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UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

WATER RESOURCES

OF THE

STATE OF COLORADO

BY

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DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF HYDROGRAPHY,
Washington, D. C., July 10, 1902.

SIR: I have the honor to transmit herewith, for publication as Water-Supply and Irrigation Paper No. 74, a manuscript by Mr. A. L. Fellows on the water resources of the State of Colorado.

Very respectfully,

F. H. NEWELL,
Hydrographer in Charge.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

WATER RESOURCES OF THE STATE OF COLORADO.

By A. L. FELLOWS.

INTRODUCTION.

The State of Colorado, located as it is in the midst of the Rocky Mountains, the crest of the continent crossing it from north to south, and comprising as it does a vast variety of physical conditions, varying from those of the highest mountain regions, where vegetation ceases to flourish, to plains where fruits almost semitropical may be raised, furnishes a diversity of problems connected with the disposition of its water supply unequaled in number and difficulty, perhaps, by those arising in any other State in the Union. The snows of winter, falling upon the continental divide, may furnish the moisture by which the herbage and trees of the mountains are watered, and the waters from these heights, collected in rivulets and streams, may supply the motive power for operating the stamp mills for the mines of the State, or may develop electric power that may be transmitted for running factories, or may be used for sifting out the particles of gold in the placers along the streams of both the Pacific and the Atlantic watersheds. Again the brooks and creeks, collected into larger streams or rivers, enter the broad plains of the eastern half of the State or the canyon and mesa country of the western half, and furnish the lifeblood of vast irrigated tracts, where crops of the most diverse kinds may be raised for the sustenance of countless families, and thus become the assets upon which agricultural communities may draw, whether they are dependent upon wheat raising, sugar factories, potatoes for the Eastern market, alfalfa for feeding lambs and sheep,[a] or any other of the numerous forms of agricultural industry practiced in Colorado. Its water supply therefore becomes of the utmost importance to the State, and it is with the hope that the compilation of all figures readily obtainable bearing upon the subject may prove of interest and value to the people, not only of Colorado, but of States similarly situated, that the preparation of this paper is undertaken.

[a] Colorado Agricultural College Bulletins.

SOURCES OF INFORMATION.

For a period of about sixteen years the measurement of streams has been carried on more or less systematically in the State both by the Hydrographic Division of the United States Geological Survey and by the State engineer's office, working at times in cooperation and at times separately, but always with the same end in view—that of throwing as much light as possible on the discharge of the streams and of determining the feasibility of storing water in available reservoirs whenever the need for such storage should become apparent. The discharge measurements given in this paper are compiled from the records of these offices. When the different records are found to be conflicting, as they sometimes appear to be, credence is given, after careful consultation with those most intimately acquainted with the existing conditions, to the one appearing to be the most likely to be correct.

The records of the United States Geological Survey and of the State engineer's office are the two principal sources from which the following tables are compiled, but information has also been obtained from engineers located in different parts of the State wherever it was possible, and in such cases due credit is given.

The drainage areas given are computed from the General Land Office maps by means of the planimeter, these being the figures accepted in the reports of the United States Geological Survey. The descriptions of streams and drainage basins and of reservoir sites are compiled largely from bulletins, irrigation papers, and reports previously published, but to a considerable extent also from personal examination and knowledge. In the computations use has been made of the tables given in Bulletin of the U. S. Geological Survey No. 140, pages 14 to 32, and Water-Supply and Irrigation Paper No. 27, page 96, to which readers are referred for directions concerning the use of meter and computations of discharge.[a] In a paper of the size to which this must be limited, it is, of course, impossible to give complete results of discharge measurements and of daily gage readings. It has been thought best, therefore, to limit the data given for each station to a table of gagings and to a general table giving the average flow for each month, the average for each year, the maximum and minimum flow for each year, and the most important data connected with the stream measured. With each table is given a brief description of the station at which the results were obtained, showing the value of these results, the prevailing conditions, and the sources from which the information was derived. References are made, wherever

[a] See also, for methods of making measurements, Annual Reports U. S. Geol. Survey: Tenth, Part II, pp. 78 to 86; Eleventh, Part II, pp. 2 to 22; Fourteenth, Part II, pp. 96 to 100; Nineteenth, Part IV, pp. 18 to 31; Twentieth, Part IV, pp. 20 to 22. Also, State Engineers' Biennial Reports: Second, pp. 5 to 9; Third, p. 5; Fourth, pp. 59 to 88; Fifth, pp. 346 to 349; Sixth, p. 8; Seventh, pp. 196 to 217; and Irrigation Bulletin No. 1.

they are deemed desirable, to the reports or water-supply papers of the United States Geological Survey that give more detailed information, so that any reader looking up discharge data upon any particular stream may be assisted in his search for the most complete information.[a] For greater convenience of reference the following table, showing the publications most fully covering the hydrographic work for each year from 1883 to 1900 inclusive, is given below:

Reports of the State engineers of Colorado.

Second Biennial Report, 1883–1884.
Third Biennial Report, 1885-1886.
Fourth Biennial Report, Parts I and II, 1887–1888.
Fifth Biennial Report, Parts I and II, 1889–1890.
Sixth Biennial Report, 1891–1892.
Seventh Biennial Report, Parts I and II, 1893–1894.
Eighth Biennial Report, 1895–1896.
Ninth Biennial Report, 1897–1898.
Tenth Biennial Report, 1899–1900.

Publications of the United States Geological Survey.

Tenth Annual Report, Part II, 1888.
Eleventh Annual Report, Part II, 1889.
Twelfth Annual Report, Part II, 1890.
Thirteenth Annual Report, Part III, 1891.
Fourteenth Annual Report, Part II, 1892.
Bulletin No. 131, Report of Progress of the Division of Hydrography, 1893.
Bulletin No. 131, Report of Progress of the Division of Hydrography; also Sixteenth Annual Report, Part II, 1894.
Bulletin No. 140, Report of Progress of the Division of Hydrography for the Calendar Year 1895; also Seventeenth Annual Report, Part II, 1895.
Eighteenth Annual Report, Part IV; also Water-Supply and Irrigation Paper No. 11, 1896.
Nineteenth Annual Report, Part IV; also Water-Supply and Irrigation Papers Nos. 15 and 16, 1897.
Twentieth Annual Report, Part IV; also Water-Supply and Irrigation Papers Nos. 27 and 28, 1898.
Twenty-first Annual Report, Part IV; also Water-Supply and Irrigation Papers Nos. 35, 36, 37, 38, and 39, 1899.
Twenty-second Annual Report, Part IV; also Water-Supply and Irrigation Papers Nos. 47, 48, 49, 50, 51, and 52, 1900.

In the compilation of this paper assistance has been given by many different persons and corporations interested in the use of water, and to all these thanks are extended. The attempt has been made to give proper credit in all cases where such assistance has been furnished. The illustrations are selected from photographs made under the auspices of the Survey, and from those furnished by parties assisting in the preparation of this paper.

[a] It is not intended that the references to publications relating to this subject shall form a complete bibliography, but an attempt is made to assist the reader in finding some of the most easily obtainable information on the subjects considered.

VALUE OF SUPPLY.

The mining industries of Colorado depend very largely upon the water supply of the mountain region for the development of power by which stamp mills and sampling works may be operated, and the mining towns are dependent upon electric-light and power plants operated by water; and the mills and factories of the State are, to a greater and greater extent, being run by the same means; further, the cultivation of between two and three millions of acres of land is made possible by water used in irrigation; and when it is seen that this water supply is so limited that the normal flow of very many of the streams is entirely exhausted and that already recourse is being had to storage in reservoirs, built to conserve, for use in seasons of low water, floodwater that would otherwise go to waste, it will then be evident that its water supply is of the greatest moment to the State. This fact has been recognized by the people themselves ever since the State was formed, and a complicated system of laws has been built up controlling the water and its distribution among consumers. This subject has already been fully treated in a number of different bulletins and papers, among which are Water-Supply and Irrigation Paper No. 9, U. S. Geological Survey, and Bulletins Nos. 58 and 60 of the United States Department of Agriculture, as well as the Irrigation Laws of Colorado, as compiled and furnished by the State engineer's office, so that nothing more than a brief discussion as to the ownership of water by Colorado is necessary at this time.

By the State constitution the water is declared the property of the State, and as such is to be distributed and used in accordance with its occurrence and availability. The entire system of State laws distributing the water among consumers is based upon this plan, the State engineer being made, next to the courts, the head of the department having immediate supervision of the subject, and being the final authority on questions relating to the use of water, subject to appeal to the courts. Next to him and his deputies are the superintendents of the various irrigation divisions, of which there are 6, each of them comprising lands drained by one of the six principal streams of the State; namely, the South Platte, the Arkansas, the Rio Grande, the San Juan, the Grand, and the Green rivers. Each of these divisions in turn is divided into water districts, each one comprising one or more of the tributaries of the various large streams, or parts of the main streams themselves, each district, of which there are 69 in the State, being under the supervision of a water commissioner, whose duty it is to regulate the use of the water under his immediate jurisdiction, appeals being possible from the commissioner to the superintendent, from the superintendent to the State engineer, and from the State engineer to the courts. This partition of the State into divi-

sions and districts will be treated more fully later, so that further description is unnecessary at present.

The uses of the water are so numerous and varied that the administration of the laws relating to water is very difficult. In Colorado the riparian doctrine does not obtain, so that this complication is removed—at least unless decisions should be rendered in the United States courts acknowledging such rights as belonging to the States into which the streams flowing out of Colorado run—but the complications are numerous enough as it is. The supply of water is so limited compared with the demands for it that early rights or priorities become of the utmost importance. The principal uses to which the water may be put may be classified in the order of importance as domestic use, irrigation, mining, and milling. The use of the normal flow of the streams is considered as of first importance, the use of stored water being a matter for secondary consideration.

The order in which water would naturally be used, however, is different, and, leaving out of consideration entirely for the present the fact that priority of use may determine right to use, it is obvious that the physical nature of the State has an important bearing upon the problems of use. The mines being situated in the mountains, and the natural conditions being usually such that the clearest and best water is found at the higher altitudes, it is evident that, other things being equal, water for domestic use and for mining would be demanded at the highest available points upon each stream. After the water begins to find its way into canyons and over waterfalls—in other words, when it is discharging from the mountains into the plains—the conditions evidently become more favorable for the development of power, the fall of the streams being rapid, and the quantities being sufficient for such use. Again, after the water debouches from the mountainous area and enters the plains, it is evident that irrigation may be practiced upon a broader scale, so that the order of use upon a stream would naturally be domestic use, mining, milling, and water power, and, finally, irrigation.

The brief discussion of the uses to which the water may be put in Colorado sufficiently demonstrates the importance of the subject. It is not within the province of this paper to treat of the administration of the laws, or to discuss the subject of priorities. Its intention is simply to show, so far as possible, how much water is available for use in some of the streams of the State, and to indicate briefly, by examples, something of what is being done in harnessing this, one of the greatest dynamics of nature, for the use of man. At the same time an effort will be made to show the necessity for the storage of the waters that now go to waste in the winter seasons and at flood stages, in order that there may be the most economical and thorough use of this great resource. That the period when storage is demanded

is already at hand is clear to all students of the hydrography of the State, for the normal flow of the majority of the streams is already utilized and exhausted. It is not now proposed to discuss the most economical use of water—that water is used in Colorado most extravagantly and in ways that would not be tolerated in a country more advanced in scientific irrigation is beyond question—but simply to consider the present use of water and endeavor to devise methods by which this use may be extended, so far as possible, under existing conditions. Necessity will compel more economical use in the future; but the present most urgent need is that the water which now goes to waste and is of no service to man shall be conserved so as to be available for beneficial use. Such streams as the South Platte, the Cache la Poudre, the Arkansas and its tributaries, the Rio Grande, and numerous other streams, furnish normally an insufficient supply for present needs, but if the flow could be equalized by the storage of water in reservoirs the irrigated area in Colorado might be greatly extended. The importance of this fact is already felt, and in many places, as upon the Big Thompson, the Cache la Poudre, and the Arkansas, considerable water is already being stored, to the great benefit of the people within the irrigable territory lying below the reservoirs.

RUN-OFF.

The physical conditions affecting the run-off in the State of Colorado are so various that it is impossible to formulate an even approximately correct rule as to the percentage of the rainfall carried from the drainage area into the streams.[a] In case of a violent storm of the nature of a cloud-burst in a rocky, mountainous district, as much as 75 or 80 per cent of the precipitation may be collected into the nearest streams; it will, however, be largely taken up by percolation into the soil before it has run a very great distance. On the other hand, a great amount of water falling gently upon a sandy plain may be entirely absorbed by the soil and may evaporate before any water whatsoever has run off. Computations of the percentage of run-off are often misleading, also, from the fact that water is being constantly taken out of the various streams for irrigation. For example, no accurate estimate could be made from the discharge of the Arkansas River at Rockyford as to the percentage of run-off from the drainage area above, as water is constantly being taken out for reservoirs and for direct irrigation, and the amount so taken can hardly be calculated unless a complete record is made of the intake of each canal, whether large or small, along the Arkansas and all its tributaries. Where there are no irrigating canals or ditches along a stream it is comparatively easy to determine the percentage of the total precipitation contained in the

[a] See also Biennial Reports of the State Engineer: Second, pp. 10-18; Fourth, pp. 17-23.

run-off at a given point; but when water is diverted from a stream in such quantities that only a comparatively small portion returns, the determination of run-off becomes difficult. Where gaging stations are located at the mouths of canyons, however, above which there is little, if any, diversion, the percentage may be determined with reasonable accuracy, although even then it is difficult to find points on any of the streams above all diversion for irrigation and yet far enough down to be of great use in the determination of run-off. For example, on the St. Vrain, the discharge at the gaging station at Lyons will not give correctly the run-off of the drainage basin above, for the reason that meadows are being irrigated at places far above the gaging station. The Boulder, again, is at times losing water that is being stored in reservoirs high up in the basin, and such is the case with the majority of the other streams. For these reasons no attempt has been made to determine what relation the total precipitation bears to the run-off. Readers interested in these computations are referred to Part IV of the Twentieth Annual Report of the United States Geological Survey. That the run-off does depend upon the precipitation, however, is self-evident, and for this reason a table giving the precipitation at various points in the State, beginning with the year 1896, is furnished. A comparison of the depth of the run-off in inches, as given in the tables of discharge, with the precipitation in inches for a given year, will give an approximately correct idea of the amount of water flowing in a stream at any given point.[a]

Normal temperature and precipitation at stations in Colorado.

[Compiled from the records of the Office of the U. S. Weather Bureau, at Denver, Colo. F. H. Brandenburg, section director.]

Station.	County.	Elevation.	Length of record.	Normal temperature.	Precipitation (in inches).					
					1896.	1897.	1898.	1899.	1900.	Normal to 1899, inclusive.
South Platte drainage:		*Feet.*	*Years.*	°*F.*						
Boxelder	Larimer	6,950	10	.....	17.83	21.42	16.34	14.42	17.93	16.46
Laporte	do	5,069	10	.....	15.49	17.72	13.63	13.34	20.06	14.37
Fort Collins	do	4,995	20	46.8	15.76	15.24	11.03	16.19	19.21	13.86
Greeley	Weld	4,637	11	47.5	13.52	16.09	(*b*)	10.79	11.51	11.83
Moraine	Larimer	7,900	11	40.6	17.28	18.87	16.86	16.58	16.72	17.56
Dumont	Clear Creek	8,000	10	.....	15.01	20.82	17.16	18.19	19.54	18.59
Denver	Arapahoe	5,291	29	49.8	11.84	15.37	12.98	9.33	15.29	14.15
Castlerock	Douglas	6,220	10	46.3	20.44	(*b*)	(*b*)	14.70	14.70	18.59
Hamps	Elbert	5,500	8	45.8	12 78	(*b*)	12.57	12.67	21.17	12.26

[a] See Reports of the Weather Bureau; also U. S. Geological Survey Reports: Tenth, Part II, pp. 13–14; Eleventh, Part II, pp. 23, 25, 205, 214, 251, and 281; Twelfth, Part II, pp. 226, 230, 231, and 245; Thirteenth, Part III, pp. 25, 28, and 153; Fourteenth, Part II, pp. 150–152; and Biennial Reports of the State Engineers of Colorado: Second, pp. 14–17; and Fifth, Part I, p. 534. Also, Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, p. 91.

[b] Record incomplete.

Normal temperature and precipitation at stations in Colorado—Continued.

Station.	County.	Elevation.	Length of record.	Normal temperature.	Precipitation (in inches).					
					1896.	1897.	1898.	1899.	1900.	Normal to 1899, inclusive.
Kansas drainage:		*Feet.*	*Years.*	° *F.*						
Leroy	Logan	4,380	12	48.1	14.18	18.48	14.95	13.22	14.74	15.10
Yuma	Yuma	4,128	10	.....	15.84	18.30	20.39	14.61	17.98	16.63
Wray	do	3,512	7	.....	16.68	20.19	18.71	10.74	18.24	15.13
Cope	Arapahoe	.....	9	50.1	(a)	(a)	28.48	(a)	21.47	18.42
Fox	do	.....	9	.....	(a)	17.19	20.84	10.06	19.92	15.56
Seibert	Kit Carson	4,705	9	.....	14.42	20.94	18.65	12.62	20.79	14.31
Cheyenne Wells.	Cheyenne	4,259	8	.....	(a)	(a)	18.50	14.01	18.60	15.76
Arkansas drainage:										
Lake Moraine.	El Paso	10,268	7	.....	19.70	30.32	23.14	18.59	33.46	22.55
Gleneyre	do	6,500	9	46.7	15.53	(a)	(a)	(a)	19.34	13.98
Colorado Springs.	do	6,098	21	.....	13.94	(a)	(a)	8.81	13.64	14.13
Leadville	Lake	10,185	8	.....	(a)	15.51	12.27	19.86	13.50	14.21
Twin Lakes	do	9,200	7	.....	(a)	(a)	(a)	(a)	13.76	15.35
Canyon	Fremont	5,363	12	.....	11.96	11.13	11.45	9.80	14.34	11.70
Pueblo	Pueblo	4,734	12	.....	10.81	12.71	10.85	13.05	13.37	11.53
Rockyford	Otero	4,177	12	.....	9.74	(a)	16.04	18.68	15.60	13.52
Las Animas	Bent	3,892	33	.....	11.81	10.89	15.63	12.11	15.48	11.19
Lamar	Prowers	3,592	11	.....	(a)	15.10	17.84	19.64	19.64	15.17
Westcliffe	Custer	7,864	8	.....	13.27	(a)	16.88	12.81	16.31	17.29
Clear View	Las Animas	9,500	11	.....	24.00	31.76	27.31	18.49	23.08	24.23
Hoehne	do	5,721	9	.....	16.05	11.80	14.07	12.36	13.30	13.92
Springfield	Baca	4,400	9	.....	(a)	(a)	20.75	12.78	22.68	18.36
Vilas	do	4,158	10	.....	(a)	(a)	(a)	15.48	19.66	13.74
Rio Grande drainage:										
Saguache	Saguache	7,740	10	42.0	(a)	8.84	8.06	5.96	6.25	7.52
San Luis	Costilla	7,596	10	42.3	12.31	13.93	14.20	10.04	10.16	13.06
San Juan drainage:										
Durango	La Plata	6,534	8	47.3	(a)	24.93	16.27	14.49	9.86	17.98
Mancos	Montezuma	7,008	2	45.6	(a)	(a)	(a)	12.35	12.44	(a)
Grand drainage:										
Breckenridge	Summit	9,524	12	33.2	24.03	24.49	16.29	29.41	14.62	29.44
Parachute	Garfield	5,105	9	49.8	(a)	(a)	(a)	18.14	7.89	11.37
G. S. ranch	Mesa	5,200	14	52.1	(a)	14.45	8.37	13.17	6.09	11.77
Grand Junction	do	4,608	10	49.2	8.22	11.10	5.45	10.87	3.64	8.89
Cedar Edge	Delta	6,175	9	.....	9.33	15.05	9.48	10.90	9.67	11.89
Delta	do	4,980	12	.....	(a)	11.87	4.72	8.44	5.19	8.78
Antlers	Garfield	5,350	15	.....	(a)	17.92	9.16	15.81	5.82	(a)
Green drainage:										
Meeker	Rio Blanco	6,182	8	.....	16.28	24.30	13.34	20.05	(a)	b16.92
Pagoda	Routt	6,500	9	41.1	17.38	29.13	18.92	24.05	12.32	20.53
Lay	do	6,200	7	.....	14.04	(a)	(a)	(a)	7.60	13.62

a Record incomplete. b Normal to 1898, inclusive.

As has been suggested, the run-off of a mountainous area will differ very considerably from the run-off of an equal area on the plains. A

given amount of precipitation in South Park, for example, will furnish to the same stream a very much greater run-off than the same amount of precipitation on the plains north of Sterling, the more rocky and broken by ravines the territory the greater being the percentage of run-off. The character of the rock formation and the nature of the canyons through which the water flows also have important bearings upon this percentage. Twelve inches of precipitation on the headwaters of the Arkansas will furnish a greater percentage of run-off than the same amount falling on an equal area of the Mesa Verde, in southwestern Colorado, the rock in the former case absorbing little water and the soil being of such nature that the water does not percolate through it to a very great extent, and the rock in the latter case being a soft sandstone and the ravines having sandy beds. For these reasons it is evident that to determine the run-off at any particular point a series of stream measurements must be made, for determinations based solely on the precipitation of a region would be only approximate.

The effect of forests in conserving moisture and in rendering the discharge of the streams more equal throughout the year is thoroughly demonstrated and generally admitted.[a] Whether or not the presence of forests increases precipitation in a given territory is of little importance compared with the question of the extent to which the forest keeps back the floods of the spring and early summer for later use. An examination of discharge tables obtained at stations that have been long maintained will show that the high-water stage is becoming each year earlier and of shorter duration. It is self-evident that anything that will tend to equalize the flow of streams throughout the year has an important bearing on the use of water. A given stream may be adequate to irrigate all the cultivable land along its borders if its water can be properly distributed throughout the irrigating season. When, however, as is the case upon many streams, the water runs off rapidly in May and in the early part of June, it will happen that while there is a great surplus of running water during the early part of the year, yet the stream may be nearly dry at a time when a great deal of water is needed for irrigation. This is the case, for example, upon the Mancos River, in the southwestern part of the State, in which during the month of May enough water goes to waste to furnish all the adjacent irrigable land with a sufficient supply if it could be properly stored.

In studying this question one should not fall into the error of supposing that in order to make the most economical and satisfactory use of the water the supply should be equal throughout the summer

[a] See Fifth Biennial Report of the State Engineer of Colorado, p. 43; Bulletin No. 55, Colorado Agricultural Experiment Station; Twentieth Annual Report, U. S. Geological Survey, Part V, and reports of the Forestry Division of the Department of Agriculture.

season. Usually more water is needed in the latter part of May and in early June than would be required in any other month; that is to say, the duty of water—the area of land that may be served by a given quantity of water—is least in May and June, and increases rapidly toward the end of the season, so that it would be a mistake to suppose that if, for example, 100 cubic feet per second were required for a given area at the time when most water was needed, that provision must also be made for a flow of 100 cubic feet per second regularly throughout the remainder of the so-called irrigation season. Such a run of water at a time when little of it was being used could not do otherwise than cause great damage by washing away the soil and making swamps of the lowlands. The amount of water used at various seasons will depend largely on the kind of crops raised and on the nature of the season. This phase of the irrigation problem is being studied by the Agricultural Department, and a number of bulletins and papers have already been written on this subject,[a] as well as on loss of water by seepage and evaporation.[b] It is therefore sufficient here to call attention to the facts that when the run-off is the greatest the use of water is also generally the greatest, and that the amount of water required diminishes somewhat as the normal supply itself diminishes, only less rapidly; so that the most economical use of the water of a given stream is obtained when all the land along that stream is cultivated that can be supplied with water directly from the stream itself for about two months of the year, the balance of the supply being stored from waters that would otherwise have gone to waste during the high stages, and the amount of land cultivated being so regulated that practically all of the water is used.

On streams where there is no flow normally, as is usually the case with the streams of the plains, the supply consisting almost entirely of a discharge lasting a few hours only during and after storms, the situation is, of course, different. If all of the water of such streams can be stored in reservoirs, it may be drawn off gradually and used for irrigation. The chief difficulties in such cases are that the water usually comes down in great quantities very heavily laden with silt, so that it is almost impracticable to construct canals that will carry it without either erosion or filling, and that reservoirs constructed in the beds of such streams usually fill with sediment very quickly. Sometimes, however, a stream is so fortunate in its situation and regimen

[a] Bulletins of the U. S. Department of Agriculture, Office of Experiment Stations, Nos. 73, 81, and 86, and Bulletin No. 22 of the Agricultural Experiment Station at Fort Collins, Colo., and U. S. Geological Survey Annual Reports as follows (see indices of same, under Duty of Water): Tenth, Part II; Eleventh, Part II; Twelfth, Part II; Thirteenth, Part III; and Fifth State Engineer's Report, p. 46; Sixth, p. 67; Seventh, p. 7; Eighth, p. 20; Ninth, pp. 17, 51, and 59. Also Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, p. 95.

[b] Bulletins Nos. 45 and 48, Agricultural Experiment Station, Fort Collins, Colo., and U. S. Geological Survey Annual Reports as follows (see indices of same, under Evaporation): Eleventh, Part II; Twelfth, Part II; Thirteenth, Part III; Fourteenth, Part II; Twentieth, Part II; also Bulletin No. 140.

that a considerable portion of its water may be drawn away from the channel in which it flows and diverted to some adjacent reservoir site. The chief differences, therefore, between a mountain or perennial stream and one flowing on the plains are that irrigation may be practiced from the first by water taken directly from the stream, while the water from the second must be stored before it can be used, and that the water of one is comparatively clear, while that of the other is inordinately filled with silt.

The storage of surplus water is a great problem in itself. In many localities where there is plenty of water that is going to waste no satisfactory reservoir sites are available; on the other hand, many of the best reservoir sites of the State are in localities where it is difficult to get water to them from the natural streams. Few people, comparatively speaking, realize how large a reservoir must be to supply any considerable amount of land with water for irrigation. Those who have reservoir propositions in view should bear in mind that where land is to be irrigated entirely by means of the water stored in a reservoir it will, making all necessary allowances, take approximately 2 acre-feet—that is, 2 acres covered with water 1 foot deep, or, what amounts to the same thing, 1 acre covered with water 2 feet deep—to irrigate a single acre of land for a season; so that to irrigate 1,000 acres of land would require a reservoir, let us say, covering an area of 100 acres 20 feet deep, if all the water is to be derived from this source and none directly from the stream. This suggestion is made for the reason that persons often recommend the examination of a reservoir site which they say would store water for a whole township, whereas in reality it would furnish little more than enough for stock use for a good-sized cattle ranch. That there are many available reservoir sites, however, throughout the State, is beyond question, and information and data concerning such sites is always gladly received. A few of the more important sites already examined will be mentioned from time to time in this paper.

WINTER DISCHARGE.

In compiling the tables given hereafter the records for the winter months have usually been accepted as furnished by the observers. It is, however, unsafe to trust these records unreservedly, for in nearly all of our mountain streams ice gorges are constantly being formed in winter, changing the velocity of the current and the gage height recorded by the observer without materially changing the discharge of the stream. It is often safer to strike an average between the November flow and the flow of about the middle of March or the first of April following than to trust to the apparent discharge as derived from the observations. For this reason the winter discharge has been

omitted from a number of stations where the figures if given would have been absolutely misleading; they are retained, however, in a few stations, and where any false impression might arise from the figures given, attention is called to that fact in a footnote.

EXPLANATION OF TABLES.

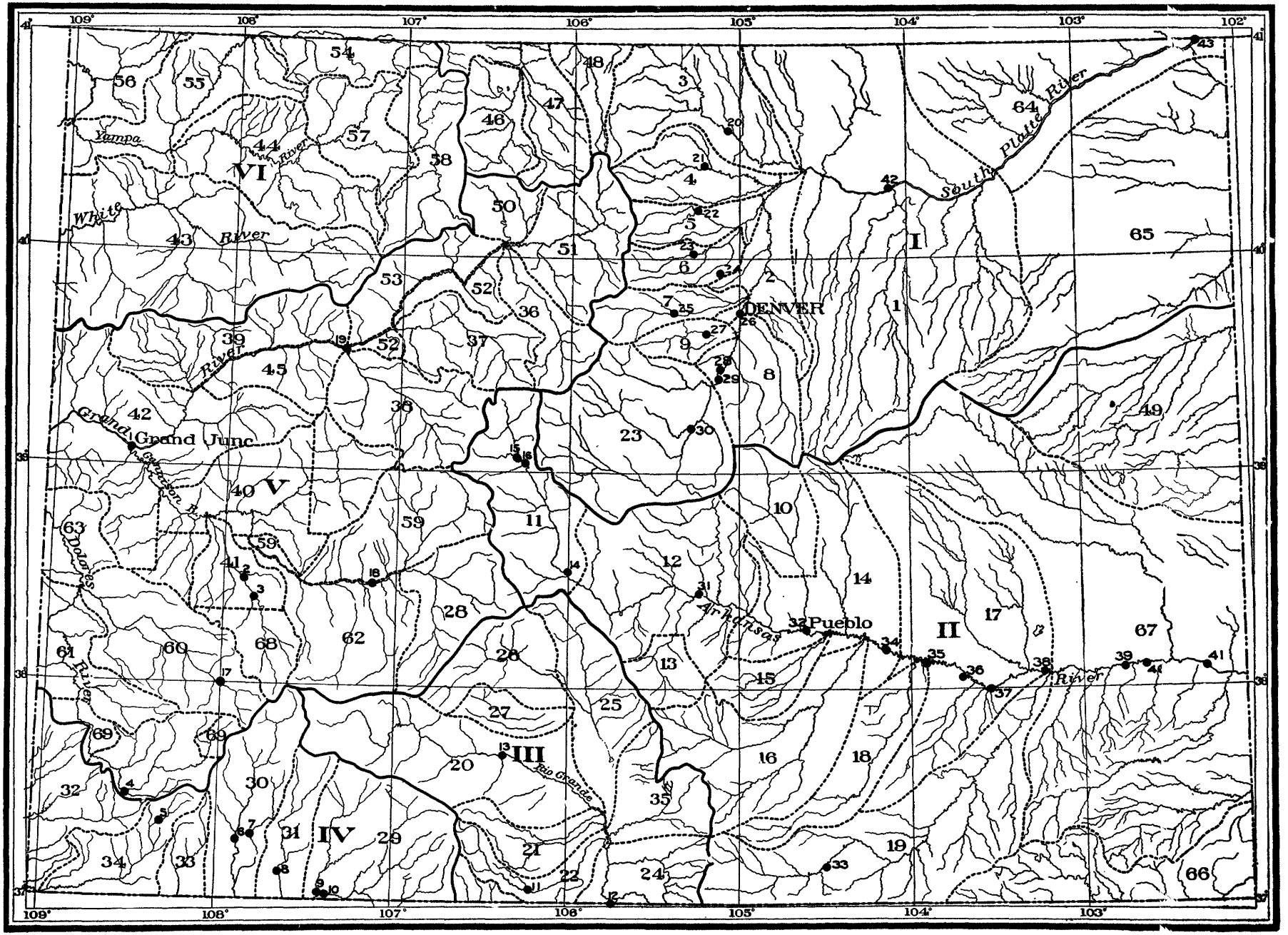
In general the tables given in this paper are summarized from all available data. For stations where records exist for from one to three years only the discharge is given for each year individually, but for stations where records have been maintained for four or more years the average discharge is usually given for each month during which the record was kept and these averages are again averaged, giving a normal discharge for each month as computed for that month of each year during which records were kept, these being again averaged for a normal year or that portion of the year covered by the records. The discharge in second feet per square mile given in the vertical columns in these tables is the amount corresponding to the average flow for the same months or periods, the depth in inches being derived directly from the flow in second feet per square mile and corresponding thereto. The discharge for that portion of each year covered by the record, or for the whole year, as the case may be, is averaged and placed below the record for that year. The number of acre-feet given is in each case the corresponding amount for the period covered. The number of second-feet per square mile is derived from the average flow for the period covered, and the depth of run-off in inches is derived from them, usually for a thirty-day period, but at times for the entire year or for the entire period covered, the variations being mentioned in the accompanying footnote in each case. It is believed that the footnote accompanying each table is sufficient for further explanation of the table.

IRRIGATION SYSTEM.

As has already been mentioned, the State of Colorado is divided into six irrigation divisions, each comprising a considerable portion of the State, drained usually by a single stream and its tributaries, these divisions being in their turn divided into districts (see Pl. I), as will be more fully described later.[a]

The six divisions are as follows: Division No. I, or South Platte River; No. II, or Arkansas River; No. III, or Rio Grande; No. IV, or San Juan River; No. V, or Grand River; No. VI, or Green River; each consisting in general of the territory drained by the stream (with its tributaries) from which the division takes its name.

[a] Bulletins Nos. 58, 60, and 73, Office of Experiment Stations, U. S. Department of Agriculture. Water-Supply and Irrigation Paper No. 9, U. S. Geological Survey, and reports of the State Engineers of Colorado.



MAP OF COLORADO, SHOWING IRRIGATION DIVISIONS, WATER DISTRICTS, AND GAGING STATIONS.

Irrigation divisions, each drained usually by a single stream and its tributaries, are indicated by roman caps (I–VI) and heavy lines; water districts, by broken lines and arabic numerals; gaging stations, by smaller arabic numerals and large dots.

SOUTH PLATTE DIVISION.

DRAINAGE.

Division No. I, or South Platte River division,[a] consists of the territory drained by South Platte River and its tributaries, but includes also North Park, drained by the North Platte and its tributaries, in which are located water districts Nos. 46, 47, and 48. Water district No. 65 is also included, which covers the territory within the northern half of the Kansas River Basin in Colorado drained by Frenchmar Creek, the North Fork of the Republican, and the Arikaree. The two latter streams, however, in district No. 65, are of little importance, so far as irrigation in Colorado is concerned, as they head too near the eastern border of the State and carry too small amounts of water to be of much value.[b] The country drained by these streams varies in altitude from about 5,000 down to 3,800 feet above sea level. This area is what has been known in the past as the rain-belt country, and for some years there was a general belief that farming could be practiced successfully in that region without irrigation, but such farming has not been found to be profitable, and agriculture in that section hereafter will be generally limited to small tracts that can be irrigated, either directly from the streams or by means of storage. In some cases artesian wells produce a flow sufficient for stock use and for the cultivation of small patches of ground. No gaging stations have been established upon any of these streams.

The streams of North Park are of more importance. District No. 46 consists of the territory drained by the North Platte proper in Colorado as far down as its junction with Middle Fork. No. 47 consists of the territory drained by the Middle Fork and its tributaries and the North Platte below its junction with Middle Fork. No. 48 consists of the drainage basin of the Laramie and its tributaries. The territory comprising North Park is in general a rolling, more or less timbered country, with numerous small streams flowing through it. The principal industry is stock raising, crop raising being limited to hay and grain. Little irrigation is practiced, this being limited principally to hay meadows. On the Laramie, however, a complication arises from the fact that a canal, called Skyline canal, takes a considerable portion of the upper tributaries across the divide into the drainage of the South Platte River, taking water away from the State of Wyoming and using it in the drainage basin of the South Platte.[c] No measurements are made in Colorado upon the tributaries

[a] State Engineers' Reports: Second, p. 26; fourth, pp. 35 and 46; fifth, p. 63, and sixth, p. 67. For details concerning the different districts, see the Biennial Reports of State Engineers; also Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, p. 94 et seq.

[b] See list of miscellaneous measurements, page 69.

[c] See Hayden's Reports; also Nineteenth Annual Report U. S. Geological Survey, Part IV, p. 300; Twentieth Annual Report, Part IV, p. 393; Water-Supply and Irrigation Paper No. 9, p. 42. Also Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, p. 97, etc.

of the North Platte, but a station has been maintained for some years upon the Laramie at Woods, in Wyoming, a few miles north of the State line, and the results of these measurements are given in the table for the Laramie at that point (page 60).

The South Platte River itself rises in South Park and flows in a generally northeasterly direction to the northeast corner of the State, which it leaves at a point a short distance below Julesburg. The drainage basin has been so fully described in previous reports and irrigation papers that only a brief description is necessary, the reader being referred to those already printed.[a] In general, the western side of the division is very mountainous, the main stream itself and all the tributaries of that section issuing from high mountains through deep canyons, many of them, however, draining parks at the headwaters, where stock raising and some cultivation of hay is carried on. From the eastern slope of the foothills to the eastern boundary of the State the country is of the plains character, and the streams draining this section are torrential in their nature. The normal flow throughout this entire division is claimed and used for irrigation, but in the high stages of the streams and in the winter season a great deal of water goes to waste which might be stored in suitable reservoirs.

