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U. S. DEPARTMENT OF AGRICULTURE.

WEATHER BUREAU.—BULLETIN [illegible].

# THE RIVERS AND FLOODS OF THE SACRAMENTO AND SAN JOAQUIN WATERSHEDS.

Prepared under the direction of WILLIS L. MOORE, Chief U. S. Weather Bureau.

BY

NATHANIEL R. TAYLOR,
LOCAL FORECASTER.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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# LETTER OF TRANSMITTAL.

UNITED STATES DEPARTMENT OF AGRICULTURE,
WEATHER BUREAU, OFFICE OF THE CHIEF,
*Washington, D. C., February 4, 1913.*

The honorable the SECRETARY OF AGRICULTURE,
*Washington, D. C.*

SIR: I have the honor to transmit herewith a paper by Mr. Nathaniel R. Taylor, local forecaster in charge of the local office of the Weather Bureau at Sacramento, Cal., on "The Rivers and Floods in Sacramento and San Joaquin Watersheds."

I recommend the publication of this paper as a bulletin of the Weather Bureau.

Very respectfully,

H. E. WILLIAMS,
*Acting Chief United States Weather Bureau.*

Approved:
JAMES WILSON, *Secretary.*

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Fig. 1.—The Sacramento and San Joaquin watersheds.

# THE RIVERS AND FLOODS OF THE SACRAMENTO AND SAN JOAQUIN WATERSHEDS.

By Nathaniel R. Taylor, Local Forecaster.

## Introduction.

This paper will be devoted to a discussion of some of the causes that modify stream flow in the Great Central Valley of California and to the tabulation of such river and rainfall data as are available in connection with flood periods, with notes on the various floods that have occurred since 1849, more especially those in the Sacramento watershed. A brief description of the larger streams and their watersheds will be given, together with distances between important points on the main rivers and their larger tributaries.

Much of the information relative to floods in the early days in the city of Sacramento has been gleaned from the History of Sacramento County, Cal., by Thompson and West, and by a perusal of the old files of the Sacramento newspapers, the Bee and the Record Union.

Information relative to the floods of the Feather and the Yuba Rivers, and to the condition of these streams during the past two decades, has been kindly furnished by Mr. W. T. Ellis, president of the Marysville Levee Commission, who has made an exhaustive study of floods in the watershed of the Feather-Yuba, and, who, more than any other official, is responsible for the almost impregnable levee system that has made Marysville practically immune from future floods.

Mr. W. E. Meek, of Antioch, Cal., and others, with whom the writer has discussed conditions in the island districts, have kindly supplied much valuable information, which has never before been published, relative to floods in the delta lands of the Sacramento and San Joaquin Rivers.

In addition to the records of the Weather Bureau, from which river and precipitation data have been taken, a study of the various Water-Supply Papers of the water resources branch of the United States Geological Survey has been the means of securing much of the information regarding elevations and descriptions of stream sources in the high Sierra.

An article published in the American Society of Civil Engineers, by W. B. Clapp, E. C. Murphy, and W. F. Martin, has been of material assistance to the writer, especially with respect to the areas and capacities of the numerous flood basins of the Sacramento Valley.

The map, tabulations, and hydrographs printed in connection with this paper are the work of Mr. Hermann J. Andree, assistant observer, United States Weather Bureau.

While the records of the Weather Bureau contain river gauge readings at several points on the Sacramento River as early as 1875, and on the San Joaquin River since 1896, it was not until May, 1906, that a thorough river service was inaugurated, which included stations at all strategic points, not only on the Sacramento and San Joaquin Rivers but on all important watercourses that feed those streams.

The work of reorganizing the river service of the Great Central Valley was performed by Mr. James H. Scarr, local forecaster, United States Weather Bureau, under the direction of Prof. Willis L. Moore, chief of the bureau.

The length of the Great Central Valley of California is about 500 miles. It varies in width from a few miles at its northern limits, near Redding, to 50 or 60 miles in the Sacramento Valley, to as much as 125 miles in parts of the San Joaquin Valley. It is bounded on the east by the Sierra Nevada and on the west by the Coast Range. These ranges meet on the north at Mount Shasta and again on the south, where they are connected by the Tehachapi cross range, the whole being shut in, except for a narrow opening in the Coast Range at San Francisco, through which its drainage reaches the Pacific.

Probably in no other part of the United States are river conditions so complicated as in the section under discussion, draining, as it does, many thousands of square miles of high mountains where heavy rains and melting snows feed innumerable streams, many of which often grow from innocent rivulets to raging torrents in a few hours' time.

The total area drained is something over 60,000 square miles, and the entire output of all waterways is borne to two trunk streams, the Sacramento and San Joaquin, that merge in Suisun Bay and finally reach the Pacific Ocean through Carquinez Strait, San Pablo and San Francisco Bays.

The table following is taken from Reports on the Control of Floods in the Sacramento Valley and the adjacent San Joaquin Valley, Cal., published in Document No. 81, Sixty-second Congress, first session, and shows the magnitude of the maximum flood discharge of the Sacramento River, as compared with that of several well-known rivers of the United States.

| | Drainage area above station (square miles). | Maximum flood discharge (cubic feet per second recorded). |
|---|---|---|
| Mississippi at Vicksburg | 1,100,000 | 1,777,000 |
| Mississippi above Missouri River | 165,000 | 366,000 |
| Missouri | 527,000 | 546,000 |
| Columbia | 237,000 | 1,390,000 |
| Ohio | 201,700 | 1,233,000 |
| Arkansas | 186,300 | 440,000 |
| Red River | 90,000 | 210,000 |
| Sacramento | 26,000 | [1] 600,000 |

[1] Estimated, 1907–1909.

The point brought out in the above table is that if the Mississippi had the same discharge per square mile as that of the Sacramento its maximum flood discharge would exceed 25,000,000 cubic feet per second. At this rate it would require only a short period of maximum flood discharge to convert the Mississippi Valley from Vicksburg to St. Louis into an inland sea of considerable depth.

While the great valley of California is one continuous area it is popularly known as two separate valleys—the Sacramento on the north and the San Joaquin on the south. These valleys meet at a point contiguous to the Mokelumne and Cosumnes Rivers, and their drainage, as has been stated, finds a common outlet to the sea.

At one time the Mokelumne River connected with the Sacramento River through Tyler Slough at Walnut Grove and Tyler emptied into the Sacramento at its junction with Georgiana Slough. Tyler Slough now being dammed causes all of the water of the Mokelumne and Cosumnes Rivers to flow into the San Joaquin. Therefore, the dividing line between the drainage area of the Sacramento and San Joaquin Valleys is formed by artificial levees that have been thrown up by reclamation districts.

River and flood conditions in the two valleys being somewhat dissimilar, they will be separately discussed in this paper.

## The Sacramento Valley.

The Sacramento drainage basin extends from Mount Shasta southward to Suisun Bay and from the Trinity Mountains and the Coast Range eastward to the Sierra Nevada. The floor of the Sacramento Valley may be said to begin at about Redding, where its width is only a few miles, and to extend southward for a distance of about 150 miles. Above Redding the valley narrows rapidly and becomes a canyon. It widens as the city of Sacramento is approached, being somewhat over 50 miles at its widest point. The level part of the valley comprises an area of some 4,600 square miles. That part included between the summits of the abutting mountains comprises about 19,000 square miles, or nearly 13,000,000 acres.

The eastern watershed of the Sacramento Valley ranges in elevation from 10,000 feet in the south to 6,000 or 7,000 feet in the north. The western watershed ranges from 4,000 feet in the south to 9,000 feet in the north, and the northern watershed from 4,000 to 8,000 feet, exclusive of Mount Shasta, which has an elevation of 14,380 feet. (Water-Supply Paper No. 251, U. S. Geological Survey.)

The mean annual precipitation in the Sacramento watershed increases with altitude and is greatest at about 5,000 feet. Beyond this elevation it decreases. It increases as the upper end of the valley is approached, being about 18 inches at Rio Vista, 20 inches at Sacramento city, 23 inches at Chico, 25 inches at Red Bluff, and 36 inches at Redding. There is a noticeable increase in the mean annual precipitation as the foothill sections are approached and a marked increase thence through the hills and up the flanks of the Sierras. (See figs. 2 and 3.)

In figure 2 the shaded columns indicate the annual precipitation in inches for the following points, viz:

| Station. | Elevation. | Station. | Elevation. |
|---|---|---|---|
| | *Feet.* | | *Feet.* |
| No. 1. Sacramento | 71 | No. 10. Auburn | 1,360 |
| No. 2. Palermo | 213 | No. 11. Dunsmuir | 2,285 |
| No. 3. Red Bluff | 307 | No. 12. Colfax | 2,421 |
| No. 4. Redding | 552 | No. 13. Nevada City | 2,580 |
| No. 5. Fruto | 624 | No. 14. Grass Valley | 2,690 |
| No. 6. Newcastle | 970 | No. 15. Edgewood | 2,955 |
| No. 7. Shasta | 1,049 | No. 16. Sisson | 3,555 |
| No. 8. Delta | 1,138 | No. 17. Bowmans Dam | 5,500 |
| No. 9. Upper Lake | 1,350 | No. 18. Summit | 7,017 |

In 1909, 113.85 inches of precipitation occurred at Bowmans Dam and 114.85 inches at Delta. At Magalia, in Butte County, there were 150.62 inches in the same year.

