DEPARTMENT OF THE INTERIOR
FRANKLIN K. LANE, Secretary

UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, Director

WATER-SUPPLY PAPER 457

SURFACE WATER SUPPLY OF THE UNITED STATES

1917

PART VII. LOWER MISSISSIPPI RIVER BASIN

NATHAN C. GROVER, Chief Hydraulic Engineer
ROBERT FOLLANSBEE, District Engineer

WASHINGTON
GOVERNMENT PRINTING OFFICE
1919

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CONTENTS.

	Page.
Authorization and scope of work	5
Definition of terms	6
Explanation of data	7
Accuracy of field data and computed records	8
Cooperation	9
Division of work	9
Gaging-station records	9
Arkansas River basin	9
East Fork of Arkansas River near Leadville, Colo	9
Arkansas River at Granite, Colo	11
Arkansas River at Salida, Colo	12
Tennessee Fork near Leadville, Colo	14
Cottonwood Creek below Hot Springs, near Buena Vista, Colo	15
Chalk Creek (upper station) near St. Elmo, Colo	18
South Fork of Arkansas River at Poncha, Colo	20
Poncha Creek at Poncha, Colo	21
West Beaver Creek near Victor, Colo	23
Boehmer Creek near Pikes Peak, Colo	24
Little Beaver Creek near Pikes Peak, Colo	24
Sackett Creek near Pikes Peak, Colo	25
Lion Creek near Halfway, Colo	26
Sheep Creek near Halfway, Colo	26
South Ruxton Creek at Halfway, Colo	27
Cabin Creek near Halfway, Colo	28
Red River basin	29
Medicine Bluff Creek near Lawton, Okla	29
Little Medicine Bluff Creek near Lawton, Okla	31
Evaporation station near Lawton, Okla	32
Index	35
Appendix—Gaging stations and publications relating to water resources	1

ILLUSTRATIONS.

		Page.
PLATE I.	*A*, Price current meters: *B*, Typical gaging station	6
II.	Water-stage recorders: *A*, Stevens continuous; *B*, Gurley printing; *C*, Friez	7

SURFACE WATER SUPPLY OF THE LOWER MISSISSIPPI RIVER BASIN, 1917.

AUTHORIZATION AND SCOPE OF WORK.

This volume is one of a series of 14 reports presenting records of measurements of flow made on streams in the United States during the year ending September 30, 1917.

The data presented in these reports were collected by the United States Geological Survey under the following authority contained in the organic law (20 Stat. L., p. 394):

Provided, That this officer [the Director] shall have the direction of the Geological Survey and the classification of public lands and examination of the geological structure, mineral resources, and products of the national domain.

The work was begun in 1888 in connection with special studies relating to irrigation in the arid West. Since the fiscal year ending June 30, 1895, successive sundry civil bills passed by Congress have carried the following item and appropriations:

For gaging the streams and determining the water supply of the United States, and for the investigation of underground currents and artesian wells, and for the preparation of reports upon the best methods of utilizing the water resources.

Annual appropriations for the fiscal years ending June 30, 1895–1918.

1895	$12,500
1896	20,000
1897 to 1900, inclusive	50,000
1901 to 1902, inclusive	100,000
1903 to 1906, inclusive	200,000
1907	150,000
1908 to 1910, inclusive	100,000
1911 to 1918, inclusive	150,000

In the execution of the work many private and State organizations have cooperated, either by furnishing data or by assisting in collecting data. Acknowledgments for cooperation of the first kind are made in connection with the description of each station affected; cooperation of the second kind is acknowledged on page 9.

Measurements of stream flow have been made at about 4,240 points in the United States and also at many points in Alaska and the Hawaiian Islands. In July, 1917, 1,180 gaging stations were being

maintained by the Survey and the cooperating organizations. Many miscellaneous discharge measurements are made at other points. In connection with this work data were also collected in regard to precipitation, evaporation, storage reservoirs, river profiles, and water power in many sections of the country and will be made available in water-supply papers from time to time. Information in regard to publications relating to water resources is presented in the appendix to this report.

DEFINITION OF TERMS.

The volume of water flowing in a stream—the "run-off" or "discharge"—is expressed in various terms, each of which has become associated with a certain class of work. These terms may be divided into two groups—(1) those that represent a rate of flow, as second-feet, gallons per minute, miners' inches, and discharge in second-feet per square mile, and (2) those that represent the actual quantity of water, as run-off in depth in inches, acre-feet, and millions of cubic feet. The principal terms used in this series of reports are second-feet, second-feet per square mile, run-off in inches, and acre-feet. They may be defined as follows:

"Second-feet" is an abbreviation for "cubic feet per second." A second-foot is the rate of discharge of water flowing in a channel of rectangular cross section 1 foot wide and 1 foot deep at an average velocity of 1 foot per second. It is generally used as a fundamental unit from which others are computed.

"Second-feet per square mile" is the average number of cubic feet of water flowing per second from each square mile of area drained, on the assumption that the run-off is distributed uniformly both as regards time and area.

"Run-off (depth in inches)" is the depth to which an area would be covered if all the water flowing from it in a given period were uniformly distributed on the surface. It is used for comparing run-off with rainfall, which is usually expressed in depth in inches.

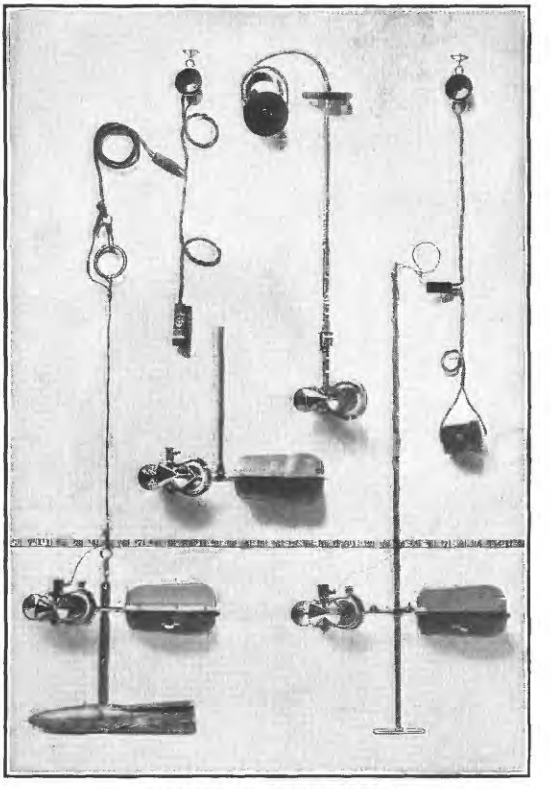
An "acre-foot," equivalent to 43,560 cubic feet, is the quantity required to cover an acre to the depth of 1 foot. The term is commonly used in connection with storage for irrigation.

The following terms not in common use are here defined:

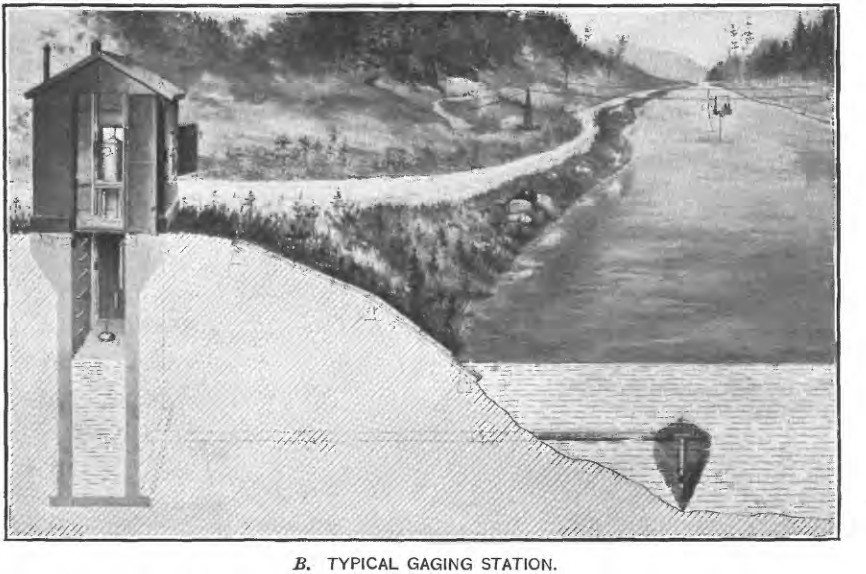
"Stage-discharge relation;" an abbreviation for the term "relation of gage height to discharge."

"Control;" a term used to designate the section or sections of the stream channel below the gage which determine the stage-discharge relation at the gage. It should be noted that the control may not be the same section or sections at all stages.

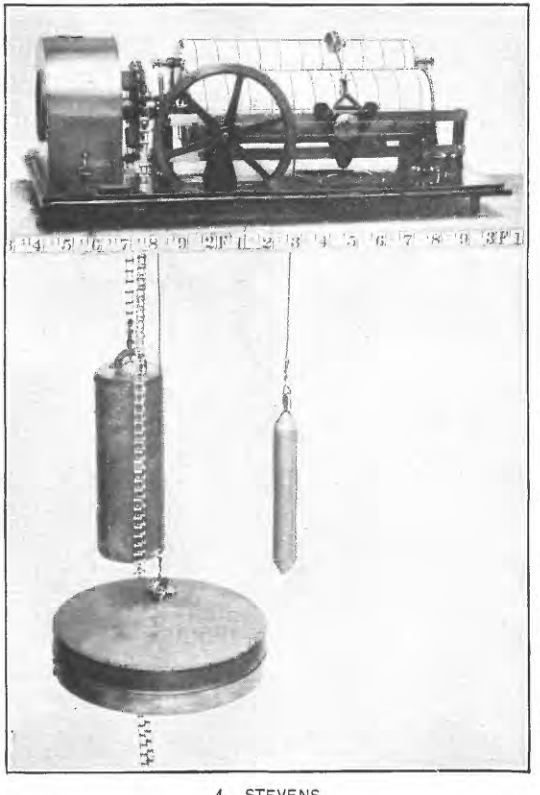
The "point of zero flow" for a given gaging station is that point on the gage—the gage height—to which the surface of the river falls when the discharge is reduced to zero.



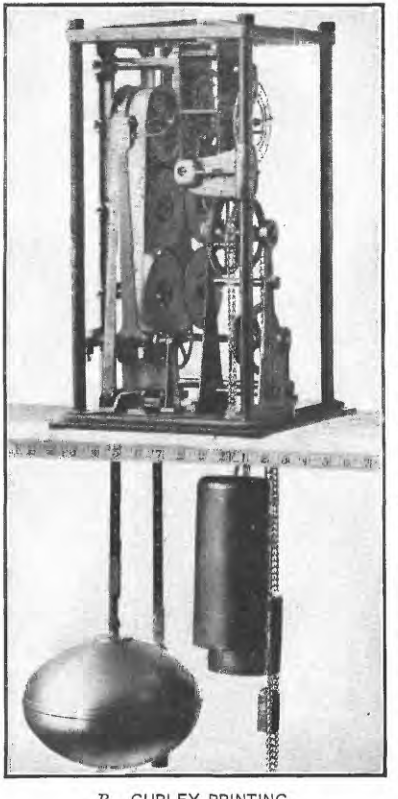
A. PRICE CURRENT METERS.



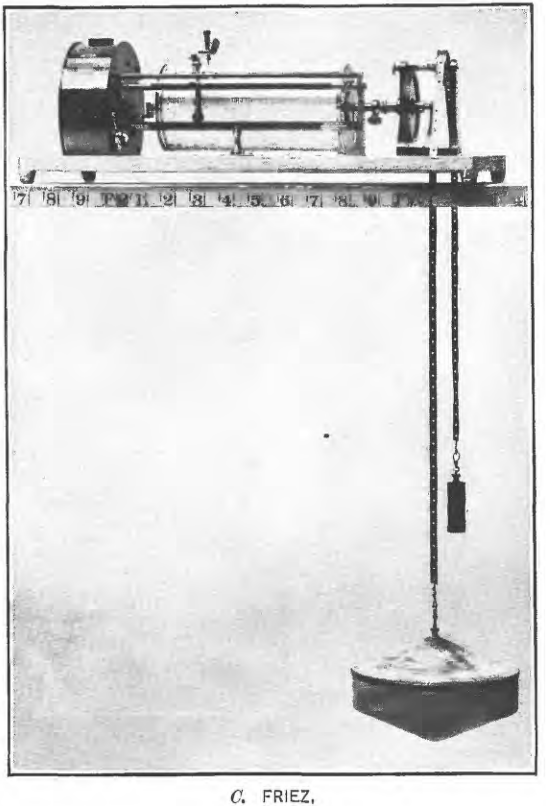
B. TYPICAL GAGING STATION.



A. STEVENS.



B. GURLEY PRINTING.



C. FRIEZ.

WATER-STAGE RECORDERS.

EXPLANATION OF DATA.

The data presented in this report cover the year beginning October 1, 1916, and ending September 30, 1917. At the beginning of January in most parts of the United States much of the precipitation in the preceding three months is stored as ground water, in the form of snow or ice, or in ponds, lakes, and swamps, and this stored water passes off in the streams during the spring break-up. At the end of September, on the other hand, the only stored water available for run-off is possibly a small quantity in the ground; therefore the run-off for the year beginning October 1 is practically all derived from precipitation within that year.

The base data collected at gaging stations consist of records of stage, measurements of discharge, and general information used to supplement the gage heights and discharge measurements in determining the daily flow. The records of stage are obtained either from direct readings on a staff gage or from a water-stage recorder that gives a continuous record of the fluctuations. Measurements of discharge are made with a current meter. (See Pls. I, II.) The general methods are outlined in standard textbooks on the measurement of river discharge.

From the discharge measurements rating tables are prepared that give the discharge for any stage, and these rating tables, when applied to the gage heights, give the discharge from which the daily, monthly, and yearly means of discharge are determined.

The data presented for each gaging station in the area covered by this report comprise a description of the station, a table giving records of discharge measurements, a table showing the daily discharge of the stream, and a table of monthly and yearly discharge and run-off.

If the base data are insufficient to determine the daily discharge, tables giving daily gage height and records of discharge measurements are published.

The description of the station gives, in addition to statements regarding location and equipment, information in regard to any conditions that may affect the permanence of the stage-discharge relation, covering such subjects as the occurrence of ice, the use of the stream for log driving, shifting of control, and the cause and effect of backwater; it gives also information as to diversions that decrease the flow at the gage, artificial regulation, maximum and minimum recorded stages, and the accuracy of the records.

The table of daily discharge gives, in general, the discharge in second-feet corresponding to the mean of the gage heights read each day. At stations on streams subject to sudden or rapid diurnal fluctuations the discharge obtained from the rating table and the mean daily gage height may not be the true mean discharge for the day.

If such stations are equipped with water-stage recorders the mean daily discharge may be obtained by averaging discharge at regular intervals during the day or by using the discharge integrator, an instrument operating on the principle of the planimeter and containing as an essential element the rating curve of the station.

In the table of monthly discharge the column headed "Maximum" gives the mean flow for the day when the mean gage height was highest. As the gage height is the mean for the day it does not indicate correctly the stage when the water surface was at crest height and the corresponding discharge was consequently larger than given in the maximum column. Likewise, in the column headed "Minimum" the quantity given is the mean flow for the day when the mean gage height was lowest. The column headed "Mean" is the average flow in cubic feet per second during the month. On this average flow computations recorded in the remaining columns, which are defined on page 6, are based.

ACCURACY OF FIELD DATA AND COMPUTED RECORDS.

The accuracy of stream-flow data depends primarily (1) on the permanency of the stage-discharge relation and (2) on the accuracy of observation of stage, measurements of flow, and interpretation of records.

A paragraph in the description of the station gives information regarding the (1) permanence of the stage-discharge relation, (2) precision with which the discharge rating curve is defined, (3) refinement of gage readings, (4) frequency of gage readings, and (5) methods of applying daily gage height to the rating table to obtain the daily discharge.

For the rating tables "well defined" indicates, in general, that the rating is probably accurate within 5 per cent; "fairly well defined," within 10 per cent; "poorly defined," within 15 to 25 per cent. These notes are very general and are based on the plotting of the individual measurements with reference to the mean rating curve.

The monthly means for any station may represent with high accuracy the quantity of water flowing past the gage, but the figures showing discharge per square mile and depth of run-off in inches may be subject to gross errors caused by the inclusion of large non-contributing districts in the measured drainage area, by lack of information concerning water diverted for irrigation or other use, or by inability to interpret the effect of artificial regulation of the flow of the river above the station. "Second-feet per square mile" and "run-off (depth in inches)" are therefore not computed if such errors appear probable. The computations are also omitted for stations on streams draining areas in which the annual rainfall is less than 20 inches. All figures representing "second-feet per square

mile" and "run-off (depth in inches)" previously published by the Survey should be used with caution because of possible inherent sources of error not known to the Survey.

The table of monthly discharge gives only a general idea of the flow at the station and should not be used for other than preliminary estimates; the tables of daily discharge allow more detailed studies of the variation in flow. It should be borne in mind, however, that the observations in each succeeding year may be expected to throw new light on data previously published.

COOPERATION.

In Colorado the State engineer paid the observers on Arkansas River at Granite and Salida. The United States Forest Service furnished readings on South Fork of Arkansas River and Poncha Creek at Poncha, and winter readings on East Fork of Arkansas River and Tennessee Fork near Leadville. It also furnished the service of a hydrographer during the winter months.

The Arkansas Valley Railway, Light & Power Co. furnished complete records for West Beaver Creek near Victor.

Mr. B. B. McReynolds, superintendent of the water department of Colorado Springs, furnished records of flow of streams in the Pikes Peak region.

The United States Reclamation Service paid for the maintenance of the stations on Medicine Bluff Creek and Little Medicine Bluff Creek near Lawton and the evaporation station in Lawton reservoir, Okla.

DIVISION OF WORK.

The field data in Colorado were collected under the direction of Robert Follansbee, by P. V. Hodges, H. W. Fear, and T. J. Watkins.

The field data in Oklahoma were collected under the direction of Robert Follansbee.

Ratings and computations were made by P. V. Hodges, assisted by S. B. Soulé and Miss Bessie Meyers.

The records were reviewed and the manuscript assembled by W. E. Dickinson.

GAGING-STATION RECORDS.

ARKANSAS RIVER BASIN.

EAST FORK OF ARKANSAS RIVER NEAR LEADVILLE, COLO.

LOCATION.—In sec. 16, T. 9 S., R. 80 W., at highway bridge about 200 yards above mouth of Tennessee Fork, 3 miles northwest of Leadville, in Lake County.

DRAINAGE AREA.—52 square miles (measured on topographic map).

RECORDS AVAILABLE.—April 25 to August 31, 1890; June 18 to September 29, 1903; June 5, 1911 to September 30, 1917.

GAGE.—Vertical staff on left bridge abutment, near upstream end; read by Fred. Coquoz. No known relation between present gage and gages used prior to 1911

DISCHARGE MEASUREMENTS.—Made from bridge or by wading.

CHANNEL AND CONTROL.—Bed composed of coarse gravel and small boulders. Control 30 feet downstream from gage; practically permanent. Banks low; subject to overflow at extreme high water.

EXTREMES OF DISCHARGE.—Maximum stage recorded during year 1.45 feet at 8 a. m. June 18 and 20 (discharge, 448 second-feet); minimum discharge occurred during winter.

ICE.—Stage-discharge relation seriously affected by ice; data insufficient for determination of winter flow.

DIVERSIONS.—The Leadville Water Co. makes a continuous diversion of 2 second-feet from East Fork above the station. During the winter this diversion may be increased to 3 second-feet.

REGULATION.—None.

ACCURACY.—Stage-discharge relation practically permanent. Rating curve used from October 1 to November 11 is well defined between 10 and 200 second-feet; curve used April 30 to September 30 is well defined between 5 and 300 second-feet. Gage read to quarter-tenths twice daily. Owing to high altitude of drainage area (9,700 feet), alternate melting and freezing at certain seasons probably causes considerable diurnal fluctuation, and mean daily gage height based on morning and evening reading may be somewhat in error. Daily discharge ascertained by applying mean daily gage height to rating table. Records good.

Discharge measurements of East Fork of Arkansas River near Leadville, Colo., during the year ending Sept. 30, 1917.

Date.	Made by—	Gage height.	Discharge.	Date.	Made by—	Gage height.	Discharge.
		Feet.	*Sec.-ft.*			*Feet.*	*Sec.-ft.*
Oct. 10	P. V. Hodges	0.25	17.2	Feb. 18	T. J. Watkins	[a] 0.20	9.5
Jan. 23	J. H. Keep	[a] 0.27	9.1	June 25	H. W. Fear	1.20	295

[a] Stage-discharge relation affected by ice.

Daily discharge, in second-feet, of East Fork Arkansas River near Leadville, Colo., for the year ending Sept. 30, 1917.

Day.	Oct.	Nov.	Apr.	May.	June.	July.	Aug.	Sept.
1	25	49	.....	.....	37	235	47	12
2	21	49	.....	.....	36	270	44	11
3	20	48	.....	.....	31	191	50	8
4	19	45	.....	.....	37	171	52	12
5	25	41	.....	.....	48	163	50	16
6	20	37	.....	.....	48	175	52	20
7	17	34	.....	5	58	171	54	17
8	19	25	.....	.....	75	171	47	17
9	20	27	.....	.....	80	159	47	16
10	17	24	.....	.....	99	134	44	12
11	19	22	.....	.....	115	138	50	8
12	17	.....	.....	.....	127	127	48	6
13	17	.....	.....	.....	175	124	37	5
14	17	.....	.....	.....	215	117	29	8
15	19	.....	.....	.....	270	104	29	5
16	22	.....	.....	.....	322	92	20	5
17	25	.....	.....	.....	415	89	16	5
18	21	.....	.....	.....	448	72	16	5
19	23	.....	.....	.....	415	80	16	6
20	28	.....	.....	.....	415	72	16	5
21	27	.....	.....	.....	382	84	16	6
22	30	.....	.....	.....	415	89	16	5
23	30	.....	.....	.....	415	179	16	5
24	32	.....	.....	.....	415	89	16	5
25	37	.....	.....	.....	382	84	16	5
26	38	.....	.....	.....	382	66	13	5
27	48	.....	.....	31	350	62	12	5
28	38	.....	.....	26	350	50	11	8
29	45	.....	.....	31	350	48	12	8
30	34	.....	5	37	350	47	16	6
31	43	.....	.....	40	.....	48	13	.....

Monthly discharge of East Fork of Arkansas River near Leadville, Colo., for the year ending Sept. 30, 1917.

Month.	Discharge in second-feet.			Run-off (total in acre-feet).
	Maximum.	Minimum.	Mean.	
October	48	17	26.2	1,610
Nov. 1-11	49	22	36.5	796
June	448	31	242	14,400
July	270	47	119	7,320
August	54	11	29.7	1,830
September	20	5	8.6	512

ARKANSAS RIVER AT GRANITE, COLO.

LOCATION.—In sec. 31, T. 11 S., R. 79 W., at Granite, in Lake County, below mouth of Lake Creek, and above Lost Canyon and Clear creeks.