The water districts now included in this division are Nos. 23,[b] 8,[c] 2,[d] 1,[e] and 64,[e] on the South Platte River; No. 9,[f] comprising the territory drained by Bear Creek; No. 7,[g] by Clear Creek; No. 6,[h] by Boulder Creek; No. 5,[h] by St. Vrain Creek; No. 4,[i] by Big Thompson Creek; No. 3,[i] by Cache la Poudre River; Nos. 46, 47, and 48,[j] by tributaries of North Platte River; and No. 65 by tributaries of Kansas River, the latter district being more properly outside of the South Platte River division, although legally a part of it.

STREAM MEASUREMENTS.

The following stations have been maintained for a greater or less time in or near the South Platte division: Cheesman Lake, Platte Canyon, Denver, and Orchard on South Platte River; Morrison, on Bear

[a] See U. S. Geological and Geographical Survey Terr., Hayden, 1875 and 1876. Annual Reports U. S. Geological Survey: Tenth, Part II, p. 69; Thirteenth, Part III, p. 82; Sixteenth, Part II, p. 542; Eighteenth, Part IV, p. 159; Nineteenth, Part IV, p. 311; Twentieth, Part IV, p. 277; Twenty-first, Part IV, p. 200. Also Bulletins No. 131, p. 30, and No. 140, p. 102; Water-Supply and Irrigation Paper No. 37, p. 221; No. 49, p. 278, and Tenth Biennial Report State Engineer of Colorado, p. 246.

[b] Fifth Biennial Report, Part II, Pl. I.

[c] Ibid., Pl. VII; also Seventh Biennial Report.

[d] Ibid., Pl. III; also Seventh.

[e] Ibid., Pl. II; also Seventh.

[f] Ibid., Pl. VIII; also Seventh.

[g] Ibid., Pl. VI; also Seventh.

[h] Ibid., Pl. V; also Seventh.

[i] Ibid., Pl. IV.

[j] Nos. 46, 47, 48, and 65 have not been mapped.

Creek; Forkscreek, on Clear Creek; Marshall, on South Boulder Creek; Boulder, on Boulder Creek; Lyons, on St. Vrain Creek; Arkins, on Big Thompson Creek; Fort Collins, on Cache la Poudre; and Woods in Wyoming, on Laramie River.

The waters of this division are used in all the different ways previously mentioned. In South Park and in the foothills along the east front of the Rocky Mountains water is being extensively stored for domestic use. In the mountains and in places where the fall is great the water is used for the development of power and also for placer mining. After leaving the mountains it is used for irrigation, and already it is being stored extensively for use late in the irrigation season, this being especially true of the territory along the Big Thompson and Cache la Poudre. Cheesman Lake and some of the other reservoirs of the upper portion of the Platte have already been described,[a] as have also a number of those of northern Colorado.[b] There are undoubtedly enough reservoir sites along the South Platte and its tributaries to store all the water that now goes to waste. A number of these on the plains through which the river flows between Greeley and Julesburg are now under consideration.

SOUTH PLATTE RIVER AT CHEESMAN LAKE.

This station has been maintained by the Denver Union Water Company for the purpose of determining the discharge of the South Platte at that point with reference to the construction of a large reservoir for the purpose of providing a sufficient domestic water supply for the city of Denver and of developing power to be transmitted from the lake to various points below. The dam is to be of solid masonry, 217 feet in height, and is already well under way (see Pl. II). The lake when full will be about 7 miles in length, and the capacity will be probably not less than 4,000,000,000 cubic feet. The same company has other large reservoirs at points lower down, but none of equal magnitude with this.[c]

The records are given for only two years. Those for 1899 are approximate, but those for 1900 have been carefully compiled and are very reliable. They are furnished through the courtesy of Mr. C. L. Harrison, chief engineer of the Denver Union Water Company.[d]

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[a] House Doc. No. 141, Fifty-fifth Congress, second session, H. M. Chittenden's Report; Water-Supply and Irrigation Paper No. 37, p. 221; Twenty-First Annual Report U. S. Geol. Survey, Part IV, fig. 192; Tenth Biennial Report of State Engineer, p. 247.

[b] Water-Supply and Irrigation Paper No. 9, and Chittenden's Report above mentioned.

[c] See Chittenden's Report above mentioned, this reservoir being there called the "South Platte site."

[d] For more detailed information concerning this station see Tenth Biennial Report of the State Engineer of Colorado, p. 248; Water-Supply and Irrigation Paper No. 37, pp. 222–223; No. 39, p. 447, and No. 49, p. 280.

Estimated monthly discharge of South Platte River at Cheesman Lake.

[Drainage area, 1,677 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1899.						
August	902	170	354	21,767	0.21	0.24
September[a]	198	105	149	8,926	.09	.10
October[a]	155	34	92	5,657	.05	.06
November[a]	171	55	125	7,438	.07	.08
December	112	44	70	4,304	.04	.04
Last 5 months of the year			[a]158	48,092	.09	.52
1900.						
January	27	23	26	1,599	.02	.02
February[b]	27	27	27	1,553	.02	.02
March	103	27	80	4,919	.05	.06
April	547	92	254	15,114	.15	.17
May	1,540	562	1,038	63,824	.62	.71
June	1,945	550	1,204	71,643	.72	.80
July	522	40	208	12,789	.12	.14
August	126	58	88	5,410	.05	.06
September	103	63	79	4,701	.05	.06
October	155	39	84	5,165	.05	.06
November	90	37	69	4,106	.04	.04
December	67	18	33	1,964	.02	.02
The year			[a]266	192,787	.15	2.16

[a] Average. [b] Estimated in part.

List of discharge measurements made on South Platte River at Cheesman Lake.

[Hydrographer, J A. Runner.]

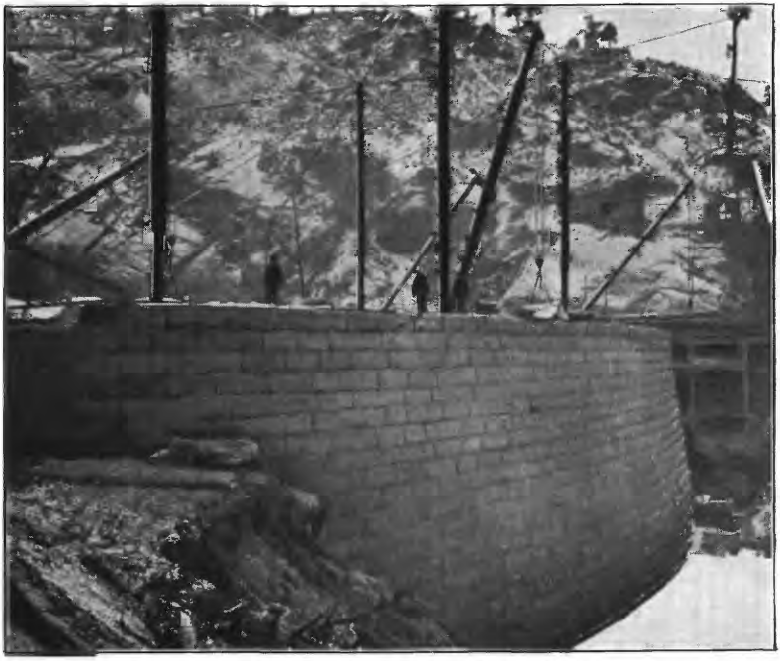
Date.	Gage height.	Discharge.	Remarks.
1899.	*Feet.*	*Sec.-ft.*	
July 31	3.62	806	All gagings are made by floats.
September 8	1.45	184	
October 3	1.23	95	
November 19	1.30	107	
December 5	1.24	97	

List of discharge measurements made on Goose Creek at Cheesman Lake.

[Hydrographer, J. A. Runner.]

Date.	Gage height.	Discharge.	Remarks.
1899.	*Feet.*	*Sec.-ft*	
September 8	0.95	24	All gagings made by floats.
October 8	.84	10	
November 19	.72	8	
December 3	.76	9	

A. DAM AT CHEESMAN LAKE, DOWNSTREAM FACE.



B. DAM AT CHEESMAN LAKE, UPSTREAM FACE.

SOUTH PLATTE RIVER AT PLATTE CANYON.

Records have been kept for a number of years of the discharge of South Platte River at a point a short distance above where it debouches from the mountainous area into the plains. The station was located first at Deansbury, but was later removed to a point about 3 miles downstream, near the pumping station of the Denver Union Water Company. The records for both stations are given in one table, as they are practically the same, no water being used along this section except what is taken out by the Denver Union Water Company at its head gate, which amount would be approximately compensated by the inflow during the same distance. The station is of importance, as it gives the discharge of the river just above the point where it begins to be used on a large scale for irrigation, and is, therefore, of great value in determining the amount available for storage and the percentage of run-off from the territory above. The situation is complicated, however, as has been previously suggested, by the fact that some irrigation is practiced in South Park, for which reason an estimate of the percentage of run-off based upon this record would necessarily be too small. The irrigation ditches of South Park, although small in size, are many in number, and the aggregate of water thus used is considerable. At a point about a mile below the gaging station the first large canal, the Northern Colorado Irrigation Company's canal,[a] is taken out by means of a diverting dam constructed across the river and a tunnel cut through a spur of the canyon wall. The physical conditions at the station are not favorable to extremely accurate measurements, for the channel is filled with bowlders and the current is very rapid. The stream bed is not, however, subject to great change, and for this reason the station has been maintained. Gagings must necessarily be made from a bridge or cable, owning to the depth and velocity of the water. The banks are so high that there is little danger of overflow.[b]

[a] See Twenty-first Annual Report U. S. Geological Survey, Part IV, p. 200; also, Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, pp. 101 and 109.

[b] Biennial Reports of the State Engineers of Colorado: Fourth, Part I, p. 63, and Part II. Pl. XVII; Fifth, Part I, pp. 19 and 24, and Part II, Pl. XI; Sixth, pp. 19 and 26; Eighth, pp. 412 to 419; Ninth, pp 328 and 329; Tenth, pp. 252 to 255. Annual Reports U. S. Geological Survey: Eighteenth, Part IV, p. 159; Nineteenth, Part IV, p. 311; Twentieth, Part IV, p. 280; Twenty-first, Part IV, p. 201. Also, Bulletin U. S. Geological Survey No. 140, p. 103, and Water-Supply and Irrigation Papers, No. 11, p. 52; No 15, p. 87; No. 37, p. 224, No. 39, p. 448, and No. 49, p. 280. Also, Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, pp. 101, 109, 114, and 125.

Discharge of South Platte River at Deansbury and Platte Canyon.

[Drainage area at Deansbury, 2,600 square miles.]

Month.	1887.	1888.	1889.	1890.	1891.	1892.	1895.	1896.	1897.	1899.	1900.	Mean.	Equivalent in acre-feet.	Mean run-off.	
														Second-feet per square mile.	Depth in inches.
	Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*			
January	.....	.....	.....	.....	.....	.....	.....	97	81	.....	98	92	5,657	0.04	0.04
February	.....	.....	.....	.....	.....	.....	.....	115	80	.....	53	83	4,610	.03	.03
March	.....	.....	.....	.....	.....	.....	.....	207	101	.....	156	155	9,531	.06	.07
April	295	.....	[a] 172	.....	[b] 142	.....	.....	473	370	454	826	405	24,100	.16	.18
May	470	.....	478	391	[c] 1,117	[d] 630	.....	502	984	760	[g] 424	862	53,002	.33	.38
June	535	.....	460	403	1,243	628	.....	281	1,046	1,346	(*f*)	743	44,212	.29	.32
July	310	545	324	520	645	847	.....	233	.....	1,161	.....	573	35,233	.22	.25
August	265	550	211	562	373	535	.....	189	.....	587	.....	409	25,148	.16	.18
September	165	410	129	196	219	328	.....	250	.....	233	.....	266	15,828	.10	.11
October	185	300	180	172	.....	292	.....	217	.....	154	.....	214	13,158	.08	.09
November	.....	.....	.....	.....	.....	.....	[e] 241	169	.....	160	.....	190	11,306	.07	.08
December	.....	.....	.....	.....	.....	.....	145	93	.....	160	.....	133	8,177	.05	.06
Mean	318	451	279	374	623	543	193	236	444	557	711	344	249,962	.13	1.79
Acre-feet for period recorded [g]	135,034	109,962	106,922	136,528	187,872	168,012	16,563	170,919	160,395	304,003	212,910	.....	.....	.....	.....

[a] Commencing April 22. [b] April 5 to 12, inclusive. [c] Commencing May 7. [d] Commencing May 29. [e] Commencing November 15.

[f] First two days in June discharge equaled 2,745 second-feet each day.

[g] The run-off for the period covered by the river height observations only; the discharge given above is for average months and an average year, based upon the records kept. The details may be found in the authorities cited for this station.

Maximum and minimum discharge and average run-off of South Platte River at Deansbury and Platte Canyon for that portion of each year covered by records.

Year.	Discharge.				Run-off.	
	Minimum.		Maximum.		Depth in inches.	Second-feet per square mile.
	Date.	Amount.	Date.	Amount.		
		Sec.-ft.		*Sec.-ft.*		
1887	Sept. —	95	June —	785	0.93	0.12
1888	Oct. —	210	July —	670	.70	.15
1889	Sept. 6	92	May 21	788	.77	.11
1890	Oct. 30	112	July 13	875	.98	.14
1891	Apr. 5	121	June 9	1,495	1.37	.24
1892	Oct. 8	270	June 26	962	1.09	.21
1895	Dec. 26	92	Nov. 19	311	.12	.08
1896	Jan. 25	90	Apr. 28	983	1.22	.09
1897	Jan. 28	67	June 1	1,550	1.15	.17
1899	Dec. 5	10	June 20	2,175	2.16	.21
1900	Feb. 14	41	June 1	2,745	1.36	.27

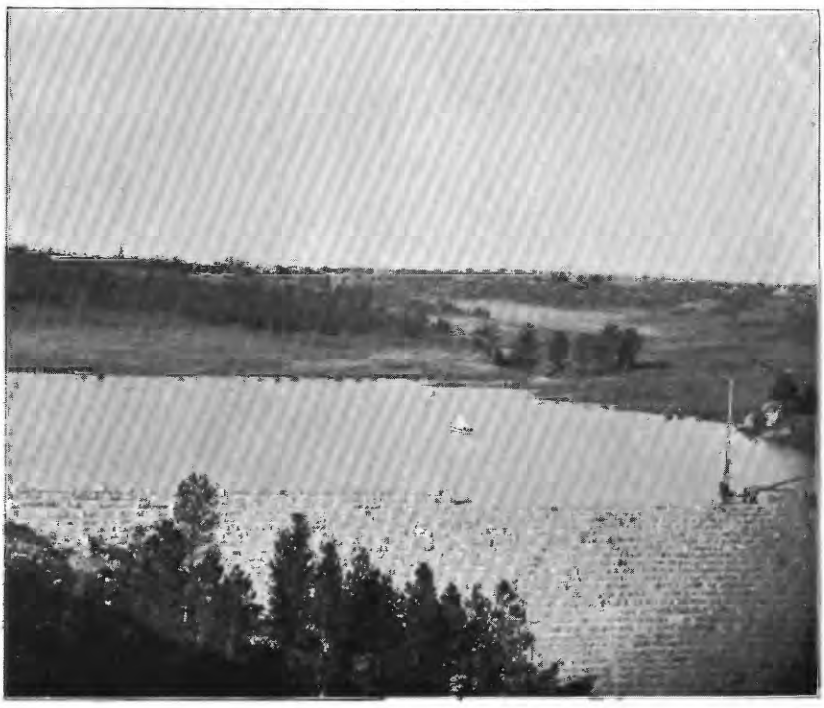
Discharge measurements made on South Platte River at Deansbury and Platte Canyon.

Date.	Hydrographer.	Gage height.	Discharge.	Remarks.
1895.		*Feet.*	*Sec.-ft.*	
Nov. 30	L. R. Hope	4	197	At Deansbury, station No. 1.
Dec. 1	do	3.20	102	Do.
Dec. 7	do	3.60	160	Do.
Dec. 8	do	3.65	166	Do.
Dec. 14	do	3.80	183	Do.
Dec. 20	do	3.35	135	Do.
1896.				
Jan. 12	L. R. Hope	3.05	94	Do.
Jan. 18	do	3.05	94	Do.
Jan. 27	do	2.90	90	Do.
Feb. 4	do	3.18	116	Do.
Feb. 11	do	3.10	101	Do.
Feb. 19	do	2.97	91	Do.
Feb. 23	do	3.42	144	Do.
Mar. 18	do	3.07	97	Do.
Mar. 20	do	3.75	184	Do.
Mar. 30	do	5.15	372	Do.
Apr. 2	do	4.30	259	Do.
Apr. 13	do	4.85	329	Do.
May 3	do	2.70	557	At Deansbury, station No. 2.
May 26	do	2.55	485	Do.
June 9	do	1.90	314	Do.

Discharge measurements made on South Platte River at Deansbury and Platte Canyon—Continued.

Date.	Hydrographer.	Gage height.	Discharge.	Remarks.
1896.		*Feet.*	*Sec.-ft*	
June 14	L. R. Hope	1.44	235	At Deansbury, station No. 2.
July 6	do	.90	138	Do.
July 24	do	1.66	289	Do.
Aug. 14	do	.73	125	Do.
Aug. 25	do	1.30	205	Do.
Sept. 28	do	1.50	239	Do.
Oct. 10	do	1.42	233	Do.
Oct. 20	do	1.23	193	Do.
Oct. 31	do	1.33	212	Do.
Nov. 10	do	1.27	201	Do.
1897.				
Jan. 8	L. R. Hope	2.75	79	At Deansbury, station No. 1.
Jan. 16	do	2.68	85	Do.
Jan. 22	do	2.56	68	Do.
Jan. 31	do	2.33	56	Do.
Feb. 17	do	2.58	72	Do.
Mar. 1	do	2.75	90	Do.
Mar. 11	do	2.82	103	Do.
Mar. 20	do	2.75	92	Do.
Mar. 27	do	3.40	165	Do.
Apr. 8	do	4.17	261	Do.
Apr. 17	do	4.70	343	Do.
Apr. 22	do	5.80	511	Do.
Apr. 8	do	1.67	261	At Deansbury, station No. 2.
Apr. 17	do	2.02	343	Do.
Apr. 22	do	2.62	511	Do.
Apr. 3	do	3.05	644	Do.
Apr. 9	do	3.50	831	Do.
May 25	do	4.15	1,006	Do.
June 10	do	3.85	985	Do.
July 1	do	3.15	678	Do.
1899.				
Apr. 14	J. E. Field	1.80	559	Do.
May 8	A. L. Fellows	1.50	500	Do.
June 10	do	2.90	1,127	Do.
July 28	do	1.80	633	Do.
Oct. 4	do	.10	146	Do.
1900.				
Mar. 5	A. L. Fellows	— .40	87	Do.
Apr. 18	do	1.55	467	Do.

A. CASTLEWOOD DAM DURING CONSTRUCTION.



B. CASTLEWOOD LAKE AND DAM.

SOUTH PLATTE RIVER AT DENVER.

Attempts have been made at different times to establish and maintain stations at a number of points in the vicinity of Denver, but the only one that has proved of sufficient value to be kept up is the one located at the Fifteenth street bridge, about 1 mile below the post-office. The location is favorable in some respects, as it is just below the mouth of Cherry Creek, upon which the Castlewood dam (see Pl. III) is situated, the junction of Cherry Creek and the South Platte marking the end of district No. 8 and the beginning of district No. 2. It is, moreover, as favorable a location with reference to channel and banks as can be found anywhere below the point at which the river strikes the sandy plains, where it becomes broad and shallow, with a changeable and shifting bottom. Owing, however, to its being located so near the mouth of Cherry Creek, considerable difficulty is experienced through a deposition of bars of sand and gravel, sometimes along the left bank of the river and again along the right bank, so that occasional changes in gage rods and frequent changes in rating tables are necessary. Measurements at this point are necessarily made as often as possible.

The station is principally valuable as giving information concerning the discharge at the head of irrigation district No. 2, so that the division of water among consumers may be regulated by the water commissioner with greater facility. Measurements are made from the bridge, except at low water, when they may be made by wading.[a]

[a] For more detailed information concerning this station see Biennial Reports of State Engineers of Colorado: Fifth, Part I, p. 26, Part II, pl. 12; Sixth, p. 19; Eighth, p. 420; Ninth, p. 330; Tenth, p. 256. Annual Reports U. S. Geological Survey: Eighteenth, Part IV, p. 162; Nineteenth, Part IV, p. 313; Twentieth, Part IV, p. 279; Twenty-first, Part IV, p. 201. Bulletin U. S. Geological Survey No. 140, p. 104. Water-Supply and Irrigation Papers, No. 11, p. 53; No. 15, p. 88; No. 27, pp. 81, 86, 89; No. 37, p. 225; No. 39, p. 448; and No. 49, p. 281. Also Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, pp. 101, 109, 114.

Discharge of South Platte River at Denver.

[Altitude, 5,183 feet; drainage area, 3,840 square miles.]

Month.	1895.	1896.	1897.	1898.	1899.	1900.	Mean.	Equivalent in acre-feet.[a]	Mean run-off.	
									Second-feet per square mile.	Depth in inches.
	Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*			
January	.....	182	95	164	55	204	140	8,608	0.04	0.04
February	.....	198	83	153	196	193	164	9,108	.04	.04
March	.....	225	179	121	409	184	223	13,711	.06	.07
April	.....	301	470	377	466	1,634	649	38,619	.17	.19
May	.....	291	735	1,444	432	4,187	1,418	87,190	.37	.43
June	.....	200	1,026	1,552	821	2,817	1,283	76,344	.33	.37
July	854	164	392	672	637	370	515	31,666	.13	.15
August	742	115	687	328	527	148	424	26,071	.11	.13
September	426	145	270	187	286	123	239	14,222	.06	.07
October	698	111	267	146	109	104	239	14,695	.06	.07
November	456	101	406	131	202	179	246	14,638	.06	.07
December	204	103	217	98	146	178	157	9,653	.04	.04
Mean	563	178	402	448	357	860	475	344,525	.12	1.67
Acre-feet for period recorded[a]	206,070	128,837	291,996	325,006	258,850	632,690	.....	.....	.....	.....

[a] The run-off given is for the period covered by the observations of each year. That given in the vertical columns is for average months and years from all the data obtained. Details for these years may be seen in authorities cited for this station.

Maximum and minimum discharge and total run-off of South Platte River at Denver for that portion of each year covered by records.

Year.	Discharge.				Run-off.	
	Minimum.		Maximum.		Depth in inches.	Second-feet per square mile.
	Date.	Amount.	Date.	Amount.		
		Sec.-ft.		*Sec.-ft.*		
1895	Dec. 23	108	Aug. 2	1,945	1.19	0.14
1896	Oct. 11	27	July 25	758	.62	.05
1897	Feb. 13	16	Aug. 5	2,458	1.426	.105
1898	Dec. 23	50	May 28	2,308	1.58	.12
1899	Jan. 22	42	Aug. 5	1,422	1.257	.093
1900	Oct. 7	51	Apr. 29	5,510	2.92	.22

Discharge measurements made on South Platte River at Denver.

Date.	Hydrographer.	Gage height.	Discharge.
1895.		*Feet.*	*Sec.-feet.*
May 7	P. J. Preston		168
July 23	F. Cogswell	5.40	1,490
Aug. 7	P. J. Preston	4.60	876
Aug. 22	do	3.90	447
Nov. 9	do	4.30	430
Nov. 29	do	3.90	303
1896.			
Jan. 6	P. J. Preston	3.60	183
Apr. 8	do	4.50	235
May 29	do	4.90	304
July 1	do	4.33	107
July 25	do	6.10	1,316
Aug. 5	do	4.35	125
Aug. 26	R. A. Sumner	4.80	83
Sept. 11	F. Cogswell	5.10	163
Oct. 30	P. J. Preston	4.70	93
Nov. 9	do	4.75	100
1897.			
Jan. 15	P. J. Preston	4.70	98
Apr. 15	F. Cogswell	5.35	385
May 1	do	5.70	595
May 25	do	5.85	778
June 4	do	6.45	1,311
June 15	do	6.75	1,406
July 13	do	5.60	687
Aug. 5	do	7.45	1,849
Aug. 20	do	5.55	473
Sept. 6	do	4.95	116
Oct. 11	do	5.70	413

Discharge measurements made on South Platte River at Denver—Continued.

Date.	Hydrographer.	Gage height.	Discharge.
1898.		*Feet.*	*Sec.-ft.*
Apr. 21	A. L. Fellows	5.90	564
July 6	.....do	6.10	443
Sept. 2	.....do	5.50	195
Oct. 8	.....do	5.00	90
Oct. 29	F. Cogswell	5.32	234
1899.			
Apr. 12	A. L. Fellows	6.00	422
May 11	.....do	6.03	355
June 12	.....do	6.20	764
July 27	.....do	5.32	213
Aug. 4	.....do	6.93	1,200
Sept. 6	.....do	5.95	288
Oct. 5	.....do	5.10	100
1900.			
Mar. 6	A. L. Fellows	5.50	244
Apr. 12	.....do	5.90	377
Apr. 16	.....do	7.24	1,439
Apr. 20	.....do	7.10	1,395
Apr. 23	.....do	8.32	3,516
June 11	.....do	8.50	3,270
July 25	.....do	5.45	257
Aug. 7	.....do	5.56	285
Aug. 29	.....do	4.90	90
Oct. 20	R. W. Hawley	5.50	226
Oct. 22	.....do	5.30	161

SOUTH PLATTE RIVER AT ORCHARD.

This station was established November 20, 1895, for the purpose of furnishing data relative to the flow of South Platte River in the winter months and during flood stages, but later was maintained throughout the entire year for the purpose of determining the total discharge. It is situated some distance below all the mountain drainage of the stream and below the territory in which there is the greatest return from seepage. For three years the rod was located in a bend of the river about one-fourth of a mile southwest of the railroad station at Orchard, but later a new rod was placed at the wagon bridge south of the town, and since that time readings have been taken at the latter point, for the reason that it was necessary to make the gagings from the wagon bridge at times of high water. The channel throughout this entire region is broad and shallow, the bottom being sandy and shifting, rendering frequent changes in the rating tables necessary.

The investigations at this point have demonstrated that great amounts of water go to waste, and private capital has been enlisted for the construction of the reservoirs of the South Platte Land, Reservoir and Irrigation Company in the vicinity of Orchard. The reservoirs of this company consist of natural basins located in the plains on each side of the river, all water being diverted from the river to the reservoir sites by means of large canals.[a]

[a] For more detailed information concerning this station see Biennial Reports of State Engineers of Colorado: Eighth, p. 426; Ninth, p. 333; Tenth, p. 261. Also publications U. S. Geological Survey: Eighteenth Annual Report, Part IV, p. 166; Nineteenth, Part IV, p. 315; Twentieth, Part IV, p. 293; Twenty-first, Part IV, p. 203; Bulletin No. 140, p. 112; Water-Supply and Irrigation Papers No. 11, p. 53; No. 15, p. 89; No. 27, pp. 84, 86, and 89; No. 37, p. 226; No. 39, p. 448, and No. 49, p. 282. Also Report on Agriculture by Irrigation, Eleventh Census, pp. 122 and 132.

Discharge of South Platte River at Orchard.

[Altitude, 4,393 feet; drainage area, 12,260 square miles.]

Month.	1895.	1896.	1897.	1898.	1899.	1900.	Mean.	Equivalent in acre-feet.	Mean run-off.	
									Sec.-feet per square mile.	Depth in inches.
	Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*			
January	.....	775	631	[a]1,068	[a]2,880	[a]1,634	[a]1,397	[a]85,898	[a]0.11	[a]0.13
February	.....	[b]610	557	811	[a]3,321	[a]1,268	[a]1,313	[a]72,920	[a].11	[a].11
March	.....	581	231	574	[a]2,377	[c]683	[c]889	[a]54,662	[a].07	[a].08
April	.....	.....	529	380	[a]1,325	4,180	[a]1,603	[a]95,386	[a].13	[a].14
May	.....	.....	898	1,946	465	8,617	2,981	183,294	.23	.26
June	.....	.....	2,637	776	1,198	4,638	2,312	137,574	.19	.21
July	.....	.....	347	173	1,593	171	571	35,110	.05	.06
August	.....	.....	803	40	761	114	429	26,378	.03	.03
September	.....	.....	92	69	45	142	87	5,177	.01	.01
October	.....	.....	303	215	429	431	344	21,151	.03	.03
November	[d]870	.....	[a]1,109	811	799	611	840	49,983	.07	.08
December	759	789	[a]1,232	[a]2,651	[a]1,544	614	[a]1,264	77,720	.10	.12
Mean	814	688	[a]789	[a]792	[a]1,394	[a]1,925	[a]1,269	[a]845,253	[a].10	[a]1.26
Acre-feet for period recorded [e]	62,199	148,829	564,500	551,150	1,009,225	1,453,570	.....	.....	.....	.....

[a] The calculations are from the gage heights reported by the observer, but the discharge given for the winter months is probably much too high, owing to ice gorges raising the water on the gage. The winter discharge marked (c) was also probably very much less than the figures would indicate.

[b] February 16 to 29, inclusive.

[d] Commencing November 22.

[e] The run-off per acre-foot given is for that period of each year covered by the observations, the discharge given is for average months and years from all data available. The details for these years may be seen in the authorities cited for this station.

Maximum and minimum discharge and average run-off of South Platte River at Orchard for that portion of each year covered by records.

Year.	Discharge.				Run-off.	
	Minimum.		Maximum.		Depth in inches	Second-feet per square mile.
	Date.	Amount.	Date.	Amount.		
		Sec.-ft.		*Sec.-ft.*		
1895	Nov. 22	818	Dec. 1	1,031	0.095	0.07
1896	Dec. 27	213	Jan. 9	960	.226	.06
1897	July 8	39	June 14	5,160	.851	.064
1898	Apr. 28	10	May 29	3,214	.90	.07
1899	June 12	10	Feb. 27	3,966	1.56	.11
1900	Aug. 16	113	May 2	11,159	2.16	.16

Discharge measurements made on South Platte River at Orchard.

Date.	Hydrographer.	Gage height.	Discharge.
1895.		*Feet.*	*Sec.-ft.*
Nov. 20	P. J. Preston	4.00	829
Dec. 27	do	3.83	667
1896.			
Feb. 19	H. A. Sumner	3.98	669
Oct. 22	P. J. Preston	3.20	240
Dec. 12	do	4.55	550
1897.			
Jan. 18	P. J. Preston	4.14	377
May 28	L. R. Hope	5.00	1,921
June 20	R. S. Sumner	4.68	1,926
June 27	do	3.20	504
July 25	do	3.60	524
Sept. 13	do	2.50	86
Nov. 9	do	4.40	1,299
1898.			
Apr. 24	A. L. Fellows	2.20	71
May 30	do	4.60	3,214
July 9	do	2.25	32
Aug. 9	do	2.25	36
Nov. 6	F. Cogswell	2.80	302
Nov. 17	do	3.15	491
1899.			
Apr. 14	A. L. Fellows	3.20	1,258
May 27	do	2.30	158
Sept. 12	do	2.05	57
Nov. 3	M. D. Williams	2.80	614

Discharge measurements made on South Platte River, at Orchard—Continued.

Date.	Hydrographer.	Gage height.	Discharge.
1900.		*Feet.*	*Sec.-ft.*
Mar. 7	A. L. Fellows	2.85	668
Apr. 21	do	5.00	4,674
July 23	do	1.35	156
Oct. 27	R. W. Hawley	2.70	324

SOUTH PLATTE RIVER AT JULESBURG.

Although no station has been regularly maintained at this point, a number of measurements, which are given in the table below, have been made here at different times. The location is important from the fact that it is near the line between Colorado and Nebraska, so that discharge measurements at this point indicate the flow from the one State into the other. The channel is broad and shallow, the bottom being sandy and shifting. A gage rod was fastened to the wagon bridge 1 mile southeast of Julesburg in the spring of 1900, but no records were kept. Measurements may be made either from the wagon bridge or at low water by wading. The majority of the gagings at this point were made by employees of the State engineer's office in connection with the annual seepage measurements of the South Platte River.[a]

Discharge measurements made on South Platte River, at Julesburg.

[Altitude 3,560 feet.]

Date.	Gage height.	Discharge.
	Feet.	*Sec.-ft.*
November 5, 1891		43
November 4, 1894		2
November 14, 1895		586
September 4, 1899		2
November 12, 1899		487
March 8, 1900	2.10	2,291
November 2, 1900		76

BEAR CREEK AT MORRISON.

Bear Creek is the first important tributary received by South Platte River after it leaves the mountains. Information concerning the discharge of this stream is important, as it supplies a large proportion of the water furnished to Denver by the Denver Union Water Company,

[a] See also Tenth Biennial Report of the State of Colorado, p. 265. Also Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, p. 131.

storage reservoirs having been provided for this purpose in Marston and Harriman lakes. Nearly the entire flow of this stream is used for the water supply of Denver and for irrigation, there being a scarcity of water along the stream except for the earliest priorities during a large portion of almost every irrigation season. Like all mountain streams, it is subject to sudden and violent rises from sharp and severe storms at its headwaters.[a]

The station was located for some years about the center of the town of Morrison, but in the spring of 1899 it was moved to a point just above Morrison, at the headgate of the Denver Union Water Company's pipe line. The conditions have generally been rather unfavorable to correctness of measurements, as the channel is somewhat changeable, being made up of loose bowlders, and at the dam where the water is diverted into the pipe line gravel bars have formed, changing the natural conditions. Measurements have been made by wading, excepting at the highest stages of the water, when they have been made from the wagon bridge just above the town of Morrison.[b]

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[a] For full description see Hayden's Report of 1875, p. 432.

[b] For further details concerning this station see Biennial Reports of State Engineers of Colorado: Fourth, Part I, p. 64, and Part II, Pl. XX; Fifth, Part I, p. 30, and Part II, Pl. XIV; Sixth, pp. 20 and 31; Eighth, p. 454; Ninth, p. 336; Tenth, pp. 223 and 266. Publications U. S. Geological Survey: Eighteenth Annual Report, Part IV, p. 167; Nineteenth, Part IV, p. 317; Twentieth, Part IV, p. 284; Twenty-first, Part IV, p. 204; Bulletin No. 140, p. 106; Water-Supply and Irrigation Papers, No. 11, p. 54; No. 15, p. 90; No. 27, pp. 81 and 86; No. 37, p. 227; No. 39, p. 448, and No. 49, p. 284. Also Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, p. 114.

Discharge of Bear Creek at Morrison.

[Altitude, 5,765 feet; drainage area, 170 square miles.]

Month.	1888.	1889.	1890.	1891.	1895.	1896.	1897.	1898.	1899.	1900.	Mean.	Mean run-off. Equivalent in acre-feet. (*a*)	Mean run-off. Depth in inches.	Mean run-off. Second-feet per square mile.
	Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*			
April	31	.....	.....	[b]50	.....	[c]49	.....	.....	[d]84	[e]306	104	6,188	0.68	0.61
May	95	[f]701	63	195	[g]69	51	[f]152	[f]117	103	487	144	8,731	.98	.85
June	100	[h]85	31	289	[i]183	32	175	143	93	379	151	8,985	.99	.89
July	65	49	34	90	136	[j]33	115	150	86	115	87	5,349	.59	.51
August	55	[k]58	24	32	122	[l]53	199	68	104	51	77	4,673	.52	.45
September	30	.....	20	25	69	50	67	45	31	[m]27	40	2,380	.27	.24
October	.....	.....	21	.....	[n]61	35	55	29	[o]21	29	36	2,152	.24	.21
November	.....	.....	17	.....	.....	.....	34	23	.....	16	22	1,309	.14	.13
December	.....	.....	.....	.....	.....	.....	[m]20	.....	.....	.....	20	1,190	.14	.12
Mean [p]	63	73	30	113	107	44	102	82	75	176	76	40,957	4.55	.45
Acre-feet [p]	3,749	4,344	1,785	6,724	6,367	2,618	6,069	4,879	4,463	10,472	.....	.....	.....	.....