In the diagram on page 14 the figures at the top of columns have the following significance:

1 equals season 1906–7.
2 equals season 1907–8.
3 equals season 1908–9.
4 equals season 1909–10.
5 equals season 1910–11.
6 equals season 1911–12.

The year is divided into two fairly well-defined seasons—the dry and the wet. The dry season extends from May to October, inclusive, and the wet from November to April, inclusive. More than 75 per cent of the annual precipitation occurs during the four months ending with March. The precipitation that occurs in the floor of the valley, that is, south of Redding, is invariably in the form of rain. Above the 4,000-foot level it is mostly in the form of snow, although heavy snow sometimes falls at altitudes as low as 2,000 feet.

(In inches.)

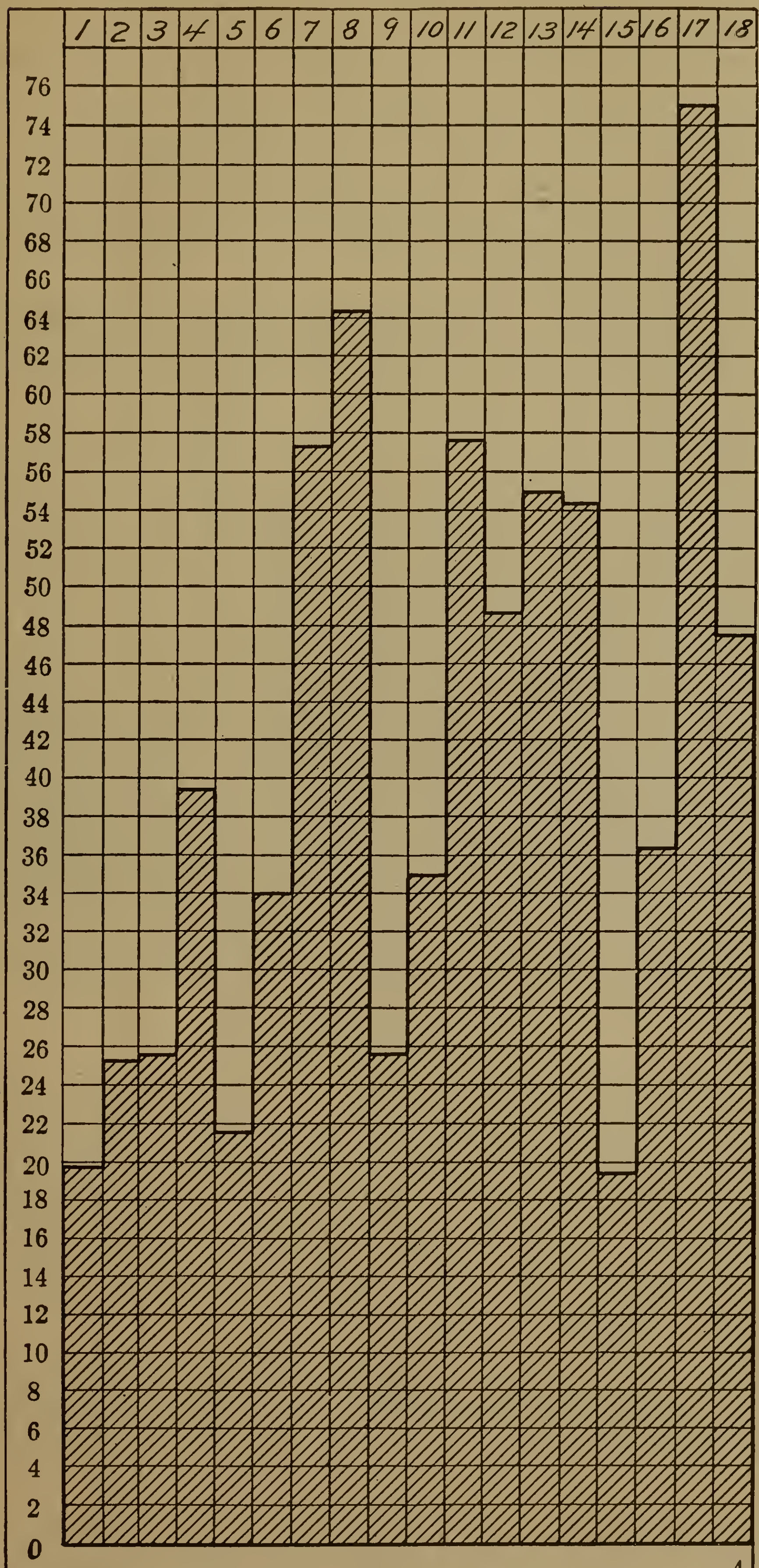



FIG. 2.—Normal annual precipitation at 18 stations in the Sacramento watershed.

In the report of the commissioner of public works in 1894 the total area of the Sacramento Valley is given as 4,250 square miles, 2,510 of which are described as highlands—that is, not subject to overflow; 450 square miles of lowlands overflowed occasionally by high floods; and 1,250 square miles of lowlands overflowed periodically. The above figures are, of course, now subject to revision on account of the fact that many of the lowlands included in the report have been reclaimed, much of which are now practically immune from even the highest floods.

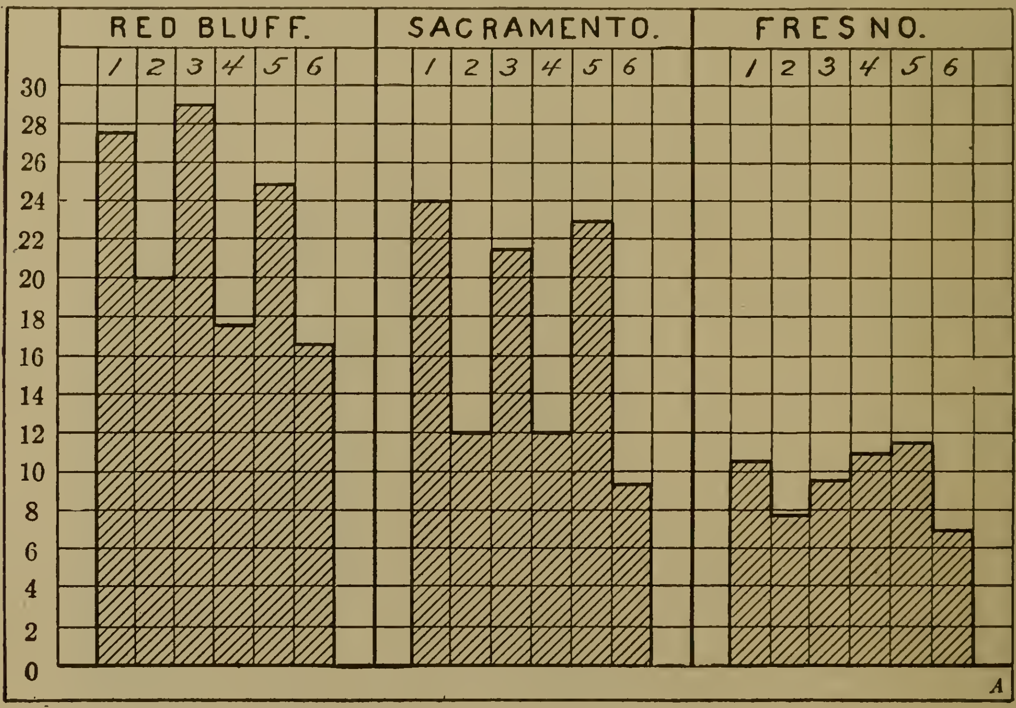



FIG. 3.—Seasonal precipitation at three stations in the central valleys for six seasons.

(In inches.)

## THE SACRAMENTO RIVER.

The Sacramento River rises on the southwestern slopes of Mount Shasta and flows almost due south for a distance of about 370 miles, and discharges into Suisun Bay. It is navigable as far as Red Bluff, 265 miles from its mouth. It emerges from its rocky canyons a short distance above Redding, but is mostly confined within banks of sufficient height to carry its maximum flood discharge until a point a short distance below Red Bluff is reached; thence it flows through a practically level plain.

The lower course of the river for a distance of nearly 100 miles occupies a ridge from 5 to 20 feet higher than the troughs of the nearly parallel flood basins on each side, which are from 2 to 7 miles from the river.

### RIVER STATIONS ON THE SACRAMENTO.

The river service on the Sacramento River now embraces seven regular river and rainfall stations, where gage readings are taken daily the year round. During the seven months ending with May, river stages and 24-hour precipitation are telegraphed daily at 7 a. m., and oftener, should floods be imminent, or in progress, to the river center at Sacramento. In addition to the stations named, special stations are maintained at Dunsmuir and Sisson, from which reports of heavy rains are wired.

The following are the regular river and rainfall stations named, from north to south: Kennett, Red Bluff, Jacinto, Colusa, Knights Landing, Sacramento, and Rio Vista. The numerical values of highest, lowest, and mean stages of the rivers for each month and the year follow in a series of tables, and the same values are presented graphically in figures 4 to 14, inclusive.

