which small streams issue. These broad plateaus are useless even for grazing, although their soil could be rendered productive by the application of water. On their margins, however, especially among the western foothills of the Sierra Blanca, agriculture is carried on along the creek bottoms. West of the Rio Grande valley are the high plateaus and mountain ranges, many of them timbered, which form the continental divide, and from which flow the tributaries of the San Juan and Gila rivers, part of the Colorado river drainage.

The agriculture of the territory is governed in its character by these great natural divisions. On the east cattle raising has for years been the only industry, and the farmer has been prevented from entering upon the domain of the cattle kings. It was therefore only among the foothills in the western end of Mora and San Miguel counties that agriculture existed in this eastern division. The Rio Grande valley, however, has from the earliest times been the home of agriculture by irrigation. The original Indian inhabitants, and subsequently the Spanish invaders, took water from the river and its tributaries, not only in very much the same manner as that now prevailing, but even to some extent by the same ditches. There has, in fact, been comparatively little change in many localities along this river within the memory of man. The towns are located at short intervals, wherever the valley widens out to form bottom lands of an extent sufficient for agricultural purposes. Each town or group of farms has its own ditch, and where the population is comparatively dense these small ditches cross and intermingle in apparently the greatest confusion. Owing to the lack of system there is a great loss of water, which might often be avoided by the construction of a single well built canal in the place of the many poorly constructed ditches.

The water is diverted from the river by means of temporary dams, constructed of bowlders and brush. These are often swept away by floods, and thus a loss of crops has at various times occurred, not because of any lack of water in the river, but because a sudden freshet has destroyed the headworks of the ditch. Usually only the lowest lying land has been irrigated, and from lack of drainage this land has in certain localities become so saturated with alkaline salts as to be worthless, resulting in the abandonment of farms, and even in the desertion of some small towns. Artificial drainage, therefore, is for such localities as necessary as irrigation.

Many Mexican farms are long, narrow strips, from 25 to 300 yards wide by about 1,000 yards long, extending from the river up the slope of the hill. As these are divided by inheritance, they are cut lengthwise, so as to give each heir a water frontage, the result being that farms so dealt with eventually become mere strips. Owing to this inconvenient form of the tract to be irrigated there is a considerable loss both of water and of time. The ditches are owned in common by the farmers of each community, and one of the irrigators is annually elected to the position of superintendent of the ditch, his business being to attend to all necessary repairs, and particularly to regulate the distribution of water, which is done largely according to his judgment. Although in the Mexican methods of controlling water there is much to criticise, there is nevertheless one fact which is worthy of commendation, and that is that the control of the water is in the hands of the farmers. The general appearance of shiftlessness and the lack of progress are due rather to climatic and race characteristics than to the defects of the agricultural system, and there is no doubt that security of water right has been insured by this common ownership of the chief source of agricultural wealth, namely, the running water.

Taking the territory as a whole, the water supply of New Mexico is comparatively well distributed, nearly all the counties of the territory having small rivers, and some of them large ones. Unfortunately, however, much of the water is far below the level of some of the best arable land. For example, the Rio Grande, the largest river, at the point where it enters New Mexico, has cut through a great lava covered plateau and flows at a depth of from 500 to 1,000 feet below the general level, a depth so great that by no possible means can water ever be brought upon much of this fertile land. Its tributaries likewise, soon after leaving the mountains, cut through this lava sheet and excavate deep canyons in the soft underlying rocks. Occasionally these narrow canyons open out, as, for example, into the valley of Espanola, where there is a large amount of irrigable land; then, the walls closing in again, the river flows through other canyons until it emerges near Pena Blanca and enters the northern end of Albuquerque valley. This alternation of canyon and narrow valley continues throughout the entire course of the river in this territory, the agricultural land being confined to the bottom lands, or lower mesas, near the river. The investigations of the United States Geological Survey have shown that the lower ends of many of these valleys furnish excellent reservoir sites, where flood waters can be stored for the benefit of the valleys below.

As in the case of Arizona, it may be said that in New Mexico nearly all the water that can be taken out upon arable land by the efforts of individuals or of farmers acting in partnership has now been appropriated, and further agricultural development must come by greater economy in the use of the present water supply and the conservation of waste waters. There are many small streams issuing from the mountains, which sink into the ground within a few miles from the point where they leave their canyons. These streams are not tributary to any river, and the farmers who have appropriated their waters are independent of the actions of other irrigators who may depend upon neighboring streams. The amount of land irrigated by these streams depends entirely upon the care with which the water is used and upon the conservation of the floods. No one outside of this small group of farmers is directly interested in the water.

In sharp contrast to the conditions of irrigation along these small lost rivers are those obtaining in the case of the irrigated lands which depend upon the great river systems of the territory, as, for example, that of the Rio Grande. Here, where the water is in great demand, the action of each individual farmer is of more or less importance to every other farmer throughout this great drainage system, for all alike depend upon the one great source of supply, and waste by one person when the water is in great demand may mean loss to somebody else.