[a] The discharge given is for average months, and the total for an average period of nine months, as shown by the observations. Details may be found in the authorities cited for this station.

[b] Commencing April 5.
[c] Commencing April 6.
[d] Commencing April 16.
[e] Commencing April 14.
[f] Commencing May 3.
[g] For May 19 to 31, inclusive.
[h] June 9 to 19, inclusive, is missing.
[i] June 3 to 12, inclusive, is missing.
[j] July 25 to 31, inclusive, is missing.
[k] Ending August 10.
[l] August 1 to 5, inclusive, is missing.
[m] Approximated.
[n] Ending October 5.
[o] Ending October 21.
[p] For period covered.

Maximum and minimum discharge and average run-off of Bear Creek at Morrison for that portion of each year covered by records.

Year.	Discharge.				Run-off.	
	Minimum.		Maximum.		Depth in inches.	Second-feet per square mile.
	Date.	Amount.	Date.	Amount.		
		Sec.-ft.		*Sec.-ft.*		
1888	Sept. —	30	June —	100	0.41	0.37
1889	May 3	18	May 20	195	.48	.43
1890	Nov. 15	15	July 23	75	.20	.18
1891	Sept. 22	12	May 27	622	.73	.66
1895	May 20	41	June 13	274	.70	.63
1896	July 14	9	Apr. 2	86	.29	.26
1897	Nov. 24	5	Aug. 3	385	.67	.60
1898	Nov. 23	20	July 13	2,083	.54	.48
1899	Oct. 21	17	Aug. 4	325	.49	.44
1900	Nov. 23	10	Apr. 29	691	1.15	1.03

Discharge measurements made on Bear Creek at Morrison.

Date.	Hydrographer.	Gage height.	Discharge.
1895.		*Feet.*	*Sec.-ft.*
May 18	P. J. Preston	0.90	47
June 12	do	2.05	331
July 24	do	1.65	171
Oct. 7	do	1.05	64
1896.			
June 17	P. J. Preston	.75	32
Aug. 4	do	2.90	55
Sept. 19	R. S. Sumner	3.05	80
Oct. 31	P. J. Preston	2.55	16
1897.			
May 20	R. L. Hope	3.60	179
June 13	R. S. Sumner	3.70	209
June 26	do	3.50	162
July 24	do	3.45	131
Sept. 11	F. Cogswell	3.05	55
Oct. 12	do	3.00	52
1899.			
Apr. 15	J. E. Field	3.80	64
May 9	A. L. Fellows	4.25	99
June 6	do	4.25	107
Aug. 5	do	4.98	192
Nov. 14	do	1.35	13

Discharge measurements made on Bear Creek at Morrison—Continued.

Date.	Hydrographer.	Gage height.	Discharge.
1900.		*Feet.*	*Sec.-ft.*
Mar. 9	A. L. Fellows	1.40	17
Apr. 14	.....do	2.85	47
Apr. 25	.....do	5.80	367
Aug. 7	.....do	3.20	63
Sept. 6	.....do	.....	24

CLEAR CREEK AT FORKSCREEK.

Clear Creek is one of the largest tributaries of South Platte River, issuing from the mountains, and emptying into the main stream about 6 miles below Denver. Like the other streams of this region, it flows for a long distance through a mountainous territory (see Pl. IV, A) and then discharges into the plains, where its water is used for irrigation. The establishment of a station at Forkscreek, which is about 12 miles up the canyon, was for the purpose of determining not only the amount of its water that may be available for irrigation and storage, but the amount that may be used for the development of power. The water of Clear Creek is used to such an extent for placer mining and for the development of power for use in stamp mills that the name "Clear Creek" has long since become a misnomer, the stream being anything but clear. After the stream empties into the plains the greater part of the water is used for irrigation, there being comparatively little surplus even during the flood stages.[a]

Measurements were also made in the years 1887 and 1888 at a point below the mouth of the canyon, and estimates were made for the year 1898 by the water commissioner of the Clear Creek water district. The discharges of these years are too unreliable to be incorporated into the table, but they are given by themselves.

Results obtained at this station are not entirely satisfactory, as the channel consists of bowlders and the fall is great, the banks being high and rocky. There is, moreover, no suitable method of crossing the river, the bridges being unsatisfactory, so that most of the measurements have been taken at low-water stages.[b]

[a] For full description of this drainage basin see Hayden's Report, of 1875, p. 432; also Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, p. 114.

[b] For further details concerning this station see Biennial Reports of State Engineer of Colorado: Fourth, Part I, p. 63, and Part II, Pl. XVIII; Fifth, Part I, p. 18; Sixth, p. 20; Ninth, p. 340; Tenth, pp. 222 and 270. Publications U. S. Geological Survey: Twenty-first Annual Report, Part IV, p. 205; Water-Supply and Irrigation Papers, No. 37, p. 228; No. 39, p. 448 and No. 49, p. 286. Report on Agriculture by Irrigation, Eleventh Census, p. 114.

A. CLEAR CREEK CANYON ABOVE FORKS CREEK.

B. HOME SUPPLY DAM ON BIG THOMPSON CREEK.

Discharge of Clear Creek at Golden.

[In cubic feet per second.]

Year.	Average for month.						
	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1897	621	793	516	304	181	130	.....
1898	285	650	420	120	75	70	57

NOTE.—This table was furnished by W. N. Palmer, water commissioner for the Clear Creek district for 1897 and 1898. The winter discharge is given as about 50 second-feet.

Estimated monthly discharge of Clear Creek at Forkscreek.

[Altitude, 6,892 feet; drainage area, 345 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1899.						
April	403	51	180	10,711	0.52	0.58
May 1 to 19	1,202	192	581	35,724	1.68	1.94
June 7 to 30	1,373	775	1,081	64,324	3.13	3.49
July	1,202	614	791	48,637	2.30	2.66
August	692	299	440	27,005	1.28	1.48
September	349	155	214	12,734	0.62	.69
October	155	133	141	8,670	0.41	.47
November	155	32	77	4,582	0.22	.24
Total	.....	.....	.....	212,387	.....	11.55
1900.						
March 10 to 31	75	44	60	2,619	0.17	.20
April	403	58	178	10,592	0.52	.58
May	1,259	367	789	48,514	2.29	2.64
June	1,259	714	968	57,601	2.80	3.12
July	719	235	378	23,242	1.10	1.27
August	235	84	137	8,424	0.40	.46
September	75	44	58	3,451	0.17	.19
October	75	51	58	3,566	0.17	.20
November	58	51	52	3,094	0.15	.17
Total	.....	.....	.....	161,103	.....	8.83

Discharge measurements made on Clear Creek at Forkscreek.

Date.	Hydrographer.	Gage height.	Discharge.
1899.		*Feet.*	*Sec.-ft.*
Mar. 24	J. E. Field	1.50	52
Apr. 20	....do	2.10	155
May 10	A. L. Fellows	2.75	365
June 7	....do	3.70	779
Aug. 12	....do	3.08	449
Nov. 15	....do	1.70	67
1900.			
Mar. 10	....do	1.60	55
Apr. 13	....do	1.70	73
Apr. 24	....do	2.60	290
Aug. 27	....do	1.78	130

ST. VRAIN CREEK NEAR LYONS.

St. Vrain Creek and its tributaries receive their supply of water from the eastern slope of that portion of the Front Range lying between Longs Peak and James Peak, a distance of about 30 miles. The general trend of the drainage is northeastward, the St. Vrain flowing at last into South Platte River about 6 miles below the town of Platteville. The principal tributaries of the St. Vrain are the North and South Forks and the Boulder, the South Boulder being an important branch of the latter. The areas drained by the upper portions of these streams are all alike mountainous, the streams flowing through deep and rugged canyons, where the water can be used only for the development of power and for placer mining; but upon leaving the foothills each one of them emerges into a broad and nearly level valley where farming by irrigation is extensively practiced.[a]

Three stations have been maintained upon the St. Vrain and its tributaries, one located at a point about one-half of a mile east of Lyons, upon the St. Vrain, one at a point at the mouth of the canyon of the Boulder, a mile above the town of Boulder, and one at a point in the mouth of the South Boulder Canyon about 3 miles west of Marshall.

Records have been kept of the gage heights at the Lyons station since April, 1888, except during the years 1893 and 1894, when very little hydrographic work was done in Colorado. A number of changes in the location and position of the gage rod have been necessary, but these have not affected the value of the tables, the station being always practically the same. As maintained at the present time the station is opposite the Tower Hotel. Most of the measurements are made by

[a] For full description of this basin see Hayden's Report of 1875, p. 436. Also Report on Agriculture by Irrigation, Eleventh Census, p. 103.

wading, but at high water they are made from a bridge located about one-quarter of a mile below the station. The channel is favorable to good results, lying in small bowlders and cobblestones, and the banks are so high that overflow is improbable. The table of discharge includes the amount carried by the Supply ditch, which is taken out above the station but of which records were also kept.[a]

[a] For more detailed data concerning this station see Biennial Reports of State Engineers of Colorado: Fourth, Part I, p. 63, and Part II, Pl. XIX; Fifth, Part I, pp. 18 and 28, Part II, Pl. XIII; Sixth, pp. 20 and 28; Eighth, p. 436; Ninth, p. 348; Tenth, pp. 213 and 280. See also publications U. S. Geological Survey: Eighteenth Annual Report, Part IV, p. 172; Nineteenth, Part IV, p. 320; Twentieth, Part IV, p. 285; Twenty first, Part IV, p. 208; Bulletin No. 140, p. 109; Water-Supply and Irrigation Papers, No. 11, p. 55; No. 15, p. 93; No. 27, pp. 83, 86, and 89; No. 37, p. 232; No. 39, p. 448; and No. 49, p. 288. Also, Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, p. 103.

Discharge of St. Vrain Creek at Lyons.

[Drainage area, 209 square miles.]

Month.	1888.	1889.	1890.	1891.	1892.[c]	1895.	1896.	1897.	1898.	1899.	1900.	Mean.	Equivalent in acre-feet.	Mean run-off.	
														Second-feet per square mile.	Depth in inches.
	Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*			
April	72	.....	.....	165	.....	.....	96	.....	.....	222	361	183	10,889	0.88	0.98
May	156	[a] 465	[b] 376	629	(c)	.....	259	[d] 571	243	300	657	406	24,964	1.94	2.24
June	320	371	436	1,046	856	[e] 790	363	766	483	829	709	634	37,726	3.03	3.38
July	208	197	292	516	587	469	225	506	261	734	290	390	23,980	1.87	2.16
August	133	102	179	151	155	243	167	303	113	330	107	180	11,068	.86	.99
September	56	44	66	96	89	98	139	127	68	95	72	86	5,117	.41	.46
October	50	39	45	.....	65	197	65	50	22	44	49	63	3,874	.30	.35
November	.....	.....	30	.....	.....	.....	37	.....	20	24	31	28	1,666	.13	.14
Mean[f]	142	203	203	434	350	359	169	387	173	322	285	246	119,284	1.18	10.70
Acre-feet[f]	60,415	66,495	80,600	159,380	106,182	100,392	81,740	140,544	73,402	155,916	138,304	.....	.....	.....	.....

[a] May 20 to 31 inclusive.

[b] May 15 to 31 inclusive.

[c] Stations were maintained upon both forks of the St. Vrain in 1892. The monthly averages given are the sums for the two forks. The average for May 29 to 31 on South Fork was 373 second-feet and from May 26 to 31 on North Fork was 231 second-feet.

[d] Commencing May 2.

[e] Commencing June 13.

[f] For period covered by observations.

Maximum and minimum discharge and average run-off of St. Vrain Creek at Lyons for that portion of each year covered by records.

Year.	Discharge.				Run-off.	
	Minimum.		Maximum.		Depth in inches.	Second-feet per square mile.
	Date.	Amount.	Date.	Amount.		
		Sec.-ft.		*Sec.-ft.*		
1888	June —	[a] 320	Oct. —	[a] 50	0.75	0.68
1889	May 28	548	Oct. 13	26	1.08	.97
1890	June 2	675	Nov. 15	18	1.08	.97
1891	May 27	1,397	Apr. 5	31	2.32	2.08
1892	June 24	1,480	Oct. 28	53	1.86	1.67
1895	June 16	1,127	Sept. 14	80	1.92	1.72
1896	May 30	666	Oct. 26	21	.90	.81
1897	June 11	1,052	Nov. 16	31	2.06	1.85
1898	June 17	637	Nov. 26	21	.91	.82
1899	June 20	1,275	Nov. 11	16	1.72	1.54
1900	Apr. 29	918	Mar. 17	10	1.52	1.36

[a] May 20 to 31 inclusive.

Discharge measurements made on St. Vrain Creek at Lyons.

Date.	Hydrographer.	Gage height.	Discharge.
1895.		*Feet.*	*Sec.-feet.*
May 11	P. J. Preston	1.65	260
July 20	do	3.40	336
Oct. 2	do	2.10	65
1896.			
June 6	P. J. Preston	3.57	389
July 29	do	2.70	189
Sept. 22	R. S. Sumner	2.50	110
Oct. 14	P. J. Preston	2.22	53
1897.			
May 25	L. R. Hope	4.15	659
June 17	R. S. Sumner	4.40	713
June 28	do	3.70	551
July 20	do	3.10	379
Sept. 15	F. Cogswell	2.10	115
Nov. 10	do	1.75	54
1898.			
May 27	A. L. Fellows	2.80	256
July 12	do	3.10	308
Aug. 5	do	2.20	73
Oct. 12	do	1.85	20

Discharge measurements made on St. Vrain Creek at Lyons—Continued.

Date.	Hydrographer.	Gage height.	Discharge.
1899.		*Feet.*	*Sec.-feet.*
Apr. 18	J. E. Field	3.00	217
May 5	A. L. Fellows	2.75	137
June 14	.....do	4.15	825
Aug. 9	.....do	3.20	263
Oct. 7	.....do	2.10	37
1900.			
Mar. 13	A. L. Fellows	2.06	35
Apr. 27	.....do	3.68	513
July 27	.....do	2.70	193

BOULDER CREEK NEAR BOULDER.

The general nature of Boulder Creek, which is one of the tributaries of the St. Vrain, has already been noted in the description of the main stream.[a]

The gaging station is located 1½ miles above the town of Boulder, in the mouth of the canyon. There are two small irrigation ditches above the station, but the amount of water diverted does not exceed 5 or 6 second-feet, and may therefore be disregarded. The channel of the stream consists of large bowlders throughout its entire course, and it is therefore difficult to make accurate measurements. Gagings are usually made by wading, but may be made from a wagon bridge just above the gage rod at high water. The normal flow is entirely used for irrigation, but during the flood season a large proportion goes to waste. Fillings have, however, been made upon a number of reservoir sites in this drainage basin, by means of which most of the surplus water might be stored.[b]

[a] For a description of this drainage basin, see Hayden's Report of 1875, p. 435. Also Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, p. 103.

[b] Biennial Reports of State Engineers of Colorado: Fourth, Part I, p. 64, and Part II, Pl. XXI; Fifth, Part I, pp. 18 and 32, and Part II, Pl. XV; Sixth, pp. 21 and 33; Eighth, p. 442; Ninth, p. 345; Tenth, pp. 224 and 277. Also publications U. S. Geological Survey: Annual Reports, Eighteenth, Part IV, p. 171; Nineteenth, Part IV, p. 319; Twentieth, Part IV, p. 286; Twenty-first, Part IV, pp. 207–208; Bulletin No. 140, p. 108; Water-Supply and Irrigation Papers, No. 11, p. 55; No. 15, p. 92; No. 27, pp. 82, 86, and 89; No. 37, p. 248; No. 49, p. 287. Also Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, p. 103.

Discharge of Boulder Creek at Boulder.

[Altitude, 5,347 feet; drainage area, 179 square miles.]

Month.	1888.	1889.	1890.	1891.	1892.	1895.	1896.	1897.	1898.	1899.	1900.	Mean.	Equivalent in acre-feet.	Mean run-off.	
														Second-feet per square mile.	Depth in inches.
	Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*			
April	81	.....	.....	.....	.....	.....	80	.....	.....	117	.....	93	5,534	0.52	0.58
May	164	[a] 676	[b] 287	[c] 327	[d] 336	[e] 316	240	323	233	353	625	353	21,705	1.97	2.27
June	261	565	341	427	447	502	264	458	447	663	640	456	27,134	2.55	2.84
July	210	277	258	240	372	355	150	339	213	577	255	295	18,139	1.65	1.90
August	157	97	[f] 173	116	148	205	88	213	62	265	94	147	9,039	0.82	0.94
September	80	34	56	[g] 61	47	86	73	83	30	87	54	63	3,749	0.35	0.39
October	60	36	[h] 33	.....	43	44	33	47	8	39	33	38	2,337	0.21	0.24
November	.....	.....	[i] 26	.....	.....	.....	.....	38	40	24	.....	32	1,904	0.12	0.13
Mean[j]	145	281	168	234	232	251	133	214	148	266	284	185	89,541	1.03	9.29
Acre-feet[j]	61,632	98,589	59,607	58,464	74,520	85,158	56,496	90,736	62,916	128,832	103,592	.....	.....	.....	.....

[a] Commencing May 8.
[b] Commencing May 13.
[c] Commencing May 18.
[d] Commencing May 23.
[e] Commencing May 14.
[f] August 12 to 14 missing.
[g] Ending September 20.
[h] October 16 to 19 missing.
[i] November 3 to 9, inclusive.
[j] For period covered by records.

Maximum and minimum discharge and average run-off of Boulder Creek at Boulder for that portion of each year covered by records.

Year.	Discharge.				Run-off.[a]	
	Minimum.		Maximum.		Depth in inches.	Second-feet per square mile.
	Date.	Amount.	Date.	Amount.		
		Sec.-feet		*Sec.-feet.*		
1888	April —	25	June —	350	0.90	0.81
1889	Sept. 20	16	May 31	785	1.75	1.57
1890	Nov. 7	23	Aug. 4	1,200	1.03	0.93
1891	Sept. 16	54	June 8	540	1.46	1.31
1892	Oct. 19	27	June 23	646	1.45	1.30
1895	Oct. 29	5	June 3	750	1.56	1.40
1896	Apr. 3	7	May 30	809	0.82	0.74
1897	Nov. 16	23	June 10	745	1.34	1.20
1898	Nov. 30	3	June 18	560	1.36	1.22
1899	Nov. 29	13	July 2	847	1.66	1.49
1900	Oct. 31	7	June 1	801	1.77	1.59

[a] The run-off given is the amount for that part of each year covered by the records and for an average month of thirty days, at the rate given as the mean for the period covered.

Discharge measurements made on Boulder Creek near Boulder.

Date.	Hydrographer.	Gage height.	Discharge.
1895.		*Feet.*	*Sec.-ft.*
July 17	P. J. Preston	1.90	317
Oct. 13	do	.50	36
1896.			
July 2	P. J. Preston	1.30	139
July 30	do	1.10	110
Sept. 23	R. S. Sumner	.80	69
Oct. 16	P. J. Preston	.50	35
1897.			
May 21	L. R. Hope	2.15	442
July 26	R. S. Sumner	1.75	298
Aug. 12	F. Cogswell	1.55	224
Oct. 13	do	.55	48
1898.			
Apr. 17	A. L. Fellows	.78	69
May 28	do	1.85	367
July 16	J. E. Field	1.50	266
Aug. 3	A. L. Fellows	.86	62
Oct. 11	do	.28	12

Discharge measurements made on Boulder Creek near Boulder—Continued.

Date.	Hydrographer.	Gage height.	Discharge.
1899.		*Feet.*	*Sec.-ft.*
Apr. 21	J. E. Field	1.00	84
May 6	A. L. Fellows	1.20	134
June 15	.....do	2.50	642
Aug. 10	.....do	1.70	276
Otc. 20	.....do	.50	36
1900.			
Apr. 28	A. L. Fellows	2.10	483
July 27	.....do	1.40	220
Aug. 28	.....do	.62	49

SOUTH BOULDER CREEK AT MARSHALL.

South Boulder Creek is a tributary of the Boulder, and its drainage basin lies north of and adjoins that of Clear Creek.[a] The station has been maintained for each irrigation season since April, 1888, except during 1893 and 1894. The rod consists of an inclined timber on the north bank of the stream, near the house of C. E. Barber. Two ditches take their water supply from the stream at points above the station, these being the South Boulder and Coal Creek ditch and the Community ditch, and their discharges are added to the discharge as found at the station, so as to give the total run-off of the basin. The channel of the stream is rocky and full of bowlders, but does not change materially. Gagings are usually made by wading, but at high water they may be made from the foot bridge just above the rod.[b]

[a] For description see Hayden's Report of 1875, p. 436. Also Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, p. 103.

[b] For more detailed data concerning this station see Biennial Reports of the State Engineers of Colorado: Fourth, Part I, p. 64, and Part II, Pl. XXIII; Fifth, Part I, p. 36, and Part II, Pl. XVII; Sixth, pp. 21 and 36; Eighth, p. 448; Ninth, p. 341; Tenth, pp. 225 and 273. Also publications of U. S. Geological Survey, Eighteenth Annual Report, Part IV, p. 169; Nineteenth, Part IV, p. 318; Twentieth, Part IV, p. 287; Twenty-first, Part IV, p. 206; Bulletin No. 140, p. 107; Water-Supply and Irrigation Papers, No. 11, p. 54; No. 15, p. 91; No. 27, pp. 82, 86, and 89; No. 37, p. 229, and No. 49, p. 286. Also Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, p. 103.

Discharge of South Boulder Creek at Marshall.

[Altitude, 5,498 feet; drainage area, 125 square miles.]

Month.	1888.	1889.	1890.	1891.	1892.	1895.	1896.	1897.	1898.	1899.	1900.	Mean.	Equivalent in acre-feet.	Mean run-off.[a] Second-feet per square mile.	Mean run-off.[a] Depth in inches.
	Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*			
April	100	.....	.....	58	.....	.....	72	.....	.....	123	.....	88	5,236	0.70	0.78
May	135	[b] 475	[c] 313	366	[d] 237	[e] 288	232	[f] 332	208	332	.....	292	17,954	2.34	2.70
June	.....	335	349	356	374	592	208	458	325	539	356	371	22,076	2.97	3.31
July	130	152	143	140	232	243	75	235	138	319	93	173	10,637	1.38	1.59
August	98	39	64	45	62	120	43	129	42	121	29	72	4,427	.58	.67
September	40	21	39	20	21	39	37	43	22	35	9	30	1,785	.24	.27
October	.....	20	[g] 31	[h] 19	18	38	23	39	20	.....	.....	26	1,599	.21	.24
November	.....	.....	.....	.....	.....	.....	.....	35	18	.....	.....	26	1,547	.21	.23
Mean[i]	115	174	157	143	157	220	99	182	110	245	121	135	65,261	1.08	9.79
Acre-feet[i]	41,724	54,855	52,878	52,824	53,492	74,188	41,947	76,893	46,652	88,938	29,280	.....	.....	.....	.....

[a] The run-off is for average months, and the total for an average period of eight months as shown by the observations. Details may be found in the authorities cited for this station.

[b] Commencing May 26.
[c] Commencing May 9.
[d] Commencing May 13.
[e] Commencing May 15.
[f] Commencing May 2.
[g] Ending October 25.
[h] Ending October 3.
[i] For period covered by the observations.

Maximum and minimum discharge and average run-off of South Boulder Creek at Marshall for that portion of each year covered by records.

Year.	Discharge.				Run-off.	
	Minimum.		Maximum.		Depth in inches.	Second-feet per square mile.
	Date.	Amount.	Date.	Amount.		
		Sec.-ft.		*Sec.-ft.*		
1888	Sept. —	30	June —	225	1.02	0.92
1889	Oct. 12	15	May 31	560	1.55	1.39
1890	Sept. 20	19	May 28	542	1.41	1.26
1891	Sept. 19	15	May 17	565	1.27	1.14
1892	Oct. 13	15	June 24	561	1.41	1.26
1895	Oct. 1	14	June 3	1,090	1.96	1.76
1896	Oct. 6	18	May 30	603	.88	.79
1897	Nov. 7	18	June 11	595	1.62	1.46
1898	Nov. 18	9	June 17	444	.98	.88
1899	Sept. 21	9	June 21	663	2.19	1.96
1900	Sept. 16	5	June 2	582	1.08	.94

Discharge measurements made on South Boulder Creek at Marshall.

Date.	Hydrographer.	Gage height.	Discharge.
1895.		*Feet.*	*Sec.-ft.*
May 14	P. J. Preston	2.00	164
July 18	do	2.00	195
Oct. 10	do	1.05	42
1896.			
July 3	P. J. Preston	1.50	88
Aug. 8	do	0.96	27
Sept. 24	R. S. Sumner	1.00	31
Oct. 17	R. J. Preston	0.90	24
1897.			
May 22	L. R. Hope	2.45	348
June 19	R. S. Sumner	2.60	363
June 25	do	2.50	370
July 27	do	1.65	122
Aug. 13	F. Cogswell	1.55	116
Oct. 14	do	0.82	14
1898.			
Apr. 23	A. L. Fellows	1.35	72
May 29	do	2.29	274
July 11	do	1.70	130
Aug. 6	do	1.15	47
Oct. 10	do	0.55	2

Discharge measurements made on South Boulder Creek at Marshall.—Continued.

Date.	Hydrographer.	Gage height.	Discharge.
1899.		*Feet.*	*Sec.-ft.*
Apr. 22	J. E. Field	1.70	115
May 6	A. L. Fellows	1.55	96
June 15	....do	2.80	451
Aug. 10	....do	1.60	109
Oct. 10	....do	0.70	7
1900.			
July 28	A. L. Fellows	1.40	35
Aug. 28	....do	1.10	10

BIG THOMPSON CREEK AT ARKINS.

This stream drains considerable territory north of Longs Peak, and is one of the largest tributaries of the South Platte, into which it flows about 4 miles above the town of Evans. The Little Thompson is an important tributary of the Big Thompson, and the country drained by these two streams forms irrigation district No. 4 (see Pl. IV, *B*). The two streams come together a short distance above where their combined waters enter the South Platte.[a]

Records were begun upon this stream in April, 1888, and have been maintained for a portion of each year since that time, except in the years 1893 and 1894. The location of the station has been changed several times, having been below both the Handy and the Home Supply ditches a portion of the time and above the Home Supply and below the Handy at other times. At present it is located at the upper point, so that only the waters carried by the Handy ditch need to be added to give the total run-off of the basin. The amounts given in the tables are for the combined flow. Irrigation is practiced on a small scale about 20 miles above the station also, but to such a limited extent that it may be disregarded.[b]

[a] For description see Hayden's Report for 1875, p. 437; also Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, pp. 116-119.

[b] For more detailed information concerning this station see Biennial Reports of the State Engineers of Colorado: Second, p. 6; Fourth, Part I, p. 64, and Part II, Pl. XXII; Fifth, Part I, pp. 18 and 34, and Part II, Pl. IX; Sixth, pp. 21 and 34; Eighth, p. 430; Ninth, pp. 310 and 333; Tenth, pp. 215, 216 and 284. Also publications U. S. Geological Survey: Eighteenth Annual Report, Part IV, p. 174; Nineteenth, Part IV, p. 321; Twentieth, Part IV, p. 288; Twenty-first, Part IV, p. 209; Bulletin No. 140, p. 110; Water-Supply and Irrigation Papers, No. 11, p. 56, No. 15, p. 94; No. 27, pp. 83, 86, and 89; No. 37, p. 233; No. 39, p. 448; and No. 49, p. 290. Also Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, pp. 116-119.

Discharge of Big Thompson Creek at Arkins.

[Altitude, 5,255 feet; drainage area, 305 square miles.]

Month.	1888.	1889.	1890.	1891.	1892.	1895.	1896.	1897.	1898.	1899.	1900.	Mean.	Equivalent in acre-feet.	Mean run-off.[a] Second-feet per square mile.	Mean run-off.[a] Depth in inches.
	Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*			
April	62	.....	.....	.....	.....	.....	.....	.....	.....	156	432	217	12,912	0.71	0.79
May	132	[b] 359	[c] 436	.....	[d] 312	[e] 482	295	590	231	353	1,432	462	28,407	1.51	1.74
June	458	382	530	[f] 817	704	943	363	679	499	1,037	1,497	719	42,783	2.36	2.64
July	275	200	454	383	498	683	259	379	317	766	379	418	25,702	1.37	1.58
August	190	89	393	159	150	441	172	196	112	316	149	215	13,220	.70	.81
September	75	49	151	95	49	194	161	71	57	102	87	99	5,891	.32	.36
October	46	46	67	.....	.....	121	96	54	23	64	.....	65	3,997	.21	.24
November	.....	.....	[g] 83	.....	.....	.....	.....	54	18	.....	.....	52	3,094	.17	.19
Mean [h]	177	188	302	364	343	477	224	289	180	399	663	281	136,006	.92	8.35
Acre-feet [h]	75,114	61,545	115,008	85,918	100,520	156,090	81,696	122,622	76,398	169,274	240,645	.....	.....	.....	.....

[a] The run-off is for average months and the total for an average period of eight months as shown by the observation. Details may be found in the authorities cited.
[b] Commencing May 20.
[c] Commencing May 8.
[d] Commencing May 15.
[e] Commencing May 20.
[f] Commencing June 4.
[g] To November 15, inclusive.
[h] For period covered by observations.

Maximum and minimum discharge and average run-off of Big Thompson Creek at Arkins for that portion of each year covered by records.

Year.	Discharge.				Run-off.[a]	
	Minimum.		Maximum.		Depth in inches.	Second-feet per square mile.
	Date.	Amount.	Date.	Amount.		
		Sec.-ft.		*Sec.-ft.*		
1888	Apr. 3	30	June 16	862	0.64	0.58
1889	Oct. 2	28	May 31	546	.69	.62
1890	Oct. 7	51	July 21	1,603	1.10	.99
1891	Sept. 17	69	June 25	1,182	1.33	1.19
1892	Sept. 29	39	June 21	1,195	1.25	1.12
1895	Oct. 2	58	June 2	1,102	1.74	1.56
1896	Oct. 26	76	May 30	1,200	.81	.73
1897	Nov. 18	54	June 11	1,040	1.04	.94
1898	Oct. 24	14	June 24	722	.65	.59
1899	Apr. 9	25	June 21	1,852	1.46	1.31
1900	Apr. 2	30	May 30	2,223	2.42	2.17

[a] The run-off given is the amount for that part of each year covered by the records and for an average month of thirty days at the rate given as the mean for the period covered.

Discharge measurements made on Big Thompson Creek at Arkins.

Date.	Hydrographer.	Gage height.	Discharge.
1895.		*Feet.*	*Sec.-ft.*
May 9	P. J. Preston	1.25	260
July 19	do	1.90	499
Oct. 1	do	.45	42
1896.			
June 1	P. J. Preston	1.70	403
July 28	do	1.50	286
Oct. 15	do	.80	74
1897.			
May 26	L. R. Hope	2.45	804
June 18	R. S. Sumner	1.60	400
June 27	do	1.50	409
July 21	do	1.20	214
Sept. 16	F. Cogswell	.60	61
Nov. 11	do	.65	79
1898.			
May 26	A. L. Fellows	1.25	263
July 13	do	1.60	444
Aug. 4	do	.70	87
Oct. 14	do	.40	30

Discharge measurements made on Big Thompson Creek at Arkins—Continued.

Date.	Hydrographer.	Gage height.	Discharge.
1899.		*Feet.*	*Sec.-ft.*
Apr. 17	J. E. Field	0.90	143
May 4	A. L. Fellows	.97	173
June 13	do	2.55	941
Aug. 8	do	1.73	406
Oct. 6	do	.50	34
1900.			
Apr. 26	A. L. Fellows	1.91	512
July 26	do	1.35	322

CACHE LA POUDRE RIVER AT FORT COLLINS.

This stream is the largest and the northernmost of the tributaries discharging from the east front of the Rocky Mountains into the South Platte. During the irrigation season its discharge is augmented by the supply diverted from the headwaters of the Laramie River, which heads immediately west of the headwaters of the Cache la Poudre, the diversion being made through a canal known as the Skyline canal, already mentioned (p. 21). Measurements of the discharge of the Cache la Poudre Basin therefore include some of the Laramie waters. As is the case with other streams of this region, the normal flow is almost entirely consumed for irrigation, and even the greater part of the flood waters is stored for late use. The earliest and most thorough irrigation of the State is carried on along this stream.[a] The station was established in 1884 at a point about 15 miles above Fort Collins, and has been maintained ever since that time under the direction of Prof. L. G. Carpenter, of the Colorado State Agricultural College.[b]

The following tables are compiled from records published from time to time by Professor Carpenter, the first table showing the normal discharge as calculated by him for the irrigating season, and the second giving a summary of discharge for the entire time. The results are to a certain extent misleading, as additions have been made to the normal discharge of the stream from year to year through the Skyline canal, taking its water from the headwaters of the Laramie

[a] Water-Supply and Irrigation Paper No. 9 and Department of Agriculture Bulletin No. 92.

[b] For more detailed information concerning this station, see Biennial Reports of the State Engineers of Colorado: Second, p. 6 and Appendix B; Third, pp. 5 and 62; Fourth, Part I, p. 61, and Part II, Pl. IX; Fifth, Part I, pp. 17 and 22; Sixth, pp. 19 and 22; Seventh, p. 172; Ninth, p. 356; Tenth, p. 288. Also, publications U. S. Geological Survey: Thirteenth Annual Report, Part III, p. 94; Twentieth, Part IV, p. 290; Bulletin No. 131, p. 30; No. 140, p. 112; Water-Supply and Irrigation Papers, No. 9, p. 16; No. 37, p. 235, and No. 49, p. 291. Also, Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, p. 116.

River, and this increase is not considered in the tables. In computing the average monthly discharge only those months are included for which the record is complete, or at least estimated:

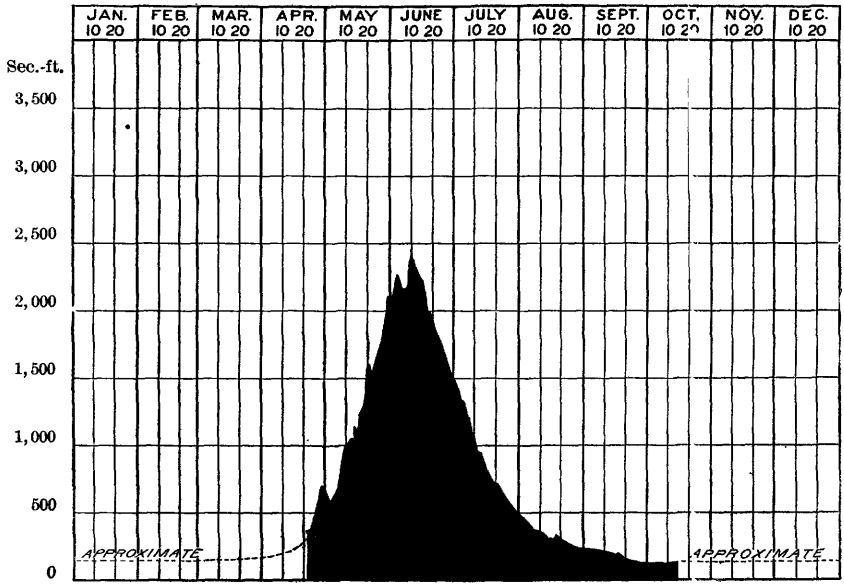


Fig. 1.—Normal discharge of Cache la Poudre River.

Normal discharge of Cache la Poudre River at Fort Collins for the years 1884 to 1900, inclusive.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
	Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*
1	.....	589	2,052	1,426	490	245	147
2	.....	597	2,120	1,399	485	238	137
3	.....	611	2,250	1,328	479	228	133
4	.....	634	2,207	1,290	469	a 225	137
5	.....	686	2,108	1,213	438	a 222	133
6	.....	729	2,149	1,152	a 426	a 219	131
7	.....	784	2,136	1,154	414	a 216	132
8	.....	842	2,165	1,118	383	a 213	133
9	.....	916	2,268	1,069	395	a 210	130
10	.....	974	2,385	1,029	398	a 207	139
11	.....	999	2,319	954	374	204	129
12	.....	1,024	2,271	965	358	189	129
13	.....	1,012	2,227	951	339	182	132
14	.....	1,046	2,188	871	338	170	130
15	.....	1,109	2,171	856	324	166	127
16	.....	1,232	2,123	814	338	168	.....
17	.....	1,240	2,038	794	325	161	.....
18	.....	1,259	1,959	774	387	154	.....
19	.....	1,311	2,005	737	333	151	.....
20	.....	1,446	1,913	694	317	146	.....
21	.....	1,625	1,966	704	306	144	.....
22	.....	1,547	1,881	650	299	140	.....
23	.....	1,534	1,810	611	291	139	.....
24	367	1,625	1,783	a 597	284	144	.....
25	406	1,720	1,755	a 583	280	148	.....
26	446	1,804	1,741	a 569	262	147	.....
27	541	1,890	1,633	a 555	251	148	.....
28	607	1,985	1,619	a 542	252	145	.....
29	706	1,980	1,561	a 529	251	143	.....
30	651	2,046	1,472	a 515	240	141	.....
31	.....	2,028	.....	502	247	.....	.....

a Interpolated.