DRAINAGE AREA.—425 square miles.

RECORDS AVAILABLE.—May 1, 1897, to September 10, 1899; April 6, 1910, to September 30, 1917.

GAGE.—Inclined staff gage established in 1910 by State engineer on left bank half a mile above Denver & Rio Grande Railroad station at Granite. Bristol water-stage recorder referred to inclined gage used April 6, 1910 to April 27, 1916. No known relation between present gage and that used from 1897 to 1899.

DISCHARGE MEASUREMENTS.—Made from highway bridge near railroad station or by wading.

CHANNEL AND CONTROL.—Bed composed of coarse gravel and small boulders. Control shifted badly in 1917. Banks not subject to overflow.

EXTREMES OF DISCHARGE.—Maximum discharge during the year, 2,540 second-feet June 19 (gage height, 4.3 feet); maximum stage recorded, 4.5 feet at 7.16 p. m. July 9; minimum discharge occurred during the winter.

ICE.—Stage-discharge relation seriously affected by ice; observations discontinued during winter months.

DIVERSIONS.—Court decrees for diversions of 74 second-feet from the Arkansas between this station and the junction of Tennessee and East forks.

REGULATION.—Discharge affected by operation of Twin Lakes reservoir, which has a storage decree for 20,645 acre-feet.

ACCURACY.—Stage-discharge relation not permanent. A sharp flood in side gulch at 4 p. m. July 9 washed a great quantity of sand and gravel onto the control, which was thereby made 20 feet narrower; this obstruction has been gradually washing away. Rating curve poorly defined. Gage read to tenths twice daily. Daily discharge ascertained by applying mean daily gage height to rating table except for period May 14 to September 30, for which shifting-control method was used. Records fair.

Discharge measurements of Arkansas River at Granite, Colo., during the year ending Sept. 30, 1917.

Date.	Made by—	Gage height.	Discharge.	Date.	Made by—	Gage height.	Discharge.
		Feet.	*Sec.-ft.*			*Feet.*	*Sec.-ft.*
Oct. 27	P. V. Hodges	1.74	176	Aug. 17	H. W. Fear	2.60	437
June 28	H. W. Fear	3.79	2,070	Sept. 7	M. N. Grant, jr	2.85	501
July 16	Robert Follansbee	3.60	1,150	21	do	2.04	202

Daily discharge, in second-feet, of Arkansas River at Granite, Colo., for the year ending Sept. 30, 1917.

Day.	Oct.	Nov.	Dec.	Apr.	May.	June.	July.	Aug.	Sept.
1	130	165	130	88	115	615	1,910	870	502
2	130	165	100	100	165	550	1,810	685	496
3	130	165	.....	100	130	563	1,810	520	520
4	130	130	.....	88	148	664	1,710	402	454
5	130	130	.....	130	148	785	1,710	460	478
6	165	130	.....	115	115	643	1,660	550	502
7	165	130	.....	100	115	800	1,610	792	248
8	165	130	.....	130	130	800	1,710	792	124
9	165	165	.....	148	115	1,110	1,950	910	148
10	165	165	.....	148	130	1,490	1,540	990	154
11	165	130	.....	130	130	1,810	1,290	950	158
12	200	130	.....	148	130	1,910	1,240	910	162
13	200	130	.....	165	148	2,030	1,200	615	224
14	200	130	.....	182	268	2,130	1,200	520	335
15	200	165	.....	200	360	2,300	1,200	520	392
16	200	130	.....	148	544	2,350	1,110	490	397
17	200	130	.....	115	643	2,420	1,110	430	325
18	200	130	.....	115	762	2,470	1,060	424	208
19	200	130	.....	115	838	2,540	1,290	397	196
20	200	130	.....	115	894	2,340	1,240	392	204
21	165	130	.....	148	894	2,210	1,110	340	186
22	209	130	.....	240	870	2,210	1,240	248	190
23	240	130	.....	220	870	2,260	1,290	208	190
24	240	100	.....	260	846	2,210	1,390	168	193
25	200	130	.....	220	629	2,210	1,440	151	176
26	165	130	.....	240	514	2,110	1,390	148	179
27	165	130	.....	182	514	2,010	1,240	130	162
28	200	130	.....	148	496	2,010	1,110	514	148
29	165	130	.....	115	466	1,960	1,060	608	130
30	200	130	.....	115	538	2,010	1,020	570	100
31	165	.....	.....	.....	602	.....	934	563	.....

Monthly discharge of Arkansas River at Granite, Colo., for the year ending Sept. 30, 1917.

Month.	Discharge in second-feet.			Run-off (total in acre-feet).
	Maximum.	Minimum.	Mean.	
October	240	130	179	11,000
November	165	100	136	8,090
April	260	88	149	8,870
May	894	115	428	26,300
June	2,540	550	1,720	102,000
July	1,950	934	1,370	84,200
August	990	130	525	32,300
September	520	100	263	15,600

ARKANSAS RIVER AT SALIDA, COLO.

LOCATION.—In sec. 32, T. 50 N., R. 9 E., at Salida, in Chaffee County, some distance above mouth of South Fork of Arkansas River, the nearest important tributary.

DRAINAGE AREA.—1,160 square miles.

RECORDS AVAILABLE.—April 11, 1895, to October 31, 1903; November 3, 1909, to September 30, 1917.

GAGE.—Bristol water-stage recorder on right bank 400 feet below highway bridge in city park; installed by State engineer.

DISCHARGE MEASUREMENTS.—Made from highway bridge.

CHANNEL AND CONTROL.—Bed composed of coarse gravel; shifts at intervals; no well-defined control. Banks high and not subject to overflow.

EXTREMES OF DISCHARGE.—Maximum stage during year, from water-stage recorder, 6.1 feet at 11 a. m., June 18 and 19 (discharge, 4,730 second-feet); minimum stage, 0.34 foot December 9, 1916 (discharge, 201 second-feet).

ICE.—Stage-discharge relation not affected by ice, as river is kept open by springs.

DIVERSIONS.—Court decrees for diversions of 202 second-feet from the Arkansas between this station and Granite.

REGULATION.—Flow at station regulated to some extent by Twin Lakes and Clear Creek reservoirs, which have storage decrees for 20,645 and 11,489 acre-feet, respectively.

ACCURACY.—Stage-discharge relation changes between narrow limits. Rating curve for period October 1 to December 31, fairly well defined between 200 and 1,000 second-feet; curve used January 1 to September 30, well defined between 200 and 3,800 second-feet. Operation of water-stage recorder fairly satisfactory. Daily discharge ascertained by applying to rating table mean daily gage height determined by inspecting recorder graph; shifting-control method used January 23 to March 31. Records good.

Discharge measurements of Arkansas River at Salida, Colo., during the year ending Sept. 30, 1917.

Date.	Made by—	Gage height.	Discharge.	Date.	Made by—	Gage height.	Discharge.
		Feet.	*Sec.-ft.*			*Feet.*	*Sec.-ft.*
Oct. 25	P. V. Hodges	1.24	504	June 27	H. E. Turner	5.23	3,760
Jan. 17	T. J. Watkins	.52	245	Sept. 5	M. N. Grant, jr	1.70	667
Feb. 20	do	.50	222	Sept. 20	do	1.07	401
June 5	H. W. Fear	2.04	866				

Daily discharge, in second-feet, of Arkansas River at Salida, Colo., for the year ending Sept. 30, 1917.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1	391	407	286	272	250	212	265	248	708	3,520	1,460	735
2	373	407	338	272	250	225	242	265	708	3,520	1,310	680
3	373	339	335	260	235	225	248	260	580	3,300	1,160	680
4	355	391	348	272	230	208	222	260	708	3,300	1,000	680
5	355	384	298	250	242	212	240	280	850	3,080	970	680
6	373	384	274	272	242	238	265	272	850	2,880	1,000	680
7	430	384	250	272	235	212	230	248	880	2,680	1,030	680
8	410	377	225	270	228	215	222	260	910	2,780	1,100	410
9	410	342	201	272	228	235	260	260	1,200	3,080	1,030	375
10	430	377	203	262	240	242	280	260	2,080	3,300	1,160	375
11	410	373	219	265	228	240	260	272	2,630	2,780	1,240	375
12	410	355	275	260	232	228	240	285	2,730	2,580	1,200	375
13	430	338	292	255	225	218	255	285	3,030	2,380	1,270	375
14	430	322	295	235	220	218	275	330	3,960	2,230	1,310	535
15	430	348	270	235	212	238	285	430	3,960	2,230	970	580
16	452	355	270	222	212	242	265	655	4,070	2,030	970	580
17	452	362	254	235	225	242	250	880	4,180	1,940	970	558
18	452	373	259	240	212	245	222	1,030	4,400	1,890	970	410
19	452	352	270	248	210	255	222	1,160	4,510	1,840	910	410
20	430	355	270	265	225	255	210	1,160	4,510	1,980	850	375
21	452	322	270	235	222	258	218	1,130	4,290	1,670	850	375
22	452	355	292	218	248	270	270	1,030	4,200	1,580	630	375
23	473	384	292	220	260	258	327	970	4,120	1,540	680	375
24	496	355	292	208	272	252	324	940	4,030	1,710	580	375
25	492	322	288	220	272	238	336	880	3,940	1,940	558	345
26	410	322	285	220	262	245	327	605	3,860	2,430	546	345
27	460	292	281	232	250	220	303	558	3,770	2,180	535	345
28	456	322	278	212	225	252	272	535	3,590	1,840	790	315
29	443	233	274	204	.....	282	250	512	3,410	1,710	790	315
30	422	259	270	220	.....	342	240	535	3,630	1,710	790	285
31	418	.....	272	252	.....	342	.....	605	.....	1,580	735	.....

NOTE.—No gage-height record Dec. 6-8, 25-29, June 22-26, 28, and Aug. 26; discharge interpolated.

Monthly discharge of Arkansas River at Salida, Colo., for the year ending Sept. 30, 1917.

Month.	Discharge in second-feet.			Run-off (total in acre-feet).
	Maximum.	Minimum.	Mean.	
October	496	355	427	26,300
November	407	233	352	20,900
December	348	201	275	16,900
January	272	204	244	15,000
February	272	210	235	13,100
March	342	208	244	15,000
April	336	210	261	15,500
May	1,160	248	561	34,500
June	4,510	500	2,880	171,000
July	3,520	1,540	2,360	145,000
August	1,460	535	947	58,200
September	735	285	467	27,800
The year	4,510	201	773	559,000

TENNESSEE FORK NEAR LEADVILLE, COLO.

LOCATION.—In sec. 16, T. 9 S., R. 80 W., at highway bridge a few hundred yards above mouth of stream and about 3 miles northwest of Leadville, in Lake County.

DRAINAGE AREA.—45 square miles (measured on topographic map).

RECORDS AVAILABLE.—May 10 to October 31, 1890; June 18 to October 16, 1903; February 8, 1911, to September 30, 1917.

GAGE.—Vertical staff on downstream side of left bridge abutment; datum lowered 0.40 foot October 6, 1914. Read by Fred Coquoz. No known relation between present gage and gages used in 1890 and 1903.

DISCHARGE MEASUREMENTS.—Made from bridge or by wading near bridge.

CHANNEL AND CONTROL.—Bed rough; composed of small boulders. Control a short distance below gage at rapids which are practically permanent. Banks not subject to overflow.

EXTREMES OF DISCHARGE.—Maximum stage recorded during year, 1.52 feet at 8 a. m., June 23 (discharge, 263 second-feet); minimum discharge occurred during winter.

ICE.—Stage-discharge relation seriously affected by ice; data insufficient for determination of winter flow.

DIVERSIONS.—Court decrees for diversions of 24 second-feet above the station; also a decree for diversion of 18.5 second-feet from the basin of Eagle River to that of Tennessee Fork above station. During the year ending September 30, 1917. 2,460 acre-feet was diverted from Eagle River basin.

ACCURACY.—Stage-discharge relation practically permanent except as affected by ice. Rating curve well defined between 10 and 240 second-feet. Gage read to quarter-tenths twice daily. Owing to the high altitude of this drainage basin (9,700 feet) alternate melting and freezing at certain seasons probably causes considerable diurnal fluctuation, so that mean daily gage height derived from morning and evening readings may be somewhat in error. Daily discharge ascertained by applying mean daily gage height to rating table; shifting-control method used October 1–9. Records good.

Discharge measurements of Tennessee Fork near Leadville, Colo., during the year ending Sept. 30, 1917.

Date.	Made by—	Gage height.	Discharge.	Date.	Made by—	Gage height.	Discharge.
		Feet.	*Sec.-ft.*			*Feet.*	*Sec.-ft.*
Oct. 10	P. V. Hodges	0.45	14.4	Feb. 18	T. J. Watkins	[a]1.35	7.5
Dec. 20	J. H. Keep	[a]0.90	12.0	June 25	H. W. Fear	1.42	231
Jan. 23	do	[a]0.68	8.2				

[a] Stage-discharge relation affected by ice.

Daily discharge, in second-feet, of Tennessee Fork near Leadville, Colo., for the year ending Sept. 30, 1917.

Day.	Oct.	Nov.	May.	June.	July.	Aug.	Sept.
1	9	12	.....	98	160	38	8
2	10	12	.....	93	155	23	7
3	7	9	.....	102	144	18	5
4	7	10	.....	117	115	18	5
5	8	10	.....	125	110	13	4
6	8	8	.....	133	107	10	4
7	7	9	28	125	102	13	6
8	5	7	.....	155	93	12	6
9	7	7	.....	172	86	9	6
10	14	10	.....	180	75	6	10
11	15	8	.....	169	90	6	9
12	12	10	.....	177	90	6	11
13	11	10	.....	177	79	7	10
14	14	.....	.....	160	79	6	9
15	14	.....	.....	155	62	6	11
16	14	.....	.....	133	46	5	11
17	9	.....	.....	152	32	4	10
18	9	.....	.....	177	36	5	10
19	10	.....	.....	194	38	5	8
20	14	.....	.....	224	40	4	8
21	12	.....	.....	240	48	5	10
22	14	.....	.....	256	58	4	6
23	12	.....	.....	256	128	6	6
24	8	.....	.....	224	64	5	6
25	12	.....	.....	209	54	4	8
26	12	.....	.....	209	48	3	6
27	14	.....	77	191	36	4	5
28	10	.....	86	172	38	6	5
29	9	.....	77	163	33	4	5
30	13	.....	70	160	36	4	5
31	16	.....	88	.....	23	6	.....

Monthly discharge of Tennessee Fork near Leadville, Colo., for the year ending Sept. 30, 1917.

Month.	Discharge in second-feet.			Run-off (total in acre-feet).
	Maximum.	Minimum.	Mean.	
October	16	5	10.8	664
November 1-13	12	7	9.4	242
June	256	93	170	10,100
July	160	23	74.4	4,570
August	38	3	8.5	523
September	11	4	7.3	434

COTTONWOOD CREEK BELOW HOT SPRINGS, NEAR BUENA VISTA, COLO.

LOCATION.—In sec. 22, T. 14 S., R. 79 W., half a mile below old Hot Springs Hotel and 6 miles west of Buena Vista, in Chaffee County. Nearest tributary, South Fork, enters 2 miles above.

DRAINAGE AREA.—72 square miles (measured on Forest atlas).

RECORDS AVAILABLE.—April 7, 1911, to September 30, 1917. From September 23, 1910, to September 13, 1911, a station was maintained in sec. 21, a mile above present site.

GAGE.—Vertical staff. On February 19, 1915, gage was moved from side of left abutment to downstream end and reset to same datum. In present position water does not pile up on gage, especially during high water, and therefore for same discharge gage height will be less. Read twice daily by E. D. Masters.

DISCHARGE MEASUREMENTS.—Made from bridge or by wading.

CHANNEL AND CONTROL.—Bed composed of boulders; very rough. Control a short distance below gage; shifted somewhat during winter of 1916–17. Banks high, overflow unlikely.

EXTREMES OF DISCHARGE.—Maximum stage recorded during year, 2.2 feet at 6 a. m. June 18 (discharge, 467 second-feet); minimum stage, 0.40 feet at 7 a. m. March 26 and 6 a. m. April 7 (discharge, 18 second-feet).

ICE.—Stage-discharge relation not affected by ice; hot springs keep creek open.

DIVERSIONS.—Court decrees for diversions of 148 second-feet from Cottonwood Creek, of which 28 second-feet are above gaging station.

REGULATION.—None.

ACCURACY.—Stage-discharge relation slightly shifting. Rating curve well defined between 20 and 350 second-feet; curve developed for 1917 used as standard, with slight shifts for 1915 and 1916. Gage read to hundredths twice daily. Daily discharge ascertained by applying mean daily gage height to rating table. Record good.

Discharge measurements of Cottonwood Creek below Hot Springs near Buena Vista, Colo., during the years ending Sept. 30, 1915–1917.

Date.	Made by—	Gage height.	Discharge.	Date.	Made by—	Gage height.	Discharge.
1914.		*Feet.*	*Sec.-ft.*			*Feet.*	*Sec.-ft.*
Oct. 7	R. H. Fletcher	0.90	54	July 27	W. R. King	1.10	92
				Oct. 27	P. V. Hodges	0.82	44.4
1915.				1917.			
Jan. 17	T. J. Watkins	0.59	22	Jan. 16	T. J. Watkins	0.61	27.0
Feb. 19	R. H. Fletcher	*a* 0.57	22	June 30	H. W. Fear	1.88	318
June 18	R. G. Hosea	1.60	228	July 16	Robert Follansbee	1.48	166
July 19	W. R. King	0.98	63	Aug. 17	H. W. Fear	1.13	85
1916.				17	....do	1.10	75
Jan. 17	T. J. Watkins	0.61	22.6				
June 23	W. R. King	*b* 1.50	238				

a Old gage read 0.63 foot. *b* Gage height uncertain.

NOTE.—New gage established at slightly different location, Feb. 19, 1915.

Daily discharge, in second-feet, of Cottonwood Creek below Hot Springs near Buena Vista, Colo., for the years ending Sept. 30, 1915–1917.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1914–15.												
1	52	43	27	21	21	24	25	47	186	221	47	43
2	48	43	24	21	19	23	25	35	203	210	44	42
3	45	38	28	19	19	23	25	33	140	199	42	46
4	55	38	27	19	18	22	25	34	109	186	41	47
5	52	38	27	19	18	23	25	34	116	192	40	46
6	52	38	25	19	18	22	25	33	105	199	40	43
7	55	37	25	19	18	22	25	32	89	146	48	42
8	52	37	25	19	19	22	25	35	105	155	96	42
9	52	37	23	19	19	22	24	38	149	133	75	41
10	52	34	23	19	21	22	24	38	169	128	63	40
11	50	34	23	19	21	23	24	46	267	109	58	40
12	48	33	22	18	19	22	25	64	308	100	63	42
13	48	37	19	18	19	22	25	82	192	100	57	40
14	46	33	18	18	18	23	27	91	160	100	52	42
15	46	24	19	19	18	23	30	82	175	94	57	42
16	46	27	18	19	18	24	26	96	210	89	53	42
17	43	29	18	19	18	22	27	100	247	82	50	42
18	43	27	18	19	18	22	26	128	228	77	47	41
19	43	27	18	19	23	22	26	100	287	70	48	40
20	43	25	18	18	24	22	32	70	308	67	50	38
21	43	27	21	21	24	21	32	59	308	67	48	38
22	50	25	21	21	22	22	32	59	330	67	46	37
23	50	27	21	21	22	21	30	67	352	64	62	36
24	62	27	21	21	22	22	27	82	330	60	59	36
25	54	27	21	21	22	22	26	109	308	60	57	47
26	50	25	22	21	23	22	27	100	287	54	52	54
27	50	27	22	21	23	24	32	82	287	64	51	53
28	46	27	22	18	23	24	43	77	247	57	48	46
29	50	27	22	19	.....	23	50	100	228	54	47	46
30	46	27	21	19	.....	24	56	105	228	52	48	50
31	46	.....	21	21	.....	24	.....	133	.....	49	47	.....

Daily discharge, in second-feet, of Cottonwood Creek below Hot Springs near Buena Vista, Colo., for the years ending Sept. 30, 1915–1917—Continued.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1915–16.												
1	45	31	29	24	22	21	22	44	169	201	149	59
2	44	30	27	25	23	21	23	49	169	199	116	57
3	42	30	27	25	22	21	24	38	179	199	109	57
4	39	30	27	24	22	20	23	44	203	186	123	54
5	38	30	27	24	22	21	22	47	179	166	105	54
6	38	30	27	24	22	20	23	58	169	166	100	54
7	39	30	27	22	22	20	21	71	155	155	100	54
8	38	30	27	23	22	21	22	96	149	160	94	54
9	38	30	27	24	22	21	22	111	186	160	94	52
10	38	30	27	24	22	22	23	136	239	166	89	50
11	39	26	27	24	22	22	24	136	279	146	85	64
12	40	22	27	21	22	22	23	123	300	128	85	57
13	39	24	27	22	21	22	25	100	343	138	85	57
14	38	22	27	22	21	22	24	96	343	128	105	57
15	40	25	27	22	22	21	24	78	343	120	94	54
16	40	25	27	22	21	21	24	60	343	128	94	52
17	40	25	26	22	21	21	27	70	389	120	89	51
18	39	27	25	24	21	22	29	60	389	120	85	50
19	40	29	25	22	21	23	29	67	389	114	82	50
20	40	30	25	21	21	24	26	70	389	109	77	49
21	40	30	25	21	21	25	25	64	389	98	74	48
22	39	30	25	22	21	24	30	64	343	92	70	47
23	39	30	25	22	21	25	36	57	239	89	64	48
24	39	30	25	22	21	24	38	57	203	85	70	49
25	38	29	25	22	21	21	40	67	221	80	70	49
26	37	29	25	22	20	21	44	70	203	85	70	48
27	37	30	24	22	21	22	48	70	203	89	68	46
28	35	26	25	23	21	22	52	74	221	89	64	46
29	35	27	25	22	21	22	59	78	221	85	64	44
30	35	29	25	24	.....	22	48	96	203	133	70	44
31	34	.....	25	22	.....	24	.....	118	.....	120	64	.....