So long as there is water enough for all there is no necessity for regulation or co-operation, but when the time comes that the land under cultivation exceeds the quantity of water that is available for its cultivation, then arises the necessity for a broad co-operation among the farmers along the river and a government by those interested so far-reaching that the rights of each one shall be protected.

Agriculture has increased near the head waters of the Rio Grande until in that portion of the river basin which is in Colorado there is more than three times as much land under irrigation as there is along its entire course in New Mexico. As a result of this, and perhaps also of climatic oscillations, the lower valleys have received less and less water, the drought being especially felt in those counties farthest south. As irrigation increases, however, the scarcity of water can not fail to be appreciated farther and farther toward the north. The farmers in these lower valleys, whose rights date back for an indefinite period, look with apprehension toward the future, fearing that all the water will be absorbed by the newer ditches farther up the river. Water storage in this great drainage basin is, however, not a matter that can be entered upon immediately or without great care. It demands a comprehensive knowledge of the water supply and of the factors by which it is modified, as well as the highest engineering skill. Canals and ditches may be laid out with less care and foresight, their failure or even their destruction involving only the property of their owners; but by weak storage dams the lives of entire communities, to say nothing of property, may be placed in constant jeopardy. The proper location of these works, their financial success, and the necessity that the greatest good shall be done to the greatest number, demand a broad yet detailed knowledge of the topography and agricultural resources of the entire basin

WELLS.

In New Mexico a number of attempts have been made to obtain artesian water, but in the majority of instances the deep wells, though reaching an abundant supply, have not been successful, in that the water does not rise to the surface and overflow. There is reported to be a well near Springer, Colfax county, delivering water at the surface, and it is possible that attempts lately made in Mora and San Miguel counties have been successful. Near Raton a drilling has been made to a depth of over 1,800 feet without obtaining artesian water. At Las Vegas a well over 1,600 feet in depth has a very slight discharge, and at Santa Fe in a well 360 feet in depth water rises to within 70 feet of the surface. In the vicinity of Roswell, in Lincoln county, a well 207 feet in depth and 1.5 inches in diameter is reported as discharging 10 gallons per minute.

At Deming, Grant county, water is obtained in large quantities by wells 40 feet or more in depth. This does not rise to the surface, but is pumped by windmills, of which there are many in use. An effort has been made to obtain water from greater depths in the hope that it might rise to the surface, and drilling in one case has been continued for 1,000 feet or more. The water is reported to rise within 10 feet of the surface and to be found in almost inexhaustible quantities. Near Fort Wingate, in Valencia county, a well 75 feet in depth is reported as flowing, but the amount is not stated.

VALUE OF PRODUCTS.

The average value of products per acre, as shown in the following table, is usually less on the large irrigated farms, but the operation of this rule is not always apparent in New Mexico, owing to the diversity in the methods of cultivation and in the habits of irrigators. As a rule, the average value of products from the lands of farmers whose names indicate that they have migrated from the eastern states is placed higher than that of the products of farms cultivated mainly by Mexicans, whose holdings are usually of small size, and who also report the average value of their products per acre in very small figures. The standard of living varying so much among the different races inhabiting the territory, a comparison of values and products on a uniform basis is difficult and somewhat unsatisfactory. Both the Mexican and the Pueblo Indian have placed very low estimates on the cost of their ditches and the value of their products, but, on the other hand, the cost of their subsistence is proportionately small.

The average value of products to the acre is greatest in Bernalillo county, containing many small, well cultivated farms, with vineyards, orchards, and market gardens, the produce of which finds a ready sale. Next in importance comes Valencia, with its small farms; then Lincoln, with larger farms, owned mainly by an English speaking people; then Socorro, similar in situation to Bernalillo; then Colfax, Grant, and others. The lowest average value of products to the acre is in San Miguel and Mora counties, where the principal farming area is owned by Mexicans and the water supply is scanty. Next to these comes Donna Ana, where the average under ordinary circumstances should be high, but where it is somewhat reduced, owing to lack of water and consequent loss of crops.

Agriculture, as practiced under the old Mexican system, can not be said to be profitable if account is taken of the labor which is required. The small ditches, often poorly constructed, require an immense amount of labor to keep them clean and in repair, and the water is applied to the land in a laborious, time wasting fashion. The owners of the smaller farms, however, have usually some other occupation, such as herding sheep or cattle, and many of them occasionally earn a small amount as day laborers, so that the time which is spent upon their own small farms may practically be considered as unemployed. It is stated that if they could earn regular wages it would be cheaper for them to buy farm produce than to raise it.

CONDITION OF IRRIGATION IN EACH COUNTY.

NUMBER OF IRRIGATORS, AREA IRRIGATED, FARMS, AND CROPS IN EACH COUNTY IN NEW MEXICO IN 1889.