Discharge of Cache la Poudre River at Fort Collins for the years 1884 to 1900, inclusive.

[Altitude, 4,994 feet; drainage area, 1,060 square miles.]

Month.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	Mean.	Mean run-off. Equivalent in acre-feet.	Mean run-off. Second-feet per square mile.	Mean run-off. Depth in inches.
	Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*			
January	.....	.....	.....	.....	.....	151	82	92	64	.....	.....	*a* 90	.....	.....	.....	.....	.....	96	5,903	0.09	0.10
February	.....	.....	.....	.....	.....	106	79	79	179	.....	.....	*a* 90	.....	.....	.....	.....	.....	95	5,464	.09	.09
March	67	.....	.....	.....	.....	46	85	59	80	.....	.....	*a* 90	.....	.....	.....	.....	.....	72	4,427	.07	.08
April	219	*b* 447	*d* 405	*a* 200	181	113	200	144	*a* 100	.....	.....	*a* 390	.....	.....	.....	.....	*c* 1,376	193	11,484	.18	.20
May	2,537	1,419	1,309	*ac* 1,822	483	649	1,044	1,221	*a* 250	*b* 762	*b* 1,436	*ac* 1,216	.....	*a* 2,052	*a* 649	*a* 1,207	2,808	1,302	80,057	1.23	.42
June	4,812	2,910	1,875	*ac* 1,401	1,113	1,338	1,280	1,900	1,512	*b* 1,815	2,063	*a* 2,382	*c* 774	1,731	1,309	2,632	2,942	2,128	126,625	2.01	2.24
July	2,144	1,857	717	735	420	514	649	541	741	617	833	1,117	458	749	478	1,441	721	867	53,310	.82	.94
August	792	656	338	307	213	187	287	228	*a* 200	*b* 235	339	495	272	*a* 352	*a* 147	557	265	352	21,644	.33	.38
September	305	273	185	175	109	67	103	138	.....	.....	164	*a* 219	*a* 273	*a* 177	*a* 78	212	149	175	10,413	.16	.18
October	.....	1,203	129	*a* 120	*a* 90	69	80	118	.....	.....	105	*a* 160	.....	.....	*a* 59	110	*c* 132	204	12,543	.19	.22
November	.....	.....	.....	.....	.....	88	61	83	.....	.....	*b* 95	*a* 110	.....	.....	.....	.....	.....	86	5,117	.08	.09
December	.....	.....	.....	.....	.....	64	70	79	.....	.....	.....	*a* 90	.....	.....	.....	.....	.....	76	4,673	.07	.08
Mean *i*	1,761	1,196	747	720	400	482	567	671	753	811	804	914	520	793	451	1,027	1,266	471	341,660	.44	6.02
Acre-feet *i*	660,177	448,308	279,909	269,892	149,877	180,684	212,625	251,559	*e* 168,709	*f* 194,040	301,403	342,657	195,048	297,108	168,966	374,808	457,002	.....	.....	.....	.....

a Estimated or interpolated in part.
b Between 20 and 31 days.
c Between 10 and 20 days.
d Less than 10 days.
e From May 17 to September 6, inclusive.
f From May 10 to September 3, inclusive.
g From May 1 to October 31, inclusive.
h From April 18 to October 16, inclusive.

i The mean and the run-off in acre-feet given is the amount for 27 weeks from April 26 to November 1, excepting where otherwise stated in the notes, and the corresponding amount for an average month of thirty days at the rate given as the mean for the period covered, while the discharge is for average months and the total for an average year as derived from the observations for all complete months, parts of months not being included in this average, although estimated entire months are. Details may be found in the authorities cited.

SKYLINE CANAL, NEAR GREELEY.

Maximum and minimum discharge and average run-off of Cache la Poudre River at Fort Collins for that portion of each year covered by records.

Year.	Discharge.				Run-off.	
	Minimum.		Maximum.		Depth in inches.	Second-feet per square mile.
	Date.	Amount.	Date.	Amount.		
		Sec.-ft.		*Sec.-ft.*		
1884	Mar. 22	30	June 28	5,611	1.85	1.66
1885	Oct. 5	220	June 3	3,815	1.26	1.13
1886	Oct. 13	110	May 29	2,666	.83	.75
1887	Sept. 18	110	June 7	2,500	.75	.68
1888	Sept. 19	90	June 15	1,550	.43	.38
1889	Dec. 17	33	June 1	1,960	.50	.45
1890	Nov. 16	39	June 2	1,804	.59	.53
1891	Mar. 31	32	June 10	3,600	.70	.63
1892	Mar. 17	40	June 21	2,535	.79	.71
1893	Aug. 31	151	June 12	2,949	.84	.76
1894	Nov. 17	42	June 6	3,672	.84	.76
1895	Sept. 18	174	June 10	3,429	.95	.86
1896	Aug. 18	192	May 30	2,771	.55	.49
1897	Oct. 1	121	May 24	3,155	.83	.75
1898	Oct. 1	35	June 17	1,699	.48	.43
1899	Oct. 7	92	June 21	3,968	1.08	.97
1900	Sept. 20	113	May 29	4,560	1.33	1.19

LARAMIE RIVER AT WOODS, WYO.

This stream, already briefly described on pages 21 and 55, rises in North Park in Northern Colorado, and flows northerly into Wyoming. There is little irrigation from Laramie River in Colorado, except that a portion of the supply of the Cache la Poudre district is supplied from this source, as already mentioned on pages 21 and 55 (see Pl. V).

The data for this station is published through the courtesy of Mr. A. J. Parshall, deputy State engineer of Wyoming.[a]

[a] For more detailed information, see publications U. S. Geological Survey, Eighteenth Annual Report, Part IV, p. 142; Nineteenth, Part IV, p. 300; Twentieth, Part IV, p. 274; Twenty-first, Part IV, p. 192; Bulletin, No. 131, p. 28; No. 140, p. 95· Water-Supply and Irrigation Papers, No. 11, p. 50; No. 15, p. 81; No. 27, pp. 78, 86, and 88; No. 37, p. 214; No. 39, p. 447, and No. 49, p. 273. Also, Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, p. 251.

Discharge of Laramie River at Woods, Wyo.

[Drainage area, 435 miles.]

Month.	1896.	1897.	1898.	1899.	1900.	Mean.	Equivalent in acre-feet.	Mean run-off.[a]	
								Second-feet per square mile.	Depth in inches.
	Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*			
April	[b] 200	128	129	571	125	231	13,745	0.53	0.59
May	619	1,964	636	1,284	1,940	1,288	79,196	2.96	3.41
June	465	1,564	969	3,221	1,776	1,599	95,147	3.68	4.09
July	127	266	89	1,253	111	369	22,689	.85	.98
August	94	93	44	191	50	94	5,780	.22	.25
September	116	65	40	56	44	64	3,808	.15	.17
October	[b] 120	[b] 60	[b] 45	65	.....	73	4,489	.17	.20
November	.....	[b] 65	[b] 40	[b] 70	.....	58	3,451	.13	.14
Mean	249	526	249	839	674	.472	228,305	1.09	9.83
Acre-feet for period recorded	105,716	254,736	120,536	406,016	243,271	.....	.....	.....	.....

[a] The run-off given is for that part of each year covered by the observations (and estimates) given and for a thirty-day month at the rate given as the mean for the whole period covered, while the discharge given is for average months, and the total for an average eight months from April to November, inclusive, as calculated from the bservations (and estimates). Details may be found in the authorities cited.

[b] Approximate for the month.

Maximum and minimum discharge and average run-off of Laramie River at Woods, Wyo., for that portion of each year covered by records.

Year.	Discharge.				Run-off.	
	Minimum.		Maximum.		Depth in inches.	Second-feet per square mile.
	Date.	Amount.	Date.	Amount.		
		Sec.-ft.		*Sec.-ft.*		
1896	Aug.	49	May	2,166	0.63	0.57
1897	Apr.	48	May	3,435	1.35	1.21
1898	Sept.	40	May	1,572	.63	.57
1899	Oct. 1	45	June 25	4,502	2.15	1.93
1900	Sept. 1	40	May 31	3,995	1.73	1.55

Discharge measurements made on Laramie River at Woods, Wyo.

Date.	Hydrographer.	Gage height.	Discharge.
1894.		*Feet.*	*Sec.-ft.*
Sept. 27	W. M. Gilcrest	----------	27
Sept. 28	....do	----------	57
Nov. 3	....do	----------	80
1895.			
May 24	W. M. Gilcrest	2.80	1,129
Oct. 23	....do	0.80	49
1896.			
Apr. 20	W. M. Gilcrest	0.85	75
May 25	....do	2.40	797
June 16	....do	1.75	350
June 27	Elwood Mead	1.25	198
Aug. 19	W. M. Gilcrest	0.85	81
Aug. 30	....do	0.80	75
Oct. 2	C. T. Johnston	1.00	121
1897.			
Apr. 10	C. T. Johnston	0.70	69
May 12	....do	2.30	1,110
May 25	....do	4.10	3,538
June 1	....do	3.60	2,509
June 2	....do	3.75	2,651
June 14	....do	2.65	1,432
June 26	....do	2.00	707
June 27	....do	2.00	706
1898.			
Apr. 30	C. T. Johnston	1.40	362
May 22	....do	2.00	758
June 4	....do	[a] 2.30	1,017
June 4	....do	[b] 2.40	1,123
June 5	....do	2.10	823

Discharge measurements made on Laramie River at Woods, Wyo.—Continued.

Date.	Hydrographer.	Gage height.	Discharge.
1899.		*Feet.*	*Sec.-ft.*
May 26	A. J. Parshall	3.30	2,598
June 8	.....do	3.10	2,319
June 21	.....do	4.40	4,145
July 6	.....do	2.80	2,194
1900.			
May 4	A. J. Parshall	1.60	460

[a] At 6 a. m. [b] At 7.30 p. m.

MISCELLANEOUS MEASUREMENTS.

The following table of miscellaneous measurements upon South Platte River and its tributaries is compiled from the Colorado State Engineers' Biennial Reports, and from all other available sources. They are at various points in the division and are valuable for the information furnished as to the discharge at given times.

Miscellaneous gagings in the South Platte River Basin.

[Compiled from the seepage measurements made by the State engineer's office at Denver, Colo.]

Stream.	Locality.	1889.		1890.		1891.		1892.		1893.		1894.	
		Date.	Amount.	Date.	Amount.	Date.	Amount.	Date.	Amount.	Date.	Amount.	Date.	Amount.
			Sec.-ft.		*Sec.-ft.*		*Sec.-ft.*		*Sec.-ft.*		*Sec.-ft.*		*Sec.-ft.*
South Platte River	Platte Canyon		131		209		204		153		133		186
Plum Creek	Mouth		3		2		3		15		6		6
South Platte River	Littleton		13		193		85		222		39		67
Bear Creek	Mouth		3		4		7		13		7		9
South Platte River	Denver		66		241		90		284		77		219
Clear Creek	Mouth		1		1		1		68		1		8
South Platte River	Brighton		8		127		74		272		36		109
Do	Platteville		10		98		90	Mar. 7 to Mar. 15	332		7		97
St. Vrain Creek	Mouth		18		21		29		71		36		62
Big Thompson Creek	....do	Oct. 18 to Oct. 25	7	Oct. 14 to Oct. 24	24	Oct. 23 to Nov. 5	13		35	Oct. 30 to Nov. 10	11	Oct. 16 to Nov. 4	28
South Platte River	Evans		46		27		88		450		86		214
Cache la Poudre River	Mouth		15		33		61		146		64		74
South Platte River	Below Poudre		120		213		.....		.....		.....		312
Do	Orchard		.....		156		107		.....		105		.....
Do	Fort Morgan		.....		25		.....		834		.....		.....
Do	Snyder		.....		13		187	.....	.....		51		142
Do	Merino		8		8		97	.....	.....		5		32
Do	Sterling		6		12		67	.....	.....		13		21
Do	Crook		0		4		40	.....	.....		.....		36
Do	Julesburg		0	.....	.....		43	.....	.....		.....		2
Cache la Poudre	Canyon	Oct. 14	69	Oct. 16	81	Oct. —	98	Mar. —	65	Nov. —	52	Mar. —	99
Do	Below Larimer and Weld canal.	Oct. 15	33	...do	77	...do	54	...do	.....	...do	69	...do	49
Do	Below Cache la Poudre canal.	Oct. 16	2	Oct. 17	2	...do	56	...do	.....	...do	.....	...do	.....
Do	Below Ogilvie ditch.	Oct. 17	3	Oct. 18	.....	...do	.....	...do	141	...do	93	...do	57
Do	Near mouth	...do	10	...do	33	...do	61	...do	176	...do	61	...do	77

Miscellaneous gagings in the South Platte River Basin—Continued.

Stream.	Locality.	1895.		1896.		1897.		1898.		1899.		1900.	
		Date.	Amount.	Date.	Amount.	Date.	Amount.	Date.	Amount.	Date.	Amount.	Date.	Amount.
			Sec.-ft.		*Sec.-ft.*		*Sec.-ft.*		*Sec.-ft.*		*Sec.-ft.*		*Sec.-ft.*
South Platte River	Platte Canyon	Nov. 7	237	Nov. 6	153	Nov. 19	235	Oct. 27	228	Oct. 23	154	Oct. 19	98
Plum Creek	Mouth	Nov. 8	11	Nov. 7	6	Nov. 20	43	Oct. 28	15	Oct. 24	4	Oct. 20	3
South Platte River	Littleton	...do....	294	...do....	43	...do....	259	Oct. 29	158	...do....	60	...do....	89
Bear Creek	Mouth	...do....	24	...do....	8	...do....	48	...do....	14	Oct. 26	13	...do....	11
South Platte River	Denver	Nov. 9	430	Nov. 9	100	...do....	878	...do....	234	Oct. 27	89	Oct. 22	161
Clear Creek	Mouth	Nov. 11	54	...do....	66	Nov. 22	52	Oct. 31	1	...do....	0	...do....	1
South Platte River	Brighton	Nov. 12	373	Nov. 10	132	Nov. 23	360	Nov. 1	62	Oct. 28	81	Oct. 23	82
Do	Platteville	Nov. 13	480	Nov. 11	173	Nov. 24	445	Nov. 2	65	Oct. 30	141	Oct. 24	44
St. Vrain Creek	Mouth	...do....	82	Nov. 12	52	Nov. 25	77	Nov. 3	39	...do....	95	...do....	53
Big Thompson Creek	.....do.....	...do....	41	...do....	35	.....	.....	...do....	16	Oct. 31	39	...do....	17
South Platte River	Evans	Nov. 14	648	...do....	294	.....	.....	...do....	225	Nov. 1	335	...do....	193
Cache la Poudre River	Mouth	Oct. 21	123	Nov. 13	85	.....	.....	Nov. 4	74	...do....	151	Oct. 25	85
South Platte River	Below Poudre	...do....	827	...do....	360	.....	.....	...do....	302	...do....	575	...do....	299
Do	Orchard	Oct. 24	941	Oct. 22	940	.....	.....	Nov. 17	491	Nov. 3	614	Oct. 27	324
Do	Fort Morgan	Oct. 26	745	Oct. 24	41	.....	.....	Nov. 18	555	Nov. 4	703	...do....	14
Do	Snyder	...do....	686	...do....	21	.....	.....	Nov. 19	533	Nov. 5	741	Oct. 29	26
Do	Merino	Oct. 28	692	Oct. 26	13	.....	.....	.....	.....	Nov. 7	553	Oct. 30	18
Do	Sterling	Oct. 29	672	...do....	30	.....	.....	.....	.....	Nov. 8	581	Oct. 31	30
Do	Crook	Oct. 30	626	Oct. 28	31	.....	.....	.....	.....	Nov. 9	582	Nov. 1	51
Do	Julesburg	Oct. 31	586	.....	.....	.....	.....	.....	.....	Nov. 12	487	Nov. 2	76
Cache la Poudre	Canyon	Oct. 9	66	Nov. —	.....	.....	.....	.....	.....	.....	.....	Sept. 4	118
Do	Below Larimer and Weld canal.	Oct. 10	1	.....	.....	.....	.....	.....	.....	.....	.....	Sept. 30	15
Do	Below Cache la Poudre canal.	Oct. 14	34	Nov. 13	10	.....	.....	.....	.....	.....	.....	Sept. 5	10
Do	Below Ogilvie ditch.	Oct. 15	71	Nov. 14	49	.....	.....	.....	.....	.....	.....	.....	.....
Do	Near mouth	...do....	117	...do....	78	.....	.....	.....	.....	.....	.....	Sept. 7	45

[a] Measurements stopped by storms.

SEEPAGE MEASUREMENTS.

The subjoined tables, taken from the records of the state engineer's office of Colorado, illustrates the extraordinary return from seepage along the South Platte and its tributaries. Measurements have been made annually for a number of years, whenever circumstances would permit, by the state engineer's office and the agricultural college at Fort Collins, Colo., working in cooperation, from the year 1889, inclusive. As may be seen from the tables, the return from seepage increases irregularly from year to year, being naturally considerably less during a very dry year than during a wet year. The year 1896, for example, was very dry, and the returns were much less than they would have been normally. The year 1898 was again dry, and the return was again small.[a]

[a] For more detailed information upon this subject see Biennial Reports of the State Engineers of Colorado: Fifth, Part I, pp. 559 to 573; Sixth, pp. 51 to 65; Seventh, 176 to 195; Eighth, 381 to 404; Ninth, 305 to 317; Tenth, 208 to 236. Also Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, p. 133.

Increase in volume of the South Platte River from the canyon to points measured, due to the return of waste or seepage waters.

Places where measurements were taken.	Oct., 1889.	Oct., 1890.	Oct., 1891.	Mar., 1892.	Oct., 1893.	Oct., 1894.	Oct. and Nov., 1895.	Oct. and Nov., 1896.	Nov. 19 to 25, 1897.	Oct. and Nov., 1898.	1899.	1900.
	Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*
River below Head City ditch	.....	.....	27.57	25.32	18.41	49.23	20.12	10.18	.....	1.21	72.93	33.96
River at Littleton	49.91	11.73	80.18	69.95	41.91	74.82	75.44	24.94	.....	27.65	133.89	74.13
River at Denver	50.91	55.61	96.38	129.56	83.18	193.74	193.24	58.89	62.32	89.28	150.29	90.35
River at Fulton ditch	.....	94.41	138.85	141.51	127.03	228.06	174.05	74.61	138.24	112.78	196.90	86.96
River at Brighton	77.02	98.91	175.19	116.17	152.91	278.04	207.13	126.81	160.79	138.94	274.38	160.62
River at Evans's No. 2 ditch	.....	.....	.....	.....	208.74	314.72	276.76	171.24	237.29	227.92	324.33	.....
River at Elwood & Wheeler ditch	119.10	172.35	218.69	136.33	.....	.....	.....	.....	.....	.....	.....	.....
River at Platteville	133.38	.....	226.93	180.54	218.82	343.05	341.57	219.05	291.54	251.29	363.05	216.70
River above St. Vrain Creek	.....	155.80	233.32	.....	.....	.....	.....	.....	.....	.....	.....	.....
River at Union ditch	.....	.....	.....	.....	252.81	398.70	362.28	228.78	.....	328.44	410.74	257.76
River at Evans	197.00	176.91	299.21	192.86	279.93	450.51	385.85	256.64	.....	362.26	474.59	330.80
River at Cache la Poudre	.....	215.20	326.13	216.17	318.20	474.86	443.05	276.88	.....	466.31	.....	353.43
River at Hoover ditch	277.10	351.66	392.66	285.25	.....	549.75	557.58	309.71	.....	482.47	564.07	.....
River at Hardin ditch	.....	.....	.....	.....	387.23	498.70	522.31	325.33	.....	497.38	.....	409.08
River at Putnam ditch	.....	333.60	418.80	330.61	365.78	549.12	565.26	344.63	.....	522.39	624.97	412.94
River at Orchard	.....	.....	.....	.....	.....	.....	671.86	344.99	.....	553.41	628.22	439.54
River at Fort Morgan canal	305.92	360.58	434.05	360.09	414.33	.....	.....	.....	.....	.....	.....	.....
River at Shaffers Ford	.....	.....	.....	.....	.....	617.43	717.78	375.38	.....	568.32	715.57	469.07
River above Bijou Creek	.....	.....	.....	.....	.....	676.88	800.92	392.85	.....	594.40	.....	.....
River at Platte and Beaver canal	307.03	367.09	472.14	431.74	464.64	631.45	.....	.....	.....	.....	.....	.....
River at Fort Morgan	.....	.....	.....	.....	.....	.....	799.37	425.24	.....	617.01	722.71	.....
River at Snyder	.....	384.18	470.60	.....	479.67	707.64	814.19	478.03	.....	654.14	795.34	596.50
River below Big Beaver Creek	.....	.....	.....	.....	.....	714.90	879.57	499.41	.....	.....	.....	.....
River at Merino	385.58	405.71	550.32	.....	514.39	766.31	959.45	544.24	.....	.....	829.21	682.54
River at Sterling	418.33	435.16	583.69	.....	548.15	.....	1,006.25	576.84	.....	.....	962.94	744.07
River 2 miles above Iliff	422.77	449.21	611.76	.....	572.99	.....	1,023.24	598.20	.....	.....	1,009.13	749.26
River 2 miles above Crook	.....	.....	598.69	.....	.....	810.11	.....	.....	.....	.....	.....	.....
River at Crook	.....	.....	.....	.....	.....	.....	975.19	629.28	.....	.....	1,078.51	772.90
River at Pole Creek	.....	.....	.....	.....	.....	.....	989.93	.....	.....	.....	.....	.....
River at State line	.....	.....	602.00	.....	.....	775.94	942.30	.....	.....	.....	1,119.74	800.19

KANSAS RIVER BASIN.

A considerable portion of eastern Colorado is drained by the headwaters of Kansas River, the principal tributaries being branches of Republican and of Smoky Hill rivers. These streams, unlike the other streams of Colorado, do not originate in the mountains; they derive their water supply directly from the run-off and underground flow of the plains. The measurements of the General Land Office show that there are about 9,459 square miles in Colorado belonging to this drainage basin. This territory, although not belonging physically either to the South Platte division or to the Arkansas division, is divided in accordance with the Colorado laws between the two, the lands drained by the North and Middle forks of the Republican and their tributaries constituting district No. 65 and being apportioned to irrigation division No. I, the South Platte division; while the lands drained by the South Fork of the Republican and the Smoky Hill rivers and their tributaries constitute district No. 49 and are allotted to irrigation division No. II, the Arkansas division. The water supply of all these streams is small, but a number of ditches have been constructed and irrigation is carried on so far as it is possible. Only a few gagings have been made upon these streams in Colorado, and these are given below in the list of miscellaneous measurements. Stations have been maintained in Nebraska, however, and some of the records of those nearest to the Colorado line are given, as found in the records of the U. S. Geological Survey.[a]

FRENCHMAN RIVER AT WAUNETA AND PALISADE, NEBR.

The station at Wauneta was located in 1895. It is the highest station upon the Frenchman, being about 25 miles east of the line between Colorado and Nebraska. The channel has not proved favorable to accurate results and the station was therefore discontinued in 1896.

The station at Palisade was located October 14, 1894, at a point about three-fourths of a mile above the railroad station at Palisade, or about 16 miles below the gaging station at Wauneta. The results were unsatisfactory here, also, and the station was discontinued in 1896.

The results have considerable importance in connection with any investigation of the Colorado water supply, as the greatest source of supply for the streams of this section is the underground flow of eastern Colorado.

[a] For more detailed information concerning this drainage basin see publications U. S. Geological Survey: Sixteenth Annual Report, Part II, p, 547; Eighteenth, Part IV, p. 194; Nineteenth, Part IV, p. 337; Twentieth, Part IV, p. 304; Bulletins No. 131, p. 32; No. 140, p. 123. For earlier history and description see Vol. XVII, Tenth Census, p. 56; also Eighth Biennial Report of State Engineer of Colorado, p. 21; and Artesian and Underflow Investigations, Ex. Doc. No. 222, Fifty-first Congress, first session, and Ex. Doc. 53, Parts 1 and 2, Fifty-first Congress, second session.

Estimated monthly discharge of Frenchman River at Palisade, Nebr.

[Drainage area, 1,032 square miles.]

Month.	Mean.	Total.	Run-off.	
			Per square mile.	Depth.
1895.	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
April	137	8,152	0.13	0.14
May	129	7,932	.13	.15
June	117	6,962	.11	.12
July	99	6,087	.10	.12
August	78	4,796	.08	.09
September	74	4,403	.07	.08
	106	38,430	.10	.70
1896.				
May	114	7,010	.11	.13
June	104	6,188	.10	.11
July	94	5,780	.09	.10
August	76	4,673	.07	.08
September	82	4,879	.08	.09
October	83	5,103	.08	.09
	92	33,488	.09	.60

NORTH AND SOUTH FORKS OF REPUBLICAN RIVER AT BENKELMAN, NEBR.

These stations are fully described in the reports to which reference has already been made in connection with the Kansas Basin. They are located upon the two forks of Republican River, near Benkelman, Nebr., about 20 miles east of the Colorado line.

The channel is in each case sandy and shifting, and frequent changes in the rating tables are necessary. Both stations were established in November, 1894, and were maintained only until the fall of 1895, when they were discontinued owing to the unsatisfactory nature of the results. A few gagings have since been made, which are included in the list of miscellaneous measurements below, page 69.

Estimated monthly discharge of North Fork Republican River at Benkelman, Nebr.

[Altitude, 2,968 feet; drainage area, about 4,900 square miles.]

Month.	Mean.	Total.
1895.	*Second-feet.*	*Acre-feet.*
March	78	4,796
April	59	3,511
May	25	1,537
June	155	9,223
July	124	7,379
August	34	2,091
September	Dry.	0

MISCELLANEOUS GAGINGS IN THE KANSAS RIVER BASIN.

In the following table are given the results of gagings of streams in the Kansas River Basin made during several years by hydrographers acting under the direction of the United States Geological Survey.

Miscellaneous gagings in the Kansas River Basin.

Stream.	Locality.	Date.	Hydrographer.	Discharge.
				Sec.-ft.
Chief Creek	5 miles below Robb, Colo.	Mar. 23, 1891	L. R. Hope	20
North Fork Republican River.	6 miles below Robb, Colo.	do	do	21
Do	3 miles below Wray, Colo.	Apr. 24, 1891	do	51
Do	At State line	do	do	70
South Fork Republican River.	2½ miles west of State line.	Apr. 26, 1891	do	78
Arikaree Creek	3 miles west of State line.	Apr. 27, 1891	do	14
Frenchman River	Wauneta, Nebr	Aug. 9, 1895	O. V. P. Stout	61
Do	do	Sept. 10, 1895	do	56
Do	do	May 15, 1896	C. E. Crownover	85
Do	do	June 18, 1886	O. V. P. Stout	48
Do	do	July 14, 1896	E. G. Youngfelt	91
Do	do	Aug. 12, 1896	O. V. P. Stout	46
Do	do	Sept. 16, 1896	E. G. Youngfelt	85
Do	do	Oct. 17, 1896	C. E. Crownover	63
Do	Palisade, Nebr	Dec. 8, 1894	O. V. P. Stout	116
Do	do	Mar. 22, 1895	do	100
Do	do	June 5, 1895	do	154
Do	do	July 4, 1895	do	74
Do	do	Aug. 9, 1895	do	68
Do	do	Aug. 10, 1895	do	72
Do	do	May 15, 1896	C. E. Crownover	103
Do	do	June 18, 1896	O. V. P. Stout	51
Do	do	July 15, 1896	E. G. Youngfelt	93
Do	do	Aug. 13, 1896	O. V. P. Stout	64
Do	do	Sept. 16, 1896	E. G. Youngfelt	85
Do	do	Oct. 17, 1896	C. E. Crownover	83
North Fork Republican River.	Benkelman, Nebr	Dec. 9, 1894	O. V. P. Stout	75
Do	do	Mar. 23, 1895	do	72
Do	do	June 4, 1895	do	141
Do	do	June 24, 1895	do	36
Do	do	Aug. 7, 1895	do	64
Do	7 miles west of Benkelman, Nebr	June 16, 1896	do	88
Do	Benkelman, Nebr	do	do	29
Do	do	Aug. 25, 1896	E. G. Youngfelt	0

Miscellaneous gagings in the Kansas River Basin—Continued.

Stream.	Locality.	Date.	Hydrographer.	Discharge.
				Sec.-ft.
South Fork Republican River.	Benkelman, Nebr.	Dec. 9, 1894	O. V. P. Stout	1
Do	do	Mar. 23, 1895	do	41
Do	do	June 4, 1895	do	348
Do	do	June 24, 1895	do	75
Do	do	July 3, 1895	do	278
Do	do	Aug. 7, 1895	do	22
Do	do	June 16, 1895	E. G. Youngfelt	3
Do	do	Aug. 18, 1900	O. V. P. Stout	3
North Fork Republican River.	do	do	do	42
Frenchman River	Wauneta, Nebr	July 27, 1900	A. B. McCoskey	74
Do	Palisade, Nebr	do	do	91

ARKANSAS RIVER DIVISION.

DRAINAGE.

The drainage basin of Arkansas River has been so fully described in other reports[a] that but a brief description of its physical character is necessary at this time. The river rises a little west of the center of the State, near Leadville, and flows southerly and westerly until it passes into Kansas, a short distance above Coolidge. Until Canyon is reached the country passed through is in general rather mountainous and comparatively little irrigation is practiced, the water being used mainly for power, for domestic supply, and for placer mining, and here and there only for irrigation in a small way. At Canyon, however, the valley becomes broader, and when the river reaches Pueblo it enters the broad plains of eastern Colorado, upon which the irrigation practiced is limited only by the amount of water available.

The territory drained by the Arkansas and its tributaries forms irrigation division No. II,[b] which is subdivided into a number of water districts. These are district No. 11,[c] at the head of the Arkansas, in which there is but little irrigation and the water is used principally for storage, placer mining, and for the development of power; district

[a] See Hayden's reports, and publications of the U. S. Geological Survey as follows: Tenth Annual Report, Part II, pp. 69 and 86; Eleventh, Part II, pp. 45 and 300; Thirteenth, Part III, p. 362; Seventeenth, Part II, p. 557; Eighteenth, Part IV, p. 223; Nineteenth, Part IV, p. 351; Twentieth, Part IV, p. 323; Twenty-first, Part IV, p. 229; Bulletin No. 131, p. 34; No. 140, p. 153; Water-Supply and Irrigation Paper No. 37, p. 225; No. 59, p. 319. Also, Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, p. 97.

[b] Fourth Biennial Report Colorado State Engineer, Part I, p. 46; for map see Fourth Biennial Report, Part II, Pla[illegible] I; Seventh Biennial Report, the same. Also, Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, p. 97.

[c] For map see Pl. I in Part II of Fourth and Seventh and Pl. II in Part II of Fifth Biennial Report of State Engineers.

No. 12,[a] the Canyon district, where irrigation is extensively practiced, both upon the main stream and upon its tributaries; district No. 14,[a] the Pueblo district, where the larger canals begin to divert the water of the main stream; district No. 17,[a] the Rockyford district, in which irrigation is very extensively practiced, the largest canals in the State having their headgates in this district, and district No. 67,[b] where the waters are entirely used for irrigation, enormous canals and reservoirs diverting the total flow during the greater portion of the year. The districts comprising the territories drained by the more important of the tributaries are as follows:

District No. 10,[c] comprising the drainage basin of Fontaine Qui Bouille; No. 13,[d] comprising the drainage basin of Grape Creek; No. 15,[e] of the St. Charles; No. 16,[f] of the Huerfano and Cucharas; No. 18,[b] the Apishapa; No. 19,[b] the Purgatory, and No. 66, in which a little irrigation is practiced upon the tributaries of the Dry Cimarron.

District No. 49,[g] in which are the headwaters of the South Fork of the Republican, can hardly be classed with any of the divisions, as it is not of the drainage basin either of the South Platte or of the Arkansas, but lies between the two, and comprises, with No. 65, the headwaters of the Kansas. Of the various tributaries of the Arkansas, those which enter the stream above Pueblo may be classed as mountain streams, while those entering below that city have more of the nature of streams of the plains, although several of them, as the Huerfano, the Apishapa, and the Purgatory, head in the mountains.[h] As is the case in the South Platte drainage, the mountain streams are perennial in nature, although there is a very high stage in the spring and early summer and a very low stage in the fall and winter. The plains streams are nearly always dry, except after storms and for comparatively short distances near their heads, where the water is generally used for irrigation. Although by far the greater portion of the water of the Arkansas is used, there are still opportunities for storage, especially along some of the plains streams. If water is to be stored, however, such canals must be constructed as will safely divert great quantities of water for short durations of time, and convey them to large reservoirs in the plains, where there are many sinks or depressions available. A number of reservoirs have been segregated

[a] For map see Pl. I in Part II of Fourth and Seventh and Pl. II in Part II of Fifth Biennial Reports of State Engineers.

[b] For map see Pl. I in Part II of Fourth and Seventh and Pl. IV in Part II of Fifth Biennial Reports of State Engineers.

[c] For map see Pls. I and IX of Part II of Fourth and Seventh and Pl. IV in Part II of Fifth Biennial Reports of State Engineers.

[d] For map see Pl, I in Part II of Fourth and Seventh Biennial Reports of State Engineers.

[e] For map see Pls. I and XI in Part II of Fourth and Seventh and Pl. IV in Part II of Fifth Biennial Reports of State Engineers.

[f] For map see Pls. I and XII in Part II of Fourth and Seventh and Pl. IV in Part II of Fifth Biennial Reports of State Engineers.

[g] See page 69.

[h] For thorough investigation of the plains region see Seventeenth Annual Report U. S. Geological Survey, Part II, p. 557.

in this basin by the General Government, but no careful surveys have been made of any of them, excepting a few at the head of the Arkansas.[a] The principal reservoirs of this division now in use are Twin Lakes[b] reservoir (see figs. 2, 3, and 4), which is being used by the Twin Lakes Land and Water Company, and the reservoirs of the Great Plains Water Company, the latter being located about 12 miles north of Lamar in great natural depressions[c] (see fig. 6).

The agriculture of the Arkansas River, as well as of the South Platte, is exceedingly varied, on the upper portions only hay and grain being cultivated, while throughout its middle and lower courses fruit is extensively raised, and lower down melons, sugar beets, and alfalfa are among the staples. Horse, cattle, and sheep raising are extensively practiced throughout the division.

STREAM MEASUREMENTS.

Stations have been maintained upon the main stream and its tributaries in the division for longer or shorter periods of time at Twin Lakes, Granite, Salida, Canyon, Pueblo, Nepesta, Manzanola, Rocky-

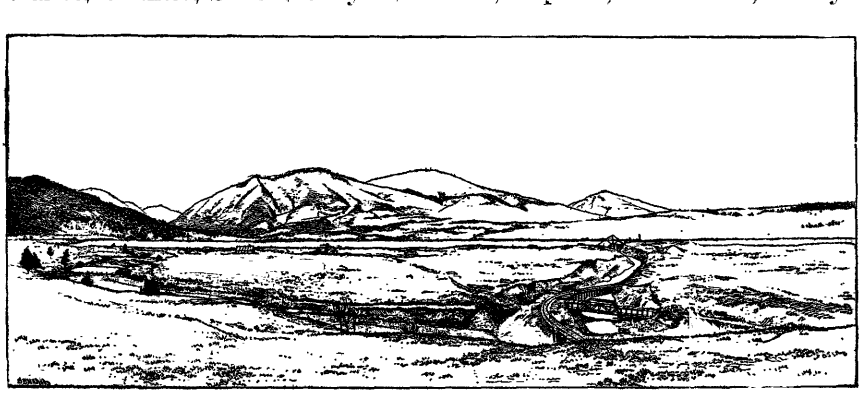


Fig. 2.—Sketch showing original outlet and artificial channel from Twin Lakes.

ford, La Junta, Las Animas, Prowers, Lamar, Granada, upon the main stream, and at Trinidad, J. J. ranch, and Las Animas on the Purgatory. Of the stations named those at Manzanola, La Junta, Las Animas, and Granada are unimportant, so far as this compilation is concerned, as the results obtained have not been of sufficient value to warrant the deduction of any conclusions from them. Those at J. J. ranch and Las Animas on the Purgatory are also omitted for the same reason. The measurements made at these points, however, will be found in the list of miscellaneous measurements (p. 99).