*Mean monthly river stages, Sacramento system.*

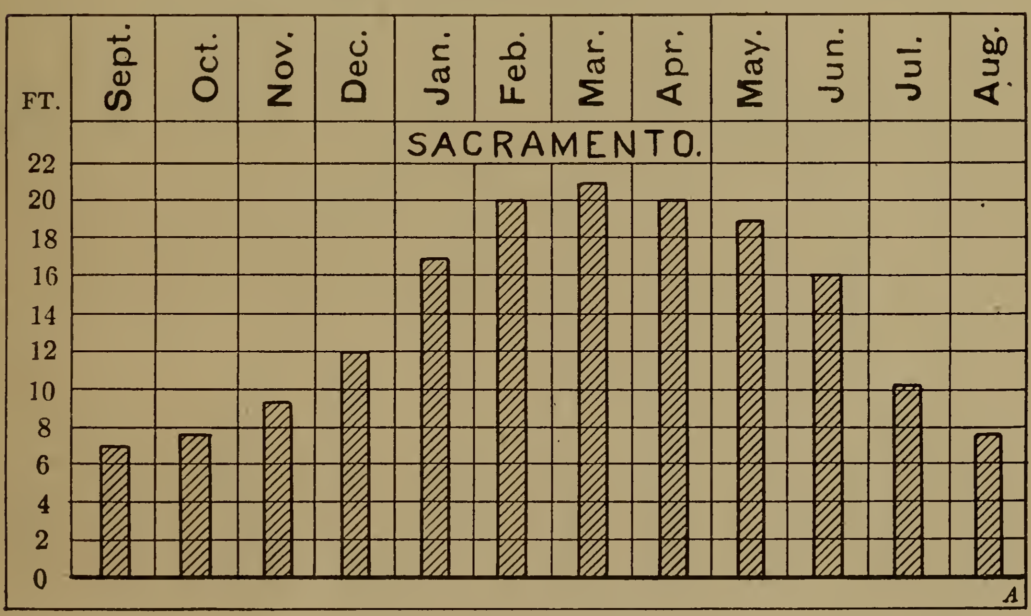



FIG. 4.—Mean monthly river stages.

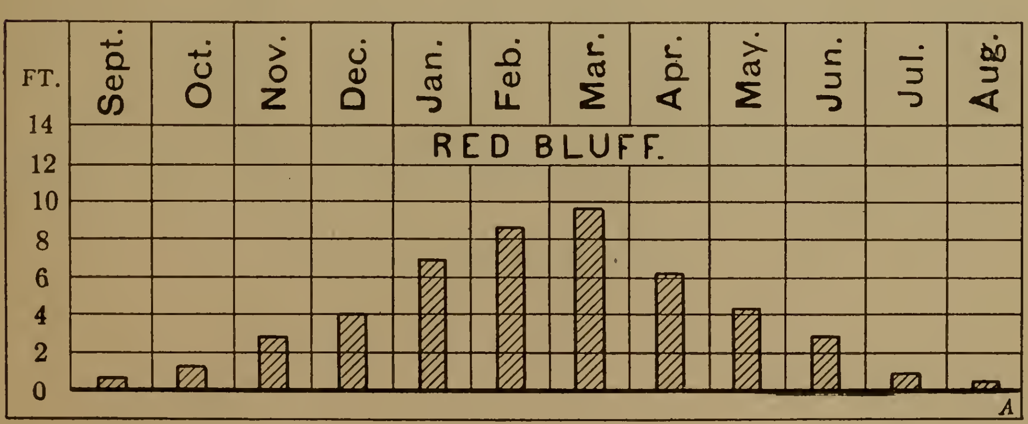



FIG. 4a.—Mean monthly river stages.

*Mean monthly river stages, Sacramento system*—Continued.

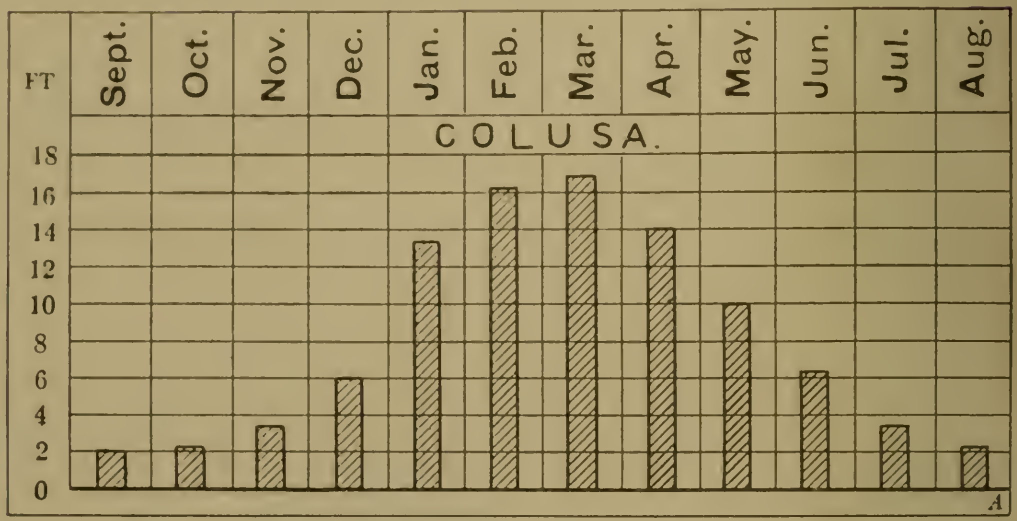



FIG. 4b.—Mean monthly river stages.

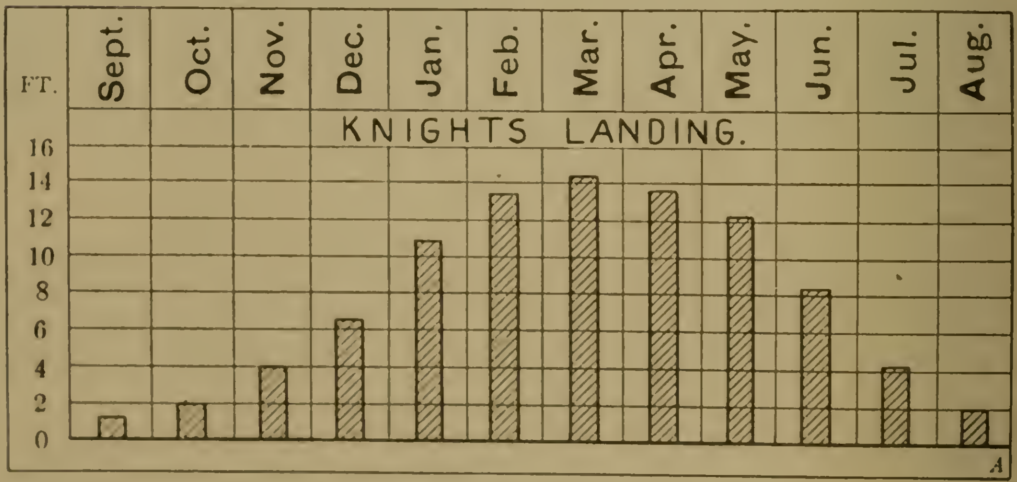



FIG. 4c.—Mean monthly river stages.

*Mean monthly river stages, Sacramento system, Sacramento, Cal.*—Continued.