COUNTIES.	Number of irrigators.	Area irrigated in acres.	Average size of irrigated farms in acres.	OWNERS OF FARMS. (a)		IRRIGATORS.		Area of counties in acres.	FARM AREA.		Cereals. (Acres.)	Alfalfa. (Acres.)	AREA IRRIGATED.			Average value of products per acre.
				Total number.	Per cent of population.	Per cent of farm owners.	Per cent of population.		Acres.	Per cent improved.			Per cent of area of county.	Per cent of total farm area.	Per cent of land owned by irrigators.	
Total	3,085	91,745	30	4,458	2.90	69.20	2.01	78,374,400	787,882	33.39	61,340	12,139	0.12	11.64	17.98	$12.80
Bernalillo	220	4,643	21	292	1.40	75.34	1.05	5,521,920	54,804	30.11	5,779	463	0.08	8.47	39.11	23.50
Colfax	46	5,994	130	70	0.88	65.71	0.58	4,224,000	128,941	35.11	2,074	1,167	0.14	4.65	7.99	16.44
Donna Ana	275	11,051	40	300	3.26	91.67	2.99	5,754,880	36,004	38.39	5,570	2,165	0.19	30.69	35.08	8.82
Grant	158	5,718	36	294	3.04	53.74	1.64	5,952,000	50,171	24.26	2,448	622	0.10	11.40	19.36	16.32
Lincoln (b)	194	7,789	40	303	4.28	64.03	2.74	16,929,280	47,373	28.09	4,134	1,893	0.05	16.44	24.28	17.48
Mora	348	11,403	33	467	4.40	74.52	3.28	2,560,000	156,730	45.66	9,880	1,812	0.45	7.28	12.25	8.78
Rio Arriba	281	6,368	23	442	3.83	63.57	2.44	4,576,000	25,519	51.74	6,272	358	0.14	24.95	35.05	15.10
San Juan	256	9,510	37	277	14.66	92.42	13.54	3,845,120	44,051	23.06	1,850	1,800	0.25	21.59	23.55	13.34
San Miguel	335	9,163	27	463	1.91	72.35	1.38	8,477,440	84,614	31.80	7,767	625	0.11	10.83	9.04	7.92
Santa Fe	123	1,358	11	207	1.53	59.42	0.91	1,466,880	6,702	44.07	1,742	167	0.09	20.08	51.99	14.22
Sierra	65	1,417	22	88	2.42	73.86	1.79	1,994,240	8,400	20.61	752	263	0.07	16.87	26.01	(c)
Socorro	218	4,798	22	295	3.07	73.90	2.27	9,904,640	35,342	24.61	2,059	281	0.05	13.58	25.80	16.46
Taos	262	6,420	25	293	2.97	89.42	2.66	1,472,000	25,852	55.52	4,787	193	0.44	24.83	27.90	8.95
Valencia	304	6,113	20	667	4.81	45.58	2.19	5,696,000	83,319	14.92	6,226	330	0.11	7.34	22.23	21.08

a Includes owned and hired farms, assuming one farmer to each.

b Act creating Chaves and Eddy counties from part of Lincoln county had not gone into effect on June 1, 1890.

c Value of products not obtained.

BERNALILLO COUNTY is in the north central portion of the territory, the main portion of the county extending from the Sandia mountains westward across the Rio Grande and to the Arizona line, while a small strip reaches from the southeast corner eastward to the head waters of the Pecos. The greater portion of the cultivated land of the county is along the Rio Grande, where there are many towns and small villages on or near the flood plain of the river. The valley is from 2 to 5 miles in width, is exceedingly fertile, and, having an elevation of about 5,000 feet, has a climate favorable to the production of all the various fruits and vegetables proper to the temperate zone. The Rio Grande furnishes an ample supply of water for the land at present under cultivation along its banks, but the methods of taking the water from the river are so primitive that losses of crops frequently occur. The ditches, many of which are of great age, are usually of small size, and are taken from the river at short intervals, each supplying a small town or collection of farms. The water is diverted from the river by rude headworks of brush and stone, which are frequently either partially or wholly destroyed in times of flood, and must be reconstructed or tightened whenever low water occurs.

In addition to the lands in the Rio Grande valley there are irrigated tracts bordering the principal tributaries, as, for example, along the Jemez and its head waters. In nearly every case the amount irrigated is but a small percentage of what could be brought under cultivation by improved methods and by comprehensive systems of water storage and canals. During May, June, and the early part of July there is usually a large excess of water, but from the middle of July, through August, and into September, there is scarcity; considerable trouble is experienced in filling the ditches, and owing to the great number and small size of the latter there is a great loss of water by evaporation and seepage.

On the lower bottom land of the Rio Grande valley much of the ground is saturated, and crops of wheat and other small grains, as well as alfalfa, grapes and other fruit, are raised without irrigation, the water being sufficiently near the surface to moisten the roots. The method of irrigation usually practiced is that of pools or borders. Small ridges of earth are thrown up by hand, inclosing rectangular spaces of from 15 to 20 feet in width and 20 to 40 feet or more in length. Into each of these little rectangles the water is allowed to flow until it forms a small pond. It is then allowed to flow into the next rectangle, and so on, until the whole field is irrigated. This requires a great outlay of time and labor, both in preparing the ridges and in applying the water.