[a] See Annual Reports U. S. Geological Survey: Tenth, Part II, p. 58; Eleventh, Part II, p. 133; Twelfth, Part II, p. 55; Thirteenth, Part III, pp. 362–370; Twentieth, Part IV, p. 31.

[b] See Annual Reports U. S. Geological Survey: Tenth, Part II, p. 95; Eleventh, Part II, p. 135; Thirteenth, Part III, pp. 365 and 460; Nineteenth, Part IV, p. 352; Twentieth, Part IV, p. 323, and Twenty-first, Part IV, p. 238.

[c] For descriptions see Reports last cited; also Twenty-first Annual Report, Part IV, p. 240.

A. QUEEN RESERVOIR DAM, NORTH OF LAMAR.

B. KICKING BIRD CANAL, NORTH OF LAMAR.

LAKE CREEK AT TWIN LAKES.

Lake Creek enters the Arkansas a short distance above the town of Granite. It is not a large stream, but it is of considerable importance owing to the fact that within its basin lie the Twin Lakes, used as reservoirs by the Twin Lakes Land and Water Company. No regular measurements have been maintained upon this stream, those that are given being derived from various sources and made in various places. The present stations are two in number, one between the two lakes, known as

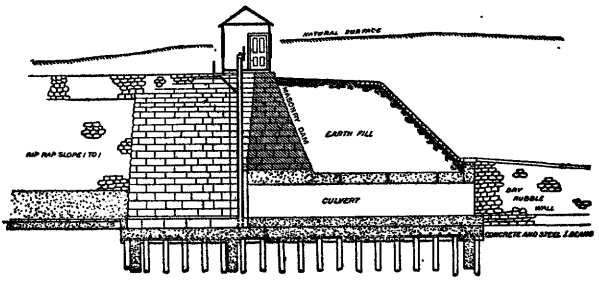


Fig. 3.—Longitudinal section through gates, dam, and culvert of Twin Lakes reservoir.

the Interlaken Station, and one below the lower lake, known as the Lower Twin Lakes Station. Measurements may be made at either station at low water by wading, but at high water advantage may be taken of bridges constructed across the stream. The channel at the Interlaken station is good, but this station must necessarily be abandoned as soon as the water is raised above what was the highwater mark before the construction of the dam described in the Twenty-first Annual Report, Part IV. At the

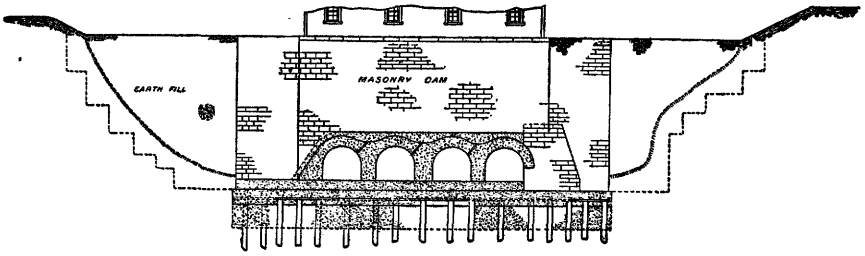


Fig. 4.—Cross section below masonry dam of Twin Lakes reservoir.

lower station the channel is rocky, but fairly permanent in its nature, and the banks are high and not liable to overflow.

The importance of the stations lies in the facts that the data obtained will furnish information concerning available power and will be of especial value in determining the amount of water to which the Twin Lakes Land and Water Company is entitled at its head gates. The waters of this stream are also largely used in placer mining. [a]

[a] For more detailed data concerning these stations, see Tenth Biennial Report of the State Engineers of Colorado, p. 293, and publications of the U. S. Geological Survey, as follows: Eleventh Annual Report, Part II, pp. 47 and 96; Twelfth, Part II, Pl. LXVI, opposite p. 240; Twenty-first, Part IV p. 238; Water-Supply and Irrigation Papers No. 37, p. 256; No. 39, p. 449; and No. 50, p. 320.

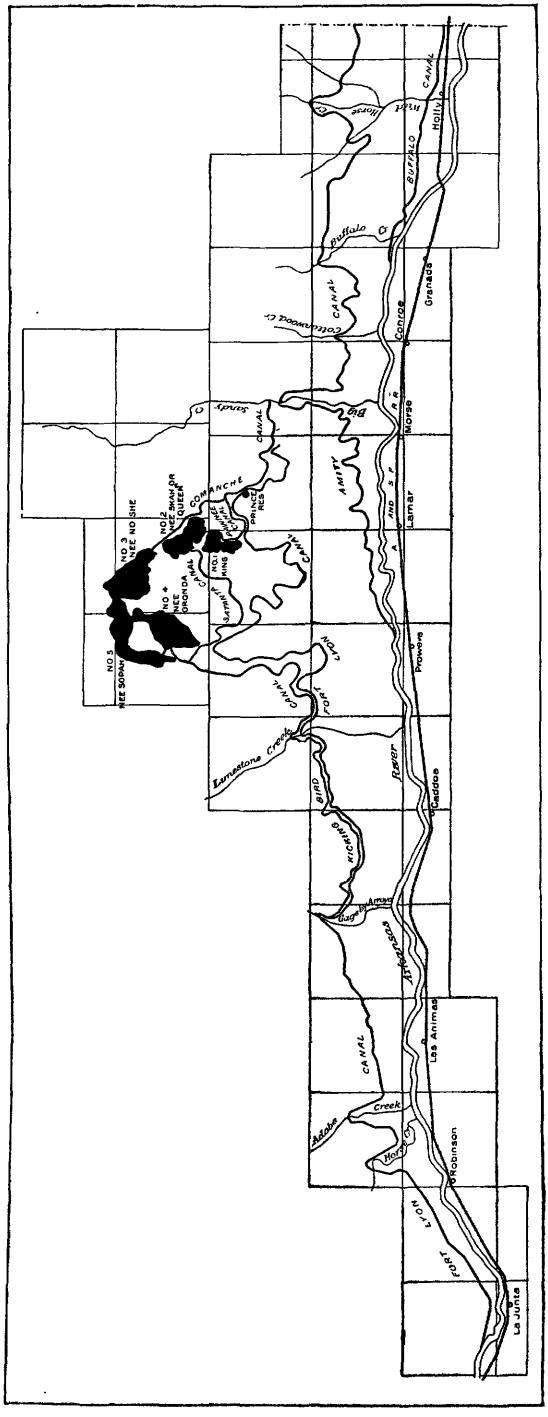


Fig. 5.—Irrigation system of the Great Plains Water Company.

Estimated monthly discharge of Lake Creek at Twin Lakes.

[Altitude, 9,012 feet; drainage area below both lakes, 109 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
June 21 to 30	.....	.....	847	50,519	7.79	8.69
July	667	370	454	27,915	4.17	4.81
August	588	230	381	23,427	3.50	4.04
September 1 to 11	.....	.....	194	11,543	1.78	1.99
July 22 to 31	.....	.....	206	4,086	1.89	.79
August	182	40	119	7,317	1.09	1.26
September 1 to 8	.....	.....	35	555	.32	.10

Discharge measurements made on Lake Creek at Twin Lakes.

Date.	Hydrographer.	Gage height.	Discharge.	Remarks.
1899.		*Feet.*	*Sec.-ft.*	
July 17	A. L. Fellows	2.80	273	At old station No. 1. (Station in channel above upper lake.)
Oct. 12	do	1.90	27	
1899.				
June 21	O. O. McReynolds	3.60	1,007	At old station No. 2. (Station at bridge over channel between lakes.)
July 17	A. L. Fellows	1.90	374	
Oct. 12	do	1.40	42	
1900.				
July 9	A. L. Fellows	1.70	203	
July 16	O. O. McReynolds	1.00	146	
1900.				
July 10	A. L. Fellows	.85	248	Interlaken Station. (Station at head of channel between lakes.)
July 18	do	.50	122	
Aug. 3	O. O. McReynolds	.25	52	
Sept. 4	C. W. Beach	.15	25	
1899.				
June 21	O. O. McReynolds	3.80	1,208	Old station No. 3. (Station at head of channel discharging from lower lake.)
June 27	do	3.20	696	
July 17	A. L. Fellows	2.55	391	
July 24	O. O. McReynolds	2.50	344	
Aug. 14	do	2.50	183	
Oct. 13	A. L. Fellows	.....	22	
1900.				
July 10	A. L. Fellows	2.50	193	
July 16	O. O. McReynolds	2.40	245	Lower Twin Lakes Station. (Station below junction of old channel and new cut discharging from lake.)
July 18	A. L. Fellows	2.35	210	
July 18	do	2.50	260	
July 18	do	1.97	118	
Aug. 11	O. O. McReynolds	2.13	156	
Sept. 4	C. W. Beach	1.30	25	

ARKANSAS RIVER AT GRANITE

This station was located at the wagon bridge across the Arkansas at Granite, measurements being made from this bridge. The results are not of great value, owing to the extremely changeable nature of the channel, which lies in beds of bowlders and gravel and shifts constantly. For that reason measurements and records have not been kept up closely. The present condition of the channel seems to be somewhat more stable, however, and the station may be reopened. It is important from the fact that the discharge of the entire upper portion of the Arkansas, which is of the most value for the development of power and for placer mining, may be learned from the data obtained at this point.[a]

Estimated monthly discharge of Arkansas River at Granite.

[Altitude, 8,930 feet; drainage area, 425 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1897.						
May	2,058	268	1,109	68,190	2.61	3.01
June	2,162	923	1,459	86,817	3.43	3.83
July	1,096	444	719	44,209	1.69	1.95
August	546	176	350	21,520	.82	.94
September	350	114	169	10,057	.40	.45
October	114	114	114	7,009	.27	.31
November	.....	.....	[b]115	6,843	.27	.30
December	.....	.....	[b]115	7,071	.27	.31
1898.						
August	151	75	113	6,948	.27	.31
September	93	8	45	2,678	.11	.12

[a] For more detailed information concerning this station see Biennial Reports of the State Engineer of Colorado: Eighth, p. 484; Ninth, p. 359; Tenth, p. 296. Also publications U. S. Geological Survey: Eleventh Annual Report, Part II, pp. 47 and 96; Nineteenth, Part IV, p. 353; Twentieth, Part IV, p. 330; Water-Supply and Irrigation Papers, No. 16, p. 117; No. 28, pp. 110, 116, and 117; No. 37, p. 257; No. 39, p. 449. Also, Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, p. 104.

[b] Approximate.

Discharge measurements made on Arkansas River at Granite.

Date.	Hydrographer.	Gage height.	Discharge.
1895.		*Feet.*	*Sec.-ft.*
July 3	A. P. Davis	0.50	1,065
Sept. 26	do	3.10	215
1897.			
Apr. 17	C. C. Babb	3.20	120
May 8	F. Cogswell	4.20	940
May 18	do	4.90	1,236
June 29	do	4.60	1,151
July 27	do	3.75	415
Aug. 31	do	3.20	206
Sept. 27	do	3.10	203
Nov. 6	do	3.00	153
1898.			
July 30	A. L. Fellows	3.50	151
Aug. 26	do	3.40	112
Oct. 26	do	3.30	75
1899.			
May 25	do	5.00	1,476
July 15	do	2.80	1,178
Oct. 14	do	1.60	130
1900.			
July 9	do	.....	570

ARKANSAS RIVER AT SALIDA.

This station is located at the footbridge near the railroad shops at Salida. It was established April 11, 1895, and has been maintained for a portion of each year since that time. The gage rod has been fastened to the north side of the footbridge, but considerable difficulty has been experienced owing to the fact that ice and logs constantly interfere with the rod, three new rods having been required in 1900. The banks are high and are not subject to overflow, but there are large bowlders in the stream which interfere with the accuracy of the results of measurements.

The importance of the maintenance of the station lies in the information furnished as to the time required for water to flow from Granite to Salida and again from Salida to Canyon, this question having a bearing upon the distribution of the use of the water turned out from Twin Lakes; and it is, moreover, valuable from the point of view that it is extremely probable that the entire discharge of the Arkansas at this point may eventually be used for power purposes in the Grand Canyon of the Arkansas.[a]

[a] For more detailed information concerning this station, see Biennial Reports of the State Engineers of Colorado: Eighth, p. 480; Ninth, p. 361; Tenth, p. 298. Also publications U. S. Geological Survey: Eighteenth Annual Report, Part IV, p. 224; Nineteenth, Part IV, p. 355; Twentieth, Part IV, p. 331, Twenty-first, Part IV, p. 230. Bulletin No. 140, p. 155; Water-Supply and Irrigation Papers, No. 16, p. 118; No. 28, pp. 110 116, and 117; No. 37, p. 258; No. 39, p. 450; and No. 50, p. 322. Also report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, p. 104.

Discharge of Arkansas River at Salida.

[Altitude, 7,035 feet; drainage area, 1,160 square miles.]

Month.	1895.	1897.	1898.	1899.	1900.	Mean.	Equivalent in acre-feet.	Run-off.[a] Second-feet per square miles.	Run-off.[a] Depth in inches.
	Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*			
March	.....	.....	.....	[b] 308	.....	[c] 308	18,938	0.27	0.31
April	[d] 1,117	.....	.....	398	155	557	33,143	.48	.54
May	1,545	1,646	.....	1,352	1,790	1,583	97,335	1.36	1.57
June	1,599	1,839	.....	2,639	2,083	2,040	121,388	1.76	1.96
July	1,159	985	.....	1,301	633	1,020	62,717	.88	1.01
August	860	518	280	497	320	495	30,436	.43	.49
September	537	397	199	281	291	341	20,291	.29	.32
October	402	289	223	.....	192	277	17,032	.24	.28
November	.....	.....	267	.....	.....	[c] 267	15,888	.23	.26
Mean	1,031	946	242	968	780	765	417,168	0.66	6.74
Acre-feet for period recorded	416,976	345,184	58,560	370,560	331,058	.....	.....	.....	.....

[a] The run-off for acre-feet given is for that part of each year covered by the observations (and estimates) given, and for a thirty-day month at the rate given as the mean for the whole period of each year covered, while the discharge is for average months and the total for an average nine months from March to November, inclusive, as calculated from the observations and estimates. Details may be found in the authorities cited.

[b] March 22 to 31, inclusive.

[c] One year only, but approximately correct.

[d] April 11 to 30, inclusive.

Maximum and minimum discharge and average run-off of Arkansas River at Salida for that portion of each year covered by records.

Year.	Discharge.				Run-off.	
	Minimum.		Maximum.		Depth in inches.	Second-feet per square mile.
	Date.	Amount.	Date.	Amount.		
		Sec.-ft.		*Sec.-ft.*		
1895	Oct. 13	402	May 14	2,462	0.99	0.89
1897	Oct. 4	320	May 31	2,910	.91	.82
1898	Oct. 7	100	Aug. 2	428	.23	.21
1899	Sept. 28	240	June 20	3,900	.92	.83
1900	Apr. 14	65	June 1	3,633	.74	.67

Discharge measurements made on Arkansas River at Salida.

Date.	Hydrographer.	Gage height.	Discharge.
1895.		*Feet.*	*Sec.-ft.*
Sept. 27	A. P. Davis	0.60	463
1896.			
May 26	T. Cogswell	3.10	[a] 2,023
June 24	do	1.40	638
Sept. 29	do	1.05	352
Oct. 27	do	.85	317
1897.			
Apr. 17	C. C. Babb	.69	219
Apr. 27	F. Cogswell	1.55	709
May 8	do	2.20	1,178
May 30	do	4.05	2,821
June 29	do	2.50	1,492
July 27	do	1.35	606
Aug. 31	do	.85	371
Sept. 27	do	1.00	405
Nov. 6	do	.90	378
1898.			
Apr. 27	A. L. Fellows	1.10	480
May 20	do	3.10	445
June 25	do	3.10	2,352
July 29	do	1.25	568
Aug. 26	do	.90	360
Oct. 26	do	.80	222

[a] Approximate; meter out of order.

Discharge measurements made on Arkansas River at Salida—Continued.

Date.	Hydrographer.	Gage height.	Discharge.
1899.		*Feet.*	*Sec.-ft.*
Apr. 26	A. L. Fellows	1.72	686
May 25	do	3.10	1,999
July 14	do	2.40	1,801
Nov. 18	do	.80	317
1900.			
Mar. 15	A. L. Fellows	.90	271
June 14	do	4.30	3,036
Aug. 8	do	1.08	443
Aug. 22	do	.87½	364

ARKANSAS RIVER AT CANYON.

This station is located near the Hot Springs Hotel, 1½ miles west of Canyon, and a short distance below the mouth of Grape Creek (see Pl. VII). It was established in the year 1889, and records have been kept up ever since that time, thus furnishing a most valuable table of discharge of the Arkansas River. The station is of particular importance as it is located at the mouth of the canyon and above practically all the irrigating ditches excepting the Canyon ditch and the South Canyon ditch, which draw their supplies at short distances above the station. Each of these carries from a very few feet up to 60 cubic feet per second, according to need during the irrigation season.

The table does not include the amounts carried by the canals, and their flow should be added to the discharge of the river at the station in order to get the total run-off at the mouth of the canyon. The channel is fairly constant, changing but little during the entire time that the station has been maintained. The banks are high and not subject to overflow.[a]

[a] For more detailed data concerning this station, see Biennial Reports of the State Engineers of Colorado: Fourth, Part I, p. 62, and Part II, Pl. XVI: Fifth, Part 1, pp. 21 and 38, and Part II, Pl. X; Sixth, pp. 19 and 24; Seventh, pp. 163 and 164; Eighth, p. 474; Ninth, p. 363; Tenth p. 300. Also publications U. S. Geological Survey: Eleventh Annual Report, Part II, p. 97; Twelfth, Part II, pp. 240 and 349; Thirteenth, Part III, pp. 19 and 363; Fourteenth, Part II, p. 106; Eighteenth, Part IV, p. 225; Nineteenth, Part IV, p. 356; Twentieth, Part IV, p. 331; Twenty-first, Part IV, p. 231; Bulletins, No. 131, p. 35; No. 140, p. 156; Water-Supply and Irrigation Papers, No. 11, p. 60; No. 16, p. 119; No. 28, pp. 110, 116, and 117; No. 37, p. 258; No. 39, p. 450; No. 50, p. 323. Also, Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, p. 112.

A. ARKANSAS RIVER AT CANYON.

B. DIVERTING DAM ON ARKANSAS RIVER AT CANYON.

Discharge of Arkansas River at Canyon.

[Altitude, 5,363 feet; drainage area, 3,060 square miles.]

Month.	1888.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	Mean.	Equivalent in acre-feet.	Mean run-off. [a]	
																Second-feet per square mile.	Depth in inches.
	Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*			
January	b 400	b 300	310	431	496	505	445	344	454	b 380	b 270	316	345	384	23,611	0.12	0.14
February	b 500	b 300	363	474	493	533	420	361	438	b 380	b 350	328	353	407	22,604	.13	.14
March	b 600	b 300	320	586	524	555	505	471	472	b 380	338	584	439	467	28,715	.15	.17
April	b 1,000	300	477	857	522	568	627	868	558	320	393	544	736	598	35,583	.20	.22
May	1,440	600	2,090	2,012	1,241	1,480	1,960	1,506	1,276	1,741	909	1,924	2,251	1,512	96,658	.51	.59
June	2,090	1,374	2,611	3,291	2,787	3,115	2,704	1,900	959	2,464	2,428	3,496	3,492	2,516	149,712	.82	.91
July	1,350	602	1,571	1,468	1,798	1,069	1,393	1,413	538	1,115	1,613	2,021	891	1,296	79,688	.42	.48
August	932	340	670	951	769	563	710	1,095	395	553	326	711	273	638	39,229	.21	.24
September	605	220	519	473	435	477	551	635	313	366	189	225	211	401	23,861	.13	.14
October	b 500	223	531	624	511	b 50	294	505	285	471	228	236	241	396	24,349	.14	.16
November	b 500	299	522	498	527	b 500	260	499	267	519	302	440	266	415	24,694	.13	.14
December	b 400	335	502	476	561	428	268	444	579	b 400	b 350	336	298	414	25,456	.14	.16
Mean [c]	860	433	874	1,012	889	857	845	837	544	757	640	930	816	792	574,160	0.23	3.49
Acre-feet [c]	632,105	313,153	634,453	733,588	645,320	620,477	612,584	607,507	393,624	549,322	464,559	673,279	590,452				

[a] The run-off in acre-foot given is for each entire year, including estimated months; the discharge given is for average months, and the tables for an average year, as calculated from all observations and estimates. Details may be found in the authorities cited.

[b] Approximate.

[c] For entire year.

Maximum and minimum discharge and average run-off of Arkansas River at Canyon for that portion of each year covered by records.

Year.	Discharge.				Run-off.[a]	
	Minimum.		Maximum.		Depth in inches.	Second-feet per square mile.
	Date.	Amount.	Date.	Amount.		
		Sec.-ft.		*Sec.-ft.*		
1888	Sept. 28	420	June 19	2,760	3.80	0.28
1889	Oct. 12	190	Aug. 9	2,620	1.92	.14
1890	Jan. 14	180	May 28	3,270	3.88	.28
1891	Jan. 11	325	June 13	4,230	4.49	.35
1892	Jan. 15	345	June 25	4,750	3.95	.29
1893	Aug.	200	June	4,750	3.80	.27
1894	Oct.	245	June	4,400	3.74	.28
1895	Dec. 16	256	June 11	2,588	3.71	.27
1896	Nov. 28	124	Aug. 30	2,876	2.41	.18
1897	Apr. 10	108	June 4	3,452	3.33	.25
1898	Oct. 3	160	June 19	3,245	2.84	.21
1899	Feb. 18	160	June 20	4,432	3.98	.30
1900	Sept. 22	194	May 29	4,251	3.50	.26

[a] The run-off given is for each entire year, including estimated months. Details may be found in the authorities cited.

Discharge measurements made on Arkansas River at Canyon.

Date.	Hydrographer.	Gage height.	Discharge.
1889.		*Feet.*	*Sec.-ft.*
July 26	Robert Robertson	2.25	421
July 26	....do	3.00	833
1890.			
Apr. 1	Robert Robertson	1.62	222
Apr. 2	....do	1.70	286
Apr. 3	....do	1.88	360
Apr. 28	....do	2.93	744
May 1	....do	2.73	775
May 2	....do	2.80	891
May 2	....do	2.78	862
May 23	....do	4.77	2,705
June 5	....do	4.85	2,641
June 12	....do	4.53	2,220
June 14	....do	4.65	2,598
June 19	....do	4.48	2,380
June 23	....do	4.55	2,386
June 27	....do	4.55	2,394
June 30	....do	4.23	2,055
July 9	....do	4.22	1,998
July 12	....do	4.05	1,806
July 16	....do	3.82	1,546

Discharge measurements made on Arkansas River at Canyon.—Continued.

Date.	Hydrographer.	Gage height.	Discharge.
1891.		*Feet.*	*Sec.-ft.*
Apr. 13	T. M. Bannon	3.00	777
Dec. 4	....do	1.85	328
1893.			
Sept. 22	F. H. Newell	2.45	291
1894.			
Apr. 15	F. H. Newell	4.20	2,395
May 18	....do	3.80	1,940
June 18	....do	4.80	2,387
Sept. 20	A. P. Davis	2.65	395
Oct. 15	....do	2.40	319
1895.			
May 31	A. P. Davis	4.35	2,434
June 13	....do	4.50	2,397
Oct. 4	....do	2.70	585
1896.			
July 31	F. Cogswell	2.40	414
Aug. 30	....do	2.00	203
Sept. 16	....do	2.05	251
Oct. 31	....do	2.20	289
Nov. 14	....do	2.55	294
1897.			
Apr. 16	C. C. Babb	2.20	260
May 7	....do	3.10	827
May 26	F. Cogswell	4.95	2,712
June 16	....do	5.25	3,071
July 14	....do	3.60	1,140
Aug. 11	....do	3.05	744
Nov. 5	....do	2.98	540
1898.			
May 21	A. L. Fellows	3.05	608
June 25	....do	4.82	2,830
July 28	....do	3.05	611
Oct. 27	....do	2.60	316
1899.			
Apr. 27	A. L. Fellows	3.20	611
May 26	....do	4.55	2,189
July 7	....do	4.50	2,651
Aug. 18	....do	2.90	553
Nov. 7	....do	2.55	306
1900.			
Mar. 14	A. L. Fellows	2.85	408
June 14	....do	5.50	3,235
July 20	....do	2.85	570
Sept. 8	....do	2.10	229
Sept. 12	R. W. Hawley	2.10	205

ARKANSAS RIVER AT PUEBLO.

The first records of the discharge of Arkansas River in the vicinity of Pueblo are for the months of May and June, 1885. From this time until August, 1889, records were kept more or less irregularly at a point near the mouth of the canyon, about 9 miles above the city of Pueblo. No other records were kept in this vicinity until September, 1894, when the station was relocated in the city of Pueblo. As only one large ditch, the Bessemer canal, takes water from the river in District No. 14, in which Pueblo is situated, the station answers admirably for assisting in the distribution of the waters of that district. Owing, however, to the changes in the channel, the construction of side walls, and the removal of a dam in the lower part of the city, it has been necessary to change the location of the rod from time to time. Up to the fall of 1898 the records of gage heights were taken from a rod situated at the north end of the Santa Fe avenue bridge; at that time, however, another rod was placed at the south end of the Main street bridge, and in March, 1900, another rod was placed at a point a short distance below the south end of the Union avenue bridge. This is the rod used at present. These changes in location have, however, no material bearing upon the actual discharge, as measurements have been taken frequently and these stations are practically one, being located in the same long stretch of clear, open channel, with no inflow, and having high retaining levees constructed by the city. (See Pl. VII, *B*.) The channel at present is probably the best in the State, although it fills to some extent at low water and scours out again at high stages. Measurements are usually made from the Main street bridge, but may be made by wading at low water.

In comparing the tables it should be borne in mind that the records for 1885 to 1889, inclusive, are for a point about 9 miles above the station for the later years, and that considerable water is taken out between the two points. Moreover, much less water was used on the higher reaches of the stream prior to 1889 than since that time, so that practically the two stations bear little relationship to each other. They are, however, given together for advantage in comparison. Measurements of the water level are kept up regularly by the office of the city engineer of Pueblo, and it is to this office that we are indebted for a large proportion of the records given in the tables.

This station is of particular importance, for, being near the head of one of the most important districts and also near the headquarters of the superintendent of the Arkansas division, it is of use in ascertaining the discharge of the river with reference to the proper distribution of the water amongst consumers. It is further important because the waters of the Arkansas are being used more and more for power, and

A. ARKANSAS RIVER BELOW MAIN STREET BRIDGE, PUEBLO.

B. ARKANSAS RIVER NEAR ROCKYFORD.

the surplus, whenever there is any, is being stored in large reservoirs, of which there are several important ones in the vicinity of Pueblo.[a]

Discharge of Arkansas River at canyon above Pueblo, 1885 to 1889, inclusive.

Month.	1885.	1886.	1887.	1889.	Average.
	Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*
May	1,069	3,046	.....	1,300	1,805
June	3,187	5,569	3,477	2,108	3,585
July	.....	1,724	3,352	766	1,947
August	.....	1,481	1,717	668	1,289
September	.....	1,372	1,129	.....	1,250

[a] For more detailed data concerning this station, see Biennial Reports of the State Engineers of Colorado: Third, pp. 168 to 174; Fourth, Part I, p. 62, and Part II, Pl. XVI; Eighth, p. 468; Ninth, p. 366; Tenth, p. 304. Also publications U. S. Geological Survey: Eleventh Annual Report, Part II, pp. 49 and 98; Eighteenth, Part IV, p. 227; Nineteenth, Part IV, p. 357; Twentieth, Part IV, p. 336; Twenty-first, Part IV, p. 232; Bulletin No. 140, p. 158; Water-Supply and Irrigation Papers, No. 11, p. 61; No. 16, p. 120; No. 28, pp. 111, 116, and 117; No. 37, p. 259; No. 39, p. 450; No. 50, p. 325. Also Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, p. 126.

Estimated mean discharge of Arkansas River at Pueblo.

[Altitude, 4,690 feet; drainage area, 4,600 square miles.]

Month.	1895.	1896.	1897.	1898.	1899.	1900.	Mean.	Equivalent in acre-feet.	Mean run-off.[a]	
									Second-feet per square mile.	Depth in inches.
	Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*			
January	460	519	328	330	407	411	409	25,148	0.09	0.10
February	476	456	335	385	603	418	446	24,770	.10	.11
March	357	396	213	320	406	391	347	21,336	.08	.09
April	744	470	241	370	418	822	510	30,347	.11	.12
May	1,561	1,101	1,674	841	1,683	2,997	1,643	101,024	.36	.41
June	2,152	895	2,213	2,202	3,384	4,006	2,475	147,273	.54	.60
July	1,900	633	1,041	1,605	2,043	878	1,350	83,008	.29	.33
August	1,275	489	467	306	811	314	610	37,507	.13	.15
September	494	309	272	125	238	232	278	16,542	.07	.08
October	551	293	413	210	303	321	349	21,459	.08	.09
November	530	314	484	309	374	338	392	23,325	.09	.10
December	462	333	356	363	327	396	373	22,935	.09	.10
Mean	914	517	670	614	916	960	765	554,674	.17	2.28
Acre-feet, total	663,419	375,960	485,818	444,664	663,839	694,960				

[a] The run-off given is for average months, and the totals for an average year, as calculated from all observations and estimates. Details may be found in the authorities cited.

Maximum and minimum discharge and average run-off of Arkansas River at Pueblo for that portion of each year covered by records.

Year.	Discharge.				Run-off.[a]	
	Minimum.		Maximum.		Depth in inches.	Second-feet per square mile.
	Date.	Amount.	Date.	Amount.		
		Sec.-ft.		*Sec.-ft.*		
1895	Dec. 26	256	June 13	2,588	2.72	0.20
1896	Aug. 10	203	Aug. 18	3,428	1.54	.11
1897	Mar. 13	146	June 2	3,750	1.98	.14
1898	Oct. 6	31	July 13	5,385	1.82	.13
1899	Sept. 13	150	June 20	4,891	2.73	.20
1900	Sept. 1	134	June 2	6,980	2.80	.21

[a] The run-off given is for each year entire, including estimated months; the discharge given is for average months, and the totals for an average year, as calculated from all observations and estimates. Details may be found in the authorities cited.

Discharge measurements made on Arkansas River at Pueblo.

Date.	Hydrographer.	Gage height.	Discharge.
1894.		*Feet.*	*Sec.-ft.*
Apr. 24	P. J. Preston	[a]	322
Sept. 19	A. P. Davis	0.35	378
Oct. 13	do	.39	370
1895.			
Feb 6	A. P. Davis	.40	411
May 20	do	1.65	1,435
June 3	do	[b]	2,261
June 4	do	[c]	1,973
June 4	do	[d]	2,022
June 11	do	2.80	2,758
Sept. 5	F. Cogswell	.70	570
1896.			
Mar. 22	F. Cogswell	.50	470
Apr. 8	do	1.30	1,016
May 27	do	2.00	1,682
June 5	do	1.65	1,403
July 10	do	.30	335
July 30	do	.50	510
Aug. 18	do	[e] .00	203
Aug. 19	do	.85	534
Aug. 19	do	10.00	16,500
Sept. 16	do	.30	294
Oct. 30	do	.35	320
Nov. 13	C. C. Babb	.31	298

[a] Measurement made at Main Street bridge.
[b] Measurement made at Swallows.
[c] Measurements made at Bridge No. 3, section 4.
[d] Measurements made at Bridge 155 B.
[e] Approximate estimate of flood at 12 m. night of August 18, 1896. A maximum velocity of 15 feet per second was obtained by means of floats.

Discharge measurements made on Arkansas River at Pueblo—Continued.

Date.	Hydrographer.	Gage height.	Discharge.
1897.		*Feet.*	*Sec.-ft.*
Apr. 16	C. C. Babb	0.20	216
May 6	F. Cogswell	1.00	799
May 21	do	2.00	1,856
June 18	do	2.55	2,219
July 16	do	1.15	981
Aug. 10	do	.95	805
Sept. 8	P. J. Preston	.10	184
Sept. 28	do	.45	394
Nov. 4	F. Cogswell	.75	601
1898.			
Apr. 5	P. J. Preston	.27	248
Apr. 29	A. L. Fellows	.06	513
May 5	C. W. Beach	.09	876
May 30	do	.10	1,144
June 3	do	1.40	1,639
June 9	A. L. Fellows	1.8	2,002
June 14	C. W. Beach	1.9	1,987
July 8	do	1.63	1,726
July 26	A. L. Fellows	[a].85	816
July 28	C. W. Beach	[a].81	743
Aug. 2	do	.45	405
Aug. 11	do	.50	468
Aug. 20	C. W. Beach, R. W. Hawley	.15	211
Aug. 30	A. L. Fellows	.00	134
Oct. 20	C. W. Beach	.20	290
Oct. 29	A. L. Fellows	.40	320
Nov. 3	C. W. Beach	.30	344
1899.			
Apr. 27	A. L. Fellows	.80	695
May 26	do	2.20	2,221
June 3	C. W. Beach	2.55	2,856
June 17	do	3.60	4,565
July 1	do	2.22	2,959
July 8	A. L. Fellows	1.61	2,098
Aug. 1	C. W. Beach	.72	1,199
Aug. 5	do	1.46	1,938
Aug. 14	A. L. Fellows	1.20	1,496
Sept. 10	do	.50	180
Sept. 18	C. W. Beach	.10	388
Oct. 6	do	.20	331
Nov. 7	A. L. Fellows	.05	411

[a] New gage rod at Main street.

Discharge measurements made on Arkansas River at Pueblo—Continued.

Date.	Hydrographer.	Gage height.	Discharge.
1900.		*Feet.*	*Sec.-ft.*
Mar. 3	A. L. Fellows	2.17	498
Mar. 16	do	2.05	435
Apr. 8	do	2.34	675
Apr. 12	C. W. Beach	2.15	608
May 21	do	5.70	5,072
June 13	A. L. Fellows	5.10	3,963
July 17	do	2.50	751
July 21	do	2.25	583
Sept. 3	R. W. Hawley	1.35	153
Sept. 5	C. W. Beach	1.43	191
Sept. 7	A. L. Fellows	1.40	174
Sept. 25	C. W. Beach	1.82	346

ARKANSAS RIVER AT NEPESTA.

This station is located at the wagon bridge a short distance above the railroad station of the Atchison, Topeka and Santa Fe Railroad at Nepesta, and is maintained by the Great Plains Water Company. It was established September 8, 1897, and records have been kept during each irrigation season since that time, only those for 1898, 1899, and 1900 being reliable, however. Two gage rods are necessary; one for use at high and the other at low water. Measurements are made from the wagon bridge. The channel is sandy and shifting and frequent changes are necessary in the rating table. The importance of the station is due to the fact that it is so conveniently located to the railroad station that representatives of the large irrigation canals upon the river may readily keep themselves informed as to the discharge and the use of the water of the stream.[a]

[a] For further information concerning this station, see Biennial Reports of the State Engineers of Colorado: Ninth, p. 370; Tenth, p. 308. Also publications U. S. Geological Survey: Nineteenth Annual Report, Part IV, p 358: Twentieth, Part IV, p. 337; Twenty-first, Part IV, p. 233; Bulletin No. 131, p. 37; Water-Supply and Irrigation Papers, No. 16, p. 121; No. 28, pp. 112, 116, and 117; No. 37, p. 260; No. 39, p. 450; No. 50, p. 326. Also Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, p. 124.

Estimated monthly discharge of Arkansas River at Nepesta.