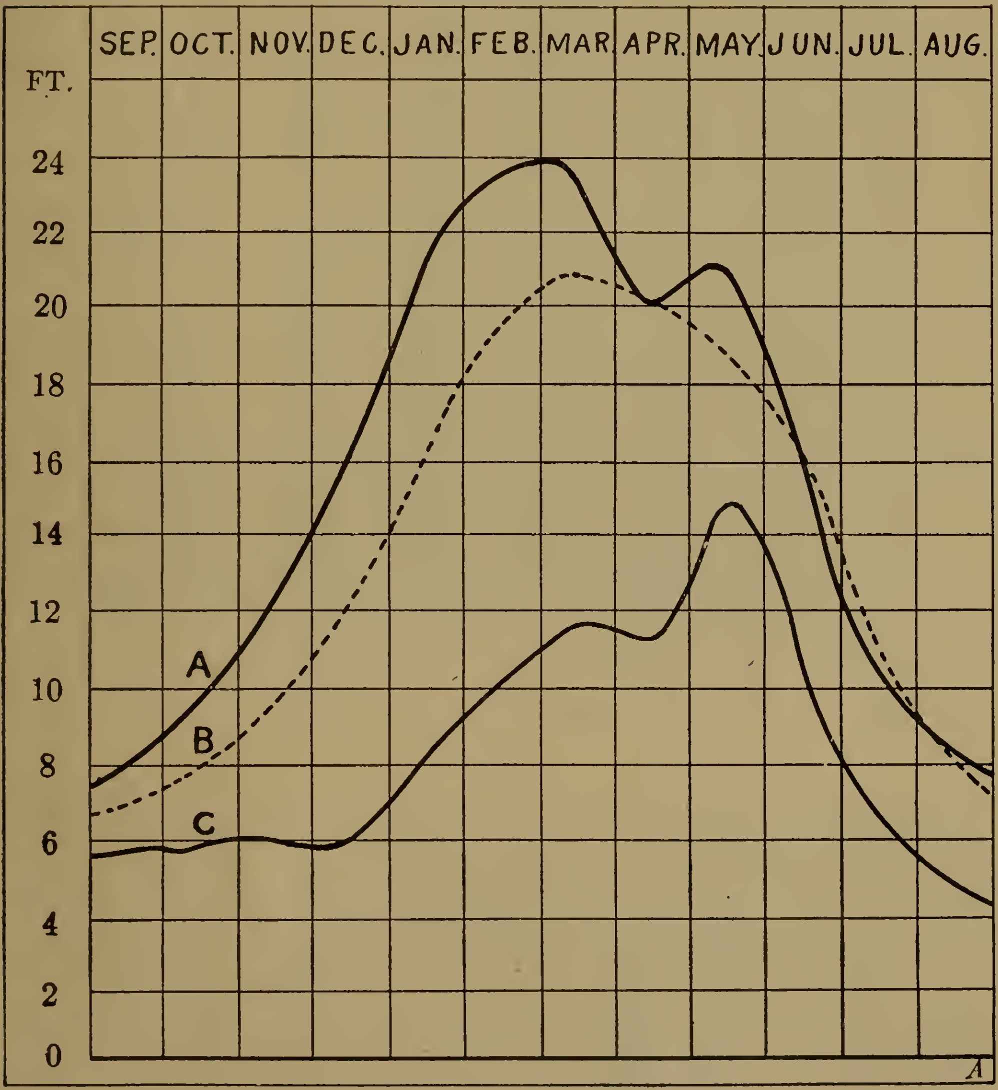



FIG. 5.—Mean monthly river stages. A, season 1900–1901 high water; B, mean stage 12 years; C, low-water season, 1911–12.

*Highest, lowest, and mean seasonal stages, Sacramento River system.*

(In feet.)

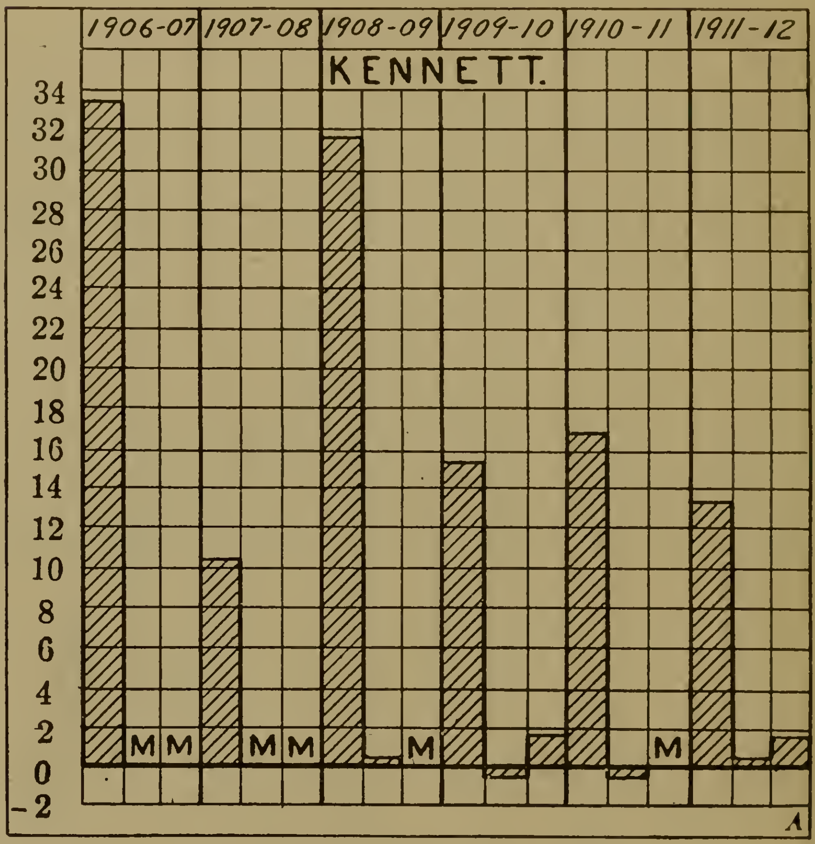



FIG. 6.—Highest, lowest, and mean stages.

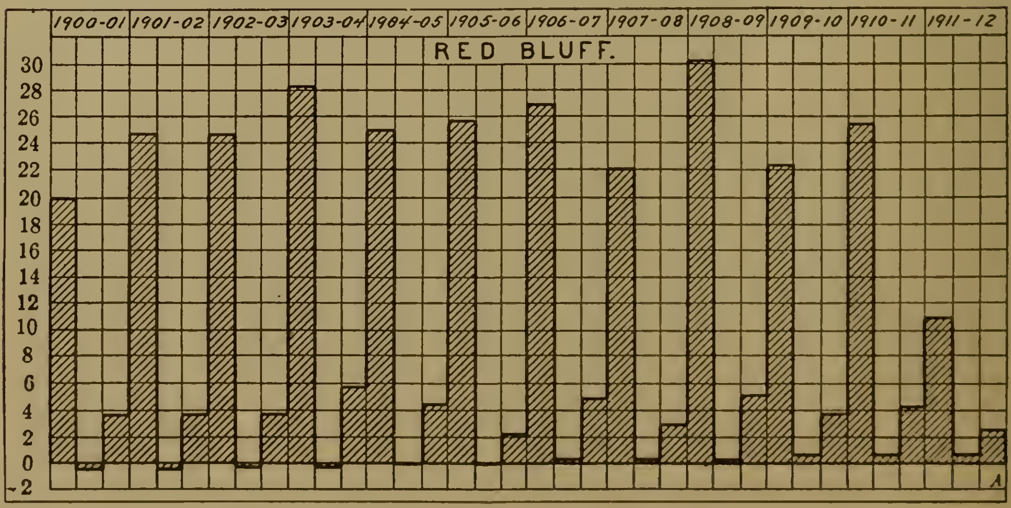



FIG. 7.—Highest, lowest, and mean stages. M = Missing.

*Highest, lowest, and mean seasonal stages, Sacramento River system*—Continued.

(In feet.)

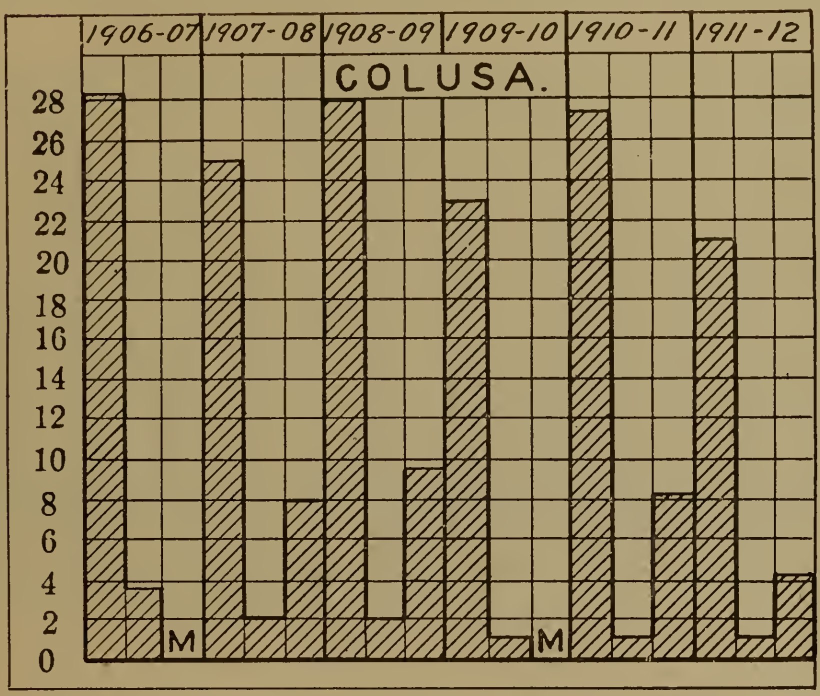



FIG. 8.—Highest, lowest, and mean stages.

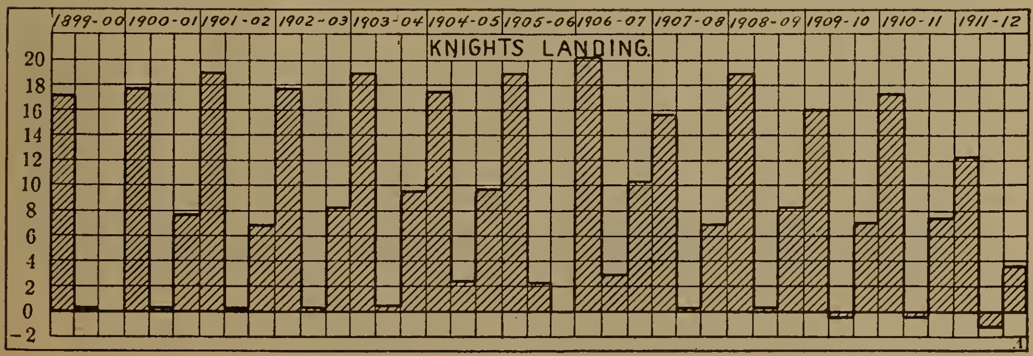



FIG. 9.—Highest, lowest, and mean stages.