COLFAX COUNTY is in the northeastern corner of the territory, being the most northern county east of the mountains. The agricultural land has an elevation of upward of 6,000 feet and possesses a climate favorable to the development of many branches of agriculture by irrigation. The water supply is derived from the head waters of the Canadian river and to a small extent from those of the Cimarron, both of these streams being tributary to the Arkansas. The greater part of the irrigated land is along the foot of the mountains, depending upon the streams flowing from the higher peaks. The ditches are mostly small, and until recently little attention has been given to the cultivation of the soil, cattle and sheep raising being the principal industries. In the vicinity of Springer is an irrigation system of considerable size taking water from Cimarron creek, a tributary of the Canadian. The main canal is 10 miles in length, 20 feet wide on bottom, and with its laterals covers land between the Cimarron and Red rivers. North of this is another system taking water from Vermejo creek, this canal being 20 feet wide, 12 miles in length, and having about 45 miles of laterals, covering land to the west of Dorsey and Maxwell. The summer floods of the streams are stored in a number of reservoirs located among the hills and out

upon the plains. It is also proposed to increase the supply by submerged dams across the stream channels and by artesian wells, the conditions being found favorable in the case of a well located 5 miles southeast of Springer, at the junction of Cimarron creek with Red river. This well is 250 feet deep and is reported to flow at the rate of 0.5 second-feet.

DONNA ANA COUNTY is in the south central part of the territory, adjoining the republic of Mexico. It includes the Mesilla valley, which lies along the Rio Grande, and in which is situated the greater portion of the irrigated land. In the extreme eastern portion of the county, west of the Mescalero Apache Indian reservation, are smaller tracts of lands irrigated by the streams which issue from the mountains, the principal towns in that locality being Tularosa and La Luz. In the valleys along the Rio Grande the supply of water is not at all times sufficient for the area now under cultivation, and during the years 1888 and 1889 it fell seriously short. This scarcity of water was due largely to fluctuations of rainfall, but to some extent to the diversions of water made by the large canals in the San Luis park of Colorado and by ditches in the northern part of New Mexico. In 1890, owing to larger rainfall, the water supply was more satisfactory and the farmers renewed their courage. The quantity of water in the Rio Grande has been measured as it leaves this county and passes El Paso, Tex. (*a*) The fluctuations of the stream are very great and during part of the year the channel is nearly or quite dry, although water can always be pumped from the underlying sands and gravels.

There are few irrigating canals of noteworthy size, the water being diverted from the river by many ditches, which are laid out without engineering skill. On account of the poor alignment, with numerous crooks and turns, sediment is deposited from the muddy waters brought by the Rio Grande, and this must be dug out at frequent intervals and at great expense. From the lack of system contentions are constantly arising between the owners of the various ditches, and there is no economy and little care in the administration of the waters. In the eastern portion of the county are enormous tracts of prairie land, between the Sacramento mountains on the east and the San Andreas range on the west. A small portion of this fertile land can be irrigated by a careful conservation of the waters which issue from many of the mountain valleys.

GRANT COUNTY is in the extreme southwestern corner of the territory, bordering upon Arizona and the republic of Mexico. The Gila river crosses the northwestern part of the county, and the Mimbres river, rising near the central portion of the county, flows southeasterly for about 30 miles, to be lost in ordinary seasons in the sand. The agricultural land lies along the valleys of these two rivers, with the exception of small patches where springs issue at the foot of the mountains, and of other areas on the plains, which are watered by means of pumps

a The results of the computations of discharge are shown by the accompanying table:

DISCHARGE OF RIO GRANDE AT EL PASO, TEXAS.

(Drainage area, 30,000 square miles.)

MONTHS.	DISCHARGE IN SECOND-FEET.			Total for month in acre-feet.	RUN-OFF.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1889.						
May 10 to 31	4,705	2,060	3,116	191,634	0.120	0.104
June	4,460	660	2,638	156,961	0.098	0.090
July	930	0	237	14,575	0.009	0.007
August	.....	.....	0	0	0.000	0.000
September	.....	.....	0	0	0.000	0.000
October	.....	.....	0	0	0.000	0.000
November	.....	.....	0	0	0.000	0.000
December	252	0	71	4,366	0.003	0.002
1890.						
January	280	126	196	12,054	0.008	0.007
February	458	108	290	16,095	0.010	0.010
March	1,140	45	424	26,076	0.016	0.014
April	4,108	470	2,190	130,305	0.081	0.073
May	7,200	3,495	5,771	354,916	0.221	0.190
June	7,200	2,925	4,404	262,038	0.164	0.147
July	2,355	235	854	52,521	0.033	0.028
August	2,497	170	734	45,141	0.028	0.024
September	660	40	176	10,472	0.006	0.006
October	116	40	65	3,997	0.003	0.002
November	610	40	284	16,898	0.011	0.009
December	610	430	535	32,902	0.020	0.018
Per annum	7,200	40	1,327	963,415	0.601	0.044
1891.						
January	715	140	451	27,736	0.017	0.015
February	2,640	470	809	44,899	0.028	0.027