[Altitude, 4,364 feet; drainage area, 9,130 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1898.						
May	2,055	350	1,116	68,621	0.12	0.14
June	3,665	918	2,103	125,137	.23	.26
July	4,125	136	1,310	80,549	.14	.16
August	697	127	311	19,123	.03	.03
September	294	160	232	13,805	.03	.03
October	511	160	279	17,155	.03	.03
November	511	260	366	21,778	.04	.04
	.....	.....	817	346,168	.09	.69
1899.						
May	2,246	259	1,154	70,957	.13	.15
June	3,882	1,156	2,622	156,020	.29	.32
July	6,066	610	2,651	163,004	.29	.33
August	6,974	172	957	58,844	.10	.12
September	285	154	200	11,901	.02	.02
October	314	172	235	14,450	.03	.03
November	2,791	191	350	20,826	.04	.04
	.....	.....	1,167	495,002	.13	1.00
1900.						
May	9,600	4,246	5,876	361,301	.64	.74
June	7,782	4,064	5,498	327,154	.60	.67
July	3,700	427	1,699	104,467	.19	.22
August	1,519	172	422	25,948	.05	.06
September	427	172	262	15,590	.03	.03
October	610	314	435	26,747	.05	.06
November	792	259	514	30,585	.06	.07
	.....	.....	2,101	891,792	.23	1.85

Discharge measurements made on Arkansas River at Nepesta.

Date.	Hydrographer.	Gage height.	Discharge.
1894.		*Feet.*	*Sec.-ft.*
May 31	F. H. Newell		[a]30,000
June 1	do		12,000
June 2	do		8,000
1897.			
Sept. 8	P. J. Preston	2.00	168
Sept. 30	do	2.34	281
1898.			
Apr. 27	P. J. Preston	2.55	360
May 6	C. W. Beach	3.05	746
May 10	do	4.25	1,998
June 6	do	3.43	1,060
July 28	do	3.25	573
Aug. 20	do	2.85	247
Nov. 6	do	2.93	212
1899.			
May 29	A. L. Fellows	4.60	1,810
June 7	C. W. Beach	4.63	1,636
Aug. 3	do	4.00	610
Aug. 25	do	3.10	215
Oct. 2	do	3.12	213
1900.			
Apr. 12	C. W. Beach	4.30	1,101
Sept. 8	R. W. Hawley	3.70	146

[a] Estimated.

ARKANSAS RIVER AT ROCKYFORD.

This station is located at the wagon bridge crossing the Arkansas River, at a point about 2 miles northeast of the town of Rockyford. It was established May 3, 1897, by Mr. S. W. Cressy, water commissioner of district No. 17, having his headquarters at Rockyford, for his convenience and information in distributing the waters of his district. Mr. Cressy maintained this station as long as he remained in charge of the office to April 7, 1900. The river is straight for a long distance above and below the bridge, but the channel is wide and the bed is sandy and very shifting, so that few measurements were made. Results must be considered as approximate.[a]

[a] For more detailed information concerning this station, see Biennial Reports of the State Engineers of Colorado: Ninth, p. 374; Tenth, p. 310. Publications U. S. Geological Survey: Nineteenth Annual Reports, Part IV, p. 353; Twentieth, Part IV, p. 338; Twenty-first, Part IV, p. 234; Water-Supply and Irrigation Papers, No. 16, p. 122; No. 28, pp. 112, 116, and 117; No. 37, p. 261; No. 39, p. 450; No. 50, p. 327. Also Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, p. 124.

For description of Laguna Canal, in this district, see Twentieth Annual Report, Part IV, p. 339.

Estimated monthly discharge of Arkansas River at Rockyford.

[Altitude, 4,177 feet; drainage area, 11,440 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1897.						
May 3 to 31	3,363	64	1,147	70,527	0.100	0.120
June	3,206	628	1,834	109,130	.160	.180
July	2,034	41	589	32,216	.052	.060
August	3,676	20	614	37,754	.054	.062
September	108	13	41	2,440	.004	.004
October	393	27	143	8,793	.013	.015
November	550	41	155	9,223	.014	.016
December[a]	.....	.....	50	3,074	.044	.051
1898.						
January	.....	.....	[a]75	[a]4,612	.007	.008
February 20 to 28	193	34	75	4,165	.01	.01
March	393	129	254	15,618	.02	.03
April	550	64	213	12,674	.02	.02
May	3,832	108	1,206	74,155	.12	.13
June	3,284	315	2,047	121,805	.18	.20
July	3,754	193	1,249	76,799	.11	.13
August	706	108	269	16,540	.02	.03
September	393	64	157	9,342	.01	.02
October	550	84	246	15,126	.02	.03
November	862	84	530	31,537	.05	.05
December	393	84	228	14,020	.02	.02
The year	3,832	34	546	396,393	.04	.68
1899.						
March 13 to 31	570	140	309	19,000	.027	.031
April	520	140	274	16,304	.024	.027
May	1,270	140	732	45,009	.064	.074
June	2,710	770	1,498	89,137	.131	.146
July	3,020	270	1,504	92,478	.131	.150
August	3,570	105	686	42,181	.060	.069
September	420	95	153	9,104	.013	.014
October	300	55	145	8,916	.013	.015
November	1,070	105	280	16,661	.024	.027
December 1 to 9	190	115	148	9,100	.013	.015
1900.						
January 16 to 31	470	190	319	19,061	.027	.031
February, 13 days	470	270	410	22,770	.036	.037
March	450	190	324	19,922	.028	.032
April 1 to 7	3,120	360	1,283	76,344	.112	.125

[a] Approximate.

Discharge measurements made on Arkansas River at Rockyford.

Date.	Hydrographer.	Gage height.	Discharge.
1897.		*Feet.*	*Sec.-feet.*
Sept. 29	P. J. Preston	0.37	140
1898.			
Apr. 17	P. J. Preston	.90	237
May 27	C. W. Beach	1.83	1,692
1899.			
May 30	A. L. Fellows	1.88	1,042
Oct. 16	....do	.88	136

ARKANSAS RIVER AT PROWERS.

This station is located at the dam constructed across the Arkansas River at the headgate of the Colorado and Kansas canal, this point being selected in September, 1899, in the hope that the channel might prove permanent, but no records were kept until the spring of 1900. The rating curve obtained at this point from gagings made thus far gives excellent results within the limits of the measurements. There being no bridge at the station, measurements can be made only at the lower stages of the river. The station is of particular importance, owing to the fact that it is located near the head of irrigation district No. 67, and may therefore be used in the regulation of the use of the waters of the Arkansas in that district.[a]

Estimated monthly discharge of Arkansas River at Prowers.

[Altitude, 3,677 feet; drainage area, 19,000 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1900.						
April 15 to 30	7,140	1,060	2,940	174,942	0.155	0.173
May	5,860	2,660	3,398	208,935	.178	.238
June	4,900	742	2,617	155,722	.138	.154
July	1,700	2	161	9,990	.008	.009
August	445	0	45	2,767	.002	.002
September [b]	30	0	6	357	.000	.000
October [b]	.....	.....	6	369	.000	.000
November [b]	16	4	8	476	.000	.000
December	41	4	18	1,107	.001	.001

[a] For more detailed information regarding this station, see Tenth Biennial Report of the State Engineers of Colorado, p. 312; Water-Supply and Irrigation Papers, U. S. Geological Survey, No. 37, p. 263, and No. 50, p. 328; also Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, p. 126.

[b] Estimated.

Discharge measurements made on Arkansas River at Prowers.

Date.	Hydrographer.	Gage height.	Discharge.
1899.		*Feet.*	*Sec.-ft.*
Sept. 8	A. L. Fellows	0.20	16
1900.			
July 5	C. W. Beach	.60	304
July 19	A. L. Fellows	.38	113
July 28	C. W. Beach	.77½	546

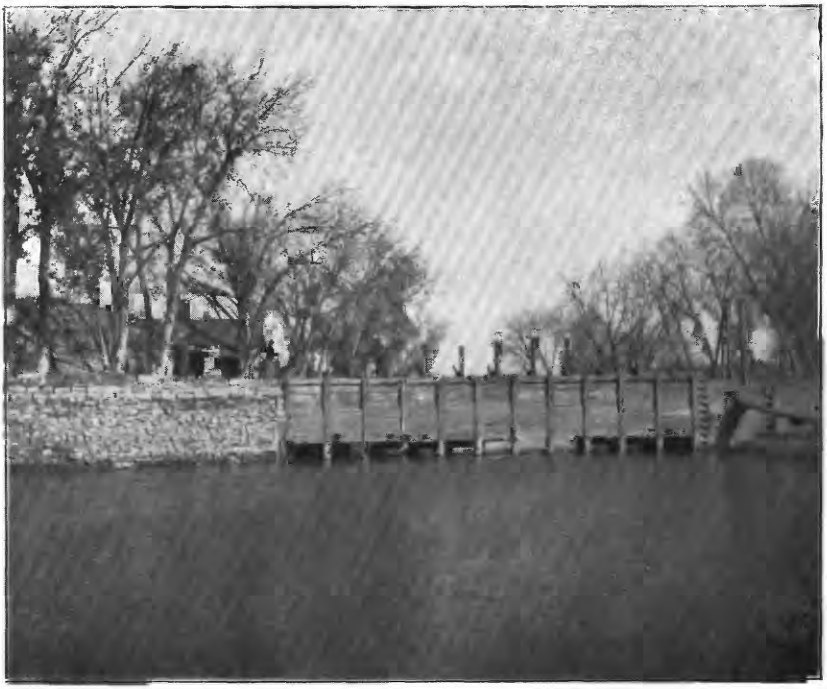
ARKANSAS RIVER NEAR LAMAR.

The greater proportion of the records of this locality are those kept by the Amity Canal Company, their headgate being at a point 7 miles west of Lamar, on the north side of the river, the headgate keeper making a daily record of the discharge both in the river and the canal. (See Pl. IX.) There is a dam across the river at this point for the diversion of water into the Amity canal, but owing to the unevenness of its crest, to the fact that timbers and driftwood lodge upon it, and to other causes, the results are not entirely reliable. Few measurements have been made except in the canal. For a short time in the year 1899 estimates were made at the wagon bridge north of Lamar by the water commissioner of district No. 67. These are of interest as giving approximately an idea of the flow of the water for the time covered, and are therefore presented in a separate table.

The principal value of hydrographic data at this point is with reference to the storage of water in reservoirs, of which those of the Great Plains Water Company, described in the Twenty-first Annual Report, Part IV, p. 240, are located, 12 miles north of the town of Lamar.[a]

[a] For further information concerning this station, see Biennial Reports of the State Engineers of Colorado; Ninth, p. 379; Tenth, p. 314. Also publications United States Geological Survey: Eleventh Annual Report, Part II, pp. 49 and 51; Twentieth, Part IV, pp. 324 and 340; Water-Supply and Irrigation Papers, No. 28, p. 114; No. 37, p. 263; No. 50, p. 329. Also Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, p. 126.

A. DAM OF AMITY CANAL ON ARKANSAS RIVER.



B. HEAD GATE OF AMITY CANAL.

Discharge of Arkansas River near Lamar.

[Altitude, 3,592 feet.]

AT HEAD OF AMITY CANAL, AS FURNISHED BY E. R. BANNISTER, HEADGATE KEEPER.

Month.	1898.		1899.		1900.	
	Second-feet.	Acre-feet.	Second-feet.	Acre-feet.	Second-feet.	Acre-feet.
January					239	14,696
February					280	11,552
March					170	10,453
April					2,973	176,906
May					4,469	274,788
June			655	38,975	3,290	195,769
July			1,870	114,982	280	17,217
August	211	12,974	884	54,355	89	5,472
September	23	1,369	74	4,403	22	1,309
October	54	3,320	87	5,349	20	1,230
November	265	15,769	249	14,817	109	6,486
December	248	15,249	131	8,055	[a] 150	9,223

[a] Approximate.

AT LAMAR BRIDGE,[a] ESTIMATED BY J. B. TRAXLER, WATER COMMISSIONER, DISTRICT NO. 67.

Day.	1899.		
	March.	April.	May.
	Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*
1	3,000	40	12
2	4,000	40	12
3	4,000	35	12
4	2,500	35	12
5	2,000	30	12
6	1,500	25	12
7	1,200	25	12
8	1,000	25	12
9	800	20	12
10	800	15	12
11	1,500	16	12
12	1,500	16	12
13	1,200	15	12
14	1,000	18	14
15	1,000	20	15½
16	1,000	15	5
17	1,000	15	5
18	800	15	5
19	400	15	5

[a] Total amount of water in district March 13, 250 second-feet; April 3, 225 second-feet; April 16, 175 second-feet; April 25, 120 second-feet; April 30, 75 second-feet; May 5, 180 second-feet; May 10, 100 second-feet; May 13, 200 second-feet; May 14, 150 second-feet; May 16, 230 second-feet; May 18 325 second-feet; May 20, 308 second-feet.

Discharge of Arkansas River near Lamar—Continued.

AT LAMAR BRIDGE, ESTIMATED BY J. B. TRAXLER, WATER COMMISSIONER, DISTRICT NO. 67—Continued.

Day.	1899.		
	March.	April.	May.
	Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*
20	300	15	5
21	300	15	.....
22	200	15	.....
23	150	15	.....
24	100	15	.....
25	75	15	.....
26	50	15	.....
27	40	12	.....
28	35	12	.....
29	35	12	.....
30	35	12	.....
31	40	.....	.....

Discharge measurements made on Arkansas River at Lamar.

Date.	Hydrographer.	Discharge.	Remarks.
1889.		*Sec.-ft.*	
May 26	F. H. Newell	300	At Lamar.
July 19	.....do	15,000	Do.
July 22	.....do	851	Do.
Aug. 3	.....do	284	Do.
Aug. 7	.....do	187	Do.
1899.			
May 31	A. L. Fellows	249	At Amity canal.
June 18	.....do	114	Do.
1900.			
Apr. 7	.....do	8,890	At Lamar.

PURGATORY RIVER AT TRINIDAD.

This station was located May 1, 1896, in the town of Trinidad, the gage rod being attached to the cylindrical pier at the west end of the Las Animas Street bridge. The station was, however, discontinued July 31, 1899, the greater portion of the water of the river being taken out at points above the station, and the channel being sl ifting and the results unreliable. A more favorable location would be at a point about 9 miles above the town, near the mouth of the canyon, and above where the most of the water is taken out for irrigation. A station at this point would also have the added advantage that it would furnish

data concerning the flow that might be used for storage, as there are important reservoir sites situated above this point.[a]

Estimated monthly discharge of Purgatory River at Trinidad.

[Altitude, 5,990 feet; drainage area, 742 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1896.						
May	113	45	67	4,120	0.09	0.10
June	780	0	60	3,570	.08	.09
July	4,600	8	342	21,029	.46	.53
August	1,657	0	76	4,673	.10	.12
September	554	0	73	4,344	.10	.11
October	189	18	71	4,366	.10	.12
November	60	25	35	2,083	.05	.06
December	.....	.....	b40	2,460	.05	.06
1897.						
January	.....	.....	b40	2,459	.05	.06
February	.....	.....	b50	2,777	.07	.07
March	.....	.....	b50	3,074	.07	.08
April	327	68	165	9,818	.22	.24
May	1,412	327	731	44,947	.99	1.14
June	1,534	189	403	23,980	.54	.60
July	1,657	30	250	15,372	.34	.39
August	2,023	10	282	17,339	.38	.44
September	383	30	97	5,772	.13	.14
October	104	54	60	3,689	.08	.09
November	54	30	42	2,499	.06	.07
December	.....	.....	b35	2,152	.05	.06
1898.						
May	882	109	264	16,233	.36	.41
June	1,282	109	377	24,433	.51	.57
July	1,147	81	259	15,925	.35	.40
August	752	42	181	11,129	.24	.28
September	1,282	42	173	10,294	.23	.26
October	58	31	39	2,398	.05	.06
November	42	36	39	2,321	.05	.06
1899.						
April	193	32	82	4,879	.11	.12
May	230	52	110	6,764	.15	.17
June	492	4	71	4,225	.10	.11
July	2,362	16	443	27,239	.60	.69

[a] For more detailed information concerning this station, see Biennial Reports of the State Engineer of Colorado: Eighth, p. 460; Ninth, p. 381; Tenth, p. 319. Also publications U. S. Geological Survey: Eighteenth Annual Report, Part IV, p. 231; Nineteenth, Part IV, p. 358; Twentieth, Part IV, p. 340; Twenty-first, Part IV, p. 235; Water-Supply and Irrigation Papers, No. 16, p. 123; No. 28, pp. 113, 116, and 117; No. 37, p. 263; No. 39, p. 450. Also, Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, p. 119.

[b] Estimated.

Discharge measurements made on Purgatory River at Trinidad.

Date.	Hydrographer.	Gage height.	Discharge.
1895.		*Feet.*	*Sec.-ft.*
Sept. 24	A. P. Davis		86
1896.			
Apr. 27	F. Cogswell	3.20	88
June 4	do	3.15	72
July 11	do	3.20	66
Sept. 14	do	3.50	30
Oct. 12	do	3.70	48
Nov. 16	C. C. Babb	3.60	24
1897.			
May 22	F. Cogswell	4.25	677
June 17	do	4.10	386
July 15	do	3.90	189
Sept. 23	P. J. Preston	3.60	49
Nov. 13	F. Cogswell	3.55	46
1898.			
Apr. 28	A. L. Fellows	3.90	150
July 27	do	3.90	149
Aug. 29	do	3.60	45
Aug. 6	C. W. Beach	3.76	101
Oct. 28	A. L. Fellows	3.40	31
1899.			
Apr. 28	do	3.60	52
July 12	do	3.30	4

MISCELLANEOUS GAGINGS.

A number of miscellaneous gagings have been made at different times at different points upon the Arkansas and its tributaries, which have been compiled, so far as they are obtainable, from the various sources already cited, and are presented in the following table. Stations have not been maintained at the points mentioned, or if maintained at all have been irregularly kept, and the records have been so unsatisfactory that it is thought best not to publish the gage heights or to approximate the discharge, the data necessary for computing the rating tables being insufficient.

Miscellaneous discharge measurements, Arkansas River and tributaries

Date.	Hydrographer.	Stream.	Locality.	Discharge.
				Sec.-ft.
Sept. 26, 1893	F. H. Newell	Arkansas	Byron	0
Sept. 24, 1894	A. P. Davis	do	Hayden	114
Sept. 29, 1897	P. J. Preston	do	Manzanola	208
May 18, 1898	C. W. Beach	do	do	847
June 13, 1898	do	Purgatory	J. J. ranch	37
Aug. 5, 1898	do	do	do	60
Sept. 15, 1898	do	Arkansas	Manzanola	208

Discharge measurements made on Arkansas River at La Junta.

Date.	Hydrographer.	Discharge.
1893.		*Sec.-ft.*
Sept. 27	F. H. Newell	24
1894.		
May 21	F. H. Newell	157
June 7	do	15,000
June 8	do	9,500
Oct. 5	do	55
1895.		
Feb. 6	F. H. Newell	182
May 19	do	658
Dec. 2	do	455
1897.		
Sept. 12	P. J. Preston	0
1899.		
May 30	A. L. Fellows	246
June 13	do	857
June 20	do	1,181

Discharge of Arkansas River at La Junta.

[Drainage area, 12,200 square miles.]

Month.	Discharge.			Total for month.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1889.	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*		
May 20 to 31	1,960	605	1,089	66,973	0.09	0.10
June	2,620	825	1,355	80,622	.11	.12
July	2,290	345	844	51,906	.07	.08
August	1,630	55	435	26,752	.04	.04

SEEPAGE MEASUREMENTS ON ARKANSAS RIVER.

A series of seepage measurements have been made upon Arkansas River for the purpose of determining the return flow. These have been carried on under the direction of Prof. L. G. Carpenter, of Fort Collins, who has published a bulletin upon the subject.

The table below is compiled from data given in the Ninth Biennial Report, page 308, of the State engineer's office of Colorado, as furnished by Professor Carpenter:

Seepage measurements of Arkansas River.

[In second-feet.]

Place.	Distance (miles).	1897.		1898.	
		Gain.	Loss.	Gain.	Loss.
Canyon to Bessemer ditch	33	54.40	.....	55.17	.....
Bessemer to Pueblo	10	.....	42.18	.....	15.96
Pueblo to Orchard Grove	8	.....	9.40	19.41	.....
Orchard Grove to Boone	16	103.47	.....	20.30	.....
Boone to Nepesta	10	40.44	.....	.....	17.65
Nepesta to Otero canal	8	.....	5.78	.....	11.00
Otero canal to Apishapa Creek	7	16.90	.....	18.15	.....
Apishapa Creek to Rockyford	16½	30.55	.....	21.21	.....
Rockyford to Fort Lyon canal	9	35.59	.....	22.39	.....
Fort Lyon canal to La Junta	3	13.04	.....	8.20	.....
La Junta to Jones ditch	11	10.85	.....	14.76	.....
Jones ditch to Las Animas	9	28.51	.....	20.08	.....
Las Animas to Fort Lyon	6	38.14	.....	13.26	.....
Fort Lyon to Caddoa	11	3.63	.....	.....	.16
Caddoa to Amity canal	10	.....	.....	.....	6.64
Amity to Lamar	11	.....	.....	6.68	.....
Lamar to Holly	30	13.21	.....	14.20	.....
Holly to Coolidge, Kans	7	.....	.....	0	.....
Total	215	387.43	57.36	243.81	51.41
Unreliable	.....	57.36	.....	51.41	.....
Gain	.....	330.07	.....	192.40	.....

NOTE.—Counting the unreliable measurement to gain as in 1898, the gain in 1897 would be 250 second-feet.

RIO GRANDE DIVISION.

DRAINAGE.

Descriptions of the Rio Grande drainage have been given in former reports, but a short résumé is here presented for the convenience of those who do not care to look up the former records.[a]

The Rio Grande and its tributaries drain the mountainous area south and east of the Continental Divide in southwestern Colorado, the principal streams flowing from the east side of the Needle Mountains and from the south and east side of the San Juan Range. Important streams also flow from La Garita Mountains in Saguache and Mineral counties. The main stream flows in an easterly direction for about 75 miles, receiving numerous tributaries from the mountainous region through which it flows. At the town of Del Norte the valley broadens into what is known as the San Luis Valley; thence the stream flows southeastward and southward for about the same distance to a point about 20 miles southeast of Antonito, where it crosses the State line. From the time the river leaves Del Norte but few streams of importance flow into it, as nearly all of those that issue from the mountains lose their waters in the plains before they reach the main stream. This is particularly true of the drainage north and east of the river from the Cochetopa Hills and the Sangre de Cristo Range. Although the streams flowing from these mountains are very numerous and carry large volumes of water, yet they furnish no source of supply to the Rio Grande itself, all the water being lost either in the sands or in broad, shallow lakes, until Trinchera Creek, flowing through the Costilla land grant, is reached. This stream, although usually dry, furnishes a supply at different times in the year. On the south and west side of the river, however, many important streams flow from the mountains, which in their higher stages carry large volumes of water to the Rio Grande. Among these are the Alamosa, La Jara, and Conejos. The supply from these streams also is used mostly during summer, so that after the flood stages are past very little water flows from any of these sources into the Rio Grande itself, as most of it is used in the upper part of the valley, and in the late summer very little passes Alamosa, below which place there are but few irrigating canals. During the flood stages, however, great volumes of water

[a] Hayden's Report of 1875, pp. 153 to 167. Publications U. S. Geological Survey: Tenth Annual Report, Part II, p. 65; Eleventh, Part II (see index); Twelfth, Part II, p. 240; Thirteenth, Part III (see index); Fourteenth, Part II, p. 110; Eighteenth, Part IV, p. 245; Nineteenth, Part IV, p. 381; Twentieth, Part IV, p. 355. Bulletins No. 131, p. 41; No. 140, p. 169; Water-Supply and Irrigation Paper No. 37. See also all Biennial Reports of the State Engineers of Colorado for irrigation in this division, and Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, p. 127. For maps see Pl. I of Part II of the fourth and seventh and Pl. V of the fifth report. See also Senate Document No. 229, Fifty-fifth Congress, second session, on the "Equitable distribution of the waters of the Rio Grande."

flow in the Rio Grande itself and several of its tributaries which might be stored and used for the extension of the irrigated area. Farming is carried on extensively among the upper valleys of several of the streams issuing from the mountains north and east of San Luis Valley, but no official measurements have been made upon any of these streams.

On the headwaters of nearly all of the tributaries of the Rio Grande, as well as on the main stream itself, are important reservoir sites, which might be utilized to store water for late use, so as to render crop raising more certain than it is now. Unfortunately, owing to international complications, it has been impossible in the past to make use of these sites, but it is hoped that this restriction will soon be removed, as it is clearly to the advantage of the agricultural interests as a whole that the water should be used to as great an extent as possible along the upper portion of the streams.

The lands drained by the Rio Grande and its tributaries constitute irrigation division No. III. The various districts into which it is divided are No. 20, comprising the Rio Grande drainage, excepting those streams included in separate districts, which are No. 21, covering Alamosa and La Jara creeks with their tributaries; No. 22, Conejos Creek; No. 24, Costilla Creek; No. 25, San Luis Creek; No. 26, Saguache Creek; No. 27, Tuttle, Carnero, La Garita, and all other creeks and their tributaries which have their sources of water supply in the La Garita Mountains and flow eastward into the San Luis Valley; and No. 35, Trinchera Creek.

There are many problems of interest connected with the use of water in the San Luis Valley, among which is the study of loss by evaporation and seepage. Investigation is being carried on in this line by Prof. L. G. Carpenter, already mentioned, of the Colorado State Agricultural College.

STREAM MEASUREMENTS.

Although hydrographic data are most desirable in this valley, but little hydrographic work has been done, owing to the scarcity of funds, both in the office of the State engineer and the United States Geological Survey, so that only three stations have been maintained for any considerable length of time, and of these only one, the station at Del Norte, has been maintained for a length of time sufficient to furnish anything like accurate information concerning the normal flow. The two that have been kept up for shorter periods are a station near the State line, upon the main Rio Grande, and one upon the Conejos, about 10 miles west of the town of Antonito, on the Denver and Rio Grande Railroad.

A. GAGING RIO GRANDE AT DEL NORTE.

B. STATE BRIDGE ACROSS RIO GRANDE NEAR COLORADO STATE LINE.

RIO GRANDE AT DEL NORTE.

This station is located about 3 miles west of the town of Del Norte, above the main canals taking water from the Rio Grande. Records have been kept since the fall of the year 1889 for very nearly the entire time. A steel cable is stretched across the river at this point and the gagings are made by means of a car traveling on the cable, distances being marked on a tag wire, and, at low water, by wading. The channel consists of small bowlders and gravel, and although the sides are not high, the stream has never been known to overflow at this point. The conditions are excellent for good results, as the bed of the stream scours but little, although the fall is comparatively rapid. The station is of great value, as the distribution of water among the numerous consumers is made to depend very largely upon the data obtained as shown on the gage rod. Information is also furnished concerning the supply available for storage in reservoir sites above.

The citizens of San Luis Valley seem to appreciate fully the advantage of this station and have frequently expressed themselves as desiring to see this service extended.[a]

[a] For detailed information concerning this station, see Biennial Reports of the State Engineers of Colorado: Fifth, Part I, pp. 21 and 40; and Part II, Pl. V; Sixth, p. 38; Seventh, p. 170; Eighth, p. 488; Ninth, p. 385; Tenth, p. 321. Also publications U. S. Geological Survey, Eleventh Annual Report, Part II, pp. 53 and 98; Twelfth, Part II, p. 246; Thirteenth, Part III, p. 99; Fourteenth, Part II, p. 110; Eighteenth, Part IV, p. 246; Nineteenth, p. 383; Twentieth, p. 359; Twenty-first, Part IV, p. 256; Bulletins No. 131, p. 41; Nos. 140 to 170; Water-Supply and Irrigation Papers, No. 11, p. 64; No. 16, p. 127 No. 28, pp. 126, 129, and 130; No. 37, p. 277; No. 39, p. 450; No. 50, p. 347. Also Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, pp. 113, 127

Discharge of Rio Grande at Del Norte.

[Altitude, 7,865 feet; drainage area, 1,400 square miles.]

Month.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	Mean.	Equivalent in acre-feet.	Mean run-off.[a] Second-feet per square mile.	Mean run-off.[a] Depth in inches.
	Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*			
January	.....	[b]552	[b]990	[c]300	[b]966	[b]1,003	[b]801	[b]1,293	[bc]1,000	[bc]1,377	[b]1,308	[b]862	[b]950	58,413	0.68	0.78
February	.....	[b]796	[b]1,294	[c]300	[bc]700	[b]995	[b]953	[b]1,258	[bc]1,000	[bc]1,472	[b]1,113	[b]1,005	[b]989	54,926	.71	.83
March	.....	487	1,280	316	[bc]500	[b]831	638	[b]1,081	[bc]1,000	[bc]1,471	[b]875	399	[b]807	49,620	.58	.67
April	.....	913	[b]1,410	1,047	533	699	[b]1,883	1,484	1,067	[b]1,912	617	419	[b]1,089	64,800	.78	.87
May	.....	4,331	3,285	2,605	1,944	1,798	2,116	2,374	3,537	2,722	1,378	2,854	2,631	161,774	1.88	2.17
June	.....	3,807	4,146	2,187	1,749	802	2,209	821	3,391	4,390	1,091	2,691	2,480	147,570	1.77	1.97
July	.....	1,515	1,693	740	395	292	958	403	1,108	1,643	703	547	908	55,830	.65	.75
August	.....	612	663	444	324	309	720	261	475	509	598	231	467	28,715	.33	.38
September	.....	383	527	263	270	286	454	477	631	319	365	256	384	22,850	.27	.30
October	[c]278	470	844	259	263	289	435	469	1,472	259	492	343	489	30,067	.35	.40
November	319	478	374	360	278	236	353	310	665	[b]816	490	253	411	24,456	.29	.32
December	281	[b]565	[c]325	[b]922	[b]642	288	[b]1,008	375	[bc]800	[bc]1,300	[b]742	[b]755	[b]666	40,950	.48	.55
Mean	292	[b]1,242	1,403	812	[b]714	[b]652	[b]1,044	[b]884	1,346	[b]1,517	814	[b]884	[b]1,023	739,971	.73	9.99
Acre-feet, total	.....	900,926	1,014,426	590,219	516,886	471,408	754,931	641,017	945,418	1,094,950	589,293	641,017	.....	.....	.....	.....

[a] The run-off given is for average months and the totals for an average year as calculated from all observations and estimates. Details may be found in the author ities cited.

[b] Probably too high because of ice piling up along the sides of the stream and thus narrowing the channel. It is not likely that the winter flow is even more than 600 second-feet. The totals are carried out, however, as though the observations gave a correct idea of the discharge.

[c] Approximate.

Maximum and minimum discharge and average run-off of Rio Grande at Del Norte for that portion of each year covered by records.

Year.	Discharge.				Run-off.[a]	
	Minimum.		Maximum.		Depth in inches.	Second-feet per square mile.
	Date.	Amount.	Date.	Amount.		
		Sec.-ft.		*Sec.-ft.*		
1890	Oct. 2	307	Apr. 27	5,930	12.06	0.89
1891	Sept. 19	290	May 7	5,650	13.56	1.00
1892	Sept. 26	243	May 24	4,710	7.92	.58
1893	Nov. 8	214	May 19	3,320	6.93	.51
1894	Nov. 27	201	May 17	2,850	6.29	.46
1895	Nov. 21	322	June 12	3,840	10.14	.75
1896	Aug. 21	214	May 3	3,579	8.58	.63
1897	Sept. 1	342	May 27	5,234	13.05	.96
1898	Nov. 9	221	June 3	5,266	14.06	1.08
1899	Sept. 13	268	May 11	2,330	7.87	.58
1900	Aug. 31	163	May 29	5,454	8.55	.63

[a] The run-off, per acre-foot, given is for each entire year, including estimates; the discharge given is for average months and the totals for an average year, as calculated from all observations and estimates. Details may be found in the authorities cited.

Discharge measurements made on Rio Grande at Del Norte.

Date	Hydrographer.	Gage height.	Discharge.
1891.		*Feet.*	*Sec.-ft.*
Apr. 10	T. M. Bannon	2.20	527
1892.			
Oct. 27	T. M. Bannon	1.58	274
1894.			
June 13	F. H. Newell	2.68	968
Sept. 27	A. P. Davis	1.52	267
1895.			
June 14	A. P. Davis and F. Cogswell	4.00	2,818
Oct. 13	F. Cogswell	1.80	414
1896.			
June 22	F. Cogswell	1.90	492
July 27	do	1.70	385
Sept. 28	do	2.30	706
Oct. 26	do	1.80	445
1897.			
Apr. 26	F. Cogswell	3.00	1,507
May 17	do	4.05	3,014
May 29	do	5.45	4,898
June 28	do	3.30	1,769
July 26	do	2.00	640
Aug. 30	do	1.55	373
Oct. 25	do	2.66	1,113

Discharge measurements made on Rio Grande at Del Norte.—Continued.

Date.	Hydrographer.	Gage height.	Discharge.
1898.		*Feet.*	*Sec.-ft.*
Apr. 14	A. L. Fellows	3.27	1,966
May 18	do	3.23	1,802
June 23	do	5.25	5,181
Aug. 25	do	1.86	521
Oct. 25	do	1.48	244
1899.			
Apr. 25	A. L. Fellows	2.42	1,004
May 24	do	2.92	1,480
June 29	do	2.10	734
Aug. 21	do	1.58	387
1900.			
Mar. 30	A. L. Fellows	1.54	346
May 12	do	3.84	2,441
June 16	do	3.66	2,382
Aug. 18	do	1.34	221

CONEJOS RIVER NEAR LOS MOGOTES.

This stream, the most important tributary of the Rio Grande in Colorado, rises on the eastern slope of the San Juan Range, which forms the western boundary of Conejos County. It flows southeastward as far as the town of Conejos; then, bending northeastward, enters the Rio Grande below the mouth of Trinchera Creek. All of the ordinary flow of this stream is used during the irrigation season, but at flood stages and in winter considerable water goes to waste. The station is located about 10 miles west of Antonito, from which town it may be reached by driving. The nearest post-office is at Los Mogotes, about 4 miles from the station, but the observer was always accustomed to get his mail at Antonito. It was established August 25, 1899, and was first located at a wagon bridge crossing the river; but owing to the fact that the rod at that point was maliciously destroyed, the station was removed to a point about 500 yards downstream, where it was attached to a pier projecting into the river near a farmhouse. The channel is fairly good, being of gravel and not particularly liable to either change or overflow. Owing to the removal of the gage from its old station and to the small number of measurements made, but few data are available.

San Antonio River is an important branch of the Conejos, and a few measurements were made upon this stream also, these being given in the list of miscellaneous measurements.[a]

[a] For more detailed information regarding this station, see Tenth Biennial Report of the State Engineer of Colorado, p. 328, and U. S. Geological Survey Water-Supply and Irrigation Papers, No. 37, p. 278, and No. 50, p. 348. Also, Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, p. 105.

Discharge measurements made on Conejos River near Los Mogotes

[A. L. Fellows, hydrographer.]

Date.	Gage height.	Discharge.
1899.	*Feet.*	*Sec.-ft.*
August 25	1.00	76
November 28	2.20	70
1900.		
March 28	1.68	144
May 11	3.10	1,087
June 23	2.30	467
August 17	1.15	33

RIO GRANDE AT CENICERO.

This station is located a short distance north of the boundary line between Colorado and New Mexico, at a point where the river is crossed by a State wagon bridge. It was established July 28, 1899, and has been kept up regularly ever since. Two gage rods are necessary, one for high and the other for low water. The channel is excellent, the bed consisting of bowlders and rock and being subject to but little change, and the banks are high and not liable to overflow. At high water gagings may be made from the bridge, but at low water they are usually made by wading. The station is an important one, as it gives information concerning the entire drainage of the Rio Grande in Colorado and the discharge of the river practically where it enters New Mexico, this information being of value to both Colorado and New Mexico and furnishing important data bearing upon storage and the use of water. The nearest railroad point is Antonito, from which the station may be reached by driving about 15 miles. The nearest post-office is at Eastdale, but the observer has been in the habit of getting his mail at Cenicero, which is on the road between Antonito and the gaging station, about 4 miles from the former.[a]

[a] For more detailed information concerning this station, see Tenth Biennial Report of the State Engineer of Colorado, p. 326; U. S. Geological Survey Water-Supply and Irrigation Papers, No. 37, p. 279; No. 39, p. 450, and No. 50, p. 349.

Estimated monthly discharge of Rio Grande at Cenicero.