*Highest, lowest, and mean seasonal stages, Sacramento River system*—Continued.

(In feet.)

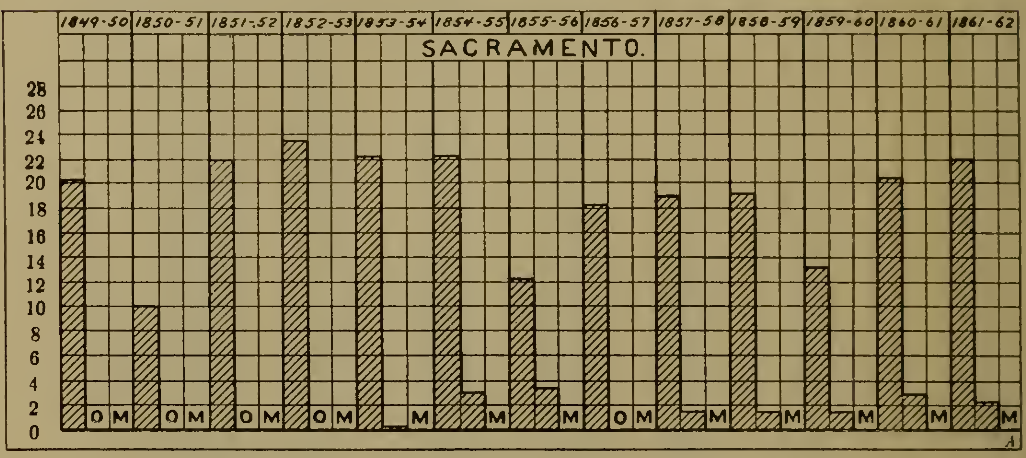



FIG. 10.—Highest, lowest, and mean stages.

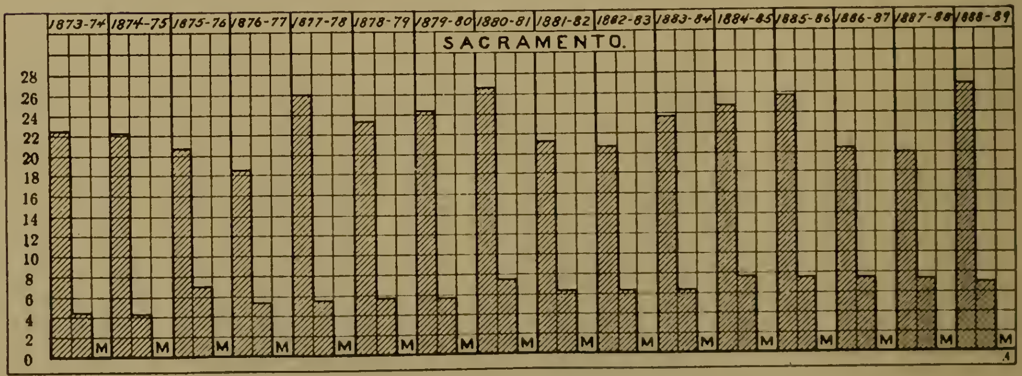



FIG. 10a.—Highest, lowest, and mean stages.

*Highest, lowest, and mean seasonal stages, Sacramento River system*—Continued.

(In feet.)

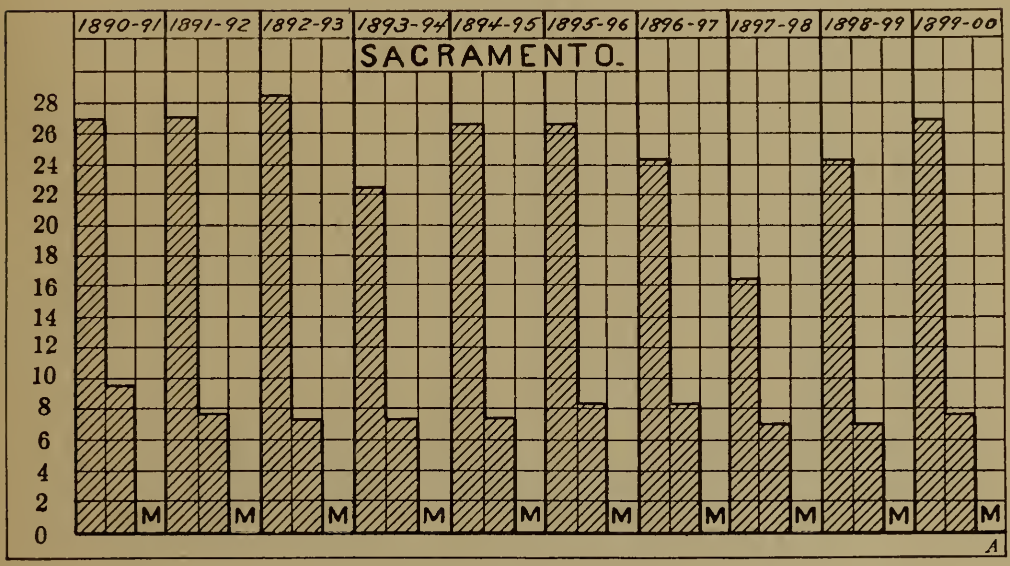



FIG. 11.—Highest, lowest, and mean stages.

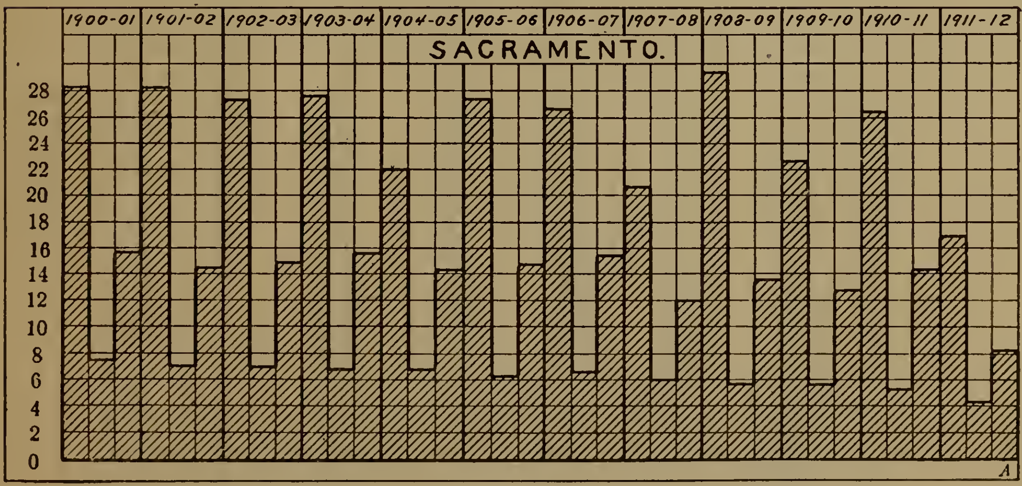



FIG. 11a.—Highest, lowest, and mean stages.

*Highest, lowest, and mean seasonal stages, Sacramento River system*—Continued.

(In feet.)

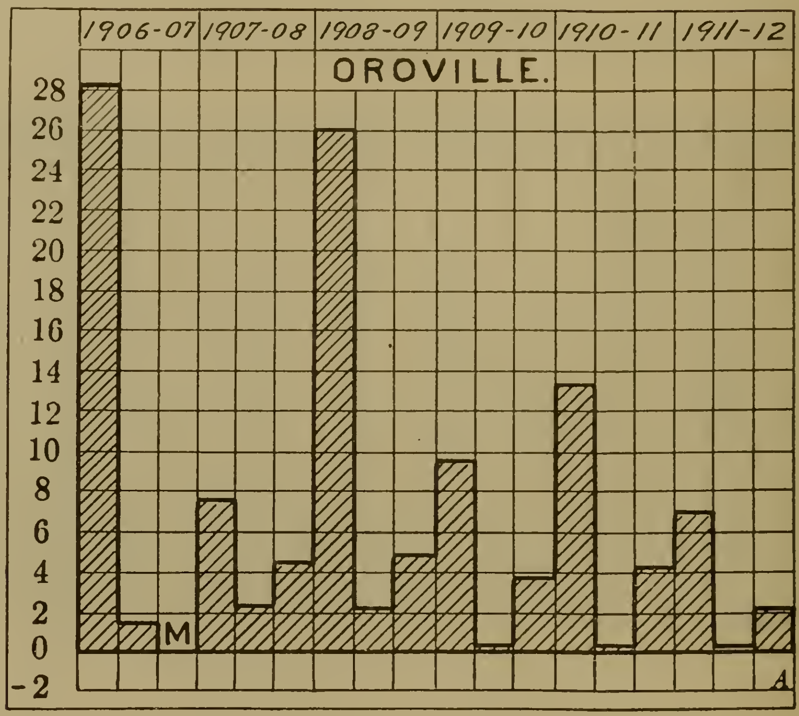



FIG. 12.—Highest, lowest, and mean stages.