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1916–17.												
1	42	40	33	28	25	22	20	25	36	283	126	46
2	46	40	33	27	25	22	20	24	33	304	118	45
3	45	38	33	27	25	22	20	23	36	283	114	45
4	46	38	33	27	25	22	22	24	50	263	109	44
5	43	35	33	27	25	23	21	23	59	243	109	44
6	49	33	33	27	25	22	22	24	52	236	103	45
7	52	38	28	27	24	23	19	24	52	228	103	48
8	50	35	26	27	24	24	21	24	64	228	92	46
9	50	33	32	27	24	24	22	22	109	236	89	45
10	50	40	32	27	24	22	22	23	166	263	83	44
11	50	38	32	27	24	22	21	22	206	228	103	43
12	50	35	32	27	24	23	21	25	217	192	83	46
13	50	30	32	27	24	23	21	30	283	182	92	43
14	48	30	32	26	24	22	21	32	304	172	92	48
15	47	33	32	26	22	22	21	44	304	172	89	45
16	46	35	32	27	23	21	21	50	348	172	83	44
17	45	35	32	27	24	22	20	59	348	160	83	44
18	42	35	31	27	24	21	20	64	442	152	75	42
19	42	35	30	27	22	22	20	72	394	143	75	41
20	40	37	30	27	23	22	20	64	325	152	75	40
21	35	35	30	27	24	22	20	48	325	138	64	42
22	42	35	30	26	24	22	22	40	325	133	59	40
23	42	35	31	26	24	22	26	40	225	138	56	40
24	44	35	30	26	24	21	28	38	348	138	56	40
25	40	33	30	27	23	22	29	37	370	182	56	40
26	43	35	30	27	23	19	30	36	370	217	50	39
27	42	35	29	27	24	20	26	35	370	172	52	39
28	42	35	30	26	22	22	24	35	370	152	59	39
29	40	33	30	26	.....	24	24	34	348	143	56	39
30	40	33	30	25	.....	22	24	32	325	133	52	39
31	38	.....	30	25	.....	22	.....	32	.....	133	48	.....

Monthly discharge of Cottonwood Creek below Hot Springs, near Buena Vista, Colo., for the years ending September 30, 1915–17.

Month.	Discharge in second-feet.			Run-off (total in acre-feet).
	Maximum.	Minimum.	Mean.	
1914–15.				
October	62	43	49.0	3,010
November	43	24	31.5	1,870
December	28	18	22.0	1,350
January	21	18	19.5	1,200
February	24	18	20.2	1,120
March	24	21	22.5	1,380
April	56	24	29.0	1,730
May	133	32	70.7	4,350
June	352	89	222	13,200
July	221	49	167	10,300
August	96	40	52.8	3,250
September	54	36	42.8	2,550
The year	352	18	57.4	45,310
1915–16.				
October	45	34	38.8	2,390
November	31	22	28.2	1,680
December	29	25	26.1	1,600
January	25	21	22.7	1,400
February	23	20	21.4	1,230
March	25	20	21.9	1,350
April	59	21	30.0	1,790
May	136	38	76.4	4,700
June	389	149	258	15,400
July	201	80	131	8,060
August	149	64	87.4	5,370
September	64	44	51.8	3,080
The year	389	20	66.1	48,000
1916–17.				
October	52	35	44.5	2,740
November	40	30	35.2	2,090
December	33	26	31.0	1,910
January	28	25	26.7	1,640
February	25	22	23.9	1,330
March	24	19	22.1	1,360
April	30	19	22.3	1,330
May	72	22	35.6	2,190
June	442	33	243	14,500
July	304	133	193	11,900
August	126	48	80.8	4,970
September	48	39	42.8	2,550
The year	442	19	66.9	48,500

CHALK CREEK (UPPER STATION) NEAR ST. ELMO, COLO.

LOCATION.—In sec. 27, T. 15 S., R. 80 W., a quarter of a mile below power plant of Tin Cup Gold Dredging Co., and 1¼ miles below St. Elmo, in Chaffee County. Nearest tributary, Coal Creek, enters a quarter of a mile below.

DRAINAGE AREA.—48 square miles (measured on Forest Atlas).

RECORDS AVAILABLE.—November 15, 1913, to September 30, 1917.

GAGE.—Friez water-stage recorder on left bank.

DISCHARGE MEASUREMENTS.—Made from footbridge near gage or by wading.

CHANNEL AND CONTROL.—Bed composed of coarse gravel. Control a short distance below gage at small rapids which shifted during 1917 highwater. Banks not subject to overflow.

EXTREMES OF DISCHARGE.—Maximum stage during year, from water-stage recorder, 3.3 feet at 7 p. m. June 16 (discharge, 545 second-feet); minimum discharge, 9 second-feet during February and March.

ICE.—Stage-discharge relation not seriously affected by ice except occasionally for short periods.

DIVERSIONS.—No court decrees for diversions of water that is not returned to the stream above the station. Below there are decrees for diversion of 133 second-feet from Chalk Creek.

REGULATION.—Low-water flow regulated to a certain extent by a small reservoir at St. Elmo, formed by the diversion dam for the Tin Cup Gold Dredging Co.'s power house.

ACCURACY.—Stage-discharge relation not permanent but shifted gradually from December 22 to June 15; permanent for remainder of year. Rating curve for period, October 1 to June 15 well defined between 8 and 200 second-feet; curve for June 16 to September 30 well defined between 16 and 280 second-feet. Water-stage recorder gave accurate record except for a few days during winter when ice formed in gage well. Daily discharge ascertained by applying to rating table mean daily gage height determined by inspecting recorder graph; shifting-control method used December 22 to June 15. Records good except those for period December 22 to June 15, which are fair.

Discharge measurements of Chalk Creek (upper station) near St. Elmo, Colo., during the year ending Sept. 30, 1917.

Date.	Made by—	Gage height.	Discharge.	Date.	Made by—	Gage height.	Discharge.
		Feet.	*Sec.-ft.*			*Feet.*	*Sec.-ft.*
Oct. 28	P. V. Hodges	1.34	23.1	Feb. 19	T. J. Watkins	0.97	9.6
Dec. 16	T. J. Watkins	1.15	12.2	June 29	H. W. Fear	2.33	253
Jan. 15	do	[a] 1.26	10.0	July 17	Robert Follansbee	1.78	102

[a] Stage-discharge relation affected by ice.

Daily discharge, in second-feet, of Chalk Creek (upper station) near St. Elmo, Colo., for the year ending Sept. 30, 1917.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1	17	19	12	11	11	9	10	23	90	296	104	27
2	22	18	12	11	10	9	11	23	86	260	86	28
3	22	15	12	11	10	9	12	24	124	245	81	26
4	18	15	12	11	10	10	28	26	165	227	79	25
5	16	15	12	11	10	10	31	22	162	218	81	23
6	27	15	12	11	10	10	18	26	143	218	72	26
7	27	12	10	11	10	10	22	22	180	212	64	26
8	32	13	10	11	10	10	16	19	228	239	53	25
9	27	13	10	12	10	10	16	22	309	272	48	23
10	27	13	12	12	10	10	12	23	366	236	58	22
11	31	12	12	12	10	10	12	27	330	197	65	23
12	28	12	12	10	10	10	14	26	339	176	81	23
13	24	12	12	9	10	9	14	36	387	155	75	22
14	26	12	12	9	10	9	16	68	426	145	64	23
15	26	12	12	10	10	9	13	103	432	130	52	22
16	26	12	12	10	10	10	12	134	431	120	50	21
17	30	12	13	10	10	10	12	155	419	108	49	21
18	29	12	13	10	10	10	12	168	416	104	48	20
19	25	12	13	11	10	10	12	138	395	116	45	20
20	23	12	13	12	10	9	16	101	371	106	40	20
21	23	12	13	12	9	9	19	86	353	98	37	20
22	23	12	14	12	9	9	23	77	365	98	34	20
23	22	12	13	12	9	9	31	79	365	118	33	20
24	23	12	12	12	9	9	44	97	365	150	31	20
25	20	12	12	12	9	9	50	93	359	188	29	19
26	23	12	10	12	9	9	46	77	338	275	27	20
27	24	12	10	12	9	10	35	70	320	197	29	20
28	23	12	10	13	9	10	30	77	308	167	31	19
29	24	12	10	12	.....	23	27	82	323	152	28	19
30	22	12	11	12	.....	12	27	84	320	140	27	19
21	20	.....	12	12	.....	10	.....	86	.....	130	26	.....

NOTE.—Stage-discharge relation affected by ice Nov. 12-25, Dec. 7-15, Dec. 26 to Jan. 26, Feb. 1 to Mar. 8, and Mar. 24-27; discharge estimated from discharge measurements, observer's notes, and weather records. Discharge estimated Mar. 18-20, and Apr. 1-2, when gage did not operate.

Monthly discharge at Chalk Creek (upper station) near St. Elmo, Colo., for the year ending Sept. 30, 1917.

Month.	Discharge in second-feet.			Run-off (total in acre-feet).
	Maximum.	Minimum.	Mean.	
October	32	16	24.2	1,490
November	19	12	12.9	768
December	14	10	11.8	726
January	13	9	11.2	689
February	11	9	9.75	541
March	23	9	10.1	621
April	50	10	21.4	1,270
May	168	19	67.5	4,150
June	432	86	307	18,300
July	296	98	177	10,900
August	104	26	52.5	3,230
September	28	19	22.1	1,320
The year	432	9	60.7	44,000

SOUTH FORK OF ARKANSAS RIVER AT PONCHA, COLO.

LOCATION.—In sec. 10, T. 49 N., R. 8 E., at single-span highway bridge about half a mile from Poncha, in Chaffee County. Nearest tributary, Poncha Creek, enters one-fourth mile below.

DRAINAGE AREA.—140 square miles (measured on Forest atlas).

RECORDS AVAILABLE.—January 14, 1911, to September 30, 1917.

GAGE.—Vertical staff on left bridge abutment; read by J. M. Cuenin. Datum lowered 1.00 foot August 19, 1914.

DISCHARGE MEASUREMENTS.—Made from bridge or by wading nearby.

CHANNEL AND CONTROL.—Bed composed of coarse gravel and small boulders; rough. Control 20 feet below gage at small rapids, may shift slightly. Banks not subject to overflow.

EXTREMES OF DISCHARGE.—Maximum stage recorded during year, 3.7 feet during night of June 19, as determined by high-water marks on gage (discharge, 449 second-feet); minimum stage, 0.55 foot at 6 p. m. April 26 (discharge, 1.8 second-feet).

ICE.—Stage-discharge relation only slightly affected by ice as river is kept open by springs.

DIVERSIONS.—Court decrees for diversions of 32 second-feet from the South Fork above station, and 29 second-feet below.

REGULATION.—None.

ACCURACY.—Stage-discharge relation not permanent; affected by ice for short periods in December and January. Standard rating curve fairly well defined. Gage read to hundredths twice daily except during high water, when a third reading was obtained from high-water mark of previous night. Daily discharge ascertained by shifting-control method. Records good.

Discharge measurements of South Fork of Arkansas River at Poncha, Colo., during the year ending Sept. 30, 1917.

Date.	Made by—	Gage height.	Discharge.	Date.	Made by—	Gage height.	Discharge.
		Feet.	*Sec. ft.*			*Feet.*	*Sec.-ft.*
Oct. 26	P. V. Hodges	1.28	30.8	June 5	H. W. Fear	1.16	18.6
Jan. 17	T. J. Watkins	1.45	39.4	27	H. E. Turner	2.40	166
Feb. 20	....do	1.49	38.9				

Daily discharge, in second-feet, of South Fork of Arkansas River at Poncha, Colo., for the year ending Sept. 30, 1917.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1	14	31	45	39	32	37	24	14	5	117	50	11
2	14	31	44	36	33	36	23	8	6	110	43	16
3	14	29	43	36	34	34	22	6	5	102	33	14
4	14	28	44	36	30	32	20	4	10	88	32	12
5	13	26	42	35	30	34	12	3	28	82	26	12
6	13	25	45	35	25	29	10	2	14	76	22	12
7	14	29	37	39	29	39	10	3	36	82	14	13
8	43	28	36	37	31	26	10	3	48	82	13	10
9	25	26	30	36	32	32	8	3	130	82	13	8
10	26	36	30	36	33	29	9	3	212	88	31	9
11	28	30	29	42	33	29	7	3	202	88	36	10
12	31	39	29	37	31	26	6	3	204	76	39	11
13	30	33	31	37	29	25	5	3	194	65	31	11
14	28	25	36	37	22	27	5	3	298	65	27	11
15	31	39	42	37	28	26	5	8	348	65	24	10
16	30	47	43	37	29	31	4	18	324	60	24	11
17	31	53	44	39	29	31	4	43	324	50	26	60
18	29	47	45	37	29	31	4	58	327	45	29	61
19	28	41	41	40	36	25	4	48	399	55	26	12
20	28	41	40	33	35	22	3	32	327	45	26	12
21	28	46	36	22	31	24	2	20	260	43	21	12
22	26	47	43	25	29	20	2	11	240	41	27	12
23	34	43	43	28	29	21	4	9	260	55	29	8
24	35	43	41	31	36	24	2	7	242	95	25	6
25	29	43	38	34	29	23	2	6	222	124	20	5
26	53	43	36	33	29	21	2	5	194	157	48	6
27	38	43	37	32	30	22	2	8	175	124	15	6
28	31	43	38	32	36	27	2	10	184	76	18	6
29	38	46	39	31	.....	28	4	10	148	70	17	5
30	39	45	43	31	.....	23	8	7	132	70	18	4
31	31	.....	44	31	.....	22	.....	3	.....	70	17	.....

NOTE.—Stage-discharge relation affected by ice Dec. 27-28, Jan. 13-15, 22-24; discharge estimated from observer's notes and weather records.

Monthly discharge of South Fork of Arkansas River at Poncha, Colo., for the year ending Sept 30, 1917.

Month.	Discharge in second-feet.			Run-off (total in acre-feet).
	Maximum.	Minimum.	Mean.	
October	53	13	28.0	1,720
November	53	25	37.5	2,230
December	45	29	39.2	2,410
January	42	22	34.5	2,120
February	36	22	30.7	1,700
March	37	20	27.6	1,700
April	24	2	7.5	446
May	58	2	11.7	719
June	399	5	183	10,900
July	157	41	79.0	4,860
August	50	13	26.5	1,630
September	61	4	13.2	786
The year	399	2	43.1	31,200

PONCHA CREEK AT PONCHA, COLO.

LOCATION.—In sec. 10, T. 49 N., R. 8 E., at single-span highway bridge near Poncha in Chaffee County, about one-fourth mile above mouth of creek.

DRAINAGE AREA.—89 square miles (measured on Forest atlas).

RECORDS AVAILABLE.—January 14, 1911, to September 30, 1917.

GAGE.—Vertical staff on downstream side of left abutment; read by J. M. Cuenin. Gage originally 20 feet upstream on opposite bank; moved to present site on May 6, 1914, and datum lowered 1.00 foot.

DISCHARGE MEASUREMENTS.—Made from bridge or by wading.

CHANNEL AND CONTROL.—Bed composed of coarse gravel which shifts slightly; no well-defined control. Banks are overflowed to a small extent during extremely high water.

EXTREMES OF DISCHARGE.—Maximum stage during year, 2.9 feet during nights of June 14 and 15, determined from high-water mark on gage (discharge, 233 second-feet); minimum stage, 1.10 feet at 8.30 a. m. November 12, 13, and 14 (discharge, 3 second-feet).

ICE.—Stage-discharge relation only slightly affected by ice as creek is kept open by springs.

DIVERSIONS.—Court decrees for diversions of 7 second-feet above station but none below.

REGULATION.—None.

ACCURACY.—Stage-discharge relation slightly shifting; affected by ice for short periods during November, December, and January. Rating curve well defined between 2 and 16 second-feet; fairly well defined between 16 and 140 second-feet. Gage read to hundredths twice daily; during certain periods the maximum stage which occurs during the night is also determined from water marks. Daily discharge ascertained by applying to rating table the mean daily gage height obtained from either two or three readings; shifting-control method used for period January 1 to September 30. Records good.

Discharge measurements of Poncha Creek at Poncha, Colo., during the year ending Sept. 30, 1917.

Date.	Made by—	Gage height.	Discharge.	Date.	Made by—	Gage height.	Discharge.
		Feet.	*Sec.-ft.*			*Feet.*	*Sec.-ft.*
Oct. 26	P. V. Hodges	1.12	2.8	Feb. 20	T. J. Watkins	1.35	8.9
Jan. 17	T. J. Watkins	1.38	9.7	June 5	H. W. Fear	2.18	72

Daily discharge, in second-feet, of Poncha Creek at Poncha, Colo., for the year ending Sept. 30, 1917.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1	7	8	12	10	9	6	11	20	48	50	23	6
2	6	10	12	9	9	7	11	22	36	44	20	7
3	6	9	11	9	9	7	9	20	40	45	19	7
4	6	7	12	8	9	8	9	23	80	40	17	7
5	7	6	12	9	9	9	8	20	76	33	16	6
6	7	7	12	9	8	8	8	18	65	34	14	6
7	7	7	12	9	8	9	9	18	82	34	12	6
8	9	5	12	10	8	8	10	20	120	38	11	6
9	7	6	12	9	8	8	10	20	131	38	11	6
10	7	9	10	9	8	8	14	20	154	40	13	6
11	9	8	10	8	9	8	11	18	142	36	12	6
12	9	6	9	8	9	8	9	18	142	31	13	7
13	10	3	7	10	8	10	15	18	142	26	13	6
14	12	3	9	10	8	10	15	18	166	25	14	7
15	12	6	10	12	8	7	17	35	192	23	13	6
16	12	7	10	12	8	10	20	52	120	21	12	7
17	12	8	10	9	8	10	21	83	120	20	13	6
18	10	8	10	8	7	9	21	110	95	22	13	6
19	7	8	12	9	8	9	19	110	131	23	12	8
20	7	8	10	9	8	10	19	92	120	20	11	7
21	7	9	8	8	8	8	19	50	92	20	10	7
22	8	10	10	8	8	10	20	68	88	16	9	8
23	10	11	10	8	8	11	30	55	88	16	9	9
24	6	12	10	8	11	11	30	55	74	24	8	9
25	6	12	8	8	9	8	31	50	80	33	8	9
26	6	13	8	8	9	11	33	47	68	35	7	9
27	6	13	8	8	9	7	30	40	64	27	8	10
28	7	12	9	8	6	12	24	40	36	25	7	10
29	9	12	11	8	.....	16	22	40	30	23	7	9
30	9	12	10	8	.....	10	20	40	47	23	7	8
31	9	.....	11	9	.....	4	.....	38	.....	26	6	.....

NOTE.—Stage-discharge relation affected by ice Nov. 21–23, Dec. 26–28 and Jan. 22–24; discharge interpolated.

Monthly discharge of Poncha Creek at Poncha, Colo., for the year ending Sept. 30, 1917.

Month.	Discharge in second-feet.			Run-off (total in acre-feet).
	Maximum.	Minimum.	Mean.	
October	12	6	8.13	500
November	13	3	8.50	506
December	12	7	10.2	627
January	12	8	8.87	545
February	11	6	8.36	464
March	16	4	8.94	550
April	33	8	17.5	1,040
May	110	18	41.2	2,530
June	192	30	95.6	5,690
July	50	16	29.4	1,810
August	23	6	11.9	732
September	10	6	7.23	430
The year	192	3	21.3	15,400

WEST BEAVER CREEK NEAR VICTOR, COLO.

LOCATION.—In sec. 30, T. 16 S., R. 68 W., at Skagway power station of Arkansas Valley Railway, Light & Power Co., about 7 miles southeast of Victor, in Fremont County.

DRAINAGE AREA.—70 square miles.

RECORDS AVAILABLE.—January 1, 1905, to September 30, 1917.

DETERMINATION OF DISCHARGE.—Water used through power house is brought by pipe line from reservoir 3½ miles upstream; quantity is measured hourly by weir, and a quantity representing the gain or loss in the reservoir during the period is added or subtracted. To determine the natural flow of the stream the seepage through the dam is measured by weir and added to the total quantity thus obtained. This method takes no account of evaporation from the surface of the reservoir.

DIVERSIONS.—Above the power reservoir are three reservoirs from which the town of Victor obtains its municipal supply. In the upper basin are four reservoirs from which water is diverted into Lake Moraine and thence by natural channels to Colorado Springs, where it is used as municipal supply. Filings for these diversions from the basin—52 second-feet by ditch and 5 second-feet by pipe line—have not yet been adjudicated. The town of Altman, for municipal supply, has also filed on five reservoir sites in the upper basin, having a combined capacity of 2,300 acre-feet. Below the power plant there are adjudicated decrees for diversions of 57 second-feet from Beaver Creek, which is formed by East and West Beaver creeks. In addition there is an irrigation reservoir in operation which has a filing for 4,760 acre-feet.

COOPERATION.—Records are furnished through courtesy of Arkansas Valley Railway Light & Power Co., and are said to be probably correct within 5 per cent.

Monthly discharge of West Beaver Creek near Victor, Colo., for the year ending September 30, 1917.

Month.	Discharge in second-feet.		Month.	Discharge in second-feet.	
	Mean.	Total in acre-feet.		Mean.	Total in acre-feet.
October	7.82	481	May	13.8	848
November	5.84	348	June	21.6	1,290
December	4.55	280	July	13.9	855
January	3.99	245	August	12.3	756
February	3.61	200	September	11.7	696
March	5.26	323			
April	9.97	593	The year	9.55	6,920

BOEHMER CREEK NEAR PIKES PEAK, COLO.

LOCATION.—In NW. ¼ sec. 32, T. 14 S., R. 68 W., 3½ miles south of Pikes Peak, El Paso County, above Little Beaver and Sackett creeks. Elevation of station, 11,000 feet.

DRAINAGE AREA.—7.2 miles (measured on topographic map). Of this area about 75 per cent is above timber line. To the natural drainage has been added that of West Beaver Creek above Strickler tunnel intake.

RECORDS AVAILABLE.—October 1, 1909, to September 30, 1917.

DETERMINATION OF DISCHARGE.—Flow measured by sharp-crested weir, 60 inches long, with complete end contraction. A stake is driven into bed of stream in pool above weir, so that its head is level with crest of weir; depth of water over stage is measured by steel scale. Discharge is computed by Francis formula.

REGULATION.—Flow regulated by series of three reservoirs having an aggregate capacity of 1,400 acre-feet; reservoirs operated by Colorado Springs water department.

DIVERSIONS.—Water diverted above weir for use in Victor is measured and added to flow over Boehmer Creek weir to show total run-off.

COOPERATION.—Monthly discharge computed from records furnished by Colorado Springs Water Department.

Monthly discharge of Boehmer Creek near Pikes Peak, Colo., for the year ending September 30, 1917.

[Drainage area, 7.2 square miles.]

Month.	Discharge in second-feet.				Run-off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on drainage area.	Total in acre-feet.
October	13.5	1.82	5.94	0.825	0.95	365
November	2.23	2.23	2.23	.310	.35	133
December	1.58	1.13	1.56	.216	.25	95.9
January	1.58	1.35	1.42	.197	.23	87.3
February	1.13	1.13	1.13	.157	.16	62.8
March	1.13	.82	1.11	.154	.18	68.2
April	2.07	.82	1.07	.149	.17	63.7
May	2.07	1.23	1.82	.253	.29	112
June	15.1	1.82	8.01	1.11	1.24	477
July	7.92	4.72	6.36	.883	1.02	391
August	10.4	3.81	7.97	1.11	1.28	490
September	8.31	2.04	2.36	.328	.37	140
The year	15.1	.82	3.51	.488	6.49	2,490

LITTLE BEAVER CREEK NEAR PIKES PEAK, COLO.

LOCATION.—In NW. ¼ NW. ¼ sec. 32, T. 14 S., R. 68 W., just above mouth of creek 3½ miles south of Pikes Peak, El Paso County, Little Beaver Creek enters Boehmer Creek from the west 0.3 mile above reservoir No. 4. Elevation of station, 11,000 feet.