[Drainage area, 7,695 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1899.						
July	170	12	42	2,582	0.005	0.006
August	129	20	53	3,259	.007	.008
September	423	31	102	6,069	.013	.015
October	170	65	117	7,194	.015	.017
November	297	170	259	15,412	.034	.038
December	381	170	318	19,553	.041	.047
Last 6 months of the year	423	12	148	54,069	.019	.131
1900.						
January	1,134	594	638	39,229	.083	.095
February	1,134	22	759	42,153	.099	.103
March	1,134	236	583	35,847	,076	.087
April	504	183	350	20,826	.045	.050
May	3,294	414	1,430	87,927	.186	.214
June	3,294	79	1,424	84,734	.185	.206
July	58	22	29	1,783	.004	.004
August	22	16	22	1,353	.003	.003
September	43	16	31	1,845	.004	.004
October	58	31	31	2,275	.005	.006
November	504	58	155	9,223	.020	.022
December	594	414	571	35,109	.074	.085
The year	3,294	16	502	362,304	.065	.879

Discharge measurements made on Rio Grande at Cenicero.

[A. L. Fellows, hydrographer.]

Date.	Gage height.	Discharge
1899.	*Feet.*	*Sec.-ft.*
June 28	0.90	20
August 24	1.00	31
November 28	1.80	297
1900.		
March 29	1.60	236
May 10	2.00	594
June 22	1.80	420
August 16	.75	18

MISCELLANEOUS MEASUREMENTS.

A table is given below of the miscellaneous measurements of which records are obtainable that have been made in the Rio Grande drainage basin in Colorado. These are of importance, as they furnish information concerning the flow of the various streams at stated times and given points.

Miscellaneous discharge measurements on Rio Grande and tributaries.

Date.	Hydrographer.	Stream.	Locality.	Discharge in second-feet.
Sept. 28, 1894	A. P. Davis	Rio Grande	Alamosa	10
June 16, 1895	F. Cogswell	do	do	1,176
Oct. 14, 1895	do	do	do	92
May 19, 1896	do	do	do	132
June 23, 1896	do	do	do	32
June 24, 1896	F. F. Anderson	Conejos	Los Mogotes	67
July 26, 1896	F. Cogswell	do		3
Aug. 20, 1899	A. L. Fellows	do	6 miles below Alamosa.	17
Aug. 23, 1899	do	do	½ mile above Alamosa.	10
May 11, 1900	do	San Antonio	Antonito	473
June 22, 1900	do	do	do	4

SEEPAGE MEASUREMENTS.

The seepage measurements given below were made under the direction of Prof. L. G. Carpenter, of Fort Collins, and were furnished by him to the State engineer of Colorado. The table is from the Tenth Biennial Report, pages 219 and 221. Professor Carpenter expects to publish a bulletin on these measurements shortly.

Seepage measurements on Rio Grande, 1900.

[In second-feet.]

Place of measurement.	Date.	Section inflow.	Section outtake.	River.	Section gain or loss.	Total gain or loss.
Railroad station at South Fork	Aug. 30	0.85	33.41	194.24		
United States Geological Survey gaging station	Aug. 31			209.83	48.15	48.15
Do	Aug. 20		146.61	249.06		
Above Del Norte canal	do			176.50	25.95	22.20
Do	Aug. 21		32.11	178.90		
At Off's	do			168.48	21.69	43.89
Do	Aug. 22		47.19	156.22		
Below Prairie canal	do	.31		99.29	−10.05	33.84
Do	Aug. 23	4.33	96	108.91		
Below Monte Vista bridge	do			14	−3.24	30.60
Do	Aug. 24		30.29	14.30		
Below San Luis canal	do	5.21	14.24	5.90	21.89	52.49
Below Hickory-Jackson ditch	do			10.65	13.98	66.47
Do	Aug. 25		10.69	11.55		
Below Alamosa	do			1	.14	66.61
Do	Aug. 27			1.01		
Above mouth of Conejos River	do	14.33		1.35	.24	66.85
Below Conejos (North Branch)	do	6.90		15.33	−.35	66.50
Below Las Sauces	do			23.98	1.75	68.25
Do	Aug. 28			22.31		
Above State bridge	do			17.22	−5.09	63.16

Seepage measurements on Conejos River, 1900.

[In second-feet.]

At State gaging station	Aug. 31			24.65		
Above San Juan bridge	do		1.97	24.77	2.09	
At bridge	do		2.15	.50	−22.12	−20.03
Above Cerritos	Aug. 30	0.77		.80	.30	−19.73
Below San Antonio Creek	do		3.32	.55	−1.02	−20.75
At McIntire place	do			3.88	6.65	−14.10
Do	Aug. 29		24	4.33		
Below McIntire spring	do		14.19	31.33	3	−11.10
Two hundred feet above bridge	do			24.02	6.88	−4.22

SAN JUAN DIVISION.

IRRIGATION.

San Juan River rises in the San Juan Mountains, the small streams at the head flowing westward, opposite to the direction taken by the branches of the Conejos. The country is generally mountainous and rough, and but little irrigation is practiced along the stream, except in the bottom lands adjacent to the channel. The stream flows but a short distance through Colorado before entering New Mexico, through which it flows for about 100 miles, then crosses the southwest corner of Colorado again, and flows thence through Utah to its junction with the Colorado at Henry Mountain. The principal tributaries flowing from Colorado into this river are the Piedra, Los Pinos, Florida, Las Animas, La Plata, and Mancos, all of which flow through comparatively narrow valleys, crossing the line into New Mexico before the San Juan itself is reached. A large portion of this country has been but very recently opened to settlement, as it remained a part of the Southern Ute Reservation until 1899, when the western half of that reservation was thrown open to settlement, and a number of settlers have come in. A very considerable portion of the most desirable lands had, however, been taken by the Indians in severalty. There are a number of excellent mesas of good farming land which will undoubtedly be eventually irrigated. A number of surveys have already been made of canal lines to cover these tracts, which will be speedily pushed to completion.

DRAINAGE.

San Juan River and its tributaries drain practically all of that portion of the southwestern corner of Colorado which comprises the Durango Land District, except a portion of the northern part, which is drained by the Dolores River, a tributary of the Grand. The northeastern quarter of this district is very mountainous, the principal tributaries of the San Juan having their headwaters among lofty mountain peaks and mountain parks of high altitude. Little irrigation is practiced in the upper valleys of any of the streams of this district, except for raising hay, above a height of about 7,000 feet, from which altitude the level of this district in Colorado runs down to about 4,500 feet. In the lower valleys agriculture is extensively practiced, and nearly all kinds of crops that may be raised in temperate climates are cultivated. A very large portion of the division will undoubtedly be irrigated eventually, and water will be used extensively for the development of power, so that the supply of water in many of the streams will prove inadequate without a comprehensive system of storage. There are fortunately a number of excellent reservoir sites on the headwaters of a number of the streams, particularly upon the San Juan, Piedra, Los Pinos, and Florida.

The drainage area of the San Juan and its tributaries, while constituting irrigation division No. IV in accordance with the laws of Colorado, is practically composed of a number of strictly independent districts, as each one of the main tributaries crosses the line between Colorado and New Mexico before it empties into the San Juan, and hence the use of the water of the various streams does not conflict to any great extent. The irrigation districts that compose the division and the streams that furnish their supply of water are No. 29, comprising the territory drained by the headwaters of the San Juan and the Piedra; No. 31, the Los Pinos district; No. 30, the Las Animas district; No. 33, the La Plata district; No. 34, the Mancos district, and No. 32, the Montezuma Valley district, the latter being practically a part of the Grand River division.[a]

STREAM MEASUREMENTS.

A number of stations have been maintained at different times in this division, those for which separate tables are given being situated near Arboles, on the San Juan and Piedra rivers; at Ignacio, on Los Pinos River; at Stewart's ranch, on Florida River; at Durango, on Animas River; and at Mancos, on Mancos River.[b]

SAN JUAN RIVER AT ARBOLES.

This station is located a short distance west of the old Arboles railroad station on the Denver and Rio Grande Railroad, where a footbridge was constructed by the Survey across the river for the purpose. The channel is not favorable to accurate measurements, the bridge crossing the river at a point where there is a deep hole and the left bank being liable to overflow. The bed of the channel is somewhat sandy and shifting, gravel bars forming at times along the bends of the river and again being displaced at the next high water. Measurements were made from the footbridge above mentioned. The station was valuable as furnishing information concerning the flow of the San Juan into New Mexico and the amount of water available for the use of the Indians along its border, as well as for use on tracts of the public domain.

The well-known Pagosa Mineral Springs are situated upon the headwaters of the San Juan, and a railroad has recently been constructed into this territory.[c]

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[a] For detailed information concerning the agriculture of this region, see the State Engineers' Reports.

[b] For more detailed information concerning this drainage basin, see Hayden's Report of 1875. Also publications U. S. Geological Survey: Eighteenth Annual Report, Part IV, p. 278; Nineteenth, Part IV, p. 409; Twentieth, Part IV, p. 400; Bulletin, No. 140, p. 195; Water-Supply and Irrigation Paper No. 38, p. 307. Also Tenth Biennial Report of the State Engineer of Colorado, p. 330. Also Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, pp. 90–135.

[c] For more detailed data concerning this station see Biennial Reports of the State Engineers of Colorado: Eighth, p. 498; Ninth, p. 388; Tenth, p. 331. Also publications U. S. Geological Survey: Eighteenth Annual Reports, Part IV, p. 279; Nineteenth, Part IV, p. 409; Twentieth, Part IV, p. 401; Twenty-first, Part IV, p, 297; Bulletin No. 140, p. 195; Water-Supply and Irrigation Papers No. 11, p. 71; No. 16, p. 144; No. 28, pp. 138, 142, and 145; No. 38, p. 307; No. 39, p. 451. Also, Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, p. 102.

A. GAGING STATION ON SAN JUAN RIVER AT ARBOLES.

B. GAGING STATION ON PIEDRA RIVER AT ARBOLES.

Discharge of San Juan River at Arboles.

[Altitude, 5,998 feet; drainage area, 1,394 square miles.]

Month.	1895.	1896.	1897.	1898.	1899.	Mean.	Equivalent in acre-feet.	Mean run-off.[a] Second-feet per square mile.	Mean run-off.[a] Depth in inches.
	Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*		
April	.....	1,123	1,987	1,498	[b]934	1,383	82,294	0.99	1.10
May	.....	1,635	3,393	1,884	917	1,957	120,331	1.40	1.61
June	[b]1,261	444	2,311	2,390	550	1,391	82,770	1.00	1.11
July	635	256	685	1,022	523	624	38,368	.45	.52
August	422	189	303	255	385	311	19,123	.22	.25
September	220	309	607	123	219	296	17,613	.21	.23
October	206	250	1,019	99	.....	394	24,226	.28	.32
November	197	210	396	83	.....	222	13,210	.16	.18
Mean	490	552	1,338	918	588	822	397,935	.59	5.32
Acre-feet for period recorded	177,785	267,180	647,576	444,324	213,561	.....	.....	.....	.....

[a] The run-off given is for average months and the total for an average period of eight months as derived from the observations. Details may be found in the authorities cited.

[b] Approximate, only part of month.

Maximum and minimum discharge and average run-off of San Juan River at Arboles for that portion of each year covered by records.

Year.	Discharge.				Run-off.[a]	
	Minimum.		Maximum.		Depth in inches.	Second-feet per square mile.
	Date.	Amount.	Date.	Amount.		
		Sec.-ft.		*Sec.-ft.*		
1895	Nov. 11	135	June 19	1,770	0.39	0.35
1896	Aug. 22	136	May 6	2,615	.45	.40
1897	Aug. 31	182	May 20	4,423	1.07	.96
1898	Sept. 25	83	June 24	3,255	.73	.66
1899	Sept. 8	96	May 13	1,976	.47	.42

[a] The run-off given in the horizontal lines is the amount for that part of each year covered by the record and the depths in inches is for a period of thirty days at the rate given as the mean in second-feet per square mile for the period covered. The discharge given is for average months and the total for an average period of eight months as derived from the observations. Details may be found in the authorities cited.

Discharge measurements made on San Juan River at Arboles.

Date.	Hydrographer.	Gage height.	Discharge.
1895.		*Feet.*	*Sec.-ft.*
June 21	F. Cogswell	7.30	1,556
Aug. 30	do	6.20	387
Oct. 11	do	5.80	215
Nov. 25	do	5.90	252
1896.			
May 16	F. Cogswell	6.65	768
June 21	do	5.90	250
July 25	do	6.00	268
Sept. 26	do	6.15	322
Oct. 24	do	6.20	349
1897.			
Apr. 25	F. Cogswell	8.30	2,753
May 16	do	8.80	3,316
June 27	do	7.60	1,604
July 25	do	6.50	446
Aug. 29	do	5.80	209
Sept. 26	do	8.00	2,048
Oct. 24	do	6.90	795
1898.			
Apr. 12	A. L. Fellows	7.30	1,403
May 17	do	7.42	1,497
June 21	do	8.10	2,579
Aug. 8	G. H. Matthes	6.30	294
Aug. 21	A. L. Fellows	6.05	213
Oct. 23	do	5.80	83

Discharge measurements made on San Juan River at Arboles.—Continued.

Date.	Hydrographer.	Gage height.	Discharge.
1899.		*Feet.*	*Sec.-ft.*
Apr. 23	A. L. Fellows	7.00	1,286
May 22	do	6.60	737
June 26	do	6.15	277
Nov. 26	do	5.75	127

PIEDRA RIVER AT ARBOLES.

This tributary of San Juan River rises among the San Juan Mountains in Hinsdale and Mineral counties, in southern Colorado, and flows in a nearly southerly direction to its junction with the San Juan about one-quarter of a mile west of the old Denver and Rio Grande Railroad station at Arboles. Very little irrigation is practiced upon this stream, and that little is along the lower course of the river. It is possible, however, to take water out for the irrigation of mesa lands lying along the west side of the stream between it and Los Pinos River. The value of the information derived from the maintenance of this station is due to the fact that it is an important source of supply for the Indians along its borders and for the owners of lands along the San Juan below their junction.[a]

[a] For more detailed information concerning this station, see Biennial Reports of the State Engineers of Colorado: Eighth, p. 504; Ninth, p. 390; Tenth, p. 334. Also publications U. S. Geological Survey: Eighteenth Annual Report, Part IV, p. 281; Nineteenth, Part IV, p. 411; Twentieth, Part IV, p. 402; Twenty-first, Part IV, p. 298; Bulletin No. 140, p. 196; Water-Supply and Irrigation Papers No. 11, p. 71; No. 16, p. 145; No. 28, pp. 139, 142 and 145; No. 38, p. 308; No. 39, p. 452.

Discharge of Piedra River at Arboles.

[Altitude, 5,998 feet; drainage area, 670 square miles.]

Month.	1895.	1896.	1897.	1898.	1899.	Mean.	Equivalent in acre-feet.	Mean run-off.[a]	
								Second-feet per square mile.	Depth in inches.
	Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*			
April	.....	[b] 804	1,460	978	[c] 380	906	53,911	1.352	1.51
May	([d])	1,048	2,025	966	315	1,089	66,960	1.625	1.88
June	432	229	1,189	1,211	168	646	33,440	.964	1.07
July	346	111	296	585	141	296	18,200	.442	.51
August	200	59	106	149	180	139	8,547	.207	.24
September	115	347	399	89	49	200	11,901	.299	.33
October	125	175	840	70	.....	303	18,631	.452	.52
November	93	121	241	37	.....	123	7,319	.184	.20
Mean	219	362	820	511	206	463	223,909	.691	6.26
Acre-feet for period recorded	71,610	167,298	396,988	247,416	90,798	.....	.....	.....	.....

[a] The run-off given is for average months and the total for an average period of eight months as derived from the observations. Details may be found in the authorities cited.

[b] April 12 to 30 inclusive.

[c] April 23 to 30 inclusive.

[d] May 19 to 30 inclusive.

Maximum and minimum discharge and average run-off of Piedra River at Arboles for that portion of each year covered by records.

Year.	Discharge.				Run-off.[a]	
	Minimum.		Maximum.		Depth in inches.	Second-feet per square mile.
	Date.	Amount.	Date.	Amount.		
		Sec.-ft.		*Sec.-ft.*		
1895	Nov. 6	60	July 12	6.70	0.37	0.327
1896	Aug. 11	23	May 6	2,066	.60	.540
			Sept. 24	3,000		
1897	Aug. 25	65	May 7	2,398	1.26	1.224
1898	Nov. 13	27	Apr. 27	1,599	.84	.763
1899	Sept. 6	25	May 13	643	.25	.307

[a] The run-off given is the amount for that part of each year covered by the records and the depth in inches for a period of thirty days as the rate given as the mean in second-feet per square mile for that period covered. The discharge given is for average months and the total for an average period of eight months as derived from the observations. Details may be found in the authorities cited.

Discharge measurements made on Piedra River at Arboles.

Date.	Hydrographer.	Gage height.	Discharge.
1895.		*Feet.*	*Sec.-ft.*
June 21	A. P. Davis and F. Cogswell	3.90	606
Aug. 30	F. Cogswell	3.20	235
Oct. 11	do	2.90	140
Nov. 25	do	2.80	115
1896.			
May 18	F. Cogswell	3.90	544
June 20	do	2.90	109
July 24	do	3.05	189
Sept. 27	do	3.70	405
Oct. 25	do	3.00	179
1897.			
Apr. 24	F. Cogswell	5.20	1,429
May 15	do	5.65	1,629
June 26	do	4.20	677
July 24	do	3.10	230
Aug. 28	do	2.60	65
Sept. 25	do	4.15	675
Oct. 23	do	4.00	586
1898.			
Apr. 13	A. L. Fellows	4.80	1,158
May 16	do	4.52	937
June 22	do	5.10	1,315
Aug. 8	G. H. Matthes	3.10	195
Aug. 24	A. L. Fellows	3.05	186
Oct. 24	do	2.60	52

Discharge measurements made on Piedra River at Arboles—Continued.

Date.	Hydrographer.	Gage height.	Discharge.
1899.		*Feet.*	*Sec.-ft.*
Apr. 23	A. L. Fellows	3.80	499
May 22	.....do	3.40	279
June 26	.....do	2.90	111
Nov. 26	.....do	2.80	88

LOS PINOS RIVER AT IGNACIO.

This stream drains the country near the western end of the San Juan Range and the southern slope of the Needle Mountains. It flows in a southerly direction for about 50 miles, crossing the Colorado line about 5 miles south of La Boca, on the Denver and Rio Grande Railroad. The valley is in general wider than the valleys of the Piedra and San Juan, and irrigation is more extensively practiced along the borders of the stream. A number of canals have been constructed by the Government for the benefit of the Indians located on the bottom lands. Several irrigation canals have also been projected, and surveys have been made by private parties for the purpose of taking out water to the adjacent mesas. The station is important as giving information concerning the supply of water available for the use of the Indians and of white settlers as well. The Indians have in general taken lands in severalty in the first bottom lands of the stream, but since the reservation was thrown open many white settlers have filed on lands higher up. The normal supply of this stream will probably eventually prove insufficient for irrigation, and this may be true even with storage. There are, however, some very fine reservoir sites upon the headwaters of the stream which may be used.

The gaging station is located at the subagency, about 2 miles north of the station of the Denver and Rio Grande Railroad. The channel is fairly suitable at this point, being of gravel and bowlders, and has suffered little change since the station was established. Measurements are usually made at the wagon bridge, to which the rod is attached, but may at times of low water be made by wading. The channel is fairly stable at this point, the banks, although low, not being particularly liable to overflow. Records have been irregular and unsatisfactory, but a table is compiled from the few that have been sent in.[a]

[a] For more detailed data concerning this station, see Tenth Biennial Report of the State Engineer of Colorado, p. 336. Also publications U. S. Geological Survey: Twenty-first Annual Report, Part IV, p. 299; Water-Supply and Irrigation Papers, No. 38, p. 309; No. 39, p. 452; No. 50, p. 389.

Estimated monthly discharge of Los Pinos River at Ignacio.

[Altitude, 6,422 feet; drainage area, 450 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1899.						
April 23 to 30	.....	.....	479	29,693	1.11	1.24
May	947	180	530	32,588	1.18	1.36
June	605	264	469	27,907	1.04	1.16
July	662	124	289	17,770	.64	.74
August	1,346	49	349	21,459	.77	.89
September	264	36	62	3,689	.14	.16
October	292	36	127	78,088	.28	.32
November	124	89	103	6,129	.23	.26
December 1 to 21	89	49	59	3,628	.13	.15
1900.						
January	101	61	82	5,042	.19	.22
February	61	61	61	3,388	.13	.13
March	141	61	94	5,780	.21	.24
April 1 to 7	193	101	166	9,878	.36	.40
May 9 to 26	1,326	785	998	61,365	2.22	2.56

Discharge measurements made on Los Pinos River at Ignacio.

[Hydrographer, A. L. Fellows.]

Date.	Gage height.	Discharge.
1899.	*Feet.*	*Sec.-ft.*
Apr. 22	3.20	437
May 20	3.40	577
June 25	2.80	244
Nov. 25	2.60	124
1900.		
Mar. 26	2.60	137
May 8	3.50	604
Aug. 14	2.00	25

FLORIDA RIVER AT STEWART'S RANCH, NEAR DURANGO.

This stream is a tributary of Animas River, and drains the country immediately west of that drained by the Los Pinos. Irrigation is extensively practiced along this stream, particularly along its lower course, and the supply, being insufficient, is exhausted early in the irrigation season. Owing to the fact that there are large tracts of land

along the stream that might be cultivated if there were enough water, a project has been considered for storing water in the upper portion of the drainage basin. The land is particularly valuable, being located near the city of Durango and being at such an altitude that wheat and other grains may be most successfully raised. The station was maintained for a portion only of one summer, with a view to ascertaining the high-water discharge. The data thus derived are given in full.[a]

Estimated monthly discharge of Florida River at Durango.

[Drainage area, 136 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1899.						
May 21 to 31	.....	.....	139	8,547	1.02	1.18
June	121	12	68	4,046	.50	.56
July	211	6	45	2,767	.33	.38

The only gagings made in the year 1899 are as given below:

Discharge measurements made on Florida River at Durango.

[Hydrographer, A. L. Fellows.]

Date.	Gage height.	Discharge.
1899.	*Feet.*	*Sec.-ft.*
May 19	2.25	236
June 24	.70	9

ANIMAS RIVER AT DURANGO.

This stream is the largest tributary of the San Juan, and derives its water from the high mountains above Silverton, draining portions of the Needle and La Plata mountains, in addition to the area south of Mount Sneffels and Red Mountain. The country drained by this stream and its tributaries is generally very mountainous down to a point about 12 miles above the city of Durango, where the valley broadens out to such an extent that irrigation is extensively practiced. The supply of water is probably more than adequate to meet all demands for irrigation, although a number of projects are being con-

[a] For more detailed data concerning this station see Tenth Biennial Report of the State Engineer of Colorado, p. 340. Also publications U. S. Geological Survey: Twenty-first Annual Report, Part IV, p. 300; Water-Supply and Irrigation Papers, No. 38, p. 311; and No. 39, p. 452. Also, Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, p. 116.

sidered with a view to using the waters of this river and of its tributaries for the development of power, both directly and through the transmission of electricity. An important project has also been undertaken for the construction of a large canal using the water of the Animas River in New Mexico.

The station is located at the wagon bridge, a short distance west of the railroad station at Durango. In 1889 a new bridge was constructed, rendering the new station much more satisfactory than the old one had been. The stream is usually gaged from the wagon bridge, but may at very low water be gaged by wading. The channel is of bowlders, and is fairly stable, although occasional changes occur. The banks are high and not liable to overflow.[a]

[a] For more detailed information concerning this station see Biennial Reports of the State Engineers of Colorado: Eighth, p. 510; Ninth, p. 392; Tenth, p. 342. Also publications U. S. Geological Survey: Eighteenth Annual Report, Part IV, p. 283; Nineteenth, Part IV, p. 414; Twent'eth, Part IV, p. 403; Twenty-first, Part IV, p. 301; Bulletin No. 140, p. 198; Water-Supply and Irrigation Papers, No. 11, p. 72; No. 16, p. 146; No. 28, pp. 139, 142, and 145; No. 38, p. 310; No. 39, p. 452; No. 50, p. 383. Also, Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, p. 116.

Estimated mean discharge of Animas River at Durango.

[Altitude, 6,551 feet; drainage area, 812 square miles.]

Month	1895.	1896.	1897.	1898.	1899.	1900.	Mean.	Equivalent in acre-feet.	Mean run-off.[a]	
									Second-feet per square mile.	Depth in inches.
	Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*		
January	.....	.....	[b]310	[b]378	.....	[b]179	389	23,919	0.48	0.55
February	.....	.....	[b]284	[b]267	.....	[b]133	261	14,495	.32	.33
March	.....	.....	[b]374	[b]306	.....	[b]224	301	18,508	.37	.43
April	.....	[c]1,634	2,608	1,510	584	335	1,334	79,379	1.64	1.83
May	.....	2,326	4,498	1,765	1,730	2,183	2,500	153,719	3.08	3.55
June	[d]646	875	3,218	3,431	1,797	1,990	1,993	118,592	2.45	2.73
July	388	349	1,120	1,364	668	409	716	44,025	.88	1.01
August	510	199	534	364	691	179	413	25,394	.51	.59
September	363	1,004	875	263	276	231	502	29,871	.62	.69
October	307	475	1,385	161	297	252	480	29,514	.59	.68
November	246	274	553	158	267	205	289	17,197	.36	.40
December	[b]251	[b]216	430	[b]250	[b]212	[b]272	272	16,725	.34	.39
Mean	387	816	1,349	851	724	550	788	571,338	.97	13.18
Acre-feet for period recorded	149,760	426,908	979,347	615,997	388,900	398,215	.....	.....	.....	.....

[a] The run-off given in the above table is for normal months and the totals for a normal year as derived from the observations. Details may be found in the authorities cited.

[b] Approximate.

[c] April 12 to 30, inclusive.

[d] June 20 to 30, inclusive.

Maximum and minimum discharge and average run-off of Animas River at Durango for that portion of each year covered by records.

Year.	Discharge.				Run-off.[a]	
	Minimum.		Maximum.		Depth in inches.	Second-feet per square mile.
	Date.	Amount.	Date.	Amount.		
		Sec.-ft.		*Sec.-ft.*		
1895	Aug. 12 / Dec. 15	208	Aug. 14	990	3.82	0.48
1896	Aug. 26	138	Sept. 24	[b]7,800	10.18	1.00
1897	Aug. 27	325	May 25	5,870	22.61	1.66
1898	Nov. 19	125	June 23	4,677	14.25	1.05
1899	Apr. 6	138	May 14	3,240	9.09	.89
1900	Feb. 17	122	May 28	3,830	9.58	.69

[a] The run-off given is the amount for that part of each year covered by the records and the depth in inches for the time. Details may be found in the authorities cited.

[b] Approximate.

Discharge measurements made on Animas River at Durango.

Date.	Hydrographer.	Gage height.	Discharge.
1895.		*Feet.*	*Sec.-ft.*
June 18	F. Cogswell	6.50	1,893
Aug. 29	do	5.80	543
Oct. 10	do	5.40	328
Nov. 24	do	5.20	260
1896.			
May 15	F. Cogswell	6.35	1,063
June 19	do	5.80	590
July 23	do	5.50	360
Sept. 25	do	7.40	2,566
Oct. 23	do	5.50	414
1897.			
Apr. 23	F. Cogswell	7.75	2,176
May 14	do	9.20	4,786
June 25	do	7.85	2,534
July 23	do	6.10	997
Aug. 27	do	5.10	328
Sept. 24	do	6.05	905
Oct. 22	do	6.50	1,121
1898.			
Apr. 11	A. L. Fellows	6.50	1,356
May 15	do	7.25	1,797
June 20	do	8.55	3,475
Aug. 5	G. H. Matthes	5.20	414
Aug. 22	A. L. Fellows	5.07	284
Oct. 22	do	4.70	160

Discharge measurements made on Animas River at Durango—Continued.

Date.	Hydrographer.	Gage height.	Discharge.
1899.		*Feet.*	*Sec.-ft.*
Apr. 21	A. L. Fellows	7.50	698
May 19	do	9.45	2,635
June 24	do	8.10	1,256
Sept. 28	do	6.52	223
Nov. 25	do	6.50	201
1900.			
Mar. 26	A. L. Fellows	6.60	246
May 9	do	8.65	1,614
June 25	do	8.80	1,740
Aug. 13	do	6.45	169

MANCOS RIVER AT MANCOS.

Mancos River rises on the southwestern slopes of the La Plata Mountains and flows in a generally southwesterly direction, emptying into the San Juan at a point about 6 miles east of the southwest corner of the State of Colorado, or the Four Corners. The upper portion of the drainage is mountainous, and little irrigation is possible until the valley broadens out in the vicinity of the town of Mancos, where all of the ordinary flow of the stream is used. Enough water goes to waste, however, at high stages to irrigate probably all of the available land along the stream if it could be properly stored. For the last 40 miles of its course the stream flows through the Mesa Verde in what is known as the Mancos Canyon, this lying in the Southern Ute Indian Reservation.[a] With plenty of water, considerable land might be irrigated for the benefit of the Indians in this canyon, but under existing conditions the stream is dry during a greater part of the summer season, and hence no irrigation is possible.

The station is located at the town of Mancos, a short distance below a wagon bridge near the center of the town. A number of ditches take their supply of water at points above the station and a number of others are located below. The channel is not gravel and is somewhat shifting, the bed changing so much in the year 1900 that no rating table was possible for that year.[b]

[a] Hayden's Report of 1875.

[b] For more detailed information concerning this station see Biennial Reports of the State Engineers of Colorado: Ninth, p. 394; Tenth, p. 346. Publications U. S. Geological Survey: Twentieth Annual Report, Part IV, p. 404; Twenty-first, Part IV, p. 284; Water-Supply and Irrigation Papers, No. 28, pp. 137, 142, 144; No. 38, p. 312; No. 39, p. 452, and No. 50, p. 384. Also Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, p. 122.

A. MANCOS CANYON IN MESA VERDE.

B. GRAND RIVER AT GRAND JUNCTION.

Estimated monthly discharge of Mancos River at Mancos.

[Altitude, 6,960 feet; drainage area, 117 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1898.						
March [a]			50	3,074	0.43	0.49
Apr. 10 to 30	375	123	261	15,531	2.23	2.49
May	270	144	206	12,667	1.76	2.03
June	291	144	213	12,674	1.82	2.03
July	333	2	104	6,395	.89	1.02
August	12	8	9	553	.08	.09
September	12	3	7	399	.06	.07
October [a]			5	307	.04	.04
November [a]			3	179	.03	.03
				51,779	.82	8.29
1899.						
March [a]			90	5,534	0.77	0.89
April	91	5	42	2,499	.36	.40
May	144	19	74	4,550	.63	.72
June	81	5	33	1,964	.28	.31
July	19	3	9	533	.08	.09
August	102	8	41	2,521	.35	.40
September	123	5	33	1,964	.28	.31
October	60	1	22	1,353	.19	.22
November [a]			5	298	.04	.04
				19,268	.30	3.07

[a] Approximate, no observations being made during these periods.

Discharge measurements made on Mancos River at Mancos.

[Hydrographer, A. L. Fellows.]

Date.	Gage height.	Discharge.
1898.	*Feet.*	*Sec.-ft.*
Apr. 9	1.80	102
May 14	2.20	185
June 18	2.00	159
Oct. 18	.80	3

Discharge measurements made on Mancos River at Mancos.—Continued.

Date.	Gage height.	Discharge.
1899.	*Feet.*	*Sec.-ft.*
Apr. 19	1.65	70
May 18	1.60	56
June 23	1.10	9
Sept. 22	.90	2
Nov. 24	1.00	3
1900.		
Mar. 23	1.05	4
May 7	1.80	82
June 26	1.70	16
Aug. 12	1.40	2

MISCELLANEOUS INVESTIGATIONS.

A number of miscellaneous gagings have been made at different points in this division, and are given in the table below. Most of these were taken during an investigation looking to the irrigation of lands belonging to the Southern Ute Indians. A full description of this investigation, with a statement of its results, may be found in the Twentieth Annual Report, Part IV, pages 408–434, and in the Twenty-first Annual Report, Part IV, page 286 et seq.

No seepage measurements have been made upon any of the streams of this region, but it is likely that the return from seepage is slight, as the stratification is such as to make any great returns improbable.

This region is also discussed in Hayden's Report for 1875.

Miscellaneous discharge measurements of San Juan River and tributaries.

[Hydrographer, Gerard H. Matthes.]

Date.	Stream.	Locality.	Discharge.
1898.			*Sec.-ft.*
Aug. 6	Los Pinos River	6 miles above Ignacio	246
Aug. 7	do	4 miles below Ignacio	196
Aug. 10	La Plata River	Hesperus	11
Aug. 18	San Juan River	Noland, Utah	609
Sept. 21	do	do	383
1899.			
Sept. 13	Mancos River	Head of canyon	3
Oct. 14[a]	do	In Mancos Canyon	100+

[a] Estimated discharge for several hours following a heavy rain.

GRAND RIVER DIVISION.

IRRIGATION.

Grand River is the largest stream in Colorado, and drains the greatest territory. The main stream rises in Middle Park, in north-central Colorado, and drains the mountainous country on the west side of the Front Range and the south side of the Continental Divide in Middle Park. The Grand River and all of its tributaries flow through mountainous regions for considerable portions of their courses, and then generally enter a country the surface of which is usually undulating, but at times badly broken by deep canyons and ravines, the bottoms of these canyons being sometimes valleys of considerable extent, and again narrowing to mere threads. Along these canyons and valleys are often mesas of varied breadths. Upon most of the streams of this division but little irrigation has been practiced, except along the lowest valleys. There are, however, a few exceptions to this rule, the most notable ones being the Uncompahgre and Dolores rivers, which will be described more fully later. Upon some of the streams—as, for example, the San Miguel—a great deal of water is used for the purpose of developing power, the supply upon this stream being hardly adequate to the demands. Considerable power is developed upon other streams of this region also, the San Miguel, the Lake Fork of the Gunnison, and the Dolores being examples. Owing to the comparatively small amount of land that can be irrigated along the main stream, only a small proportion of the water in this division has been used, but a number of projects are under consideration with a view to diverting the water in great canals to the fertile mesas along the various streams, and in one case—namely, the Gunnison River—of taking water from that stream through the Divide for the purpose of irrigating lands in another valley—the Uncompahgre. Another great project now under consideration is that of taking the water of Grand River, by means of a very large canal, to the uplands of the western part of Colorado and the eastern part of Utah.

A number of the smaller tributaries of the Grand and its branches furnish a supply that is inadequate for the demands of irrigation, and storage is resorted to on a number of these streams, Surface Creek and Roan Creek being examples. The crops of this region vary with the altitude, only hay and grain being raised at the higher elevations, while fruits of an almost tropical nature may be raised where the Grand crosses the State line into Utah. A beet-sugar factory has been located at Grand Junction, and is successfully operated.

Irrigation division No. V, the Grand River division, covers the lands irrigated by the Grand and its tributaries. The relations existing between the different districts of this division are not so close as

is usually the case in the eastern half of the State. Except in a few cases the different districts are not interdependent, so that the water in one district is generally used without much reference to others, this being usually due to the fact that each stream flows into a river so large (the Grand) that its supply has not yet been exhausted. This will not long remain the case, however, and eventually the interdependence of the different districts will undoubtedly be almost as close as it is upon the South Platte.

There are 20 districts in this division, for the names and boundaries of which see Biennial Reports of the State Engineers of Colorado. For map see Pl. I of this paper, p. 20.

STREAM MEASUREMENTS.

The following stations have been maintained for a length of time sufficient to warrant publication of the records, measurements at other stations being given in the list of miscellaneous measurements for this division. These stations are at Glenwood Springs and Grand Junction, on Grand River; Iola and Grand Junction, on Gunnison River; Fort Crawford and Montrose, on Uncompahgre River; Dolores, on Dolores River; and Fall Creek, on San Miguel River.[a]

GRAND RIVER AT GLENWOOD SPRINGS.

This station was located May 12, 1899, at the request of the Denver and Rio Grande Railroad Company, at the railroad bridge one-quarter of a mile west of the depot and just above the mouth of Roaring Fork. A wire gage was used at this point, but records were kept up during the stage of high water only. On January 1, 1900, a new gage rod was located near the Glenwood Springs electric-light plant. Measurements are made from the wagon bridge across the river near the railroad station. The channel is good, being composed of gravel and of rock, and is not liable to great change, and the banks are high and not subject to overflow. Gagings are made from the bridge. The station is of importance, as it furnishes a good idea of the flow of Grand River available for the great irrigation projects contemplated below, measurements being made of Roaring Fork also whenever they are made at the Glenwood station.[b]

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[a] For further descriptions of this division see Hayden's Report of 1875. Also publications U. S. Geological Survey: Twelfth Annual Report, Part II, p. 290; Eighteenth, Part IV, p. 260; Nineteenth, Part IV, p. 360; Twentieth, Part IV, p. 373; Twenty-first, Part IV, p. 280; Bulletins No. 13, p. 47; No. 140, p. 186, and Water-Supply and Irrigation Papers. Also Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell. For agricultural statistics see Biennial Reports of the State Engineers of Colorado.