MONTHS.	DISCHARGE IN SECOND-FEET.			Total for month in acre-feet.	RUN-OFF.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1891.						
March	4,635	470	1,866	114,759	0.072	0.062
April	8,625	1,040	4,265	253,767	0.159	0.142
May	16,620	8,340	11,852	726,528	0.454	0.396
June	8,340	5,045	6,714	399,483	0.249	0.224
July	6,345	610	2,271	139,666	0.088	0.076
August	1,785	17	662	40,713	0.025	0.022
September	9,480	0	768	45,695	0.030	0.027
October	3,535	560	1,488	91,512	0.057	0.050
November	515	235	341	20,289	0.012	0.011
December	560	190	344	21,156	0.013	0.011
Per annum	16,620	0	2,053	1,926,203	1,204	0.088
1892.						
January	470	155	326	20,049	0.013	0.011
February	830	290	476	27,370	0.017	0.016
March	2,070	390	752	46,248	0.029	0.025
April	7,485	470	3,147	187,246	0.117	0.105
May	10,050	5,205	7,093	436,219	0.272	0.236
June	6,485	560	2,943	175,108	0.109	0.098
July	2,500	0	668	41,082	0.026	0.022
August	140	0	13	800	0.000	0.000
September	.....	.....	0	0	0.000	0.000
October	.....	.....	0	0	0.000	0.000
November	.....	.....	0	0	0.000	0.000
December	.....	.....	0	0	0.000	0.000
Per annum	10,050	0	1,285	934,122	0.583	0.043

run by windmills. An attempt has been made to obtain water from the channel of Mimbres river above Deming by a deep cut or drain to intercept the water supposed to be flowing beneath the surface. So far as can be ascertained the scheme is impracticable, and it has apparently been abandoned, after the construction of 8 or 10 miles of canal.

The principal industries of the county are mining and stock raising, the cultivation of the soil being carried on largely in connection with herding or in the vicinity of the railroad towns and mining camps. The irrigating ditches are small and are usually built by a few owners to supply a cluster of farms. The Mimbres river can not always be relied upon to furnish sufficient water for the land at present under cultivation, and injury to the crops is liable to occur, especially in the month of June. Much of the water which sinks into the ground in the channel of this river as well as on the plains can be recovered by wells and by that means small garden spots are rendered very productive. The windmills, which raise the water both for stock and for irrigation, are reported to furnish a supply for from 1 acre to 6 acres of fruit trees and vegetables.

LINCOLN COUNTY at the time of taking the census included an area of 26,452 square miles in the southeastern corner of New Mexico. About that time two new counties were authorized, known respectively as Chaves and Eddy, the former being in the northeastern part and the latter in the southeastern part of this area. An examination of the returns shows that of the 7,789 acres reported as irrigated in Lincoln county there were 2,101 acres in that portion of the county to be included in Eddy county and 2,011 acres to be included in Chaves county, leaving 3,677 acres in the remainder of Lincoln county. This county lies within the drainage basin of the Pecos river, the principal tributary of the Rio Grande. The waters of this stream come largely from the west, from streams rising in the Sierra Blanca and other mountains on the western side of Lincoln county and from springs issuing from the limestones which underlie much of the country. On the east side of the Pecos there are no living streams, the plains gradually rising toward the escarpments of the Llano Estacado. As a whole, it may be said that the water supply is large and its distribution favorable for the development of agriculture. In that part of Lincoln county not to be included in Chaves and Eddy counties the principal irrigated areas are in the vicinity of Fort Stanton and of Lincoln, water being obtained from Bonito creek, and in the vicinity of Ruidoso irrigating ditches being taken from Ruidoso creek.

A large number of streams flow easterly from the Capitan, Sierra Blanca, and Sacramento mountains, most of these disappearing in the sands, a few finally reaching the Pecos. Farmers have settled along most of these streams and have diverted the water by small ditches, bringing under cultivation a small part of the arable land. Along the head waters of the larger of these creeks there appears to be an ample supply of water, and it is reported that in the upper valleys some crops are successfully raised without irrigation. Cattle raising is the principal industry and the crops are largely for forage purposes.

In that portion of the county to be included in Chaves county the principal area of land under cultivation is in the vicinity of Roswell, where a large amount of water is obtained from the springs and surface streams. There are a number of small ditches taking water from the Hondo and neighboring streams, and 5 miles east of Roswell is the head of the Northern canal, belonging to the Pecos Irrigation and Improvement Company. This canal follows southerly along the west side of the Pecos river, crossing South Spring river, from which some water is obtained, and extending to or beyond the Feliz river. The bottom width is stated to be 35 feet and the length 25 miles, it being proposed to continue this to a length of 50 miles. About 70 miles southerly from Roswell is the town of Eddy, in the portion of the county to be known by the same name, above which are the main works of the company just mentioned. A dam has been built across Pecos river, raising the water and backing it up for a distance of upward of 7 miles, forming a storage reservoir, which can be drawn upon during the months of drought. The dam, built of limestone, is 1,140 feet in length, 135 feet wide at base, and having a maximum height of 40 feet. The headworks of the canal are on the east side, this being 45 feet wide at bottom. At a distance of 4 miles below the dam the canal divides, the principal branch crossing the river and continuing in a southerly course toward the Texas line. The river is crossed by means of a flume 25 feet in width and 475 feet in length, built at a height of 40 feet above the river. The total length of this branch is stated to be 30 miles, the intention being to extend it to a total length of 55 miles. The east branch is 25 feet wide on bottom and has a length of 20 miles. About 15 miles below Eddy is the head of the Hagerman canal, covering land on the east side of the river below that to be irrigated by the east branch above mentioned. Farther to the south, in Texas, are other canals, taking the excess or seepage water from these systems. Water rights under these canals are sold at the rate of $10 an acre, the annual charge being $1.25 per acre. Besides these large canals there are a number of ditches covering lands along the valleys of the Penasco, Seven Rivers, and Black River, the water supply being, however, relatively small for the lands needing irrigation.