DRAINAGE AREA.—1.00 square mile (measured on topographic map). Approximately 25 per cent of area above timber line; remainder sparsely timbered.

RECORDS AVAILABLE.—October 1, 1909, to September 30, 1917.

DETERMINATION OF DISCHARGE.—Flow measured by sharp-crested weir, 24 inches long, with complete end contraction. A stake is driven into bed of stream in pool above weir, so that its head is level with crest of weir; depth of water over stake is measured by steel scale. Discharge is computed by Francis formula.

DIVERSIONS.—None.

REGULATION.—None.

COOPERATION.—Monthly discharge computed from records furnished by Colorado Springs Water Department.

Monthly discharge of Little Beaver Creek near Pikes Peak, Colo., for the year ending Sept. 30, 1917.

[Drainage area, 1.00 square mile.]

Month.	Discharge in second-feet.				Run-off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on drainage area.	Total in acre-feet.
October	0.30	0.22	0.28	0.28	0.32	17.2
November	.10	.10	.10	.10	.11	6.0
December	.10	.00	.05	.05	.06	3.1
January	.00	.00	.00	.00	.00	.0
February	.00	.00	.00	.00	.00	.0
March	.00	.00	.00	.00	.00	.0
April	.00	.00	.00	.00	.00	.0
May	.00	.00	.00	.00	.00	.0
June	3.29	.10	1.82	1.82	2.03	108
July	2.97	.63	1.15	1.15	1.33	70.7
August	.86	.63	.75	.75	.86	52.9
September	.93	.63	.78	.78	.87	46.4
The year	3.29	.00	.41	.41	5.58	304

SACKETT CREEK NEAR PIKES PEAK, COLO.

LOCATION.—In the SE. ¼ NW. ¼ sec. 32, T. 14 S., R. 68 W., just above mouth of creek, 4 miles southeast of Pikes Peak, El Paso County. Sackett Creek enters Boehmer Creek from the north a short distance above reservoir No. 4. Elevation of station, 11,000 feet.

DRAINAGE AREA.—0.65 square mile (measured on topographic map). About 30 per cent of area above timber line, and remainder sparsely timbered.

RECORDS AVAILABLE.—October 1, 1909, to September 30, 1917.

DETERMINATION OF DISCHARGE.—Flow measured by sharp-crested weir 24 inches long with complete end contraction. A stake is driven into bed of stream in pool above weir, so that its head is level with crest of weir; depth of water over stake is measured by steel scale. Discharge is computed by Francis formula.

DIVERSIONS.—None.

REGULATION.—None.

COOPERATION.—Monthly discharge computed from records furnished by Colorado Springs Water Department.

Monthly discharge of Sackett Creek near Pikes Peak, Colo., for the year ending Sept. 30, 1917.

[Drainage area, 0.65 square mile.]

Month.	Discharge in second-feet.				Run-off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on drainage area.	Total in acre-feet.
October	0.10	0.06	0.09	0.138	0.16	5.53
November	.00	.00	.00	.00	.00	.0
December	.00	.00	.00	.00	.00	.0
January	.00	.00	.00	.00	.00	.0
February	.00	.00	.00	.00	.00	.0
March	.00	.00	.00	.00	.00	.0
April	.00	.00	.00	.00	.00	.0
May	.63	.05	.17	.262	.30	10.5
June	2.96	.36	1.26	1.94	2.16	75.0
July	.82	.16	.42	.646	.74	25.8
August	.40	.16	.19	.292	.34	11.7
September	.16	.05	.11	.169	.19	6.55
The year	2.96	.00	.19	.292	3.89	135

LION CREEK NEAR HALFWAY, COLO.

LOCATION.—In NW. ¼ sec. 15, T. 14 S., R. 68 W., at mouth of creek, half a mile southwest of Halfway, El Paso County. Lion Creek enters Ruxton Creek from the west. Elevation of station, 9,250 feet.

DRAINAGE AREA.—2.00 square miles (measured on topographic map). Includes all area above the Crater apparently tributary to Sheep Creek. About 30 per cent of area above timber line, and remainder sparsely timbered.

RECORDS AVAILABLE.—April 1, 1908, to September 30, 1917.

DETERMINATION OF DISCHARGE.—Flow measured by sharp-crested weir 30 inches long with complete end contraction. A stake is driven into bed of stream in pool above weir, so that its head is level with crest of weir; depth of water over stake is measured by steel scale. Discharge is computed by Francis formula.

DIVERSIONS.—None.

REGULATION.—None.

COOPERATION.—Monthly discharge computed from records furnished by Colorado Springs Water Department.

Monthly discharge of Lion Creek near Halfway, Colo., for the year ending September 30, 1917.

[Drainage area, 2.00 square miles.]

Month.	Discharge in second-feet.				Run-off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on drainage area.	Total in acre-feet.
October	1.30	0.97	1.14	0.570	0.66	70.1
November	1.03	.73	.84	.420	.47	50.0
December	.79	.56	.70	.350	.40	43.0
January	.62	.32	.54	.270	.31	33.2
February	.67	.36	.52	.260	.27	28.9
March	.56	.41	.47	.235	.27	28.9
April	1.03	.51	.71	.355	.40	42.2
May	1.98	.56	1.05	.525	.61	64.6
June	1.98	.73	1.06	.530	.59	63.1
July	.91	.56	.71	.355	.41	43.7
August	1.17	.73	.92	.460	.53	56.6
September	1.24	.73	.94	.470	.52	55.9
The year	1.98	.32	.80	.400	5.44	580

SHEEP CREEK NEAR HALFWAY, COLO.

LOCATION.—In SW. ¼ sec. 11, T. 14 S., R. 68 W., a quarter of a mile west of Halfway, El Paso County. No tributary between station and mouth, a short distance below. Sheep Creek enters Ruxton Creek from the west a short distance above Halfway. Elevation of station, 9,100 feet.

DRAINAGE AREA.—0.73 square mile (measured on topographic map). Does not include any area above the Crater as this is most probably tributary to Lion Creek. Practically all below timber line, but sparsely timbered.

RECORDS AVAILABLE.—April 1, 1908, to September 30, 1917.

DETERMINATION OF DISCHARGE.—Flow measured by sharp-crested weir 30 inches long with complete end contraction. A stake is driven into bed of stream in pool above weir, so that its head is level with crest of weir; depth of water over stake is measured by steel scale. Discharge is computed by Francis formula.

DIVERSIONS.—None.

REGULATION.—None.

COOPERATION.—Monthly discharge computed from records furnished by Colorado Springs Water Department.

Monthly discharge of Sheep Creek near Halfway, Colo., for year ending September 30, 1917.

[Drainage area, 0.73 square miles.]

Month.	Discharge in second-feet.				Run-off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on drainage area.	Total in acre-feet.
October	0.67	0.46	0.52	0.711	0.82	32.0
November	.46	.36	.37	.506	.56	22.0
December	.36	.27	.28	.383	.44	17.2
January	.27	.13	.19	.260	.30	11.7
February	.16	.04	.11	.151	.16	6.11
March	.51	.10	.16	.219	.25	9.84
April	.67	.13	.37	.507	.57	22.0
May	1.45	.32	.87	1.19	1.37	53.5
June	1.45	.51	.86	1.18	1.32	51.2
July	.56	.32	.45	.616	.71	27.7
August	.61	.19	.48	.658	.76	29.5
September	.51	.32	.39	.534	.60	23.2
The year	1.45	.04	.42	.575	7.86	306

SOUTH RUXTON CREEK AT HALFWAY, COLO.

LOCATION.—In SW. ¼ sec. 11, T. 14 S., R. 68 W., just above hydroelectric intake at Halfway, El Paso County. No tributary between station and mouth, a short distance below. South Ruxton Creek enters Ruxton Creek from the south at Halfway. Elevation of station 9,000 feet.

DRAINAGE AREA.—3.95 square miles (measured on topographic map). Practically all below timber line and heavily timbered.

RECORDS AVAILABLE.—June 1, 1906, to September 30, 1917.

DETERMINATION OF DISCHARGE.—Flow measured by two sharp-crested weirs with complete end contraction. Discharge is computed by Francis formula. The main weir is one-third mile above the mouth of the creek and a short distance above the hydroelectric intake, which has a capacity of 4.63 second-feet. The second weir is half-way between the main weir and the mouth of the creek and measures the inflow chiefly from springs below the intake and a small amount of seepage. At all times except during high water the capacity of the intake is sufficient to take the entire flow passing the main weir, and the flow at the two weirs is combined to give the total run-off of the basin. During high water the excess passing the intake and recorded at the lower weir does not represent increased flow between the weirs, and is discarded. In its place is used a constant quantity based on inflow and seepage at other times.

DIVERSIONS.—None.

REGULATION.—None.

COOPERATION.—Monthly discharge computed from records furnished by Colorado Springs Water Department.

Monthly discharge of South Ruxton Creek at Halfway, Colo., for the year ending September 30, 1917.

[Drainage area, 3.95 square miles.]

Month.	Discharge in second-feet.				Run-off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on drainage area.	Total in acre-feet.
October	2.40	1.90	2.08	0.527	0.61	128
November	1.90	1.38	1.62	.411	.46	96.4
December	1.45	1.17	1.32	.334	.39	81.2
January	1.17	.97	1.09	.276	.32	67.0
February	1.03	.85	.96	.243	.25	53.3
March	1.03	.85	.91	.230	.27	56.0
April	1.90	.79	1.14	.289	.32	67.8
May	3.22	1.17	2.15	.544	.63	132
June	5.17	2.93	4.09	1.04	1.16	243
July	3.60	2.49	2.97	.752	.87	183
August	2.84	2.10	2.52	.638	.74	155
September	3.50	1.98	2.38	.603	.67	142
The year	5.17	.79	1.94	.491	6.69	1,400

CABIN CREEK NEAR HALFWAY, COLO.

LOCATION.—In SW. ¼ NW. ¼ sec. 11, T. 14 S., R. 68 W., just above hydroelectric intake, about three-eighths mile north of Halfway, El Paso County. Cabin Creek enters Ruxton Creek half a mile below Halfway. Elevation of station about 9,000 feet.

DRAINAGE AREA.—2.4 square miles (measured on topographic map). About 15 per cent of area above timber line and remainder sparsely timbered.

RECORDS AVAILABLE.—October 1, 1906, to September 30, 1917.

DETERMINATION OF DISCHARGE.—Flow measured by two sharp-crested weirs with complete end contraction. Discharge computed by Francis formula. The main weir is about one-third of a mile above the mouth of the creek and just above the hydroelectric intake. The second weir is 50 feet above the mouth of the creek and measures the flow from springs and small tributaries entering below the intake. Except during high water the measured flow at the weirs is combined to give the total run-off from the basin. During high water the record from the lower weir is discarded and the inflow estimated. (See South Ruxton Creek at Halfway, Colo., p. 27.)

DIVERSIONS.—None.

REGULATIONS.—None.

COOPERATION.—Monthly discharge computed from records furnished by Colorado Springs Water Department.

Monthly discharge of Cabin Creek near Halfway, Colo., for the year ending September 30, 1917.

[Drainage area, 2.4 square miles.]

Month.	Discharge in second-feet.				Run-off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on drainage area.	Total in acre-feet.
October	1.45	0.91	1.13	0.471	0.54	69.5
November	.97	.61	.76	.317	.35	45.2
December	.68	.36	.52	.217	.25	32.0
January	.37	.16	.27	.112	.13	16.6
February	.23	.04	.15	.0625	.07	8.33
March	.46	.13	.21	.0875	.10	12.9
April	.73	.32	.51	.212	.24	30.3
May	2.49	.56	1.57	.654	.75	96.5
June	3.50	1.63	2.51	1.05	1.17	149
July	1.60	1.03	1.30	.542	.62	79.9
August	1.45	.97	1.23	.512	.59	75.6
September	1.60	.97	1.07	.446	.50	63.7
Total	3.50	.04	.94	.392	5.31	680

RED RIVER BASIN.

MEDICINE BLUFF CREEK NEAR LAWTON, OKLA.

LOCATION.—In sec. 18, T. 3 N., R. 12 W., at Medicine Park, 12 miles northwest of Lawton, in Comanche County; nearest tributary, Little Medicine Bluff Creek, enters a few hundred yards above.

DRAINAGE AREA.—About 110 square miles.

RECORDS AVAILABLE.—November 26, 1912, to September 30, 1917.

GAGE.—Stevens water-stage recorder installed February 16, 1915, on left bank one-third mile below Medicine Park Hotel. Original gage was vertical staff on left bank a short distance below hotel, and set to datum 0.68 foot higher than that of the present gage; fall between the two points, 0.18 foot. February 19, 1917, a dam was completed 200 feet downstream, which turned section of the creek into a pool and completely changed control. Datum of water-stage recorder raised.

DISCHARGE MEASUREMENTS.—Made from cable 100 yards above gage or by wading at control.

CHANNEL AND CONTROL.—Bed composed of sand and gravel overlying bedrock. Banks high and not subject to overflow. Control prior to February 19, 1917, a rock ledge in the lowest part of which for a width of 10 feet are boulders; practically permanent; control since February, 1917, crest of concrete dam.

EXTREMES OF DISCHARGE.—Maximum stage during year, from water-stage recorder, 2.45 feet October 8 (discharge, 44 second-feet); minimum discharge 0.2 second-foot during greater part of February, March, and April.

ICE.—Stage-discharge relation not affected by ice.

DIVERSIONS.—The Lawton waterworks diverts about 1.6 second-feet from Lawton reservoir on Medicine Bluff Creek.

REGULATION.—Flow controlled to a great extent by Lawton reservoir, which is 1½ miles upstream; capacity, 14,000 acre-feet.

ACCURACY.—Stage-discharge relation practically permanent before and after completion of dam which forms new control; completely changed by construction of dam. Well-defined rating curve applicable until February 15 and fairly well defined curve after February 19. Operation of water-stage recorder satisfactory until May 6, when it was removed. Daily discharge ascertained by applying to rating table mean daily gage height obtained by inspecting recorder graph. Records good.

Discharge measurements of Medicine Bluff Creek near Lawton, Okla., during the year ending Sept. 30, 1917.

[Made by Robert Follansbee.]

Date.	Gage height.	Discharge.
	Feet.	*Sec.-ft.*
Feb. 15	1.55	[a] 0.5
19	[b] 1.74	11.0
Sept. 29	1.65	[a] 2.5

[a] Estimated. [b] Stage-discharge relation changed by new control.

Daily discharge, in second-feet, of Medicine Bluff Creek near Lawton, Okla., for the year ending Sept. 30, 1917.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.
1	1.5	3.4	4.6	0.5	0.9	0.2	0.2	1.6
2	1.2	1.6	4.4	1.3	.2	.2	.2	1.6
3	1.2	.7	4.4	1.5	.2	.2	.2	1.6
4	1.2	.8	4.4	1.3	.2	.2	.2	.7
5	2.1	.6	4.4	.8	.2	.2	.2	1.1
6	2.8	.9	4.2	.9	.6	.2	.2	1.1
7	7.3	3.8	4.0	.9	.7	.2	.2	.....
8	23	5.4	4.0	.9	1.1	.2	.2	.....
9	4.4	5.2	3.8	1.1	1.3	.2	.2	.....
10	3.6	5.0	3.6	1.6	1.6	.2	.2	.....
11	1.8	5.2	3.6	.8	.7	.2	.2	.....
12	.9	5.4	3.6	2.0	.8	.2	.2	.....
13	1.0	6.2	3.2	1.3	2.8	.2	.2	.....
14	.8	5.2	2.8	.7	1.3	.2	.2	.....
15	1.1	5.0	1.4	.6	1.1	.2	.2	.....
16	1.3	5.6	.7	.9	1.0	.2	.2	.....
17	3.0	5.0	.9	1.1	.8	.2	.2	.....
18	3.0	4.8	1.1	1.0	.6	.2	.2	.....
19	3.4	5.0	1.1	1.1	11.0	.2	.2	.....
20	4.4	5.4	1.1	1.2	.2	.2	.2	.....
21	5.8	6.8	.7	1.3	.2	1.1	.2	.....
22	5.2	6.8	.5	1.8	.2	1.6	.2	.....
23	5.4	5.8	1.2	.9	.2	1.1	.2	.....
24	5.8	5.4	1.3	.9	.2	1.6	.2	.....
25	5.4	5.4	1.3	.9	.2	1.6	.2	.....
26	5.4	5.4	1.5	.9	.2	.7	.2	.....
27	5.4	5.4	1.4	.9	.2	.2	.2	.....
28	5.4	5.2	.5	.9	.2	.2	.7	.....
29	15	5.2	.4	.9	.....	.2	1.1	.....
30	11	5.0	.4	.9	.....	.2	2.0	.....
31	3.4	.....	.4	2.8	.....	.2	.....	.....

NOTE.—Discharge estimated Jan. 24-27 and Feb. 16-18. Discharge for May to September estimated, and represents the leakage from Lawton reservoir. Discharge on Feb. 19 is a temporary flow from water stored in Lawton reservoir.

Monthly discharge of Medicine Bluff Creek near Lawton, Okla., for the year ending Sept. 30, 1917.

Month.	Discharge in second-feet.			Run-off (total in acre-feet).
	Maximum.	Minimum.	Mean.	
October	23	0.8	4.59	282
November	6.8	.6	4.55	271
December	4.6	.4	2.29	141
January	2.8	.5	1.12	68.9
February	11.0	.2	1.03	57.2
March	1.6	.2	.41	25.2
April	2.0	.2	.31	18.4
May	.....	.....	a2.0	123
June	.....	.....	a2.0	119
July	.....	.....	a2.0	123
August	.....	.....	a2.0	123
September	.....	.....	a2.0	119
The year	23	.2	2.03	1,470

a Estimated. Leakage from Lawton reservoir.

Corrected monthly discharge of Medicine Bluff Creek, near Lawton, Okla., for the year ending Sept. 30, 1917.

Month.	Discharge in second-feet, mean.	Run-off, total in acre-feet.	Month.	Discharge in second-feet, mean.	Run-off, total in acre-feet.
October	0	0	May	3.9	240
November	0	0	June	0	0
December	0	0	July	0	0
January	0	0	August	2.4	148
February	1.6	89	September	0	0
March	6.8	418			
April	0	0	The year		895

NOTE.—Record corrected for storage, evaporation, and diversion by Lawton waterworks.

LITTLE MEDICINE BLUFF CREEK NEAR LAWTON, OKLA.

LOCATION.—150 feet below west line of sec. 18, T. 3 N., R. 12 W., half a mile above the mouth of creek and 12½ miles northwest of Lawton, in Comanche County.

DRAINAGE AREA.—About 10 square miles.

RECORDS AVAILABLE.—November 26, 1912, to September 30, 1917.

GAGE.—Vertical staff on left bank; read by J. B. Lenertz. Upstream 200 feet is a gage referred to same datum, which is read by observer during flood to determine slope between it and regular gage.

DISCHARGE MEASUREMENTS.—Made by wading near gage.

CHANNEL AND CONTROL.—Bed composed of ledge rock overlain with sand. Control is rock ledge just below gage. Between station and crest of small dam on Medicine Bluff Creek just below Little Medicine Bluff Creek there is a fall of about 8 feet.

EXTREMES OF DISCHARGE.—Maximum stage recorded during year, 0.25 foot October 15 (discharge, 0.85 second-foot); channel practically dry last part of year.

ICE.—Stage-discharge relation not affected by ice.

DIVERSIONS.—None.

REGULATION.—None.

ACCURACY.—Stage-discharge relation practically permanent. Rating curve well defined. Gage read to half-tenths once daily. Daily discharge ascertained by applying daily gage height to rating table. The discharge being so extremely small it is probable that the percentage error is large, though the actual error in determination is small.

Discharge measurements of Little Medicine Bluff Creek near Lawton, Okla., during the year ending Sept. 30, 1917.

[Made by Robert Follansbee.]

Date.	Gage height.	Discharge.
	Feet.	*Sec.-ft.*
Feb. 19	0.12	[a] 0.1
Sept. 29		0.0

[a] Estimated.

Daily discharge, in second-feet of Little Medicine Bluff Creek near Lawron, Okla., for the year ending Sept. 30, 1917.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
1	0.05	0.10	0.10	0.05	0.05	0.05	0.05
2	.05	.10	.10	.05	.05	.05	.05
3	.05	.10	.10	.05	.05	.05	.05
4	.05	.10	.10	.05	.05	.05	.05
5	.05	.10	.10	.05	.05	.05	.05
6	.05	.10	.10	.05	.05	.05	.05
7	.05	.10	.10	.05	.00	.05	.00
8	.05	.10	.10	.05	.00	.05	.00
9	.05	.25	.10	.05	.00	.05	.00
10	.05	.25	.10	.05	.00	.05	.00
11	.05	.25	.10	.05	.00	.05	.00
12	.10	.20	.05	.05	.00	.25	.00
13	.10	.20	.05	.05	.00	.40	.05
14	.10	.10	.05	.05	.10	.40	.05
15	.85	.10	.05	.00	.10	.40	.05
16	.40	.10	.05	.00	.10	.40	.05
17	.40	.10	.05	.00	.10	.25	.05
18	.25	.10	.00	.00	.10	.25	.05
19	.25	.10	.05	.00	.10	.25	.05
20	.10	.10	.05	.10	.10	.10	.05
21	.10	.25	.05	.10	.10	.10	.05
22	.10	.40	.05	.10	.10	.10	.05
23	.10	.40	.05	.10	.10	.10	.05
24	.10	.25	.05	.10	.10	.10	.05
25	.10	.25	.05	.05	.10	.10	.05
26	.08	.25	.05	.05	.10	.10	.05
27	.08	.25	.05	.05	.05	.10	.05
28	.08	.25	.05	.05	.05	.05	.05
29	.08	.25	.05	.05	.....	.05	.05
30	.10	.10	.05	.05	.....	.05	.05
31	.10	.....	.05	.05	.....	.05	.....

NOTE.—Stream practically dry most of the summer. A discharge of about 0.1 second-foot occurred May 30–31 and August 20–21.

Monthly discharge of Little Medicine Bluff Creek near Lawton, Okla., for the year ending Sept. 30, 1917.

Month.	Discharge in second-feet.			Run-off (total in acre-feet).
	Maximum.	Minimum.	Mean.	
October	0.85	0.05	0.13	8.0
November	.40	.10	.18	10.7
December	.10	.05	.07	4.3
January	.10	.00	.05	3.1
February	.16	.00	.06	3.3
March	.40	.05	.13	8.0
April	.05	.00	.04	2.4
The period	.....	.....	.....	39.8

EVAPORATION STATION NEAR LAWTON, OKLA.

LOCATION.—In a somewhat sheltered bay on the west side of Lawton reservoir, 12 miles northwest of Lawton, in Comanche County.

RECORDS AVAILABLE.—February 20, 1913, to September 30, 1917.

EQUIPMENT FOR MEASUREMENT.—A galvanized iron pan, 3 feet square and 18 inches deep, floating in the center of a skeleton raft 75 feet from shore. In the center of the pan is a vertical needle point, which is the reference point for measuring evaporation. Rainfall measured by rain gage placed on raft from February 20, 1913, to February 20, 1917, when rain gage was moved to dam three-quarters of a mile distant. September 29, 1917, rain gage was again moved to point on shore near evaporation pan.