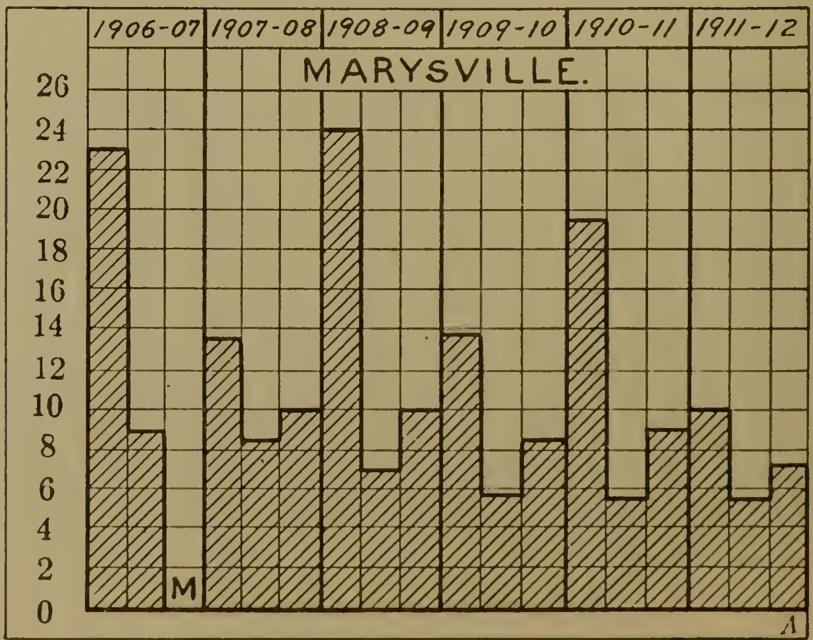



FIG. 13.—Highest, lowest, and mean stages.

*Highest, lowest, and mean seasonal stages, Sacramento River system*—Continued.

[Highest only for Marysville, 1862–1906.]

(In feet.)

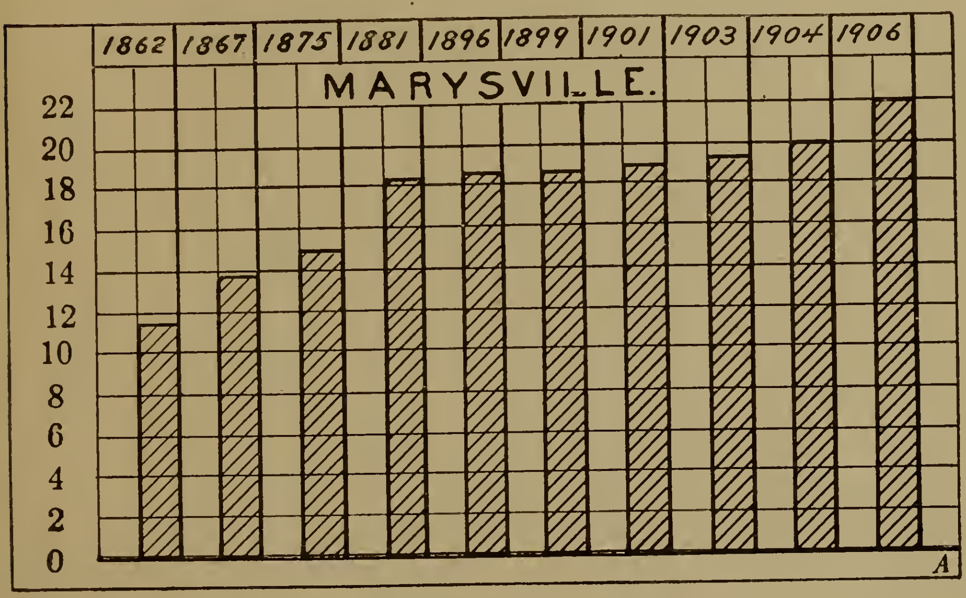



FIG. 13b.—Highest stages.

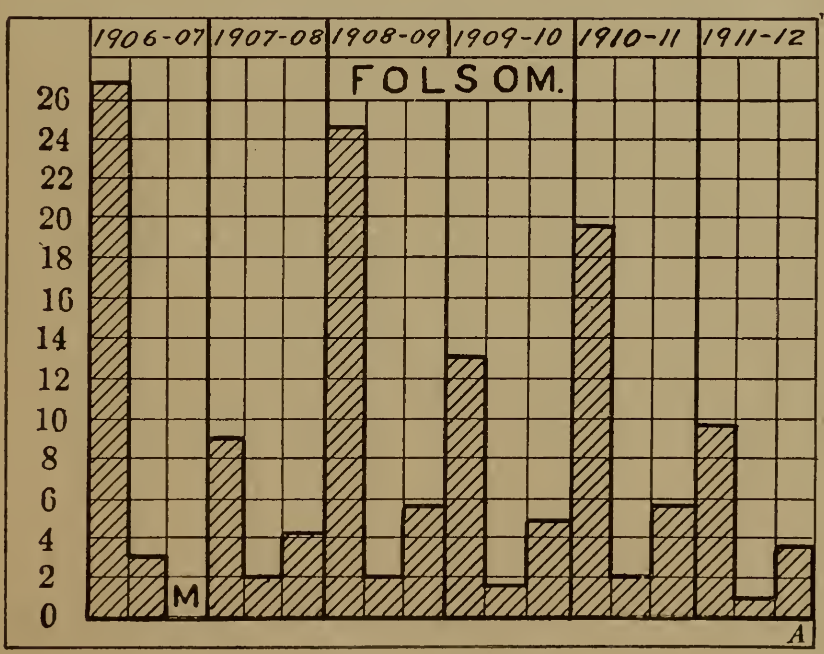



FIG. 14.—Highest, lowest, and mean stages.

## SACRAMENTO RIVER SYSTEM.

TABLE NO. 1.—*Highest, lowest, and mean stages for each month and the mean for each year at Kennett.*

Stages in bold-face type indicate the extremes for each year.
Kennett is on the Sacramento River, 323 miles from its mouth. Elevation, 616 feet; flood stage, 25 feet.

| Year. | September. | | | October. | | | November. | | | December. | | | January. | | | February. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. |
| 1906–7 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 12.8 | 2.9 | 5.1 | 19.2 | 5.6 | 9.6 |
| 1907–8 | ...... | ...... | ...... | ...... | ...... | ...... | 5.5 | 0.0 | 0.7 | 8.9 | 2.7 | 6.8 | **10.6** | 4.3 | 6.1 | 11.0 | 2.8 | 5.2 |
| 1908–9 | ...... | ...... | ...... | ...... | ...... | ...... | 1.9 | **0.0** | .3 | 1.0 | 0.4 | .5 | 30.0 | .7 | 11.3 | **31.8** | 6.0 | 11.1 |
| 1909–10 | 0.3 | 0.2 | 0.2 | 1.9 | 0.3 | 0.8 | 8.8 | 1.2 | 2.6 | 12.0 | 1.5 | 2.0 | 9.3 | 1.8 | 3.1 | **15.6** | 2.4 | 4.1 |
| 1910–11 | — .5 | **— .5** | — .5 | — .2 | — .5 | — .3 | 2.0 | — .2 | .6 | 4.0 | .9 | 2.2 | 8.9 | 1.6 | 3.0 | 7.9 | 2.4 | 4.6 |
| 1911–12 | .8 | **.1** | .4 | 0.6 | .3 | .4 | .7 | .3 | .4 | .9 | .3 | .4 | **13.5** | .7 | 2.0 | 3.2 | 1.0 | 2.5 |
| 1906–12 | .8 | — .5 | ...... | 1.9 | — .5 | ...... | 8.8 | — .2 | .9 | 12.0 | .3 | 2.4 | 30.0 | .7 | 5.1 | 31.8 | 1.0 | 6.2 |

| Year. | March. | | | April. | | | May. | | | June. | | | July. | | | August. | | | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | |
| 1906–7 | **33.2** | 5.4 | 10.4 | 11.8 | 5.0 | 8.1 | 5.0 | 2.9 | 3.8 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| 1907–8 | 5.9 | 2.4 | 3.2 | 3.6 | 1.8 | 2.3 | 2.8 | 1.8 | 2.4 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| 1908–9 | 11.5 | 5.5 | 7.2 | 6.5 | 5.7 | 6.4 | 5.5 | 1.0 | 3.0 | 1.0 | 0.9 | 1.0 | 1.0 | 0.5 | 0.7 | 0.5 | 0.2 | 0.3 | ...... |
| 1909–10 | 10.0 | 3.3 | 5.4 | 4.0 | 2.3 | 3.0 | 2.8 | .7 | 1.5 | .9 | .2 | .6 | .2 | .1 | .1 | .0 | **— .5** | — .3 | 1.9 |
| 1910–11 | **17.0** | 2.4 | 5.9 | 10.8 | 5.5 | 7.0 | 6.5 | 2.2 | 4.1 | .6 | .3 | .4 | .9 | .5 | .7 | ...... | ...... | ...... | ...... |
| 1911–12 | 5.4 | 1.0 | 2.9 | 4.4 | 2.0 | 2.3 | 7.9 | 2.0 | 2.8 | 2.4 | 1.6 | 1.8 | 1.6 | .6 | 1.0 | .7 | .3 | .5 | 1.4 |
| 1906–12 | 33.2 | 1.0 | 5.8 | 11.8 | 1.8 | 4.8 | 7.9 | .7 | 2.9 | 2.4 | .2 | .9 | 1.6 | .1 | .6 | .7 | — .5 | ...... | ...... |