[b] For more specific information concerning this station see Tenth Biennial Report of the State Engineer of Colorado, p. 350; Water-Supply and Irrigation Papers, U. S. Geological Survey, No. 37, p. 293; No. 50, p. 375, and Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, p. 112.

Estimated monthly discharge of Grand River at Glenwood Springs.

[Altitude, 5,743 feet; drainage area, 5,838 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
January	970	810	890	54,724	0.15	0.17
February	935	810	883	49,039	.15	.16
March	1,460	902	1,187	72,896	.20	.23
April	3,940	1,120	1,818	108,178	.31	.35
May	22,895	3,245	11,963	735,577	2.05	2.36
June	22,390	7,622	14,817	881,673	2.54	2.83
July	7,270	1,515	3,121	191,903	.54	.62
August	1,460	935	1,134	69,727	.19	.22
September	870	755	800	47,603	.14	.16
October	755	755	755	46,423	.13	.15
November	935	728	805	47,901	.14	.16
December	840	570	681	41,873	.12	.14
The year	22,895	570	3,238	2,347,607	.56	7.55

Discharge measurements made on Grand River at Glenwood Springs.

[Hydrographer, A. L. Fellows.]

Date.	Gage height.	Discharge.
1899.	*Feet.*	*Sec.-ft.*
May 12	6.05	17,577
June 17	10.22	29,187
November 17	2.75	1,084
1900.		
March 19	3.80	1,140
July 8	5.40	3,764
August 23	3.60	1,086

GRAND RIVER AT GRAND JUNCTION.

This station was established October 18, 1894, and is located at the State wagon bridge across Grand River near the pump house of the city waterworks at Grand Junction, a short distance above the mouth of Gunnison River. The Grand at this point discharges through two channels, and a separate record of each is maintained, requiring separate discharge measurements. During the last four years by far the greater part of the water has run through the left channel; during the year 1900 there was a flow through the right channel for but a short time. Gage rod No. 1 is attached to the pier on the right bank of the river on the lower side; gage rod No. 2 consists of a wire and weight

fastened to the upper side of the bridge over the left channel. The channel is sandy and shifting, and the discharge must therefore be considered as approximate only. Owing to the small number of measurements made and to the changes in the channel it has been found impracticable to construct rating tables covering the entire period, so that the discharge for 1895, 1896, and 1900 are not given.[a]

Estimated total monthly discharge of Grand River at Grand Junction.

[Altitude, 4,594 feet; drainage area, 8,644 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1897.						
January	.....	.....	[b]1,000	[b]61,488	[b]0.12	[b]0.14
February	.....	.....	[b]1,050	[b]58,314	[b].12	[b].12
March	.....	.....	[b]1,100	[b]67,637	[b].13	[b].15
April	11,476	1,280	3,723	221,534	.43	.48
May	37,950	12,785	29,436	1,809,948	3.41	3.93
June	37,008	15,618	25,350	1,508,429	2.93	3.27
July	15,006	3,400	8,830	542,935	1.02	1.18
August	5,470	1,720	3,000	184,463	.35	.40
September	2,650	1,640	1,803	107,286	.21	.23
October	2,350	1,560	1,813	111,478	.21	.24
November	1,820	1,455	1,663	98,955	.19	.21
December	.....	.....	[b]1,550	[b]95,306	[b].18	[b].21
The year	37,950	.....	6,693	4,867,773	.78	10.56
1898.						
January	.....	.....	[b]2,944	[b]181,020	[b].34	[b].39
February	.....	.....	[b]2,985	[b]165,777	[b].35	[b].36
March	.....	.....	[b]2,113	[b]129,924	[b].24	[b].28
April	.....	.....	[b]4,305	[b]256,165	[b].50	[b].56
May	12,642	4,633	7,130	438,406	.83	.94
June	17,262	8,279	13,702	815,326	1.59	1.77
July	7,611	1,725	4,445	273,312	.51	.59
August	1,725	949	1,127	69,297	.13	.15
September	1,143	561	907	53,970	.11	.12
October	1,143	561	915	56,261	.11	.13
November	1,337	755	1,072	63,788	.12	.14
December	.....	.....	1,011	62,164	.17	.20
The year	17,262	.....	3,555	2,565,410	.42	5.63

[a] For more detailed information concerning this station see Biennial Reports of the State Engineers of Colorado: Eighth, p. 534; Ninth, p. 396; Tenth, p. 352. Also publications U. S. Geological Survey: Eighteenth Annual Report, Part IV, p. 260; Nineteenth, Part IV, p. 400; Twentieth, Part IV, p. 389; Twenty-first, Part IV, p. 281; Bulletins, No. 131, p. 48; No. 140, p. 187; Water-Supply and Irrigation Papers No. 11, p. 67; No. 16, p. 137; No. 28, pp. 135, 142, and 144; No. 37, p. 294; No. 39, p. 451; No. 50, p. 376. Also Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, p. 121.

[b] Approximate.

Estimated total monthly discharge of Grand River at Grand Junction—Continued.

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1899.						
March			1,799	110,616	0.21	0.24
April			3,940	234,446	.46	.52
May			19,375	1,191,322	2.24	2.59
June			31,306	1,862,836	3.62	3.99
July			14,070	865,130	1.63	1.88
August			4,577	281,429	.53	.21
September			2,164	128,886	.25	.68

Discharge measurements made on Grand River at Grand Junction.

[Total discharge of both channels.]

Date.	Hydrographer.	Gage height.	Discharge.
1894.		*Feet.*	*Sec.-ft.*
Oct. 18	A. P. Davis	2.10	1,585
1895.			
June 27	A. P. Davis	4.03	16,500
Oct. 1	do	.82	2,059
1896.			
Aug. 20	F. Cogswell	3.00	1,023
Sept. 20	do	3.90	1,694
Oct. 17	do	3.60	1,542
Nov. 10	C. C. Babb	3.35	1,497
1897.			
Apr. 20	C. C. Babb	5.60	5,176
May 19	W. B. Dougall	10.20	32,686
July 29	F. Cogswell	5.35	4,044
Sept. 29	do	4.05	2,062
Oct. 28	do	3.98	1,764
Nov. 23	C. C. Babb	3.90	1,423
1898.			
Apr. 25	A. L. Fellows	5.15	4,802
May 23	do	5.85	6,087
June 27	do	7.40	11,215
Aug. 27	do	3.35	1,237
Oct. 15	do	3.20	949

Discharge measurements made on Grand River at Grand Junction—Continued.

Date.	Hydrographer.	Gage height.	Discharge.
1899.		*Feet.*	*Sec.-ft.*
Apr. 15	A. L. Fellows	4.70	2,946
May 13	do	10.00	23,153
June 18	do	11.55	[a] 40,000
Sept. 19	do	4.20	1,989
Nov. 18	do	3.90	1,916
1900.			
Mar. 20	A. L. Fellows	4.15	1,762
July 7	do	5.80	6,177

[a] Approximate.

GUNNISON RIVER AT IOLA.

Gunnison River, the largest tributary of the Grand in Colorado, rises in the south central part of the State, in the Saguache Mountains and Cochetopa Hills, and flows in a westerly direction, emptying into the Grand near the western boundary of the State, a short distance from Grand Junction. Comparatively little of the water is yet used for irrigation, but a canal line has now been surveyed with a view to taking the water from Gunnison River and carrying it to the valley of the Uncompahgre for the purpose of irrigating the fertile plains there. It was for the purpose of determining the amount of water available for such a project that the Iola station was located, although several important tributaries enter the Gunnison between the point selected at Iola and the point where the canal would probably be taken out. The rod is placed at a wagon bridge which crosses the Gunnison about one-quarter of a mile above the railroad station of the Denver and Rio Grande Railroad at Iola, measurements having been made and records kept up during the year 1900 only. The channel is favorable to accuracy, being wide, and the bed being of gravel and bowlders and not particularly liable to change. The banks, although not high, are not subject to overflow.[a]

[a] For more specific information concerning this station see Tenth Biennial Report of the State Engineer of Colorado, p. 357; Water-Supply and Irrigation Paper, U. S. Geological Survey, No. 50, p. 378.

Estimated monthly discharge of Gunnison River at Iola.

[Drainage area, 2,298 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
April	1,258	551	773	45,997	0.34	0.38
May	4,388	1,157	2,875	176,777	1.25	1.44
June	4,265	1,460	2,726	162,208	1.19	1.33
July	1,359	350	727	44,701	.32	.37
August	450	350	360	22,136	.16	.18
September	350	250	260	15,471	.11	.12
October	250	250	250	15,372	.11	.13

Discharge measurements made on Gunnison River at Iola.

[Hydrographer, A. L. Fellows.]

Date.	Gage height.	Discharge.
1900.	*Feet.*	*Sec.-ft.*
May 3	3.00	1,272
June 28	3.40	1,658
July 5	2.90	1,169
August 9	2.20	431
August 25	2.10	392

GUNNISON RIVER AT GRAND JUNCTION.

This station was located on July 3, 1895, at the wagon bridge across the Gunnison, about 1 mile from its junction with the Grand, and observations were made until December 21 of that year, after which none were made until 1897. The station was never satisfactory, high water from Grand River setting back into the mouth of the Gunnison, making the gage readings unreliable. The readings were discontinued, therefore, after the fall of 1899. The channel was uneven and somewhat shifting, some very large bowlders interfering very materially with the gagings. The banks are so high that there was no liability of overflow.[a]

[a] For more detailed information concerning this station see Biennial Reports of the State Engineers of Colorado: Eighth, p. 544; Ninth, p. 401; Tenth, p. 359. Also publications U. S. Geological Survey: Nineteenth Annual Report, Part IV, p. 404; Twentieth, Part IV, p. 390; Twenty-first, Part IV, p. 278; Bulletin No. 140, p. 189; Water-Supply and Irrigation Papers: No. 16, p. 141; No. 28, pp. 136, 142, and 144; No. 37, p. 297; No. 39, p. 451.

Estimated monthly discharge of Gunnison River at Grand Junction

[Altitude, 4,594 feet; drainage area, 7,935 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1897.						
May	20,732	11,844	16,921	1,040,438	2.13	2.46
June	19,116	5,370	11,161	664,124	1.41	1.57
July	5,370	1,510	3,231	198,668	.41	.47
August	1,850	160	975	59,951	.12	.14
September	1,510	160	628	37,369	.09	.09
October	2,020	1,060	1,472	90,510	.19	.22
November	1,200	230	933	55,517	.12	.13
1898.						
May	8,996	3,965	5,318	326,993	.67	.77
June	11,361	4,158	8,850	526,610	1.12	1.25
July	3,965	1,076	2,543	156,364	.32	.37
August	968	578	689	42,365	.09	.10
September	578	399	479	28,502	.06	.07
October	672	399	533	32,773	.07	.08
November	672	314	497	29,573	.06	.07
1899.						
April	8,792	968	3,550	211,240	.45	.50
May	16,750	3,902	10,296	633,080	1.30	1.50
June	16,752	8,078	12,380	736,662	1.56	1.74
July	8,430	2,246	4,349	267,410	.55	.63
August	4,562	908	1,921	118,118	.24	.28
September	1,000	758	875	52,066	.11	.12

Discharge measurements made on Gunnison River at Grand Junction.

Date.	Hydrographer.	Gage height.	Discharge.
1894.		*Feet.*	*Sec.-ft.*
Oct. 17	A. P. Davis	1.25	748
1895.			
June 28	A. P. Davis	4.74	4,178
July 17	do	3.60	2,642
Oct. 1	do	1.95	781
1897.			
Apr. 20	C. C. Babb	5.20	5,975
May 20	W. B. Dougall	7.30	6,644
July 28	F. Cogswell	2.65	1,814
Sept. 28	do	2.40	1,246
Oct. 27	do	2.50	1,270
Nov. 23	C. C. Babb	2.30	828

Discharge measurements made on Gunnison River at Grand Junction.—Continued.

Date.	Hydrographer.	Gage height.	Discharge.
1898.		*Feet.*	*Sec.-ft.*
Apr. 26	A. L. Fellows	4.65	5,932
May 23	.....do	4.50	4,647
June 28	.....do	4.62	5,274
Aug. 27	.....do	1.80	866
Oct. 15	.....do	1.50	578
1899.			
Apr. 15	A. L. Fellows	3.50	3,002
May 13	.....do	7.00	14,280
June 18	.....do	7.15	12,769
Sept. 19	.....do	2.20	1,061
Nov. 18	.....do	2.00	968
1900.			
Mar. 20	A. L. Fellows	2.50	1,477
July 7	.....do	2.90	2,121

UNCOMPAHGRE RIVER AT FORT CRAWFORD.

Uncompahgre River rises in Ouray County, in the high peaks of southwestern Colorado, and flows northwesterly, emptying into Gunnison River at Delta. The upper portion of its drainage basin is mountainous, but farther downstream the country is less broken and irrigation is possible along the valleys and adjacent mesas. Water is used to a certain extent for power purposes and in milling along the upper course of the stream. In the vicinity of Montrose a number of canals divert nearly all of the normal flow for irrigation purposes, and recourse must be had to storage or to the diversion of the waters of the Gunnison, already mentioned, for further irrigation in this district. The Fort Crawford station is located at a wagon bridge about one-quarter of a mile east of the railroad station at Fort Crawford, the post-office, known as Uncompahgre, being about 8 miles above, or south of, Montrose. The channel proved unsatisfactory, consisting of gravel bars which changed radically from time to time, rendering the rating tables untrustworthy. The discharge tables are therefore largely approximate.[a]

[a] For further details concerning this station, see Biennial Reports of the State Engineers of Colorado: Fifth, Part I, pp. 19 and 41, and Part II, Pl. XIX; Eighth, p. 528; Ninth, p. 403; Tenth, p. 361. Also publications U. S. Geological Survey: Eighteenth Annual Report, Part IV, p. 265; Nineteenth, Part IV, p. 402; Twentieth, Part IV, p. 391; Twenty-first, Part IV, p. 279; Bulletin No. 140, p. 188; Water-Supply and Irrigation Papers, No. 11, p. 69; No. 16, p. 139; No. 28, pp. 136, 142, and 144; No. 37, p. 296; No. 39, p. 451. Also Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, p. 122.

Discharge of Uncompahgre River at Fort Crawford.

[Altitude, 6,168 feet; drainage area, 497 square miles.]

Month.	1895.	1896.	1897.	1898.	1899.	Mean.	Equivalent in acre-feet.	Mean run-off.[a] Second-feet per square mile.	Mean run-off.[a] Depth in inches.
	Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*		
April	.....	.....	386	327	263	325	19,339	0.65	0.72
May	.....	1,010	787	306	534	659	40,520	1.33	1.53
June	[b] 1,082	519	994	704	709	802	47,722	1.61	1.80
July	470	126	527	430	252	361	22,197	.73	.84
August	277	38	136	111	138	140	8,608	.28	.32
September	117	148	146	67	41	104	6,188	.21	.23
October	70	106	204	58	.....	109	6,702	.22	.25
November	82	86	127	54	.....	87	5,177	.18	.20
Mean	350	290	413	257	323	326	156,453	.66	5.89
Acre-feet for period recorded	110,346	123,050	194,424	124,440	117,303	.....	.....	.....	.....

[a] The run-off given is for average months and the total for an average eight months from April to November, inclusive, as calculated from the observations. Details may be found in the authorities cited.

[b] June 25 to 30.

Maximum and minimum discharge and average run-off of Uncompahgre River at Fort Crawford for that portion of each year covered by records.

Year.	Discharge.				Run-off.[a]	
	Minimum.		Maximum.		Depth in inches.	Second-feet per square mile.
	Date.	Amount.	Date.	Amount.		
		Sec.-ft.		*Sec.-ft.*		
1895	Nov. 6	55	June 28	1,535	0.78	0.70
1896	Aug. 15	10	May 27	3,375	.64	.58
1897	Sept. 1	55	June 15	1,467	.92	.83
1898	Aug. 3	15	June 24	985	.58	.52
1899	Sept. 10	4	June 15	1,163	.72	.65

[a] The run-off given is for that part of each year covered by the observations and for a thirty-day month, at the rate given as the mean second-feet per square mile for the period covered.

Discharge measurements made on Uncompahgre River at Fort Crawford.

Date.	Hydrographer.	Gage height.	Discharge.
1895.		*Feet.*	*Sec.-ft.*
June 25	F. Cogswell	4.60	834
Aug. 26	do	3.25	218
Oct. 7	do	2.60	89
Nov. 18	do	2.55	92
1896.			
May 11	F. Cogswell	4.30	568
June 15	do	4.10	560
July 18	do	3.50	204
Aug. 21	do	2.90	31
Sept. 21	do	3.25	122
Oct. 18	do	3.10	95
1897.			
Apr. 18	F. Cogswell	3.90	487
May 10	do	4.55	884
June 21	do	5.05	1,081
July 19	do	4.50	473
Aug. 23	do	3.45	70
Sept. 20	do	3.85	153
Oct. 18	do	4.00	195
1898.			
Apr. 5	A. L. Fellows	3.55	91
May 9	do	3.92	203
June 15	do	5.18	720
Aug. 12	do	3.80	74

Discharge measurements made on Uncompahgre River at Fort Crawford—Cont'd.

Date.	Hydrographer.	Gage height.	Discharge.
1898.		*Feet.*	*Sec.-ft.*
Oct. 16	A. L. Fellows	3.75	56
1899.			
Apr. 16	A. L. Fellows	4.50	328
May 15	do	5.22	747
June 19	do	5.18	773
Sept. 21	do	3.65	69
Nov. 20	do	3.70	79

UNCOMPAHGRE RIVER AT MONTROSE.

This station was located at Montrose in the fall of 1899, no records being kept, however, until the spring of 1900. There is but little water at this point during the greater part of the year, as the canals above divert most of the flow. The station is located at a bridge crossing the river opposite the town of Montrose, about one-half of a mile from the station of the Denver and Rio Grande Railroad. The channel is favorable to accuracy, being of gravel and bowlders and not liable to change, and the banks are high and not subject to overflow. Records were kept up for a short time only, as there was but little water during the greater part of the irrigation season of 1900.[a]

Estimated monthly discharge of Uncompahgre River at Montrose.

[Altitude, 5,811 feet; drainage area, 565 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1900.						
April 8–30	71	18	50			
May	369	51	177	10,883	0.31	0.36
June	369	122	260	15,471	.46	.52
July 1–7	158	68	127			

[a] For further details concerning this station, see Tenth Biennial Report of the State Engineer of Colorado, p. 363. Also Water-Supply and Irrigation Paper, U. S. Geological Survey, No. 50, p. 379.

Discharge measurements made on Uncompahgre River at Montrose.

[Hydrographer, A. L. Fellows.]

Date.	Gage height.	Discharge.
1899.	*Feet.*	*Sec.-ft.*
Sept. 20	0.40	15
Nov. 20	.45	15
1900.		
July 5	1.80	150
Aug. 10	.50	2

DOLORES RIVER AT DOLORES.

Dolores River is an important tributary of Grand River, rising in the La Plata and San Miguel Mountains, of which the highest peak, Mount Wilson, attains an elevation of over 14,000 feet. Its course is southwesterly for about 50 miles, where it turns and flows in an almost due northerly direction for nearly 100 miles, when it again turns west and enters Grand River, after crossing the Colorado-Utah line. The river flows for the greater part of its course through deep canyons, and comparatively little irrigation is practiced along the stream itself, excepting in the vicinity of Dolores, where for some 40 miles the valley widens out to from one-half of a mile to one mile, and a considerable area is cultivated. In the Paradox Valley again considerable land is cultivated, mostly, however, from small tributaries running into the main stream. At Rico a portion of the water is used for the development of power. By far the greater part of Dolores River, however, is used in the San Juan irrigation division, being diverted by means of a tunnel and a great cut into the Montezuma Valley. The head gates of the canals carrying this water are about 2 miles west of the present town of Dolores. The gaging station is located above these head gates and about one-half of a mile above the Rio Grande Southern Railroad station at Dolores. The channel is fairly favorable to accurate results, the bed being of small stones and gravel, and the banks being high and not liable to overflow.[a]

[a] For further details concerning this station, see Biennial Reports of the State Engineers of Colorado: Eighth, p. 516; Ninth, p. 405; Tenth, p. 364. Also publications U. S. Geological Survey: Eighteenth Annual Report, Part IV, p. 261; Nineteenth, Part IV, p. 407; Twentieth, Part IV, pp. 312 and 408; Twenty-first, Part IV, p. 282; Bulletin No. 140, p. 191; Water-Supply and Irrigation Papers: No. 11, p. 68; No. 16, p. 143; No. 28, pp. 138, 142, and 144; No. 38, p. 305; No. 39, p. 451; No. 50, p. 380. Also Report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, p. 122.

Discharge of Dolores River at Dolores.

[Altitude, 6,942 feet; drainage area, 524 square miles.]

Month.	1895.	1896.	1897.	1898.	1899.	1900.	Mean.	Equivalent in acre-feet.	Mean run-off.[a]	
									Second-feet per square mile.	Depth in inches.
	Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*			
April	[b]500	747	1,483	1,092	437	284	757	45,045	1.44	1.61
May	[b]800	952	2,436	1,207	785	1,318	1,250	76,859	2.39	2.76
June	[b]800	263	1,465	1,510	499	808	891	53,018	1.70	1.90
July	270	130	268	490	207	84	258	15,864	.49	.56
August	248	38	148	120	204	29	131	8,055	.25	.29
September	99	195	394	78	33	90	148	8,807	.28	.31
October	79	113	391	37	93	83	132	8,116	.25	.29
November	134	179	172	48	49	88	111	6,605	.21	.23
Mean	366	327	855	573	288	348	460	222,369	.88	7.95
Acre-feet for period recorded	177,144	158,356	413,824	277,428	139,324	168,360				

[a] The run-off given in the horizontal lines is the total acre-feet for the eight months of each year. That given in the vertical columns is the acre-feet for normal months and the total for a normal eight months, the average monthly flow from each square mile, and the average for the eight months and the normal depth in inches for each normal month with the total depth for the normal eight months. Details may be found in the authorities cited.

[b] Estimated.

Maximum and minimum discharge and average run-off of Dolores River at Dolores for that portion of each year covered by records.

Year.	Discharge.				Run-off.[a]	
	Minimum.		Maximum.		Depth in inches.	Second-feet per square mile.
	Date.	Amount.	Date.	Amount.		
		Sec.-ft.		*Sec.-ft.*		
1895	Nov. 8	42	June 27	848	0.78	0.70
1896	Aug. 16	8	Apr. 26	1,578	.69	.62
1897	Aug. 31	76	Apr. 18	2,944	1.82	1.63
1898	Sept. 25	34	June 2	2,030	1.22	1.09
1899	Sept. 5	23	May 14	1,461	.61	.55
1900	Aug. 26	20	May 19	1,731	.73	.66

[a] The run-off given is the total acre-feet for the eight months of each year, the average second-feet per square mile, and the depth in inches for thirty days at the average rate.

Discharge measurements made on Dolores River at Dolores

Date.	Hydrographer.	Gage height.	Discharge.
1895.		*Feet.*	*Sec.-ft.*
June 22	F. Cogswell	3.50	756
Aug. 28	.....do	2.70	163
Oct. 9	.....do	2.50	89
Nov. 20	.....do	2.40	75
1896.			
May 13	F. Cogswell	3.50	553
May 14	.....do	3.50	586
June 17	.....do	3.00	179
July 21	.....do	2.80	124
Aug. 24	.....do	2.60	42
Sept. 23	.....do	4.80	1,550
Sept. 24	.....do	4.15	1,047
Oct. 1	.....do	2.75	76
1897.			
Apr. 21	F. Cogswell	5.10	2,133
May 12	.....do	5.15	2,216
June 23	.....do	4.20	1,089
July 21	.....do	3.00	273
Aug. 25	.....do	3.65	92
Sept. 22	.....do	3.32	404
Oct. 20	.....do	3.35	330
1898.			
Apr. 8	A. L. Fellows	3.15	325
May 12	.....do	4.30	1,163
June 17	.....do	4.80	1,870

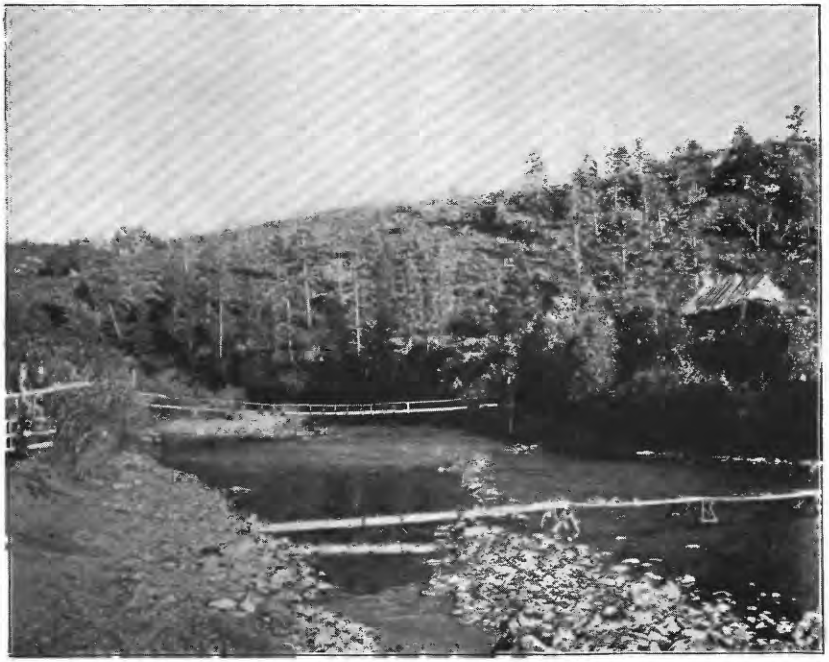
Discharge measurements made on Dolores River at Dolores—Continued.

Date.	Hydrographer.	Gage height.	Discharge.
1898.		*Feet.*	*Sec.-ft.*
Aug. 16	G. H. Matthes	2.80	102
Sept. 11	do	2.70	72
Sept. 28	do	2.55	46
Oct. 21	A. L. Fellows	2.55	40
1899.			
Apr. 20	A. L. Fellows	3.60	613
May 17	do	4.15	963
June 27	do	3.30	307
Nov. 22	do	2.70	56
1900.			
Mar. 24	A. L. Fellows	2.90	145
May 5	do	3.90	767
June 27	do	3.25	320
Aug. 11	do	2.60	31

SAN MIGUEL RIVER AT FALL CREEK.

This stream, an important tributary of the Dolores, rises in San Miguel County and drains an area immediately west of the headwaters of Uncompahgre River. The stream and its tributaries run for the most part in a northeasterly direction, and it enters the Dolores in the western part of Montrose County. A comparatively small amount of water has thus far been used for irrigation, but plans are now being developed having reference to the use of the water on a considerable scale in the western part of San Miguel County. The station is located at a wagon bridge near the railway station at Fall Creek. The channel is fairly stable and the banks are not liable to overflow. The station was discontinued in the fall of 1899.[a]

[a] For further information concerning this station see Biennial Reports of the State Engineers of Colorado: Eighth, p. 522; Ninth, p. 407; Tenth, p. 368. Also publications U. S. Geological Survey: Annual Reports, Eighteenth, Part IV, p. 264; Nineteenth, Part IV, p. 406; Twentieth, Part IV, p. 395; Twenty-first, Part IV, p. 283; Bulletin No. 140, p. 193; Water-Supply and Irrigation Papers, No. 11, p. 68; No. 16, p. 142; No. 28, pp. 137, 142, and 144; No. 38, p. 306; No. 39, p. 451. Also report on Agriculture by Irrigation, Eleventh Census, by F. H. Newell, p. 131.



A. GAGING STATION ON DOLORES RIVER AT DOLORES

B. GAGING STATION ON SAN MIGUEL RIVER AT FALL CREEK.

Discharge of San Miguel River at Full Creek.

[Altitude, 7,466 feet; drainage area, 327 square miles.]

Month.	1895.	1896.	1897.	1898.	1899.	Mean.	Equivalent in acre-feet.	Mean run-off.	
								Second-feet per square mile.	Depth in inches.
	Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*			
April	[b] 200	281	213	[b] 200	134	206	12,258	0.63	0.70
May	[b] 500	770	[b] 500	296	416	496	30,498	1.52	1.75
June	[b] 556	349	774	813	538	606	36,060	1.85	2.06
July	341	157	375	380	238	298	18,323	.91	1.05
August	227	65	183	133	195	161	9,900	.49	.56
September	100	176	215	89	101	136	8,093	.42	.47
October	64	82	184	50	[b] 75	91	5,595	.28	.32
November	45	57	96	40	[b] 70	62	3,689	.19	.21
Mean	254	242	318	250	221	257	124,416	.79	7.12
Acre-feet for period recorded	122,936	117,128	153,912	121,000	106,764	----	----	----	----

[a] The run-off given is for the acre-feet for normal months with the total for a normal eight months as given, the average monthly flow per square mile with the average for the eight months, and the normal depth in inches for each month with the total depth for the normal eight months. Details may be found in the authorities cited.

[b] Estimated.

Maximum and minimum discharge and average run-off of San Miguel River at Fall Creeek for that portion of each year covered by records.

Year.	Discharge.				Run-off.[a]	
	Minimum.		Maximum.		Depth in inches.	Second-feet per square mile.
	Date.	Amount.	Date.	Amount.		
		Sec.-ft.		*Sec.-ft.*		
1895	Dec. 24	6	June 29	587	0.87	0.78
1896	Nov. 7	22	May 27	2,404	.82	.74
1897	Apr. 4	52	June 16	997	1.08	.97
1898	Nov. 21	22	June 23	1,335	.84	.76
1899	Apr. 2	25	June 11	1,000	.75	.68

[a] The run-off is for the average of second-feet per square mile, and the depth in inches for thirty days at the average rate.

Discharge measurements made on San Miguel River at Fall Creek.

Date.	Hydrographer.	Gage height.	Discharge.
1895.		*Feet.*	*Sec.-ft.*
June 24	F. Cogswell	4.00	512
Aug. 27	do	3.20	205
Oct. 8	do	2.65	81
1896.			
May 12	F. Cogswell	3.75	360
June 16	do	3.45	290
July 20	do	3.15	175
Aug. 23	do	2.60	62
Sept. 22	do	2.75	85
Oct. 20	do	2.60	63
1897.			
Apr. 20	F. Cogswell	3.40	304
May 11	do	4.05	572
June 22	do	4.45	811
July 20	do	3.45	336
Aug. 24	do	2.85	145
Sept. 21	do	3.30	248
Oct. 19	do	3.05	197
1898.			
Apr. 7	A. L. Fellows	2.50	66
May 11	do	3.30	270
June 16	do	4.40	841
Aug. 13	do	2.80	133
Oct. 17	do	2.30	30

Discharge measurements made on San Miguel River at Fall Creek—Continued.

Date.	Hydrographer.	Gage height.	Discharge.
1899.		*Feet.*	*Sec.-ft.*
Apr. 18	A. L. Fellows	2.85	164
May 16	.....do	3 70	562
June 21	.....do	3 60	449
Nov. 21	.....do	2.35	52

MISCELLANEOUS MEASUREMENTS.

But few measurements are on record for this division, the danger of shortage having been only recently felt. Many measurements have undoubtedly been made, mostly for the purpose of ascertaining the flow with reference to development of power, but these are not, as a rule, available. Further investigations are needed in this division, as the supply of water will become of great moment before many years have elapsed. The following are, however, on record. Other measurements may also be found on page 108 et seq. of the Ninth Biennial Report of the State Engineer:

Stream measurements in Grand River division.

Date.	Hydrographer.	Stream.	Locality.	Discharge.
1895.				*Sec.-ft.*
Oct. 22	D. R. Crosby	Grand River	Palisade	2,767
1899.				
Apr. 19	A. L. Fellows	Dolores	Rico	168
May 16	.....do	Fall Creek	Falls Creek	62
June 17	.....do	Roaring Fork	Glenwood	11,258
June 21	.....do	Fall Creek	Fall Creek	45
Sept. 22	.....do	Dolores	Rico	23
Nov. 17	.....do	Roaring Fork	Glenwood	457
Nov. 22	.....do	Dolores	Rico	16
1900.				
July 8	A. L. Fellows	Roaring Fork	Glenwood	1,570
Aug. 23	.....do	.....do	.....do	423

GREEN RIVER DIVISION.

DRAINAGE AND IRRIGATION.

Green River and its tributaries drain the northwestern corner of Colorado. The Green itself traverses Colorado for only a very short distance, and during its course it runs through a deep canyon, so that but little irrigation is practiced along its borders, this being on the bottom lands. It is possible, however, that a tract of land of considerable size may eventually be irrigated from this stream, in the extreme northwestern corner of the State. The principal tributaries of the Green in Colorado are Yampa and White rivers. These drain areas of considerable size and importance, in which there are vast tracts of irrigable land that will undoubtedly be eventually cultivated so far as the water supply will permit. These streams resemble the tributaries of Grand River in general, excepting that they traverse a country that is more open and rolling. Not much irrigation is now practiced except along lands immediately adjoining the stream, but a number of plans have been projected for taking the water on to the uplands, which will no doubt be eventually carried out. No permanent stations have been maintained anywhere in this division, so that all measurements on record are compiled in the following list of miscellaneous gagings. Problems relating to the use of water are, however, becoming of great moment in this part of the State, and it is important that stations should be established at as early a date as possible, at least upon the main streams.

The Green River irrigation division, as a political subdivision, comprises all lands in Colorado drained by Green River and its tributaries. The water districts of which it is composed are Nos. 43, 44, 54, 55, 56, 57, and 58. No. 43 consists of the lands irrigated by ditches taken from White River and its tributaries; No. 44 of lands irrigated by water taken from that portion of Yampa River above the mouth of Little Snake River and below the mouth of Fortification Creek, and from the tributaries to that portion of Yampa River; No. 54 of all lands lying in the State of Colorado irrigated by water taken from that portion of Little Snake River and its tributaries above the most westerly intersection of said river with the Colorado State line; No. 55 of all lands irrigated by water from the Yampa or Little Snake rivers and their tributaries below districts Nos. 44 and 55; No. 56 of Green River and tributaries in Colorado, except Yampa River; No. 57 of Yampa River and tributaries between the mouth of Fortification Creek and Elk River; and No. 58 of Yampa River and tributaries above No. 57. But little attention has thus far been paid to the priorities of water rights in these districts.[a]

[a] For further data concerning this division, see publications U. S. Geological Survey: Ninth Annual Report, p. 677; Eighteenth, Part IV, p. 268; Nineteenth, Part IV, p. 394; Twentieth, Part IV, p. 380; Eleventh Census Irrigation Report by F. H. Newell and Bulletin No. 140, p. 200. Also Biennial Reports of the State Engineer of Colorado, Ninth, p. 409; and all biennial reports for commissioners' reports.

A. STEAMBOAT SPRINGS.

B. YAMPA RIVER VALLEY NEAR HAYDEN.

MISCELLANEOUS GAGINGS.

In the following table are given the results of gagings made in May, 1895, and September, 1898, on certain specified streams in the Green River irrigation division:

Miscellaneous gagings made in the Green River irrigation division.

Date.	Hydrographer.	Stream.	Locality.	Discharge.
1895.				*Sec.-ft.*
May 16	H. A. Sumner	White River	White River	3,047
1898.				
Sept. 14	A. L. Fellows	White River	Meeker	300
Sept. 15	do	Williams River	Hamilton	25
Sept. 17	do	Yampa River	3 miles below Hayden	111
Do.	do	Elk River	Trull	63
Sept. 18	do	Yampa River	Steamboat Springs	65
Sept. 19	do	Snake River	Honnold	17
Sept. 20	do	Slater Fork	Slater	9
Sept. 21	do	Snake River	Dixon, Wyo	19
Sept. 22	do	Yampa River	Below Maybell	99
Sept. 24	do	Green River	Ladore	552
Sept. 26	do	Yampa River	Craig	79

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