MORA COUNTY lies south of Colfax and parallel with it, extending in a narrow belt from the mountains eastward toward the plains. It has the largest amount of irrigated land of any county in the territory, aggregating nearly one-half of 1 per cent of the total area of the county. The principal body of irrigated land is in the Mora valley, along the river of the same name. At the upper end of this valley there is an ample supply of water, but farther down the demand far exceeds the supply, resulting often in disappointment and loss to the farmer. Small reservoirs are in successful operation, but the amount of land which they supply is insignificant. They prove, however, the feasibilty of this method of water conservation. High among the foothills and in the mountain

valleys a small amount of dry farming has been attempted, but with little success. Besides the Mora river, there are considerable bodies of land depending upon Ocate creek and its tributaries, but the water supply from this stream is not always sufficient to meet the demands upon it.

RIO ARRIBA COUNTY is situated in the northern portion of the territory, adjoining the Colorado line. It embraces on the west a portion of the head waters of the San Juan river, and on the east it extends nearly to the Rio Grande. On the southeast a prolongation of the county extends across the Rio Grande and thus includes the Espanola valley, where is situated the largest body of irrigated lands in this county. This valley is about 20 miles in length and from 2 to 4 miles wide. It extends from La Joya on the north to San Ildefonso at the southern end, and includes various Mexican towns and Indian pueblos. The Chama enters the valley from the west and joins the Rio Grande, thus adding to the already ample water supply. Next in importance to this valley is that of the Chama, in the vicinity of Tierra Amarilla, on the grant of that name. The greater portion of the drainage basin of the Chama is included within this county. The water supply from this river and its tributaries is usually sufficient for the area at present under cultivation, but it occasionally fails in the months of June and July.

In the extreme northwestern corner of the county, on the head waters of the San Juan, at an elevation of about 7,000 feet and over, there is a small amount of dry farming, and near Tres Piedras, in the eastern part of the county, there are also a few farmers endeavoring to cultivate the soil without irrigation, but with little success at either locality.

In a few places tanks or small reservoirs have been constructed to store the water of certain springs. These have been successful, but the area thus irrigated is insignificant. The necessity of water storage is not as yet generally felt, since the loss of crops for want of water is due usually to the condition of the ditches rather than to a deficient amount of water available. Many of the ditches, especially in the Espanola valley, are of great age, some of them of which the history is known having been constructed as long ago as 1712. The land under these ditches has been divided and subdivided by inheritance, so that the ownership is now very large, and great difficulty has accordingly been found in maintaining the ditches and keeping them clear from sediment. On Nutrias and El Rito creeks, tributaries of the Chama, there has been some loss of crops for lack of water, but taking the county as a whole the water supply is ample for present requirements. At Embudo, above Espanola valley, the Rio Grande has been measured and the quantity of water in the river computed for a number of years. (*a*)

a The results are shown by the accompanying table:

DISCHARGE OF RIO GRANDE AT EMBUDO, NEW MEXICO.

(Drainage area, 7,000 square miles.)

MONTHS.	DISCHARGE IN SECOND-FEET.			Total for month in acre-feet.	RUN-OFF.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1889.						
January	495	379	431	26,508	0.07	0.06
February	576	420	473	26,251	0.07	0.07
March	1,042	537	784	48,216	0.13	0.11
April	4,420	970	2,261	134,539	0.36	0.32
May	5,075	2,443	3,430	210,945	0.56	0.49
June	5,660	1,300	2,922	173,859	0.47	0.42
July	1,105	230	471	28,966	0.07	0.07
August	253	181	206	12,669	0.03	0.03
September	264	184	212	12,614	0.03	0.03
October	324	243	283	17,404	0.05	0.04
November	597	263	360	21,777	0.06	0.05
December	610	364	542	33,333	0.09	0.08
Per annum	5,660	181	1,032	747,070	1.99	0.15
1890.						
January	617	200	437	26,875	0.07	0.07
February	670	344	553	30,691	0.08	0.08
March	1,044	330	682	41,943	0.11	0.10
April	3,220	842	2,083	123,938	0.33	0.30
May	6,071	2,080	4,960	305,040	0.82	0.71
June	5,740	2,708	4,107	244,366	0.65	0.59
July	2,040	920	1,593	97,969	0.26	0.23
August	1,134	636	814	50,061	0.13	0.12
September	1,044	466	545	32,427	0.09	0.08
October	636	523	562	34,563	0.09	0.08
November	660	550	616	36,652	0.10	0.09
December	660	636	648	39,852	0.11	0.09
Per annum	6,071	200	1,467	1,064,377	2.84	0.21