Daily evaporation, in inches, at Lawton reservoir, near Lawton, Okla., for the year ending Sept. 30, 1917.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1	0.14	0.18	0.06	0.04	.....	0.03	0.08	0.12	0.16	0.35	0.34	0.10
2	.15	.14	.06	.04	.....	.03	.09	.13	.18	.52	.32	.18
3	.13	.16	.05	.04	.....	.03	.07	.10	.20	.10	.30	.26
4	.14	.13	.07	.03	.....	.03	.08	.09	.24	.10	.34	.16
5	.18	.14	.05	.05	.....	.04	.10	.11	.18	.16	.30	.18
6	.17	.09	.05	.04	.....	.06	.11	.23	.24	.22	.66	.20
7	.17	.08	.04	.04	.....	.04	.....	.28	.22	.26	.20	.24
8	.16	.08	.04	.05	.....	.07	.....	.14	.50	.30	.10	.10
9	.13	.06	.06	.05	.....	.05	.....	.00	.24	.32	.20	.12
10	.13	.07	.04	.04	.....	.06	.....	.02	.10	.36	.09	.26
11	.12	.06	.03	.03	.....	.08	.....	.04	.12	.34	.50	.16
12	.11	.05	.02	.03	.....	.10	.....	.10	.16	.32	.28	.20
13	.10	.06	.02	.02	.03	.08	.12	.10	.11	.30	.06	.10
14	.09	.06	.02	.02	.14	.07	.11	.12	.14	.34	.20	.18
15	.09	.05	.02	.02	.....	.06	.13	.11	.18	.30	.22	.25
16	.09	.05	.03	.02	.....	.06	.14	.14	.22	.28	.18	.14
17	.08	.06	.04	.02	.....	.08	.14	.20	.30	.62	.20	.15
18	.10	.08	.03	.02	.....	.09	.15	.24	.26	.34	.18	.12
19	.07	.07	.03	.02	.....	.08	.12	.32	.25	.36	.10	.14
20	.08	.10	.02	.02	.....	.10	.13	.00	.20	.34	.97	.16
21	.09	.09	.02	.03	.05	.10	.14	.00	.28	.32	.18	.18
22	.09	.06	.02	.03	.07	.09	.14	.06	.27	.30	.20	.17
23	.10	.05	.02	.02	.06	.11	.14	.04	.30	.32	.10	.16
24	.04	.06	.02	.02	.07	.10	.12	.08	.24	.06	.20	.18
25	.07	.07	.02	.02	.07	.10	.13	.10	.20	.22	.18	.20
26	.09	.06	.02	.02	.08	.07	.25	.14	.26	.34	.20	.18
27	.09	.04	.02	.02	.04	.09	.11	.18	.28	.36	.24	.36
28	.07	.07	.02	.03	.04	.10	.09	.16	.30	.34	.10	.20
29	.10	.06	.02	.03	.....	.11	.08	.29	.28	.36	.10	.21
30	.12	.05	.02	.04	.....	.10	.20	.08	.30	.34	.15	.18
31	.14	.....	.03	.02	.....	.12	.....	.09	.....	.36	.10	.....

NOTE.—Pan frozen Dec. 12–14, 20–30, Jan. 14–20, 23–26, Mar. 1–4; evaporation estimated. No record Feb. 1–2, 15–20, and Apr. 7–12. Irregularities in daily evaporation due partly to fact that rain gage did not always indicate the amount of precipitation at pan. Oct. 1 to May 2 pan and raft rested on dry ground, owing to subsidence of reservoir level.

Monthly evaporation, in inches, at Lawton reservoir, near Lawton, Okla., for the year ending Sept. 30, 1917.

October	3.43	May	3.81
November	2.38	June	6.91
December	1.01	July	9.55
January	.92	August	7.49
March	2.33	September	5.42

95189°—19—WSP 457——3

INDEX.

	Page.
Accuracy of data and records, degrees of	8–9
Acre-foot, definition of	6
Appropriations, record of	5
Arkansas River at Granite, Colo	11–12
at Salida, Colo	12–14
East Fork of, near Leadville, Colo	9–11
South Fork of, at Poncha, Colo	20–21
Arkansas River basin, gaging-station records in	9–28
Arkansas Valley Railway, Light & Power Co., acknowledgment to	9
Authorization of work	5–6
Boehmer Creek near Pikes Peak, Colo	24
Buena Vista, Colo., Cottonwood Creek near	15–18
Cabin Creek near Halfway, Colo	28
Chalk Creek (upper station) near St. Elmo, Colo	18–20
Colorado State engineer, acknowledgment to	9
Control, definition of	6
Cooperation, record of	9
Cottonwood Creek below Hot Springs, near Buena Vista, Colo	15–18
Current meters, plate showing	6
Data, accuracy of	8–9
explanation of	7–8
Definitions of terms	6
Dickinson, W. E., work of	9
Errors, possibility of	8–9
Evaporation station near Lawton, Okla	32–33
Fear, H. W., work of	9
Follansbee, Robert, work of	9
Friez water-stage recorder, plate showing	7
Gaging station, typical, plate showing	6
Gaging stations, number of	5–6
Granite, Colo., Arkansas River at	11–12
Gurley water-stage recorder, plate showing	7
Halfway, Colo., Cabin Creek near	28
Lion Creek near	26
Sheep Creek near	26–27
South Ruxton Creek at	27–28
Hodges, P. V., work of	9
Hot Springs near Buena Vista, Colo., Cottonwood Creek below	15–18
Lawton, Okla., evaporation station near	32–33
Little Medicine Bluff Creek near	31–32
Medicine Bluff Creek near	29–31
Leadville, Colo., East Fork of Arkansas River near	9–11
Tennessee Fork near	14–15
Lion Creek near Halfway, Colo	26
Little Beaver Creek near Pikes Peak, Colo	24–25
Little Medicine Bluff Creek near Lawton, Okla	31–32
McReynolds, B. B., acknowledgment to	9
Medicine Bluff Creek near Lawton, Okla	29–31
Meyers, Miss Bessie, work of	9
Pikes Peak, Colo., Boehmer Creek near	24
Little Beaver Creek near	24–25
Sackett Creek near	25
Poncha, Colo., South Fork of Arkansas River at	20–21
Poncha Creek at Poncha, Colo	21–23
Poorly defined, use of term	8
Price current meters, plate showing	6
Red River basin, gaging-station records in	29–33
Run-off (depth in inches), definition of	6
Sackett Creek near Pikes Peak, Colo	25
St. Elmo, Colo., Chalk Creek near	18–20
Salida, Colo., Arkansas River at	12–14
Second-foot, definition of	6
Sheep Creek near Halfway, Colo	26–27
Soulé, S. B., work of	9
South Ruxton Creek at Halfway, Colo	27–28
Stage-discharge relation, definition of	6
Stevens water-stage recorder, plate showing	7
Tennessee Fork near Leadville, Colo	14–15
Terms, definitions of	6
U. S. Forest Service, acknowledgment to	9
U. S. Reclamation Service, acknowledgment to	9
Victor, Colo., West Beaver Creek near	23
Water-stage recorders, plate showing	7
Watkins, T. J., work of	9
Well-defined, use of term	8
West Beaver Creek near Victor, Colo	23
Zero flow, point of, defined	6

STREAM-GAGING STATIONS

AND

PUBLICATIONS RELATING TO WATER RESOURCES

PART VII. LOWER MISSISSIPPI RIVER BASIN

STREAM-GAGING STATIONS AND PUBLICATIONS RELATING TO WATER RESOURCES.

INTRODUCTION.

Investigation of water resources by the United States Geological Survey has consisted in large part of measurements of the volume of flow of streams and studies of the conditions affecting that flow, but it has comprised also investigation of such closely allied subjects as irrigation, water storage, water powers, underground waters, and quality of waters. Most of the results of these investigations have been published in the series of water-supply papers, but some have appeared in the bulletins, professional papers, annual reports, and monographs.

The results of stream-flow measurements are now published annually in 12 parts, each part covering an area whose boundaries coincide with natural drainage features, as indicated below:

Part I. North Atlantic slope basins.
II. South Atlantic and eastern Gulf of Mexico basins.
III. Ohio River basin.
IV. St. Lawrence River basin.
V. Upper Mississippi River and Hudson Bay basins.
VI. Missouri River basin.
VII. Lower Mississippi River basin.
VIII. Western Gulf of Mexico basins.
IX. Colorado River basin.
X. Great Basin.
XI. Pacific slope basins in California.
XII. North Pacific slope basins (in three parts).

HOW GOVERNMENT REPORTS MAY BE OBTAINED OR CONSULTED.

Water-supply papers and other publications of the United States Geological Survey containing data in regard to the water resources of the United States may be obtained or consulted as indicated below:

1. Copies may be obtained free of charge by applying to the Director of the Geological Survey, Washington, D. C. The edition printed for free distribution is, however, small and is soon exhausted.

2. Copies may be purchased at nominal cost from the Superintendent of Documents, Government Printing Office, Washington, D. C., who will on application furnish lists giving prices.

3. Sets of the reports may be consulted in the libraries of the principal cities in the United States.

4. Complete sets are available for consultation in the local offices of the water-resources branch of the Geological Survey, as follows:

Boston, Mass., 2500 Customhouse.
Albany, N. Y., Room 18, Federal Building.
Atlanta, Ga., Post Office Building.
Madison, Wis., care of Railroad Commission of Wisconsin.
Helena, Mont., Montana National Bank Building.
Denver, Colo., 403 New Post Office Building.
Salt Lake City, Utah, 421 Federal Building.
Boise, Idaho, 615 Idaho Building.
Austin, Tex., Old Post Office Building.
Portland, Oreg., Post Office Building.
Tacoma, Wash., 406 Federal Building.
San Francisco, Calif., 328 Customhouse.
Los Angeles, Calif., 619 Federal Building.
Honolulu, Hawaii, 14 Capitol Building.
Topeka, Kans., 25 Federal Building.

A list of the Geological Survey's publications may be obtained by applying to the Director, United States Geological Survey, Washington, D. C.

STREAM-FLOW REPORTS.

Stream-flow records have been obtained at more than 4,100 points in the United States, and the data obtained have been published in the reports tabulated below:

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

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

Report.	Character of data.	Year.
10th A, pt. 2	Descriptive information only	
11th A, pt. 2	Monthly discharge and descriptive information	1884 to Sept., 1890.
12th A, pt. 2	....do	1884 to June 30, 1891.
13th A, pt. 3	Mean discharge in second-feet	1884 to Dec. 31, 1892.
14th A, pt. 2	Monthly discharge (long-time records, 1871 to 1893)	1888 to Dec. 31, 1893.
B 131	Descriptions, measurements, gage heights, and ratings	1893 to 1894.
16th A, pt. 2	Descriptive information only	
B 140	Descriptions, measurements, gage heights, ratings, and monthly discharge (also many data covering earlier years).	1895.
W 11	Gage heights (also gage heights for earlier years)	1896.
18th A, pt. 4	Descriptions, measurements, ratings, and monthly discharge (also similar data for some earlier years).	1895 and 1896.
W 15	Descriptions, measurements, and gage heights, eastern United States, eastern Mississippi River, and Missouri River above junction with Kansas.	1897.
W 16	Descriptions, measurements, and gage heights, western Mississippi River below junction of Missouri and Platte, and western United States.	1897.
19th A, pt. 4	Descriptions, measurements, ratings, and monthly discharge (also some long-time records).	1897.
W 27	Measurements, ratings, and gage heights, eastern United States, eastern Mississippi River, and Missouri River.	1898.
W 28	Measurements, ratings, and gage heights, Arkansas River and western United States.	1898.

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

Report	Character of data.	Year.
20th A, pt. 4	Monthly discharge (also for many earlier years)	1898.
W 35 to 39	Descriptions, measurements, gage heights, and ratings	1899.
21st A, pt. 4	Monthly discharge	1899.
W 47 to 52	Descriptions, measurements, gage heights, and ratings	1900.
22d A, pt. 4	Monthly discharge	1900.
W 65, 66	Descriptions, measurements, gage heights, and ratings	1901.
W 75	Monthly discharge	1901.
W 82 to 85	Complete data	1902.
W 97 to 100	do	1903.
W 124 to 135	do	1904.
W 165 to 178	do	1905.
W 201 to 214	do	1906.
W 241 to 252	do	1907–8.
W 261 to 272	do	1909.
W 281 to 292	do	1910.
W 301 to 312	do	1911.
W 321 to 332	do	1912.
W 351 to 362	do	1913.
W 381 to 394	do	1914.
W 401 to 414	do	1915.
W 431 to 444	do	1916.
W 451 to 464		1917.

NOTE.—No data regarding stream flow are given in the 15th and 17th annual reports.

The records at most of the stations discussed in these reports extend over a series of years, and miscellaneous measurements at many points other than regular gaging stations have been made each year. An index of the reports containing records obtained prior to 1904 has been published in Water-Supply Paper 119.

The following table gives, by years and drainage basins, the numbers of the papers on surface-water supply published from 1899 to 1917. The data for any particular station will, in general, be found in the reports covering the years during which the station was maintained. For example, data for Machias River at Whitneyville, Me., 1903 to 1917, are published in Water-Supply Papers 97, 124, 165, 201, 241, 261, 281, 301, 321, 351, 381, 401, 431, and 451, which contain records for the New England streams from 1903 to 1917. Results of miscellaneous measurements are published by drainage basins.

Numbers of water-supply papers containing results of stream measurements, 1899–1917.

Year.	I North Atlantic slope (St. John River to York River).	II South Atlantic and eastern Gulf of Mexico (James River to the Missis-sippi).	III Ohio River.	IV St. Lawrence River and Great Lakes.	V Hudson Bay and upper Missis-sippi River.	VI Missouri River.	VII Lower Missis-sippi River.	VIII Western Gulf of Mexico.	IX Colorado River.	X Great Basin.	XI Pacific slope in Calif-ornia.	XII North Pacific slope basins.		
												Pacific slope in Washing-ton and upper Columbia River.	Snake River basin.	Lower Columbia River and Pacific slope in Oregon.
1899 [a]	35	[b] 35, 36	36	36	36	[c] 36, 37	37	37	[d] 37, 38	38, [e] 39	38, [f] 39	38	38	38
1900 [g]	47, [h] 48	48	48, [i] 49	49	49	49, [j] 50	50	50	50	51	51	51	51	51
1901	65, 75	65, 75	65, 75	65, 75	[k] 65, 66, 75	66, 75	[k] 65, 66, 75	66, 75	66, 75	66, 75	66, 75	66, 75	66, 78	66, 75
1902	82	[b] 82, 83	83	[l] 82, 83	[k] 83, 85	84	[k] 83, 84	84	85	85	85	85	85	85
1903	97	[b] 97, 98	98	97	[k] 98, 99, [m] 100	99	[k] 98, 99	99	100	100	100	100	100	100
1904	[n] 124, [o] 125, [p] 126	[p] 126, 127	128	129	[k] 128, 130	130, [q] 131	[k] 128, 131	132	133	133, [r] 134	134	135	135	135
1905	[n] 165, [o] 166, [p] 167	[p] 167, 168	169	170	171	172	[k] 169, 173	174	[s] 175, [s] 177	176, [r] 177	177	178	178	[t] 177, 178
1906	[n] 201, [o] 202, [p] 203	[p] 203, 204	205	206	207	208	[k] 205, 209	210	211	212, [r] 213	213	214	214	214
1907–8	241	242	243	244	245	246	247	248	249	250, [r] 251	251	252	252	252
1909	261	262	263	264	265	266	267	268	269	270, [r] 271	271	272	272	272
1910	281	282	283	284	285	286	287	288	289	290	291	292	292	292
1911	301	302	303	304	305	306	307	308	309	310	311	312	312	312
1912	321	322	223	324	325	326	327	328	329	330	331	332A	332B	332C
1913	351	352	353	354	355	356	357	358	359	360	361	362A	362B	362C
1914	381	382	383	384	385	386	387	388	389	390	391	392	393	394
1915	401	402	403	404	405	406	407	408	409	410	411	412	413	414
1916	431	432	433	434	435	436	437	438	439	440	441	442	443	444
1917	451	452	453	454	455	456	457	458	459	460	461	462	463	464

[a] Rating tables and index to Water-Supply Papers 35-39 contained in Water-Supply Paper 39. Estimates for 1899 in Twenty-first Annual Report, Part IV.
[b] James River only.
[c] Gallatin River.
[d] Green and Gunnison rivers and Grand River above junction with Gunnison.
[e] Mohave River only.
[f] Kings and Kern rivers and south Pacific slope basins.
[g] Rating tables and index to Water-Supply Papers 47-52 and data on precipitation, wells, and irrigation in California and Utah contained in Water-Supply Paper 52. Estimates for 1900 in Twenty-second Annual Report, Part IV.
[h] Wissahickon and Schuylkill rivers to James River.
[i] Scioto River.
[j] Loup and Platte rivers near Columbus, Nebr., and all tributaries below junction with Platte.
[k] Tributaries of Mississippi from east.
[l] Lake Ontario and tributaries to St. Lawrence River proper.
[m] Hudson Bay only.
[n] New England rivers only.
[o] Hudson River to Delaware River, inclusive.
[p] Susquehanna River to Yadkin River, inclusive.
[q] Platte and Kansas rivers.
[r] Great Basin in California except Truckee and Carson river basins.
[s] Below junction with Gila.
[t] Rogue, Umpqua, and Siletz rivers only.

In these papers and in the following lists the stations are arranged in downstream order. The main stem of any river is determined by measuring or estimating its drainage area—that is, the headwater stream having the largest drainage area is considered the continuation of the main stream, and local changes in name and lake surface are disregarded. All stations from the source to the mouth of the main stem of the river are presented first, and the tributaries in regular order from source to mouth follow, the streams in each tributary basin being listed before those of the next basin below.

The exceptions to this rule occur in the records for Mississippi River, which are given in four parts, as indicated on page III, and in the records for large lakes, where it is simpler to take up the streams in regular order around the rim of the lake than to cross back and forth over the lake surface.

PART VII. LOWER MISSISSIPPI RIVER BASIN.

PRINCIPAL STREAMS.

The principal streams flowing to the Mississippi below the mouth of the Missouri on the west and the Ohio on the east, are Meramec, White, Arkansas (whose chief tributaries are Huerfano, Purgatory, Cimarron, Verdigris, Neosho, and Canadian rivers), Yazoo, Homochitto, and Red rivers. The streams drain wholly or in part the States of Arkansas, Colorado, Kansas, Kentucky, Louisiana, Mississippi, Missouri, New Mexico, Oklahoma, Tennessee, and Texas.

In addition to the annotated list of publications relating specifically to the section, these pages contain a similar list of reports that are of general interest in many sections and cover a wide range of hydrologic subjects, and also brief references to reports published by State and other organizations. (See p. xx.)

GAGING STATIONS.

NOTE.—Dash after a date indicates that station was being maintained Sept. 30, 1917; period after a date indicates discontinuance.

MERAMEC RIVER BASIN.

Meramec River near Meramec, Mo., 1903–1906.
Meramec River near Eureka, Mo., 1903–1906.
Meramec River (Station No. 1) at Fenton, Mo., 1903.
Meramec River (Station No. 2) below Fenton, Mo., 1903.
  Dry Fork of Meramec River near St. James, Mo., 1903.
  Spring Branch:
    Meramec Spring near Meramec, Mo., 1903–1906.
    Courtois Creek at Scotia, Mo., 1905–6.

WHITE RIVER BASIN.

White River at Beaver, Ark., 1909–10.
White River near Branson, Mo., 1909–10.
White River near Lead Hill, Ark., 1909–10.
White River near Cotter, Ark., 1909–10.
  Buffalo River near Gilbert, Ark., 1909–10
  North Fork River near Henderson, Ark., 1909–10.
  Black River:
    Eleven Point River:
    Greer Spring at Greer, Mo., 1904.
    Little Red River near Pangburn, Ark., 1909–10.

ARKANSAS RIVER BASIN.

Arkansas River, East Fork (head of Arkansas River), near Leadville, Colo., 1890; 1911–
Arkansas River at Granite, Colo., 1897–1899; 1910–
Arkansas River at Salida, Colo., 1895–1903; 1909–
Arkansas River at Canon City, Colo., 1888–1913.
Arkansas River near Rock Canyon, Colo., 1889.

Arkansas River at Pueblo, Colo., 1885–1889; 1894–1913.
Arkansas River near Nepesta, Colo., 1897–1903; 1909–1913.
Arkansas River near Manzanola, Colo., 1898.
Arkansas River near Rocky Ford, Colo., 1897–1903.
Arkansas River at La Junta, Colo., 1889; 1894–95; 1901; 1903; 1908; 1912–13.
Arkansas River at Las Animas, Colo., 1898; 1909.
Arkansas River at New Fort Lyons, Colo., 1911.
Arkansas River near Prowers, Colo., 1903.
Arkansas River at Prowers, Colo., 1900–1901.
Arkansas River near Amity canal head gates, Colo., 1898–99; 1901.
Arkansas River near Lamar, Colo., 1913.
Arkansas River near Granada, Colo., 1898–1901; 1903.
Arkansas River near Holly (Barton or Byron), Colo., 1894; 1901–2; 1907–1913.
Arkansas River near Coolidge, Kans., 1903.
Arkansas River near Syracuse, Kans., 1902–1906.
Arkansas River at Dodge, Kans., 1903–1906.
Arkansas River near Hutchinson, Kans., 1895–1905.
Arkansas River at Arkansas City, Kans., 1902–1906.
Tennessee Fork near Leadville, Colo., 1890; 1903; 1911–
Lake Fork of Arkansas River near Arkansas Junction, Colo., 1890; 1903.
Half Moon Creek near Leadville, Colo., 1911–1914.
Lake Creek near Twin Lakes, Colo., 1899–1900.
Twin Lakes outlet near Twin Lakes, Colo., 1910.
Clear Creek near Granite, Colo., 1890; 1910.
Cottonwood Creek near Buena Vista, Colo., 1890.
Cottonwood Creek at Hot Springs tunnel, near Buena Vista, Colo., 1910–11.
Cottonwood Creek below Hot Springs, near Buena Vista, Colo., 1911–
South Fork of Cottonwood Creek near Buena Vista, Colo., 1890.
North Cottonwood Creek near Buena Vista., Colo, 1911–1914.
Chalk Creek (upper station) near St. Elmo, Colo., 1913–
Chalk Creek near St. Elmo, Colo., 1911–1916.
Chalk Creek near Buena Vista, Colo., 1910.
South Fork of Arkansas River at Poncha, Colo., 1911–
Poncha Creek at Poncha, Colo., 1911–
Grape Creek near Canon City, Colo., 1907–1909.
Oil or Fourmile Creek near Canon City, Colo., 1910.
West Beaver Creek (head of Beaver Creek) near Victor, Colo., 1905–
Boehmer Creek near Pikes Peak, Colo., 1909–
Little Beaver Creek near Pikes Peak, Colo., 1909–
Sackett Creek near Pikes Peak, Colo., 1909–
Fountain Creek:
Lion Creek near Halfway, Colo., 1908–
Sheep Creek near Halfway, Colo., 1908–
South Ruxton Creek near Halfway, Colo., 1906–
Cabin Creek near Halfway, Colo., 1906–
Huerfano River at Badito, Colo., 1912.
Huerfano River near Undercliffe, Colo., 1908.
Cucharas River at Walsenburg, Colo., 1907–8.
Purgatory (Las Animas) River at Trinidad, Colo., 1896–1899; 1905–1912.
Purgatory River near canyon entrance (Alfalfa), Colo., 1905–1907.
Purgatory River at J. J. ranch near La Junta, Colo., 1898.
Purgatory River near Las Animas, Colo., 1889 and 1909.
Big Sandy Creek at Hugo, Colo., 1910–1912.