TABLE No. 2.—*Highest, lowest, and mean stages for each month and the mean for each year at Red Bluff.*

Stages in bold-face type indicate the extremes for each year.
Red Bluff is on the Sacramento River, 265 miles from its mouth. Elevation, 236 feet; flood stage, 23 feet.

| Year. | September. | | | October. | | | November. | | | December. | | | January. | | | February. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. |
| 1899–1900 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | **24.7** | 2.7 | 9.4 | 7.7 | 1.8 | 3.4 |
| 1900–1 | 1.3 | **−0.5** | −0.3 | 8.0 | **−0.5** | 1.5 | 7.3 | 0.4 | 2.4 | 17.6 | 3.1 | 6.8 | **19.4** | 4.3 | 8.1 | **20.1** | 4.3 | 8.9 |
| 1901–2 | 0.4 | **− .4** | − .2 | 2.0 | − .1 | .3 | 12.3 | − .1 | 2.0 | 17.5 | 1.1 | 4.2 | 6.7 | .6 | 1.9 | **24.7** | .6 | 15.1 |
| 1902–3 | .2 | **− .1** | .1 | 4.0 | − .1 | .8 | 23.3 | .5 | 5.9 | 12.4 | 2.5 | 5.8 | **24.4** | 1.8 | 6.8 | 6.2 | 4.2 | 4.8 |
| 1903–4 | .0 | **− .2** | − .1 | 1.2 | − .1 | .2 | 24.5 | .0 | 7.5 | 14.4 | 2.9 | 5.4 | 5.0 | 2.8 | 3.6 | **28.2** | 3.4 | 12.0 |
| 1904–5 | 5.7 | .3 | .9 | 17.4 | .4 | 4.2 | 5.4 | 1.8 | 3.2 | 16.0 | 3.4 | 5.8 | **24.5** | 2.5 | 9.3 | 19.3 | 4.6 | 8.4 |
| 1905–6 | .3 | **.2** | .3 | .3 | **.2** | .3 | 1.3 | .3 | .5 | 1.3 | .6 | .7 | 24.6 | .7 | 5.0 | 13.0 | 2.7 | 6.9 |
| 1906–7 | .7 | .4 | .6 | .5 | **.3** | .4 | 3.5 | .3 | .8 | 17.5 | .6 | 4.2 | 15.0 | 3.8 | 6.8 | 24.4 | 6.3 | 11.9 |
| 1907–8 | 1.2 | .9 | 1.1 | 1.8 | .9 | 1.1 | 1.7 | .9 | 1.1 | 12.0 | 1.0 | 3.3 | 16.5 | 3.0 | 7.1 | **22.0** | 3.9 | 7.7 |
| 1908–9 | .8 | **.5** | .6 | 3.0 | .6 | 1.0 | 3.0 | .8 | 1.4 | 3.9 | 1.0 | 1.6 | 27.9 | 1.8 | 16.4 | **30.1** | 9.4 | 15.8 |
| 1909–10 | 1.8 | **1.0** | 1.1 | 2.4 | 1.3 | 1.5 | 12.7 | 1.6 | 3.9 | **22.4** | 2.8 | 5.1 | 13.8 | 2.9 | 5.5 | 21.5 | 4.0 | 6.7 |
| 1910–11 | 1.1 | 1.0 | **1.0** | 1.8 | 1.0 | 1.1 | 5.8 | 1.0 | 1.7 | 7.0 | 1.8 | 3.4 | 18.5 | 1.6 | 5.3 | 15.5 | 3.7 | 8.0 |
| 1911–12 | 1.4 | 1.2 | 1.2 | 1.4 | 1.3 | 1.3 | 1.4 | 1.3 | 1.4 | 1.6 | 1.4 | 1.4 | **17.8** | 1.3 | 3.7 | 4.9 | 2.5 | 3.4 |
| 1899–1912 | 5.7 | − .5 | .5 | 17.4 | − .5 | 1.1 | 24.5 | − .1 | 2.6 | 22.4 | .6 | 4.0 | 27.9 | .6 | 6.8 | 30.1 | .6 | 8.7 |

| Year. | March. | | | April. | | | May. | | | June. | | | July. | | | August. | | | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | |
| 1899–1900 | 23.2 | 2.9 | 6.3 | 6.6 | 3.3 | 4.8 | 3.8 | 1.4 | 2.5 | 1.2 | −0.3 | 0.3 | −0.3 | **−0.5** | −0.4 | −0.5 | **−0.5** | −0.5 | ...... |
| 1900–1 | 12.4 | 4.2 | 7.4 | 6.5 | 3.2 | 3.7 | 5.3 | 2.2 | 3.1 | 2.0 | .6 | 1.2 | .5 | − .1 | .2 | − .1 | − .3 | − .2 | 3.6 |
| 1901–2 | 16.6 | 4.7 | 9.3 | 6.4 | 4.4 | 4.9 | 4.4 | 3.6 | 4.0 | 3.6 | 1.5 | 2.3 | 1.4 | .3 | .6 | .5 | .2 | .3 | 3.7 |
| 1902–3 | 19.8 | 5.2 | 9.2 | 11.8 | 4.1 | 6.0 | 4.0 | 1.8 | 3.0 | 1.6 | .4 | .8 | .4 | .2 | .3 | .2 | .0 | .1 | 3.6 |
| 1903–4 | 26.3 | 10.4 | 17.8 | 15.4 | 8.6 | 11.1 | 10.2 | 5.5 | 7.5 | 5.5 | 3.8 | 4.7 | 3.1 | .5 | 1.2 | .5 | .3 | .4 | 5.9 |
| 1904–5 | 20.0 | 5.0 | 9.6 | 10.6 | 4.0 | 5.9 | 6.3 | 3.0 | 3.9 | 3.0 | 1.5 | 2.4 | 1.5 | .4 | .9 | .4 | **.1** | .3 | 4.6 |
| 1905–6 | **25.5** | 6.4 | 11.9 | **25.5** | 6.0 | 8.5 | 14.8 | 3.4 | 6.2 | 10.8 | 3.0 | 5.9 | 3.0 | 1.4 | 2.2 | 1.4 | .7 | 1.2 | 4.1 |
| 1906–7 | **26.8** | 7.7 | 13.8 | 14.0 | 6.5 | 10.1 | 6.3 | 4.0 | 5.1 | 6.0 | 2.7 | 3.6 | 2.7 | 1.5 | 2.1 | 1.5 | 1.2 | 1.3 | 5.1 |
| 1907–8 | 6.7 | 3.8 | 5.2 | 4.9 | 3.3 | 3.9 | 6.7 | 3.0 | 3.6 | 3.0 | 1.9 | 2.4 | 1.9 | .8 | 1.4 | .8 | .5 | .7 | 3.2 |
| 1908–9 | 12.8 | 6.8 | 8.4 | 7.8 | 5.9 | 6.6 | 5.9 | 3.8 | 4.7 | 4.1 | 2.4 | 3.1 | 2.3 | 1.5 | 1.8 | 1.5 | 1.0 | 1.3 | 5.2 |
| 1909–10 | 16.2 | 6.5 | 9.4 | 7.1 | 4.0 | 5.5 | 4.3 | 2.2 | 3.1 | 2.1 | 1.4 | 2.0 | 1.4 | **1.0** | 1.2 | 1.0 | **1.0** | 1.0 | 3.8 |
| 1910–11 | **25.5** | 3.6 | 10.2 | 15.0 | 6.1 | 8.3 | 7.3 | 4.7 | 5.6 | 5.0 | 2.4 | 3.7 | 2.4 | 1.5 | 1.9 | 1.5 | 1.2 | 1.3 | 4.3 |
| 1911–12 | 10.8 | 2.4 | 5.2 | 9.1 | 3.1 | 4.0 | 9.6 | 3.8 | 5.6 | 5.0 | 2.0 | 3.1 | 2.0 | 1.2 | 1.6 | 1.2 | **1.0** | 1.0 | 2.7 |
| 1899–1912 | 26.8 | 2.4 | 9.5 | 25.5 | 3.1 | 6.4 | 14.8 | 1.4 | 4.4 | 10.8 | − .3 | 2.7 | 3.1 | − .5 | 1.2 | 1.5 | − .5 | .6 | 4.2 |

TABLE NO. 3.—*Highest, lowest, and mean stages for each month and the mean for each year at Monroeville.*

Monroeville is on the Sacramento River, 207 miles from its mouth and 51 miles above Colusa. Elevation, 103.1 feet; flood stage, 22 feet. This station has been discontinued.