MONTHS.	DISCHARGE IN SECOND-FEET.			Total for month in acre-feet.	RUN-OFF.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1891.						
January	666	550	586	36,039	0.10	0.08
February	1,000	550	616	34,182	0.09	0.09
March	1,450	735	917	56,395	0.15	0.13
April	5,690	735	2,370	141,015	0.38	0.34
May	8,550	4,520	5,965	366,847	0.98	0.85
June	6,340	4,925	5,040	299,880	0.80	0.72
July	4,130	1,250	2,356	144,894	0.39	0.34
August	1,805	320	933	57,379	0.15	0.13
September	2,025	320	469	27,905	0.08	0.07
October	3,350	225	1,681	103,381	0.28	0.24
November	970	515	778	46,291	0.12	0.11
December	880	340	553	34,009	0.09	0.08
Per annum	8,550	225	1,855	1,348,217	3.61	0.26
1892.						
January	615	440	497	30,565	0.08	0.07
February	700	490	596	34,270	0.09	0.08
March	1,550	700	1,051	64,636	0.17	0.15
April	4,910	860	2,979	177,250	0.47	0.42
May	6,665	4,130	4,890	300,735	0.81	0.70
June	4,715	1,550	3,146	187,187	0.50	0.45
July	1,400	280	538	33,087	0.09	0.08
August	300	152	191	11,748	0.04	0.03
September	165	140	152	9,044	0.02	0.02
October	260	165	202	12,423	0.03	0.03
November	460	243	317	18,861	0.05	0.05
December	490	165	324	19,926	0.05	0.05
Per annum	6,665	140	1,240	899,730	2.40	0.18

SAN JUAN COUNTY is in the extreme northwestern corner of the territory, at an elevation of from 5,000 to 6,000 feet. The agricultural land is confined to the northern edge of the county, along the valleys of the San Juan and its tributaries, which receive their waters from the high mountain ranges of southwestern Colorado. The southern portion of the county consists of high plateaus, on which the rainfall is very small, and from which therefore there are no perennial streams. Farming in this county without irrigation is impossible, except perhaps in a few spots on the bottom lands, where corn and potatoes have occasionally matured. The climate is excellent and is reported to be favorable for fruit culture, apples, pears, plums, apricots, peaches, nectarines, cherries, and various smaller fruits attaining great perfection. Beyond this the principal crop is alfalfa, of which there are obtained three and sometimes four cuttings annually, the best results, however, being usually obtained when but three cuttings are made. The settlers in this county, on account of their lack of capital, have been compelled to make use of small ditches, not always satisfactory.

Probably the best agricultural land in the county is that which is at present untouched, lying on the mesas back from the river. This is more nearly level and better adapted to cultivation than that now being farmed, but neither the present owners nor the inhabitants of the county possess the capital necessary to the extension of their ditches to these lands or to the construction of new canals of sufficient size. This county offers perhaps some of the best opportunities in the entire west for the construction and profitable operation of large irrigating canals or systems of ditches, on account of the abundance of the water and of the great extent of arable mesa lands. The Animas river is especially noteworthy for its constant discharge and its large amount of unappropriated water. This stream has a decided fall, and it has also gravelly banks and bed, so that the channel shifts but slightly in times of flood, and there are consequently no great obstacles to be overcome in the construction and maintenance of canal headworks. It is bounded, however, by rocky bluffs, and the construction of canals of any considerable size would involve an outlay of capital probably far in excess of the means possessed by the present inhabitants of the county. The San Juan river also contains a large amount of water in excess of what is needed for the land now under cultivation, but it is even less favorably situated for the construction of irrigation works than is the Animas. The land now irrigated consists of a narrow strip along the bottoms, which is quite uneven, and in its natural state is covered with brush.

SAN MIGUEL COUNTY is one of the largest in the territory, but the greater portion of it consists of plains too arid for cultivation. The agricultural land is principally in the western part of the county near the base of the mountains, a small amount extending southward along the Pecos river. The water supply of the county is derived from two drainage systems, both of which have their rise in the same range and on the same side of it. The most northerly of these is that of the Sapello river and its tributaries, a portion of the Canadian river drainage, and the second consists of the head waters of the Pecos, which finds its way into the Rio Grande. The Sapello river does not furnish sufficient water for the lands now under cultivation along its course, and there is general complaint of scarcity whenever a dry season occurs. A number of small reservoirs have been successfully constructed, and they would be of great benefit if their owners possessed sufficient capital to enlarge them to a size sufficient to meet the demand for water.

On the head waters of the Pecos there appears to be a greater quantity of available water, but lower on the stream the same want is felt. In the southern part of the county there are many engineering difficulties to prevent the inhabitants from diverting the river successfully upon their lands. In this portion of the county the principal industry is sheep raising, agriculture being confined to small garden patches. Irrigation is, however, carried on to a small extent by means of springs and of tributary streams which enter the Pecos mainly from the east. As in Mora county, there is a little dry farming, especially in the valleys among the mountains, where corn, beans, potatoes, and forage crops are raised.