Arkansas River tributaries—Continued.
Big Sandy Creek near Kit Carson, Colo., 1910–1912.
Big Spring Creek near Arena, Colo., 1910–1912.
Walnut River near Arkansas City, Kans., 1902–3.
Salt Fork of Arkansas River near Alva, Okla., 1904–5.
Salt Fork of Arkansas River near Tonkawa, Okla., 1903–1905.
Medicine Lodge River near Kiowa, Kans., 1895–96.
Cimarron River near Arkalon, Kans., 1895–96; 1903–1905.
Cimarron River near Kenton, Okla., 1904–5.
Cimarron River near Garrett, Okla., 1905–1907.
Cimarron River near Waynoka, Okla., 1903–1905.
Verdigris River near Independence, Kans., 1904.
Verdigris River near Liberty, Kans., 1895–1903.
Verdigris River near Catoosa, Okla., 1903–1905.
Fall River at Fall River, Kans., 1904–5.
Neosho River near Neosho Rapids, Kans., 1904.
Neosho River near Iola, Kans., 1895–1903.
Neosho River near Humboldt, Kans., 1904.
Neosho River (or Grand River) near Fort Gibson, Okla., 1899; 1903–1905.
Canadian River near Sanchez, N. Mex., 1912–1914.
Canadian River at Logan, N. Mex., 1904–5; 1908–1914.
Canadian River at Calvin, Okla., 1905–1908.
Chicorica Creek near Raton, N. Mex., 1910–1914.
Una del Gato Creek near Raton, N. Mex., 1910–1913.
Cimarron River at Ute Park, N. Mex., 1907–1914.
Cimarron River at Springer, N. Mex., 1907–1909.
Rayado River near Cimarron, N. Mex., 1911; 1913; 1914.
Rayado River above Abreu's ranch, near Cimarron, N. Mex., 1911–1914.
Rayado River at Abreu's ranch, near Cimarron, N. Mex., 1908–9.
Rayado River below Abreu's ranch, near Cimarron, N. Mex., 1912–13.
Rayado River near Springer, N. Mex., 1907–1909.
Urraca Creek near Cimarron, N. Mex., 1912–1914.
East Fork of Ocate River at Ocate, N. Mex., 1914.
Ocate River at Ocate, N. Mex., 1914.
West Fork of Ocate River at Ocate, N. Mex., 1914.
Sweetwater Creek near Colmar, N. Mex., 1914.
Mora River and La Cueva canal at La Cueva, N. Mex., 1903–1911.
Mora River near Weber, N. Mex., 1903–4.
Mora River near Watrous, N. Mex., 1894–1896.
Mora River near Shoemaker, N. Mex., 1914.
Sapello River at Sapello, N. Mex., 1903–4.
Sapello Mill tailrace at Sapello, N. Mex., 1903–4.
Sapello River at Los Alamos, N. Mex., 1903–1911.
Manuelitos River near Sapello, N. Mex., 1903–4.
Pajarito Creek near Hanley, N. Mex., 1911–1913.
Pajarito Creek below Vigil Creek, near Hanley, N. Mex., 1912–13.
Ute Creek near Logan, N. Mex., 1904–1906; 1909–1914.
Beaver Creek (head of North Fork of Canadian River) at Beaver, Okla., 1904–5.
North Fork of Canadian River near Woodward, Okla., 1903–1906.
North Fork of Canadian River near El Reno, Okla., 1902–1908.
North Fork of Canadian River near Oklahoma, Okla., 1899.
North Fork of Canadian River near Eufaula, Okla., 1899.

ARKANSAS RIVER CANALS.

Oxford Farmers canal near Nepesta, Colo., 1902–3.
Colorado-Kansas canal near Prowers, Colo., 1903.
Keese ditch near Prowers, Colo., 1903.

YAZOO RIVER BASIN.

Tallahatchie River (head of Yazoo River) at Batesville, Miss., 1906–1912.
Tallahatchie River at Phillip, Miss., 1908–1913.
Yazoo River at Greenwood, Miss., 1908–1913.
Yazoo River at Yazoo City, Miss., 1900–1905.
Coldwater River at Savage, Miss., 1908–1912.
Yalobusha River at Grenada, Miss., 1906; 1908–1912.
Sunflower River near Ruleville, Miss., 1909–1912.
Sunflower River at Baird, Miss., 1908–1912.

HOMOCHITTO RIVER BASIN.

Homochitto River at Rosetta, Miss., 1906.

RED RIVER BASIN.

Red River at Arthur City, Tex., 1905–1911.
Salt Fork of Red River at Mangum, Okla., 1905–6.
Turkey Creek [Deep Red Run] at Olustee, Okla., 1905–1908.
North Fork of Red River near Granite, Okla., 1903–1908.
North Fork of Red River near Snyder, Okla., 1905.
North Fork of Red River near Headrick, Okla., 1905–1908.
Elm Fork of Red River near Mangum, Okla., 1905–1908.
Elk Creek near Hobart, Okla., 1904–1908.
Otter Creek near Mountain Park, Okla., 1903–1908.
Horse Creek near Mountain Park, Okla., 1905–6.
Dry Fork of Otter Creek near Mountain Park, Okla., 1905–6.
Cache Creek:
Medicine Bluff Creek near Lawton, Okla, 1912–
Evaporation station near Lawton, Okla., 1913–
Little Medicine Bluff Creek near Lawton, Okla., 1912–
Wichita River at Wichita Falls, Tex., 1910–11.
Washita River at Anadarko, Okla., 1902–1908.
Washita River near Pauls Valley, Okla., 1899.
Ouachita River near Malvern, Ark., 1903–1905.
Ouachita River near Arkadelphia, Ark., 1905–6.

REPORTS ON WATER RESOURCES OF THE LOWER MISSISSIPPI RIVER BASIN.

PUBLICATIONS OF UNITED STATES GEOLOGICAL SURVEY.

WATER-SUPPLY PAPERS.

Water-supply papers are distributed free by the Geological Survey as long as its stock lasts. An asterisk (*) indicates that this stock has been exhausted. Many of the papers marked in this way may, however, be purchased (at price noted) from the SUPERINTENDENT OF DOCUMENTS, WASHINGTON, D. C. Omission of the price indicates that the report is not obtainable from Government sources. Water-supply papers are of octavo size.

*5. Irrigation practice on the Great Plains, by E. B. Cowgill. 1897. 39 pp., 12 pls. 10c.

Describes reservoirs for storm and pumped waters, ditching, methods of distributing water, cultivation and subirrigation, duty of water, and winter irrigation.

*6. Underground waters of southwestern Kansas, by Erasmus Haworth. 1897. 65 pp., 12 pls. 15c.

Describes physiography, drainage, geologic formations and water supply, and irrigation development in Meade, Dodge, and Garden quadrangles, including all of Meade County, nearly all of Seward, Haskell, and Gray counties, about one-third of Ford County, and one-fourth of Finney County; discusses waters of Dakota sandstone and of the Tertiary formations.

*43. Conveyance of water in irrigation canals, flumes, and pipes, by Samuel Fortier. 1901. 86 pp., 15 pls. 15c.

Describes the location and construction of various types of canals for irrigation.

*57. Preliminary list of deep borings in the United States, Part I (Alabama-Montana), by N. H. Darton. 1902. 60 pp. (See No. 149.) 5c.

*61. Preliminary list of deep borings in the United States, Part II (Nebraska-Wyoming), by N. H. Darton. 1902. 67 pp. 5c.

Nos. 57 and 61 contain information as to depth, diameter, yield, and head of water in borings, more than 400 feet deep; under head "Remarks" give information concerning temperature, quality of water, purposes of boring, etc. The lists are arranged by States, and the States are arranged alphabetically. A second, revised, edition was published in 1905 as Water-Supply Paper 149 (q. v.).

74. Water resources of the State of Colorado, by A. L. Fellows. 1902. 151 pp., 14 pls. 25c.

Discusses under South Platte, Arkansas, Rio Grande, San Juan, Grand, and Green River divisions, drainage and irrigation, and gives records of stream flow.

96. Destructive floods in the United States in 1903, by E. C. Murphy. 1904. 81 pp., 13 pls. 15c.

Contains notes on early floods in Mississippi Valley.

101. Underground waters of southern Louisiana, by G. D. Harris, with discussions of their uses for water supplies and for rice irrigation, by M. L. Fuller. 1904. 98 pp., 11 pls. 20c.

Discusses the topography and stratigraphic geology of the area and the origin of the well waters, gives statistics of artesian wells, describes methods of well drilling and pumping, and treats briefly of rice cultivation.

102. Contributions to the hydrology of eastern United States, 1903; M. L. Fuller, geologist in charge. 1904. 522 pp. 30c.

Contains brief reports on springs and wells of Arkansas and Missouri. The reports comprise tabulated well records giving information as to location, owner, depth, yield, head, etc., supplemented by notes as to elevation above sea, materials penetrated, temperature, use, and quality many miscellaneous analyses.

105. The water powers of Texas, by T. U. Taylor. 1904. 116 pp., 17 pls. 15c.

Gives a résumé of the available data regarding water powers and briefly describes the principal streams, including Red and Canadian rivers.

*107. Water powers of Alabama, with an appendix on stream measurements in Mississippi, by B. M. Hall. 1904. 253 pp., 9 pls. 20c.

Appendix contains gage heights, rating tables, estimates of monthly discharge of Yazoo River.

110. Contributions to the hydrology of eastern United States, 1904; M. L. Fuller, geologist in charge. 1905. 211 pp., 5 pls. 10c.

Contains a "Summary of the water supply of the Ozark region in northern Arkansas, by George I. Adams"; describes the drainage and some of the immense springs of the area, many of which have been developed as resorts.

114. Underground waters of eastern United States; M. L. Fuller, geologist in charge. 1905. 285 pp., 18 pls. 25c.

Contains brief reports as follows:

Mississippi, by L. C. Johnson.

Louisiana and southern Arkansas, by A. C. Veatch.

Northern Arkansas, by A. H. Purdue.

Each of these reports discusses the geologic formation as related to water supply, treats particularly of the mineral waters, and gives a list of the principal publications.

145. Contributions to the hydrology of eastern United States, 1905; M. L. Fuller, geologist in charge. 1905. 220 pp., 6 pls. 10c.

Contains five short reports relating to areas draining to the lower Mississippi River:

Water resources of the Joplin district, Missouri-Kansas, by W. S. Tangier Smith. Describes topography, geology, streams, springs, and wells; gives analyses of waters.

Water resources of the Winslow quadrangle, Arkansas, by A. H. Purdue. Area includes a few square miles of Oklahoma, discusses water-bearing formations, and the quality of spring and well waters.

Notes on certain hot springs of the southern United States, by Walter Harvey Weed. Gives an account of the history, topography, geology, flow, temperature, and composition of the Hot Springs of Arkansas, including many analyses.

Notes on certain large springs of the Ozark region, Missouri and Arkansas, complied by Myron L. Fuller. Treats briefly of the conditions under which the springs emerge, and of their flow, temperature, and quality.

Water resources of the contact region between the Paleozoic and Mississippi embayment deposits in northern Arkansas, by A. H. Purdue. Describes geology and water resources of a belt 12 to 15 miles wide extending along the western edge of the Mississippi embayment deposits from Arkansas River northward to the Missouri line. Considers source of water, amount, chemical character and use of water, prospects for flowing wells, etc.

147. Destructive floods in the United States in 1904, by E. C. Murphy and others. 1905. 206 pp., 18 pls. 15c.

Describes floods on Kansas, Neosho, Verdigris, Osage, Arkansas, Canadian, and Purgatory rivers, discussing the streams, precipitation, damages, prevention of future damages, etc.

*148. Geology and water resources of Oklahoma, by C. N. Gould. 1905. 178 pp., 22 pls. 20c.

Describes topography, geology, climate, streams, springs, deep wells (water and oil and gas,) and artesian water, and discusses the water supply by counties; treats of irrigation from reservoirs, springs, and wells; gives analyses of well waters and table of well records.

149. Preliminary list of deep borings in the United States (second edition, with additions), by N. H. Darton. 1905. 175 pp. 10c.

Gives by States (and within the States by counties), location, depth, diameter, yield, height, of water, and other available information, concerning wells 400 feet or more in depth; includes all wells listed in Water-Supply Papers 57 and 61; mentions also principal publications relating to deep borings.

*153. The underflow in Arkansas Valley in western Kansas, by C. S. Slichter. 1906. 90 pp., 3 pls. 15c.

Discusses origin and extent of the underflow, fluctuations of ground-water level, the chemical composition of the waters (including analyses); gives results of measurements at various points and summaries and details of pumping tests.

*154. The geology and water resources of the eastern portion of the Panhandle of Texas, by C. N. Gould. 1906. 64 pp., 15 pls. 10c.

Discusses topography, geology, streams, springs, ground waters, and irrigation; gives details by counties.

159. Summary of the underground-water resources of Mississippi, by A. F. Crider and L. C. Johnson. 1906. 86 pp., 6 pls. 20c.

Describes geography, topography, and general geology of the State; discusses the source, depth of penetration, rate of percolation, and recovery of underground waters, artesian requisites, and special conditions in the Coastal Plain formations; gives notes on wells by counties, deep-well records, and selected records in detail; treats of sanitary aspect of wells and gives analyses.

*160. Underground-water papers, 1906; M. L. Fuller, geologist in charge. 1906. 104 pp., 1 pl.

Contains brief report entitled "Drainage of wet lands in Arkansas by wells," by A. F. Crider.

*162. Destructive floods in the United States in 1905, with a discussion of flood discharge and frequency and an index to flood literature, by E. C. Murphy and others. 1906. 105 pp., 4 pls. 15c.

Gives account of flood on Purgatory River, Colorado, and estimates of flood flow and discharge of Arkansas River at Pueblo, Colo.; contains also index to literature on flood flow in American streams.

*164. Underground waters of Tennessee and Kentucky west of Tennessee River and of an adjacent area in Illinois, by L. C. Glenn. 1906. 173 pp., 7 pls. 25c.

Describes physical features, static level, and uses of waters, artesian conditions, source and properties of underground water; discusses topography, geology, and water resources by counties; gives logs of wells, analyses of waters, and bibliography of most important reports.

*191. The geology and water resources of the western portion of the Panhandle of Texas, by C. N. Gould. 1907. 70 pp., 7 pls. 15c.

Describes the topography and general geology of the area, the deep-seated waters, springs, and streams, and the use of the waters for irrigation; discusses details of topography, geology, and water supply by counties.

*195. Underground waters of Missouri, their geology and utilization, by E. M. Shepard, 1907. 224 pp., 6 pls. 30c.

Describes the topography and geology of the State, the waters of the various formations, and discusses the water supplies by districts and counties; gives statistics of city water supplies, analyses of water, and many well records.

236. The quality of surface waters in the United States, Part I, Analyses of waters east of the one hundredth meridian, by R. B. Dole. 1909. 123 pp. 10c.

Describes collection of samples, methods of examination, preparation of solutions, accuracy of estimates, and expression of analytical results; gives results of analyses of waters of Mississippi, Arkansas, and Red rivers.

273. Quality of the water supplies of Kansas, by H. N. Parker, with a preliminary report on stream pollution by mine waters in southeastern Kansas, by E. H. S. Bailey. 1911. 375 pp., 1 pl. 30c.

Describes the topographic and geologic features of the State and the artesian basins; discusses the significance of mineral constituents and classification of waters; gives details concerning quality of underground water by counties and surface water by drainage basins.

274. Some stream waters of the western United States, with chapters on sediment carried by the Rio Grande and the industrial application of water analyses. by Herman Stabler. 1911. 188 pp. 15c.

Describes collection of samples, plan of analytical work, and methods of analyses; discusses soap-consuming power of waters, water softening, boiler waters, and water for irrigation; gives results of analyses of samples of water from Sapello River, Salt, North, and Elm forks of Red River, and Turkey Creek.

*276. Geology and underground waters of northeastern Texas, by C. H. Gordon. 1911. 78 pp., 2 pls. 10c.

Describes geography, physiography, and geology of area comprising Bowie, Red River, Lamar, Delta, Hopkins, Franklin, Titus, Morris, Camp, and Cass counties; discusses the source and availability of underground waters, artesian waters, of the various formations, and reviews the geographic relations, geology, and water resources by counties.

*317. Geology and underground waters of the Wichita region, north-central Texas, by C. H. Gordon. 1913. 88 pp., 2 pls. 10c.

Describes the physiography, climate, surface and deep waters of an area in Montague, Clay, Wichita, Wilbarger, Hardeman, Foard, Knox, Baylor, Archer, Jack, Young, Throckmorton, and Haskell counties; gives details by counties.

*345. Contributions to the hydrology of the United States, 1914. N. C. Grover, chief hydraulic engineer. 1915. 225 pp., 17 pls. 30c.

(*a*) Preliminary report on ground water for irrigation in the vicinity of Wichita, Kans., by Q. E. Meinzer, pp 1–9

(*b*) Ground water for irrigation in the vicinity of Enid, Okla., by A. T. Schwennesen, pp. 11–23, pl. 1.

(*d*) Ground water for irrigation in the valley of North Fork of Canadian River near Oklahoma City, Okla., by A. T. Schwennessen, pp. 41–51.

399. Geology and ground waters of northeastern Arkansas, by L. W. Stephenson and A. F. Crider, with a discussion of the chemical character of the waters by R. B. Dole. 1916. 315 pp., 11 pls. 35c.

Describes the physiography of Arkansas, the character and distribution of the geologic formations, the streams, lakes, ponds, and swamps, the source, disposal, quantity, and distribution of the ground waters and their economic uses; gives details by counties; discusses, under chemical character of the waters, standards of classification, methods of purification, and the quality of surface and ground water; contains bibliography and gives many geologic sections and analyses of waters.

421. Profile surveys in 1915 along the Rio Grande, Pecos River, and Mora River, N. Mex., prepared under the direction of W. H. Herron, acting chief geographer. 1916. 11 pp., 11 pls. 15c.

Gives the results of surveys made to determine the location of undeveloped water power on some of the rivers of the United States that are adapted to the development of power by low or medium heads of 20 to 100 feet.

ANNUAL REPORTS.

Each of the papers contained in the annual reports was also issued in separate form.

Annual reports are distributed free by the Geological Survey as long as its stock lasts. An asterisk (*) indicates that this stock has been exhausted. Many of the papers so marked, however, may be purchased from the SUPERINTENDENT OF DOCUMENTS, WASHINGTON, D. C.

*Tenth Annual Report of the United States Geological Survey, 1888–89, J. W. Powell, Director. 1890. 2 parts. *Pt. II. Irrigation, viii, 123 pp. 35c.

Makes a preliminary report on the organization and prosecution of the survey of the arid lands for purposes of irrigation; includes an account of the methods of topographic and hydraulic work, the segregation work on reservoir sites and irrigable lands, field and office methods, and brief descriptions of the topography of some of the river basins.

Eleventh Annual Report of the United States Geological Survey, 1889–90, J. W. Powell, Director. 1891. 2 parts. Pt. II. Irrigation, xiv, 395 pp., 30 pls. and maps. $1.25. Contains:

*Hydrography, pp. 1–110. Discusses scope of work, methods of stream measurement, rainfall and evaporation, and describes the more important streams.

*Engineering, pp. 111–200. Gives an account of the surveys in the Arkansas division.

*The arid lands, pp. 201–289. Includes a report on artesian irrigation on the Great Plains, a discussion of the general considerations affecting artesian water supply, the economic limit to the utilization of artesian water for irrigation, irrigation by artesian wells in various countries, and the geologic conditions and statistics of artesian wells on the Great Plains.

*Topography, pp. 291–343. Comprises reports of the topographic surveys in Colorado and New Mexico, and on reservoir sites.

Twelfth Annual Report of the United States Geological Survey, 1890–91, J. W. Powell, Director. 1891. 2 parts. Pt. II. Irrigation, xviii, 576 pp., 93 pls. $2.00. Contains:

*Report upon the location and survey of reservoir sites during the fiscal year ended June 30, 1891, by A. H. Thompson, pp. 1–212, pls. 54–57. Describes reservoir sites in Chaffee, Custer, Fremont, Park, El Paso, Pueblo, Huerfano, Las Animas, Bent, Otero, Baca, Kiowa, and Lake counties, Colo.

Hydrography of the arid regions, by F. H. Newell, pp. 213–361, pls. 58–106. Discusses the available water supply of the arid regions, the duty of water, flood waters, relation of rainfall to river flow, classifies the drainage basins, and describes the rivers of the Arkansas River basin.

Thirteenth Annual Report of the United States Geological Survey, 1891–92, J. W. Powell, Director. 1892. (Pts. II and III, 1893.) 3 parts. *Pt. III. Irrigation, xi, 486 pp., 77 pls. $1.85. Contains:

*Engineering results of irrigation survey, by H. M. Wilson, pp. 351–427, pls. 147–182. Describes work at Twin Lakes reservoir and Twin Lakes dam, Colorado.

*Report upon the construction of topographic maps and the selection and survey of reservoir sites in the hydrographic basin of Arkansas River, Colo., by A. H. Thompson, pp. 429–444.

Sixteenth Annual Report of the United States Geological Survey, 1894–95, Charles D. Walcott, Director. 1896. (Pts. II, III, and IV, 1895.) 4 parts. *Pt. II. Papers of an economic character, xix, 598 pp., 43 pls. $1.25. Contains:

The public lands and their water supply, by F. H. Newell, pp. 457–533, pls. 45–39. Describes general character of the public lands, the lands disposed of (railroad, grant, and swamp lands and private miscellaneous entries), lands reserved (Indian, forest, and military reservations), the vacant lands, and the rate of disposal of vacant lands; discusses the streams, wells, and reservoirs as sources of water supply; gives details for each State.

Seventeenth Annual Report of the United States Geological Survey, 1895–96, Charles D. Walcott, Director. 1896. 3 parts in 4 vols. *Pt. II. Economic geology and hydrography, xxv, 864 pp., 113 pls. $2.35. Contains:

The underground water of the Arkansas Valley in eastern Colorado, by G. K. Gilbert, pp. 551–601, pls. 56–68. Describes the geology and topography of the district, the general conditions under which artesian water occurs, the gathering grounds, capacity, distribution, and quality of the water of the Dakota sandstone, the water of the upland sands, the terraces, and the dune sands, and the underflow of rivers and creeks.

Twenty-first Annual Report of the United States Geological Survey, 1899–1900, Charles D. Walcott, Director. 1900. (Pts. III, IV, VI, VI continued, and VII, 1901.) 7 parts in 8 vols. and separate case for maps with Pt. V. Pt. IV, Hydrography, 768 pp., 156 pls. $2.35. Contains:

*The High Plains and their utilization, by W. D. Johnson, pp. 601–741, pls. 113–156. Describes the area situated in an irregular belt lying about midway across the long eastward slope of the Great Plains and including parts of Wyoming, Colorado, and Nebraska (North and South Platte, Platte, Republican, and Smokey Hill River basins), Colorado, Kansas, New Mexico, Oklahoma, and Texas (Arkansas River basin), and Colorado, New Mexico, and Texas (Rio Grande basin); discusses the origin and structure of the High Plains, the precipitation, temperature, and other factors of climate, experiments with irrigation, and the use of mountain streams, local storm-water storage, and artesian waters. Concluded in the Twenty-second Annual Report, Pt. IV, pp. 631–669, pls. 51–65. ($2.20.)

*Pt. VII, Texas, 666 pp., 71 pls. $1.90. Consists of:

Geography and geology of the Black and Granite prairies, Texas, with detailed descriptions of the Cretaceous formations and special reference to artesian waters, by Robert T. Hill. Describes an area in Texas and southern Indian [Oklahoma] Territory, comprising about 50,000 square miles; describes relief, drainage, and soils; gives a résumé of principles governing underground water; describes the artesian well systems of Texas and gives details of artesian conditions in Black and Grand prairies by counties; treats briefly of the chemical qualities of the artesian waters and gives analyses.

Twenty-second Annual Report of the United States Geological Survey, 1900–1901, Charles D. Walcott, Director. 1901. (Parts III and IV, 1902.) 4 parts. *Pt. IV, Hydrography, 690 pp., 65 pls. Contains:

The High Plains and their utilization (conclusion of paper in Twenty-first Ann. Rept., pt. 4), by W. D. Johnson, pp. 631–669, pls. 51–65.

BULLETINS.

An asterisk (*) indicates that the Geological Survey's stock of the paper is exhausted. Many of the papers so marked may be purchased from the SUPERINTENDENT OF DOCUMENTS, WASHINGTON, D. C. Bulletins are of octavo size.

238. Economic geology of the Iola quadrangle, Kans., by G. I. Adams, Erasmus Haworth, and W. R. Crane. 1904. 83 pp., 11 pls.

Contains (pp. 75–77) a brief discussion of the water supply.

*264. Record of deep-well drilling for 1904, by M. L. Fuller, E. F. Lines, and A. C. Veatch. 1905. 106 pp. 10c.

Discusses the importance of accurate well records to the driller, to owners of oil, gas, and water wells, and to the geologist; describes the general methods of work; gives tabulated records of wells in Arkansas, Colorado, New Mexico, Oklahoma, Kansas, Missouri, Tennessee, and Texas; and detailed records of wells in Otero County, Colo.; Greenwood, Montgomery, and Neosho counties, Kans., and St. Louis County, Mo. These wells were selected because they give definite stratigraphic information.

*298. Record of deep-well drilling for 1905, by M. L. Fuller and Samuel Sanford 1906. 299 pp. 25c.

Gives an account of progress in the collection of well records and samples; contains tabulated records of wells in Arkansas, Colorado, Kansas, Kentucky, Louisiana, Mississippi, Missouri, New Mexico, Oklahoma, Tennessee, and Texas; and detailed records of wells in Hempstead County, Ark.; Fremont and Pueblo counties, Colo.; Allen, Chase, Coffee, and McPherson counties, Kans.; Panola County, Miss.; Nowata, Washington, Tulsa, Murray, Okmulgee, and Pawnee counties, Okla., and Clay and Roberts counties, Tex. The wells of which detailed sections are given were selected because they afford valuable stratigraphic information.

PROFESSIONAL PAPERS.

Professional papers are distributed free by the Geological Survey as long as its stock lasts. An asterisk (*) indicates that this stock has been exhausted. Many of the papers marked with an asterisk may, however, be purchased from the SUPERINTENDENT OF DOCUMENTS, WASHINGTON, D. C. Professional papers are of quarto size.

*32. Preliminary report on the geology and underground-water resources of the central Great Plains, by N. H. Darton. 1905. 433 pp., 72 pls. $1.80.

Describes altitudes and slopes, climate, drainage, stratigraphic structure, historical geology, and the water horizons; discusses deep wells and prospects (by counties and towns) in South Dakota, Nebraska, central and western Kansas, eastern Colorado, and eastern Wyoming; discusses also the occurrence of coal, petroleum, and natural gas, salt, gypsum, gold, iron ore, and other minerals.

*46. Geology and underground-water resources of northern Louisiana and southern Arkansas, by A. C. Veatch. 1906. 422 pp., 51 pls. $1.50.

Describes the historical geology and topographic development of a portion of the Coastal Plain; discusses the fundamental principles governing underground waters and their application to this region; contains account of methods and costs of well making, gives well predictions and a short discussion of the underground conditions in each county, and data in regard to wells arranged in tables by counties, followed by notes giving sections, analyses of waters, etc.; contains also a dictionary of altitudes, arranged by counties.

*52. Geology and underground waters of the Arkansas Valley in eastern Colorado, by N. H. Darton. 1906. 90 pp., 28 pls.

Describes the stratigraphic, structural, and historical geology of the Arkansas Valley and the relation of the geologic formations to the underground waters; discusses the source, depths, areas of flow, head, quantity, and quality of the waters of the "Dakota" sandstone, and the waters of the "Red Beds" and Morrison formations, the Laramie and associated formations, the later Tertiary deposits, and the dune sands. "An extension of the preliminary examination of the region by G. K. Gilbert in 1894 and 1895." See Seventeenth Annual Report, part 2, 1896, pp. 551–601.

GEOLOGIC FOLIOS.

Under the plan adopted for the preparation of a geologic map of the United States the entire area is divided into small quadrangles, bounded by certain meridians and parallels, and these quadrangles, which number several thousand, are separately surveyed and mapped.[1] The unit of survey is also the unit of publication, and the maps and description of each quadrangle are issued in the form of a folio. When all the folios are completeted they will constitute the Geologic Atlas of the United States.

A folio is designated by the name of the principal town or of a prominent natural feature within the quadrangle. Each folio includes maps showing the topography, geology, underground structure, and mineral deposits of the area mapped and several pages of descriptive text. The text explains the maps and describes the topographic and geologic features of the country and its mineral products. The topographic map shows roads, railroads, waterways, and, by contour lines, the shapes of the hills and valleys and the height above sea level of all points in the quadrangle. The areal-geology map shows the distribution of the various rocks at the surface. The structural-geology map shows the relations of the rocks to one another underground. The economic-geology map indicates the location of mineral deposits that are commercially valuable. The artesian-water map shows the depth to underground-water horizons. Economic-geology and artesian-water maps are included in folios if the conditions in the areas mapped warrant their publication. The folios are of special interest to students of geography and geology and are valuable as guides in the development and utilization of mineral resources.

The folios numbered from 1 to 163, inclusive, are published in only one form (18 by 22 inches), called the library edition. Some of the folios that bear numbers higher than 163 are published also in an octavo edition (6 by 9 inches). Owing to a fire in the Geological Survey building May 18, 1913, the stock of geologic folios was more or less damaged by fire and water, but 80 or 90 per cent of the folios are usable. They will be sold at the uniform price of 5 cents each, with no reduction for wholesale orders. This rate applies to folios in stock from 1 to 184, inclusive (except reprints), also to the library edition of folio 186. The library edition of folios 185, 187, and higher numbers sells for 25 cents a copy, except that some folios which contain an unusually large amount of matter sell at higher prices. The octavo edition of folio 185 and higher numbers sells for 50 cents a copy, except folio 193, which sells for 75 cents a copy. A discount of 40 per cent is allowed on an order for folios or for folios together with topographic maps amounting to $5 or more at the retail rate.

All the folios contain descriptions of the drainage of the quadrangles. The folios in the following list contain also brief discussions of the underground waters in connection with the economic resources of the areas and more or less information concerning the utilization of the water resources.

An asterisk (*) indicates that the stock of the folio is exhausted.

36. Pueblo, Colorado. 5c.
*58. Elmoro, Colorado. 5c.
68. Walsenburg, Colorado. 5c.
*71. Spanish Peaks, Colorado. 5c.
122. Tahlequah, Oklahoma-Arkansas. 5c.
*132. Muskogee, Oklahoma. 5c.
*135. Nepesta, Colorado. 5c.
148. Joplin district, Missouri-Kansas. (Reprinted in 1914.) 50c.
*154. Winslow, Arkansas–Oklahoma (Ind. T.). 5c.
*159. Independence, Kans. 5c.

[1] Index maps showing areas in the lower Mississippi River basin covered by topographic maps and by geologic folios will be mailed on receipt of request addressed to the Director, U. S. Geological Survey, Washington, D. C.

186. Apishapa, Colorado.[1]
198. Castle Rock, Colorado. 25c.
202. Eureka Springs-Harrison, Arkansas. 25c.
203. Colorado Springs, Colorado. 25c.

MISCELLANEOUS REPORTS.

Other Federal bureaus, State and other organizations have from time to time published reports relating to water resources of various sections of the country. Notable among those pertaining to the lower Mississippi River drainage basin are the reports of the State geologists of Kansas, Tennessee, Louisiana, and Texas, the Mississippi Agricultural Experiment Station, the Chief of Engineers, United States Army, the Mississippi River Commission, and the Tenth Census, volume 17. The following reports deserve special mention:

Special report on well waters in Kansas, by Erasmus Haworth, State geologist: Kansas Univ. Geol. Survey Bull. 1, 1913.

Report of the Board of irrigation survey and experiment for 1895 and 1896 to the Legislature of Kansas, 1897.

Report on the underground waters of Louisiana, by G. D. Harris, A. C. Veatch, and others: Louisiana Geol. Survey Bull. 1, 1905.

Geology and underground water resources of northern Louisiana, with notes on adjoining districts, by A. C. Veatch: Louisiana Geol. Suevey Bull. 4, 1906.

Report on water purification investigation and on plans proposed for sewerage waterworks systems: New Orleans Sewerage and Water Board, 1903.

Water powers of Arkansas: A preliminary report on White River and some of its tributaries, by W. N. Gladson. 1911.

Preliminary report upon the drainage of lands overflowed by the North and Middle forks of Forked Deer River and Rutherford Fork of Obion River in Gibson County, Tenn., by A. E. Morgan and S. H. McCrory: Tennessee Geol. Survey Bull. 3–B, 1910.

The delta of the Mississippi: the physics of the river, the control of its floods, and the redemption of the alluvion, by Col. Caleb G. Forshey, Cambridge, 1873.

Report upon the physics and hydraulics of the Mississippi River, by A. A. Humphreys and H. L. Abbot: Prof. Papers Corps Top. Eng. U. S. Army, No. 4, 1861.

GEOLOGICAL SURVEY HYDROLOGIC REPORTS OF GENERAL INTEREST.

The following list comprises reports not readily classifiable by drainage basins and covering a wide range of hydrologic investigations.

WATER-SUPPLY PAPERS.

*1. Pumping water for irrigation, by H. M. Wilson. 1896. 57 pp., 9 pls.

Describes pumps and motive powers, windmills, water wheels, and various kinds of engines; also storage reservoirs to retain pumped water until needed for irrigation.

*3. Sewage irrigation, by G. W. Rafter. 1897. 100 pp., 4 pls. (See Water-Supply Paper 22.) 10c.

Discusses methods of sewage disposal by intermittent filtration and by irrigation; describes utilization of sewage in Germany, England, and France, and sewage purification in the United States.

[1] Issued in two editions—library (18 by 22 inches), 5c. and octavo (6 by 9 inches), 50c. Specify edition desired.

*8. Windmills for irrigation, by E. C. Murphy. 1897. 49 pp., 8 pls. 10c.

Gives results of experimental tests of windmills during the summer of 1896 in the vicinity of Garden, Kans.; describes instruments and methods and draws conclusions.

*14. New tests of certain pumps and water lifts used in irrigation, by O. P. Hood. 1898. 91 pp., 1 pl.

Discusses efficiency of pumps and water lifts of various types.

*20. Experiments with windmills, by T. O. Perry. 1899. 97 pp., 12 pls. 15c.

Includes tables and descriptions of wind wheels, compares wheels of several types, and discusses results.

*22. Sewage irrigation, Part II, by G. W. Rafter. 1899. 100 pp., 7 pls. 15c.

Gives résumé of Water-Supply Paper No. 3; discusses pollution of certain streams, experiments on purification of factory wastes in Massachusetts, value of commercial fertilizers, and describes American sewage-disposal plants by States; contains bibliography of publications relating to sewage utilization and disposal.

*41. The windmill: its efficiency and economic use, Part I, by E. C. Murphy. 1901. 72 pp., 14 pls. 5c.

*42. The windmill: its efficiency and economic use, Part II, by E. C. Murphy. 1901. 75 pp. (73–147), 2 pls. (15–16.) 10c.

Nos. 41 and 42 give details of results of experimental tests with windmills of various types.

*56. Methods of stream measurement. 1901. 51 pp., 12 pls. 15c.

Describes the methods used by the Survey in 1901–2. See also Nos. 64, 94, and 95.

64. Accuracy of stream measurements, by E. C. Murphy. 1902. 99 pp., 4 pls. (See No. 95.) 10c.

Describes methods of measuring velocity of water and of measuring and computing stream flow and compares results obtained with the different instruments and methods; describes also experiments and results at the Cornell University hydraulic laboratory. A second, enlarged, edition published as Water-Supply Paper 95.

*67. The motions of underground waters, by C. S. Slichter. 1902. 106 pp., 8 pls. 15c.

Discusses origin, depth, and amount of ground waters; permeability of rocks and porosity of soils; causes, rates, and laws of motions of ground water; surface and deep zones of flow, and recovery of waters by open wells and artesian and deep wells; treats of the shape and position of the water table; gives simple methods of measuring yield of flowing wells; describes artesian wells at Savannah, Ga.

72. Sewage pollution in the metropolitan area near New York City and its effect on inland water resources, by M. O. Leighton. 1902. 75 pp., 8 pls. 10c.

Defines "normal" and "polluted" waters and discusses the damage resulting from pollution.

*80. The relation of rainfall to run-off, by G. W. Rafter. 1903. 104 pp. 10c.

Treats of measurements of rainfall and laws and measurements of stream flow; gives rainfall, run-off, and evaporation formulas; discusses effect of forests on rainfall and run-off.

87. Irrigation in India (second edition), by H. M. Wilson. 1903. 238 pp., 27 pls. 25c.

First edition was published in Part II of the Twelfth Annual Report.

93. Proceedings of first conference of engineers of the Reclamation Service, with accompanying papers, compiled by F. H. Newell, chief engineer. 1904. 361 pp. 25c. [Requests for this report should be addressed to the U. S. Reclamation Service.]

Contains the following papers of more or less general interest:
Limits of an irrigation project, by D. W. Ross.
Relation of Federal and State laws to irrigation, by Morris Bien.
Electrical transmission of power for pumping, by H. A. Storrs.
Correct design and stability of high masonry dams, by Geo. Y. Wisner.
Irrigation surveys and the use of the plane table, by J. B. Lippincott.
The use of alkaline waters for irrigation, by Thomas H. Means.

*94. Hydrographic manual of the United States Geological Survey, prepared by E. C. Murphy, J. C. Hoyt, and G. B. Hollister. 1904. 76 pp., 3 pls. 10c.

Gives instruction for field and office work relating to measurements of stream flow by current meters. See also No. 95.

*95. Accuracy of stream measurements (second, enlarged edition), by E. C. Murphy. 1904. 169 pp., 6 pls.

Describes methods of measuring and computing stream flow and compares results derived from different instruments and methods. See also No. 94.

*103. A review of the laws forbidding pollution of inland waters in the United States, by E. B. Goodell. 1904. 120 pp. (See No. 152.)

Explains the legal principles under which antipollution statutes become operative, quotes court decisions to show authority for various deductions, and classifies according to scope the statutes enacted in the different States.

110. Contributions to the hydrology of eastern United States, 1904; M. L. Fuller, geologist in charge. 1905. 211 pp., 5 pls. 10c.

Contains the following reports of general interest. The scope of each paper is indicated by its title.

Description of underflow meter used in measuring the velocity and direction of underground water, by Charles S. Slichter.

The California or "stovepipe" method of well construction, by Charles S. Slichter.

Approximate methods of measuring the yield of flowing wells, by Charles S. Slichter.

Corrections necessary in accurate determinations of flow from vertical well casings, from notes furnished by A. N. Talbot.

Experiment relating to problems of well contamination at Quitman, Ga., by S. W. McCallie.

113. The disposal of strawboard and oil-well wastes, by R. L. Sackett and Isaiah Bowman. 1905. 52 pp., 4 pls. 5c.

The first paper discusses the pollution of streams by sewage and by trade wastes, describes the manufacture of strawboard and gives results of various experiments in disposing of the waste. The second paper describes briefly the topography, drainage, and geology of the region about Marion, Ind., the contamination of rock wells and of streams by waste oil and brine.

*114. Underground waters of eastern United States: M. L. Fuller, geologist in charge. 1905. 285 pp., 18 pls. 25c.

Contains report on "Occurrence of underground waters," by M. L. Fuller, discussing sources, amount, and temperature of waters, permeability and storage capacity of rocks, water-bearing formations, recovery of water by springs, wells, and pumps, eseential conditions of artesian flows, and general conditions affecting underground waters in eastern United States.

119. Index to the hydrographic progress reports of the United States Geological Survey, 1888 to 1903, by J. C. Hoyt and B. D. Wood. 1905. 253 pp. 15c.

120. Bibliographic review and index of papers relating to underground waters published by the United States Geological Survey, 1879–1904, by M. L. Fuller. 1905. 128 pp. 10c.

Scope indicated by title.

*122. Relation of the law to underground waters, by D. W. Johnson. 1905. 55 pp. 5c

Defines and classifies underground waters, gives common-law rules relating to their use, and cites State legislation acts affecting them.

140. Field measurements of the rate of movement of underground waters, by C. S. Slichter. 1905. 122 pp., 15 pls. 15c.

Discusses the capacity of sand to transmit water, describes measurements of underflow in Rio Hondo, San Gabriel, and Mohave River valleys, Cal., and on Long Island, N. Y.; gives results of tests of wells and pumping plants, and describes stovepipe method of well construction.

143. Experiments on steel-concrete pipes on a working scale, by J. H. Quinton. 1905. 61 pp., 4 pls. 5c.

Scope indicated by title.

145. Contributions to the hydrology of eastern United States, 1905; M. L. Fuller, geologist in charge. 1905. 220 pp., 6 pls. 10c.

Contains brief reports of general interest as follows:
Drainage of ponds into drilled wells, by Robert E. Horton. Discusses efficiency, cost, and capacity of drainage wells and gives statistics of such wells in southern Michigan.
Construction of so-called fountain and geyser springs, by Myron L. Fuller.
A convenient gage for determining low artesian heads, by Myron L. Fuller.

146. Proceedings of second conference of engineers of the Reclamation Service, with accompanying papers, compiled by F. H. Newell, chief engineer. 1905. 267 pp. 15c. [Requests for this report should be addressed to the U. S. Reclamation Service.]

Contains the following papers (scope indicated by title) of more or less general interest:
Proposed State code of water laws, by Morris Bien.
Power engineering applied to irrigation problems, by O. H. Ensign.
Estimates on tunneling in irrigation projects, by A. L. Fellows.
Collection of stream-gaging data, by N. C. Grover.
Diamond-drill methods, by G. A. Hammond.
Mean-velocity and area curves, by F. W. Hanna.
Importance of general hydrographic data concerning basisn of streams gaged, by R. E. Horton.
Effect of aquatic vegetation on stream flow, by R. E. Horton.
Sanitary regulations governing construction camps, by M. O. Leighton.
Necessity of draining irrigated land, by Thos. H. Means.
Alkali soils, by Thos. H. Means.
Cost of stream-gaging work, by E. C. Murphy.
Equipment of a cable gaging station, by E. C. Murphy.
Silting of reservoirs, by W. M. Reed.
Farm-unit classification, by D. W. Ross.
Cost of power for pumping irrigating water, by H. A. Storrs.
Records of flow at current-meter gaging stations during the frozen season, by F. H. Tillinghast.

147. Destructive floods in the United States in 1904, by E. C. Murphy and others, 1905. 206 pp., 18 pls. 15c.

Contains a brief account of "A method of computing cross-section area of waterways," including formulas for maximum discharge and areas of cross section.

*150. Weir experiments, coefficients, and formulas, by R. E. Horton. 1906. 189 pps. 38 pls. (See Water-Supply Paper 200.) 15c.

Scope indicated by title.

151. Field assay of water, by M. O. Leighton. 1905. 77 pp., 4 pls.

Discusses methods, instruments, and reagents used in determining turbidity, color, iron, chlorides, and hardness in connection with the studies of the quality of water in various parts of the United States.

152. A review of the laws forbidding pollution of inland waters in the United States. (second edition), by E. B. Goodell. 1905. 149 pp. 10c.

*155. Fluctuations of the water level in wells, with special reference to Long Island, N. Y., by A. C. Veatch. 1906. 83 pp., 9 pls. 25c.

Includes general discussion of fluctuation due to rainfall and evaporation, barometric changes, temperature changes, changes in rivers, changes in lake level, tidal changes, effects of settlement, irrigation, dams, changes in ground-water developments, and to indeterminate causes.

*160. Underground-water papers, 1906; M. L. Fuller, geologist in charge. 1906. 104 pp., 1 pl.

Gives account of work in 1905; lists publications relating to underground waters, and contains the following brief reports of general interest:
Significance of the term "artesian," by Myron L. Fuller.
Representation of wells and springs on maps, by Myron L. Fuller.
Total amount of free water in the earth's crust, by Myron L. Fuller.
Use of fluorescein in the study of underground waters, by R. B. Dole.
Problems of water contamination, by Isaiah Bowman.
Instances of improvement of water in wells, by Myron L. Fuller.

*162. Destructive floods in the United States in 1905, with a discussion of flood discharge and frequency and an index to flood literature, by E. C. Murphy and others. 1906. 105 pp., 4 pls. 15c.

*163. Bibliographic review and index of underground-water literature published in the United States in 1905, by M. L. Fuller, F. G. Clapp, and B. L. Johnson. 1906. 130 pp. 15c.

Scope indicated by title.

*179. Prevention of stream pollution by distillery refuse, based on investigations at Lynchburg, Ohio, by Herman Stabler. 1906. 34 pp., 1 pl. 10c.

Describes grain distillation, treatment of slop, sources, character, and effects of effluents on streams; discusses filtration, precipitation, fermentation, and evaporation methods of disposal of wastes without pollution.

*180. Turbine water-wheel tests and power tables, by R. E. Horton. 1906. 134 pp., 2 pls. 20c.