SANTA FE COUNTY, which includes the capital of the territory, is the smallest in area of all the counties in New Mexico. The largest body of irrigated land is on the extreme northern edge of the county, in the Espanola valley. The principal water supply for this district comes from the Nambe river, which flows into the Rio Grande near the Indian town of San Ildefonso. Besides this area, there are in the vicinity of the city of Santa Fe and along Santa Fe creek various small irrigated tracts depending upon the water of the latter stream. The ditches in this county are small and numerous, each supplying a village or group of farms. There is apparently sufficient water for the acreage now under cultivation, loss of crops, whenever it occurs, being generally due either to poor management or to accidents to the ditches rather than to a deficiency of water in the rivers.

SIERRA COUNTY, as its name implies, is rough and mountainous, and of all the counties of the territory it contains the smallest amount of cultivated land. The Rio Grande flows through the county from north to south, but for the greater portion of the distance it is in a deep, narrow canyon, with little or no agricultural land along its course. In the mountain valleys to the west of the Rio Grande are scattered tracts of cultivated land, but the water supply is insufficient for their further extension without recourse to storage. During certain seasons of the year there is an ample supply of water, and by the construction of small reservoirs in localities that are admirably adapted for the purpose the area of agricultural land can be largely increased. The principal industry of the county is mining, and next in importance to this is grazing, the higher valleys, so far as concerns the needs of cattle, being well watered and having an abundant supply of forage.

SOCORRO COUNTY includes a large portion of the Rio Grande valley, and extends on the west to the head waters of the Gila, where there is some little land under cultivation. The greater portion of the county, however, is composed of high table-lands and forested mountain ranges; in fact, Socorro county is probably the best timbered county in the territory, including, as it does, the great forest areas at the head waters of the San Francisco river and other tributaries of the Gila. Cattle raising is also an important industry, since the valleys contain excellent pasturage.

The character of the irrigated lands along the Rio Grande is similar to that of Bernalillo county, the water supply, however, being somewhat less. As in the latter county, the losses of crops, when they occur, are largely due to lack of care in maintaining the ditches and headworks. Many of the inhabitants view with apprehension the apparent diminution from year to year of the supply of water, and many forebodings are entertained as to the future of their agricultural operations, for they believe that ultimately in seasons of scarcity all the water will be absorbed by the ditches to the north of them, if not by the great canals in southern Colorado. On the head waters of the Gila, however, where the altitude is about 6,000 feet, there is ample water for all the land under cultivation, and the inhabitants, from their situation, feel assured of a sufficient supply for their future needs. Being in a different territory from that in which the greater portion of the water of the Gila is used, they are under no obligations as to economy in its use or as to the storage of floods.

TAOS COUNTY is in the northern part of New Mexico, adjoining the Colorado line, and extends from the summits of the Taos mountains westward across the Rio Grande. At the foot of these mountains, at an elevation of about 7,000 feet, are large tracts of arable land. Only a small portion of this land has been utilized for agriculture, the unregulated water supply being inadequate for the entire area. The Rio Grande flows in a canyon at a depth of from 600 to 1,000 feet below the general level of the plateau, so that its waters can not be diverted, except to a very small extent upon the narrow flood plains in the bottom of the canyon. Nearly all the streams issuing from the mountains have been utilized by the construction of ditches, which carry the waters to the lands of the Mexican and Indian owners. Taos and Embudo creeks and their tributaries supply water for the greater portion of the land now under irrigation.

In general it may be said that irrigation in this county is of the most primitive character, there having been apparently little improvement or other change during several decades, or perhaps during the entire century. The inhabitants are scattered along the creek bottoms, wherever a small ditch can be taken out from a perennial stream. The principal towns are among the oldest on the continent, and they have had comparatively little growth for many years. The water supply that is easily available may be said to be entirely appropriated, but there are great possibilities depending upon a better conservation of the flood waters, since the greater portion of the level arable land of the county is not as yet under cultivation. Loss of crops from lack of water is unusual, since by long experience the inhabitants have learned to adapt their acreage to the probable supply from the streams. The ownership of the land, especially in the small towns, is greatly subdivided by inheritance, the tracts lying in long, narrow strips. These holdings are so small that the customary unit of measurement is the yard rather than the acre. For example, a man's farm may be given as 1,000 yards long and 30 yards wide, the 30 yards being along the ditch and the 1,000 yards sloping away from it. The local customs as to management of water are very old, having been handed down with the land from past generations.

VALENCIA COUNTY is a long, narrow county, extending two-thirds of the width of the territory, the Rio Grande crossing it about the center at its narrowest part. The principal portion of the irrigated land is along this river, the conditions being in every way similar to those prevailing in Bernalillo county to the north. The principal tributary of the Rio Grande in this county is the San Jose, which flows into the Rio Puerco. A small amount of irrigation is carried on by means of the water of this stream. In the eastern part of the county, to the east of the Manzano range, and at an elevation of about 7,000 feet, corn, oats, wheat, barley, rye, beans, and potatoes are raised without irrigation. The crops, however, are not so good as those raised elsewhere on irrigated land.