Scope indicated by title.

*185. Investigations on the purification of Boston sewage, by C.-E. A. Winslow and E. B. Phelps. 1906. 163 pp. 25c.

Discusses composition, disposal, purification, and treatment of sewage and tendencies in sewage-disposal practice in England, Germany, and the United States; describes character of crude sewage at Boston, removal of suspended matter, treatment in septic tanks, and purification in intermittent sand filtration and coarse material; gives bibliography.

*186. Stream pollution by acid-iron wastes, a report based on investigations made at Shelby, Ohio, by Herman Stabler. 1906. 36 pp., 1 pl.

Gives history of pollution by acid-iron wastes at Shelby, Ohio, and resulting litigation; discusses effect of acid-iron liquors on sewage-purification processes, recovery of copperas from acid-iron wastes, and other processes for removal of pickling liquor.

*187. Determination of stream flow during the frozen season, by H. K. Barrows and R. E. Horton. 1907. 93 pp., 1 pl. 15c.

Scope indicated by title.

*189. The prevention of stream pollution by strawboard waste, by E. B. Phelps. 1906. 29 pp., 2 pls.

Describes manufacture of strawboard, present and proposed methods of disposal of waste liquors, laboratory investigations of precipitation and sedimentation, and field studies of amount and character of water used, raw material and finished product, and mechanical filtration.

*194. Pollution of Illinois and Mississippi rivers by Chicago sewage (a digest of the testimony taken in the case of the State of Missouri *v.* the State of Illinois and the Sanitary District of Chicago), by M. O. Leighton. 1907. 369 pp., 2 pls.

Scope indicated by amplification of title.

*200. Weir experiments, coefficients, and formulas (revision of paper No. 150), by R. E. Horton. 1907. 195 pp., 38 pls. 35c.

Scope indicated by title.

*226. The pollution of streams by sulphite-pulp waste, a study of possible remedies, by E. B. Phelps. 1909. 37 pp., 1 pl. 10c.

Describes manufacture of sulphite pulp, the waste liquors, and the experimental work leading to suggestions as to methods of preventing stream pollution.

*229. The disinfection of sewage and sewage filter effluents, with a chapter on the putrescibility and stability of sewage effluents, by E. B. Phelps. 1909. 91 pp., 1 pl. 15c.

Scope indicated by title.

*234. Papers on the conservation of water resources. 1909. 96 pp., 2 pls. 15c.

Contains the following papers, whose scope is indicated by their titles: Distribution of rainfall, by Henry Gannett; Floods, by M. O. Leighton; Developed water powers, compiled under the direction of W. M. Steuart, with discussion by M. O. Leighton; Undeveloped water powers, by M. O. Leighton; Irrigation, by F. H. Newell; Underground waters, by W. C. Mendenhall; Denudation, by R. B. Dole and Herman Stabler; Control of catchment areas, by H. N. Parker.

*235. The purification of some textile and other factory wastes, by Herman Stabler and G. H. Pratt. 1909. 76 pp. 10c.

Discusses waste waters from wool scouring, bleaching and dyeing cotton yarn, bleaching cotton piece goods, and manufacture of oleomargarine, fertilizer, and glue.

236. The quality of surface waters in the United States, Part I, analyses of waters east of the one hundredth meridian, by R. B. Dole. 1909. 123 pp. 10c.

Describes collection of samples, methods of examination, preparation of solutions, accuracy estimates, and expression of analytical results.

238. The public utility of water powers and their governmental regulation, by René Tavernier and M. O. Leighton. 1910. 161 pp. 15c.

Discusses hydraulic power and irrigation, French, Italian, and Swiss legislation relative to the development of water powers, and laws proposed in the French Parliament; reviews work of bureau of hydraulics and agricultural improvements of the French department of agriculture, and gives résumé of Federal and State water-power legislation in the United States.

*255. Underground waters for farm use, by M. L. Fuller. 1910. 58 pp., 17 pls. 15c.

Discusses rocks as sources of water supply and the relative safety of supplies from different materials; springs, and their protection; open or dug and deep wells, their location, yield, relative cost, protection, and safety; advantages and disadvantages of cisterns and combination wells and cisterns.

*257. Well-drilling methods, by Isaiah Bowman. 1911. 139 pp., 4 pls. 15c.

Discusses amount, distribution, and disposal of rainfall, water-bearing rocks, amount of ground water, artesian conditions, and oil and gas bearing formations; gives history of well drilling in Asia, Europe, and the United States; describes in detail the various methods and the machinery used; discusses loss of tools and geologic difficulties; contamination of well waters and methods of prevention; tests of capacity and measurement of depth; and costs of sinking wells.

*258. Underground-water papers, 1910, by M. L. Fuller, F. G. Clapp, G. C. Matson, Samuel Sanford, and H. C. Wolff. 1911. 123 pp., 2 pls. 15c.

Contains the following papers (scope indicated by titles) of general interest:
Drainage by wells, by M. L. Fuller.
Freezing of wells and related phenomena, by M. L. Fuller.
Pollution of underground waters in limestone, by G. C. Matson.
Protection of shallow wells in sandy deposits, by M. L. Fuller.
Magnetic wells, by M. L. Fuller.

*315. The purification of public water supplies, by G. A. Johnson. 1913. 84 pp., 8 pls. 10c.

Discusses ground, lake, and river waters as public supplies, development of waterworks systems in the United States, water consumption, and typhoid fever; describes methods of filtration and sterilization of water and municipal water softening.

334. The Ohio Valley flood of March-April, 1913 (including comparisons with some earlier floods), by A. H. Horton and H. J. Jackson. 1913. 96 pp., 22 pls. 20c.

Although relating specifically to floods in the Ohio Valley, this report discusses also the causes of floods and the prevention of damage by floods.

337. The effects of ice on stream flow, by William Glenn Hoyt. 1913. 77 pp., 7 pls. 15c.

Discusses methods of measuring the winter flow of streams.

*345. Contributions to the hydrology of the United States, 1914. N. C. Grover, chief hydraulic engineer. 1915. 225 pp., 17 pls. 30c. Contains:

*(e) A method of determining the daily discharge of rivers of variable slope, by M. R. Hall, W. E. Hall, and C. H. Pierce, pp. 53-65.

364. Water analyses from the laboratory of the United States Geological Survey, tabulated by F. W. Clarke, chief chemist. 1914. 40 pp. 5c.

Contains analyses of waters from rivers, lakes, wells, and springs in various parts of the United States, including analyses of the geyser water of Yellowstone National Park, hot springs in Montana, brines from Death Valley, water from the Gulf of Mexico, and mine waters from Tennessee, Michigan, Missouri and Oklahoma, Montana, Colorado and Utah, Nevada and Arizona, and California.

371. Equipment for current-meter gaging stations, by G. J. Lyon. 1915. 64 pp., 37 pls. 20c.

Describes methods of installing automatic and other gages and of constructing gage well shelters, and structures for making discharge measurements and artificial controls.

*375. Contributions to the hydrology of the United States, 1915. N. C. Grover, chief hydraulic engineer. 1916. 181 pp., 9 pls. 15c. Contains:

*(c) The relation of stream gaging to the science of hydraulics, by C. H. Pierce and R. W. Davenport, pp. 77–84.

(e) A method of correcting river discharge for a changing stage, by B. E. Jones, pp. 117–130.

(f) Conditions requiring the use of automatic gages in obtaining records of stream flow, by C. H. Pierce, pp. 131–139.

Three papers presented at the conference of engineers of the water-resources branch in December, 1914.

*400. Contributions to the hydrology of the United States, 1916. N. C. Grover, chief hydraulic engineer. 1917. 108 pp., 7 pls. Contains:

(a) The people's interest in water-power resources, by G. O. Smith, pp. 1–8.

(c) The measurement of silt-laden streams, by Raymond C. Pierce, pp. 39–51.

(d) Accuracy of stream-flow data, by N. C. Grover and J. C. Hoyt, pp. 53–59.

416. The divining rod, a history of water witching, with a bibliography, by Arthur J. Ellis. 1917. 59 pp. 10c.

A brief paper published "merely to furnish a reply to the numerous inquiries that are continually being received from all parts of the country" as to the efficacy of the divining rod for locating underground water.

425. Contributions to the hydrology of the United States, 1917. N. C. Grover, chief hydraulic engineer. 1918. Contains:

(c) Hydraulic conversion tables and convenient equivalents, pp. 71–94.

ANNUAL REPORTS.

*Fifth Annual Report of the United States Geological Survey, 1883–84, J. W. Powell, Director. 1885. xxxvi, 469 pp., 58 pls. $2.25. Contains:

*The requisite and qualifying conditions of artesian wells, by T. C. Chamberlain, pp. 125–173, pl. 21. Scope indicated by title.

Twelfth Annual Report of the United States Geological Survey, 1890–91, J. W. Powell, Director. 1891. 2 parts. Pt. II, Irrigation, xviii, 576 pp., 93 pls. $2. Contains:

*Irrigation in India, by H. M. Wilson, pp. 363–561, pls. 107–146. See Water-Supply Paper 87.

Thirteenth Annual Report of the United States Geological Survey, 1891–92, J. W. Powell, Director. 1892. (Pts. II and III, 1893.) 3 parts. *Pt. III, Irrigation, xi, 486 pp., 77 pls. $1.85. Contains:

*American irrigation engineering, by H. M. Wilson, pp. 101–349, pls. 111–146. Discusses the economic aspects of irrigation, alkaline drainage, silt, and sedimentation; gives brief history of legislation; describes perennial canals in Idaho-California, Wyoming, and Arizona; discusses water storage at reservoirs of the California and other projects, subsurface sources of supply, pumping, and subirrigation.

Fourteenth Annual Report of the United States Geological Survey, 1892–93, J. W. Powell, Director. 1893. (Pt. II, 1894.) 2 parts. *Pt. II, Accompanying papers, xx, 597, pp. 73 pls. $2.10. Contains:

*The potable waters of eastern United States, by W. J. McGee, pp. 1–47. Discusses cistern water, stream waters, and ground waters, including mineral springs and artesian wells.

*Natural mineral waters of the United States, by A. C. Peale, pp. 49–88, pls. 3 and 4. Discusses the origin and flow of mineral springs, the source of mineralization, thermal springs, the chemical composition and analysis of spring waters, geographic distribution, and the utilization of mineral waters; gives a list of American mineral-springs resorts; contains also some analyses.

Nineteenth Annual Report of the United States Geological Survey, 1897–98, Charles D. Walcott, Director. 1898. (Parts II, III, and V, 1899.) 6 parts in 7 vols. and separate cases for maps with Pt. V. *Pt. II, Papers chiefly of a theoretic nature, v. 958 pp., 172 pls. $2.65. Contains:

*Principles and conditions of the movements of ground water, by F. H. King, pp. 59–294, pls. 6–16. Discusses the amount of waters stored in sandstone, in soil, and in other rocks, the depth to which ground water penetrates; gravitational, thermal, and capillary movements of ground waters, and the configuration of the ground-water surface; gives the results of experimental investigations on the flow of air and water through a rigid, porous media, and through sands, sandstones, and silts; discusses results obtained by other investigators, and summarizes results of observations; discusses also rate of flow of water through sand and rock, the growth of rivers, rate of filtration through soil, interference of wells, etc.

*Theoretical investigation of the motion of ground waters, by C. S. Slichter, pp. 295–384, pl. 17. Scope indicated by title.

PROFESSIONAL PAPERS.

*72. Denudation and erosion in the southern Appalachian region and the Monongahela basin, by L. C. Glenn. 1911. 137 pp., 21 pls. 35c.

Describes the topography, geology, drainage, forests, climate, population, and transportation facilities of the region, the relation of agriculture, lumbering, mining, and power development to erosion and denudation, and the nature, effects, and remedies of erosion; gives details of conditions in Holston, Nolichucky, French Broad, Little Tennessee, and Hiwassee river basins, along Tennessee River proper, and in the basins of the Coosa-Alabama system, Chattahoochee, Savannah, Saluda, Broad, Catawba, Yadkin, New, and Monongahela rivers.

86. The transportation of débris by running water, by G. K. Gilbert, based on experiments made with the assistance of E. C. Murphy. 1914. 263 pp., 3 pls. 70c.

The results of an investigation which was carried on in a specially equipped laboratory at Berkeley, Calif., and was undertaken for the purpose of learning "the laws which control the movement of bed load and especially to determine how the quantity of load is related to the stream's slope and discharge and to the degree of comminution of the débris."

A highly technical report.

105. Hydraulic mining débris in the Sierra Nevada, by G. K. Gilbert. 154 pp., 34 pls. 1917.

Presents the results of an investigation undertaken by the United States Geological Survey in response to a memorial from the California Miners' Association asking that a particular study be made of portions of the Sacramento and San Joaquin valleys affected by detritus from torrential streams. The report deals largely with geologic and physiographic aspects of the subject, traces the physical effects, past and future, of the hydraulic mining of earlier decades, the similar effects which certain other industries induce through stimulation of the erosion of the soil, and the influence of the restriction of the area of inundation by the construction of levees. Suggess- cooperation by several interests for the control of the streams now carrying heavy loads of débris.

BULLETINS.

*32. Lists and analyses of the mineral springs of the United States (a preliminary study), by A. C. Peale. 1886. 235 pp.

Defines mineral waters, lists the springs by States, and gives tables of available analyses.

*319. Summary of the controlling factors of artesian flows, by Myron L. Fuller, 1908. 10c.

Describes underground reservoirs, the sources of underground waters, the confining agents, the primary and modifying factors of artesian circulation, the essential and modifying factors of artesian flow, and typical artesian systems.

*479. The geochemical interpretation of water analyses, by Chase Palmer. 1911. 31 pp. 5c.

Discusses the expression of chemical analyses, the chemical character of water and the properties of natural waters; gives a classification of waters based on property values and reacting values, and discusses the character of the waters of certain rivers as interpreted directly from the results of analyses; discusses also the relation of water properties to geologic formations, silica in river water, and the character of the water of the Mississippi and the Great Lakes and St. Lawrence River as indicated by chemical analyses.

INDEX BY AREAS AND SUBJECTS.

A=Annual Reports; M=Monograph; B=Bulletin; P=Professional Paper; W=Water-supply Paper; G F=Geologic folio.]

Arkansas: Quality of waters, etc. W 102, 145, 236, 399; G F 154
Surface waters. G F 202
Underground waters. W 57, 102, 110, 114, 145, 149, 160, 399; P 46; G F 122, 154, 202
Artesian waters: Essential conditions. A 5; B 319; W 67, 114
Bibliographies [1]. W 119, 120, 163, 416
Chemical analyses [2]. W 151, 236, 274, 364; B 479
Colorado: Quality of waters. W 236, 274; G F 135, 203
Surface waters. W 74, 147, 162; G F 203
Underground waters. A 16, ii; 17, ii; 21, iv; 22, iv; P 32, 52; W 57, 149; G F 36, 58, 68, 71, 135, 186, 198, 203
Conservation. W 234, 400*a*
Conversion tables. 425*c*
Débris reports. P 86, 105
Denudation. P 72
Divining rod. W 416
Engineering methods. P 86; W 1, 3, 8, 20, 41, 42, 43, 56, 64, 93, 94, 95, 110, 143, 146, 150, 180, 187, 200, 257, 337, 345*e*, 371, 375*c*, *e*, and *f*; 400*c* and *d*; 425*c*
Floods. W 96, 147, 162, 334
Ice measurements. W 146, 187, 337
Irrigation, general. A 10, ii; 11, ii; 12, ii; 13, iii; 16, ii; W 20, 22, 41, 42, 87, 93, 146
Kansas: Quality of waters. B 238; W 153, 273; G F 148
Surface waters. B 238; W 96, 147, 273
Underground waters. A 16, ii; 21, iv; 22, iv; B 238; P 32; W 6, 57, 145, 149, 153, 273, 345*a*; G F 148, 159
Kentucky: Quality of waters. W 164
Underground waters. W 57, 102, 110, 114, 149, 164
Legal aspects: Surface waters. W 103, 152, 238
Underground waters. W 122
Louisiana: Quality of waters. W 101, 236
Underground waters. W 57, 101, 114, 149; P 46
Mineral springs: Analyses. A 14, ii; B 32
Origin, distribution, etc. A 14, ii
Lists. B 32; W 114
Mississippi: Quality of waters. W 159
Surface waters. W 107
Underground waters. W 57, 102, 114, 149, 159
Missouri: Quality of waters, etc. W 195; G F 148
Surface waters. W 162; G F 148
Underground waters. W 57, 102, 110, 114, 145, 149, 195; G F 148

[1] Many of the reports contain brief subject bibliographies. See abstracts.

[2] Many analyses of river, spring, and well waters are scattered through publications, as noted in abstracts.

Motions of ground waters..... A 19, ii; B 319; W 67, 110, 140, 155
New Mexico: Quality of waters..... W 274
River profiles..... W 421
Surface waters..... W 147, 162
Underground waters..... A 21, iv; 22, iv; W 61, 149
Oklahoma [Indian Territory]: Quality of waters..... A 21, vii; W 148, 274; G F 154
Surface waters..... W 147, 148; G F 132
Underground waters.. A 21, vii; W 57, 61, 148, 149, 345*b* and *d*; G F 122, 132, 154
Pollution: By industrial wastes..... W 179, 186, 189, 226, 235
By sewage..... W 72, 194
Laws forbidding..... W 103, 152
Indices of..... W 144, 160
Sanitation; quality of water; pollution; sewage irrigation..... W 3, 22, 72, 103, 110, 113, 114, 144, 145, 152, 160, 179, 185, 186, 189, 194, 226, 229, 235, 236, 255, 258, 315
Sewage disposal and purification..... W 3, 22, 72, 113, 185, 194, 229
Tennessee: Quality of waters..... W 164, 236
Underground waters..... W 61, 102, 114, 149, 164
Texas: Quality of waters..... A 21, vii; W 276, 317
Surface waters..... W 105, 154, 162, 191
Underground waters..... A 21, iv; 21, vii; 22, iv; W 61, 149, 154, 191, 276, 317
Underground waters: Legal aspects..... W 122
Methods of utilization..... W 114, 255, 257
Pollution..... W 110, 145, 160, 258
Windmill papers..... W 8, 20, 41, 42

INDEX OF STREAMS.

	Page.
Arkansas River, Colo.-Kans.	IX–X
Arkansas River canals, Colo.	XII
Arkansas River, East Fork, Colo.	IX
Arkansas River, Lake Fork, Colo.	X
Arkansas River, Salt Fork, Okla.	XI
Arkansas River, South Fork, Colo.	X
Arkansas River, Tennessee Fork, Colo.	X
Beaver Creek, Okla.	XI
Beaver Creek, Little, Colo.	X
Beaver Creek, West, Colo.	X
Big Sandy Creek, Colo.	X, XI
Big Spring Creek, Colo.	XI
Black River, Mo.	IX
Boehmer Creek, Colo.	X
Buffalo River, Ark.	IX
Cabin Creek, Colo.	X
Cache Creek, Okla.	XII
Canadian River, N. Mex.-Okla.	XI
Canadian River, North Fork, Okla.	XI
Chalk Creek, Colo.	X
Chicorica Creek, N. Mex.	XI
Cimarron River (tributary to Arkansas River), Kans.-Okla.	XI
Cimarron River (tributary to Canadian River), N. Mex.	XI
Clear Creek, Colo.	X
Coldwater River, Miss.	XII
Colorado-Kansas canal, Colo.	XII
Cottonwood Creek, Colo.	X
Cottonwood Creek, North, Colo.	X
Cottonwood Creek, South Fork, Colo.	X
Courtois Creek, Mo.	IX
Cucharas River, Colo.	X
Deep Red Run. *See* Turkey Creek.	
Dry Fork of Otter Creek, Okla.	XII
East Fork. *See* name of main stream.	
Eleven Point River, Mo.	IX
Elk Creek, Okla.	XII
Elm Fork of Red River, Okla.	XII
Evaporation station, Okla.	XII
Fall River, Kans.	XI
Fountain Creek, Colo.	X
Fourmile Creek. *See* Oil Creek.	
Grand River. *See* Neosho River.	
Grape Creek, Colo.	X
Greer Spring, Mo.	IX
Half Moon Creek, Colo.	X
Homochitto River, Miss.	XII
Horse Creek, Okla.	XII
Huerfano River, Colo.	X
Keese ditch, Colo.	XII
La Cueva canal, N. Mex.	XI
Lake Creek, Colo.	X
Lake Fork of Arkansas River, Colo.	X
Lion Creek, Colo.	X
Little Beaver Creek, Colo.	X
Little Medicine Bluff Creek, Okla.	XII
Little Red River, Ark.	IX
Manuelitos River, N. Mex.	XI
Medicine Bluff Creek, Okla.	XII
Medicine Bluff Creek, Little, Okla.	XII
Medicine Lodge River, Kans.	XI
Meramec River, Mo.	IX
Meramec River, Dry Fork, Mo.	IX
Meramec Spring, Mo.	IX
Mora River, N. Mex.	XI
Neosho River, Kans.-Okla.	XI
North Cottonwood Creek, Colo.	X
North Fork River, Ark.	IX
North Fork. *See* name of main stream.	
Ocate River, N. Mex.	XI
Ocate River, East Fork, N. Mex.	XI
Ocate River, West Fork, N. Mex.	XI
Oil Creek, Colo.	X
Otter Creek, Okla.	XII
Otter Creek, Dry Fork, Okla.	XII
Ouachita River, Ark.	XII
Oxford Farmers canal, Colo.	XII
Pajarito Creek, N. Mex.	XI
Poncha Creek, Colo.	X
Purgatory River, Colo.	X
Rayado River, N. Mex.	XI
Red River, Tex.	XII
Red River, Elm Fork, Okla.	XII
Red River, Little, Ark.	IX

	Page.
Red River, North Fork, Okla.	XII
Red River, Salt Fork, Okla.	XII
Ruxton Creek, South, Colo.	X
Sackett Creek, Colo.	X
Salt Fork of Arkansas River, Okla.	XI
Salt Fork of Red River, Okla.	XII
Sandy Creek, Big, Colo.	X, XI
Sapello Mill tailrace, N. Mex.	XI
Sapello River, N. Mex.	XI
Sheep Creek, Colo.	X
South Fork. *See* name of main stream.	
South Ruxton Creek, Colo.	X
Spring Branch, Mo.	IX
Sunflower River, Miss.	XII
Sweetwater Creek, N. Mex.	XI
Tallahatchie River, Miss.	XII
Tennessee Fork of Arkansas River, Colo.	X
Turkey Creek [Deep Red Run], Okla.	XII
Twin Lakes outlet, Colo.	X
Una del Gato Creek, N. Mex.	XI
Urraca Creek, N. Mex.	XI
Ute Creek, N. Mex.	XI
Verdigris River, Kans.-Okla.	XI
Walnut River, Kans.	XI
Washita River, Okla.	XII
West Beaver Creek, Colo.	X
West Fork. *See* name of main stream.	
White River, Ark.-Mo.	IX
Wichita River, Tex.	XII
Yalobusha River, Miss.	XII
Yazoo River, Miss.	XII

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