| Year. | September. | | | October. | | | November. | | | December. | | | January. | | | February. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. |
| 1907-8 | ...... | ...... | ...... | ...... | ...... | ...... | 1.4 | 1.4 | 1.4 | 10.9 | 1.4 | 2.7 | 10.2 | 2.6 | 5.4 | 16.5 | 3.0 | 6.1 |
| 1908-9 | ...... | ...... | ...... | ...... | ...... | ...... | 2.2 | .5 | .8 | 2.2 | .7 | 1.0 | 22.0 | .9 | 13.7 | 22.0 | 7.6 | 12.9 |
| 1909-10 | 1.0 | 0.8 | 0.9 | ...... | ...... | ...... | 7.4 | 1.2 | 2.5 | 14.0 | 2.1 | 3.8 | 11.0 | 2.5 | 4.1 | 13.6 | 3.0 | 4.8 |
| 1910-11 | ...... | ...... | ...... | ...... | ...... | ...... | 3.1 | .0 | .4 | 4.4 | 1.0 | 2.0 | 14.8 | 1.0 | 3.9 | 13.6 | 3.0 | 5.3 |
| 1907-1911 | ...... | ...... | ...... | ...... | ...... | ...... | 7.4 | .0 | 1.3 | 14.0 | .7 | 2.4 | 22.0 | .9 | 6.8 | 22.0 | 3.0 | 7.3 |

| Year. | March. | | | April. | | | May. | | | June. | | | July. | | | August. | | | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | |
| 1907-8 | 4.6 | 3.0 | 4.2 | 4.0 | 2.5 | 3.4 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| 1908-9 | 10.2 | 5.2 | 6.6 | 6.1 | 4.5 | 5.2 | 4.6 | 2.9 | 3.6 | 3.1 | 1.9 | 2.4 | 1.8 | 1.2 | 1.5 | 1.1 | 0.9 | 1.0 | ...... |
| 1909-10 | 11.7 | 5.6 | 7.2 | 5.6 | 3.2 | 4.2 | 3.1 | 1.7 | 2.4 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| 1910-11 | 22.0 | 3.0 | 8.1 | 10.0 | 1.4 | 5.4 | 5.4 | 3.6 | 4.3 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| 1907-1911 | 22.0 | 3.0 | 6.5 | 10.0 | 1.4 | 4.5 | 5.4 | 1.7 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... |

TABLE NO. 4.—*Highest, lowest, and mean stages for each month and the mean for each year at Colusa.*

Stages in bold-face type indicate the extremes for each year.
Colusa is on the Sacramento River, 156 miles from its mouth and 57 miles above Sacramento. Elevation, 36.8 feet; flood stage, 29 feet.

| Year. | September. | | | October. | | | November. | | | December. | | | January. | | | February. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. |
| 1906-7 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 25.1 | 7.4 | 16.4 | 28.2 | 16.1 | 22.1 |
| 1907-8 | 3.7 | 3.3 | 3.5 | 4.1 | 3.3 | 3.5 | 4.5 | 3.6 | 3.8 | 21.3 | 3.7 | 7.3 | 21.8 | 8.9 | 15.6 | **25.2** | 11.1 | 17.1 |
| 1908-9 | 2.4 | **2.0** | 2.1 | 4.3 | **2.0** | 2.6 | 6.7 | 2.7 | 3.4 | 6.2 | 3.4 | 4.1 | **28.0** | 3.7 | 22.6 | 27.4 | 19.8 | 22.8 |
| 1909-10 | 2.7 | 2.0 | 2.1 | ...... | ...... | ...... | 19.2 | 3.2 | 6.8 | 23.0 | 6.3 | 10.6 | 21.8 | 6.4 | 10.6 | **23.2** | 9.7 | 12.8 |
| 1910-11 | 1.5 | **1.0** | 1.2 | 2.4 | 1.2 | 1.4 | 6.3 | 1.4 | 2.3 | 11.4 | 3.2 | 5.9 | 23.3 | 2.6 | 8.6 | 24.2 | 8.7 | 16.3 |
| 1911-12 | 1.8 | 1.2 | 1.3 | 2.0 | 1.6 | 1.8 | 2.2 | 1.8 | 1.9 | 2.3 | 1.9 | 2.0 | **21.2** | 2.1 | 5.6 | 9.8 | 4.9 | 6.7 |
| 1906-1912 | 3.7 | 1.0 | 2.0 | 4.3 | 1.2 | 2.3 | 19.2 | 1.4 | 3.6 | 23.0 | 1.9 | 6.0 | 28.0 | 2.1 | 13.2 | 28.2 | 4.9 | 16.3 |

| Year. | March. | | | April. | | | May. | | | June. | | | July. | | | August. | | | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | |
| 1906-7 | **28.6** | 18.6 | 22.4 | 22.0 | 15.8 | 19.8 | 15.4 | 10.8 | 12.9 | 11.8 | 7.5 | 9.6 | 7.2 | 4.8 | 5.9 | 4.8 | 3.7 | 4.1 | ...... |
| 1907-8 | 14.8 | 10.3 | 12.8 | 10.8 | 8.7 | 12.8 | 10.6 | 7.6 | 8.7 | 7.3 | 4.3 | 5.8 | 4.2 | 2.6 | 3.4 | 2.6 | **2.0** | 2.3 | 8.0 |
| 1908-9 | 20.9 | 15.5 | 17.7 | 17.5 | 13.5 | 15.1 | 13.3 | 8.9 | 10.9 | 9.2 | 5.6 | 7.4 | 5.5 | 2.9 | 3.9 | 2.9 | 2.1 | 2.4 | 9.6 |
| 1909-10 | 23.0 | 13.6 | 18.1 | 16.3 | 9.3 | 12.3 | 8.9 | 4.6 | 6.7 | 4.5 | 2.4 | 3.3 | 2.4 | 1.4 | 1.9 | 1.4 | **1.0** | 1.1 | ...... |
| 1910-11 | **27.4** | 8.6 | 19.3 | 22.0 | 13.2 | 16.7 | 14.1 | 10.1 | 12.0 | 10.6 | 5.2 | 8.2 | 5.1 | 2.6 | 3.7 | 2.6 | 1.3 | 1.9 | 8.1 |
| 1911-12 | 18.3 | 4.4 | 9.8 | 11.8 | 5.6 | 7.0 | 15.9 | 7.1 | 10.3 | 10.3 | 3.2 | 5.5 | 3.1 | 1.2 | 1.9 | 1.2 | **.7** | .9 | 4.6 |
| 1906-1912 | 28.6 | 4.4 | 16.7 | 22.0 | 5.6 | 14.0 | 15.9 | 4.6 | 10.2 | 11.8 | 2.4 | 6.6 | 7.2 | 1.2 | 3.4 | 4.8 | .7 | 2.1 | 7.6 |

TABLE NO. 5.—*Highest, lowest, and mean stages for each month and the mean for each year at Knights Landing.*

Stages in bold-face type indicate the extremes for each year.
Knights Landing is on the Sacramento River, 99 miles from its mouth and 35 miles above Sacramento. Elevation, 16.1 feet; flood stage, 18 feet.

| Year. | September. | | | October. | | | November. | | | December. | | | January. | | | February. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. |
| 1899-1900 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | **17.2** | 12.2 | 14.9 | 11.9 | 7.8 | 9.8 |
| 1900-1901 | 1.3 | 0.4 | 0.7 | 6.8 | **0.4** | 2.9 | 10.4 | 2.2 | 5.1 | 13.2 | 5.5 | 9.0 | 15.2 | 9.0 | 13.9 | **17.9** | 12.3 | 14.1 |
| 1901-2 | 1.6 | **.3** | .6 | 2.7 | .5 | 1.0 | 10.4 | 1.2 | 2.7 | 11.8 | 4.7 | 8.2 | 5.2 | 3.5 | 4.2 | **19.2** | 3.4 | 12.7 |
| 1902-3 | 1.3 | .6 | .9 | 5.0 | **.5** | 1.4 | 13.4 | 1.8 | 8.7 | 13.7 | 6.8 | 11.0 | **17.7** | 6.5 | 10.8 | 16.7 | 12.1 | 14.4 |
| 1903-4 | .9 | **.7** | .7 | 2.5 | **.7** | 1.2 | 16.2 | 1.0 | 8.0 | 15.2 | 7.5 | 11.3 | 11.2 | 7.2 | 8.6 | **19.1** | 6.7 | 12.7 |
| 1904-5 | 6.3 | 2.8 | 3.6 | 9.9 | 3.4 | 6.1 | 7.7 | 5.2 | 5.8 | 12.9 | 5.4 | 4.2 | **17.8** | 12.1 | 15.6 | 17.6 | 15.2 | 16.3 |
| 1905-6 | 2.6 | **2.2** | 2.3 | 2.3 | **2.2** | 2.2 | 3.0 | 2.3 | 2.5 | 3.9 | 2.8 | 3.1 | 17.7 | 3.0 | 10.7 | 17.2 | 11.2 | 14.2 |
| 1906-7 | 4.6 | 3.5 | 3.9 | 3.5 | **2.9** | 3.0 | 6.3 | 3.0 | 3.9 | 16.3 | 3.3 | 8.4 | 16.5 | 13.5 | 15.3 | 18.8 | 14.9 | 16.3 |
| 1907-8 | 3.3 | 2.4 | 2.8 | 2.8 | 2.0 | 2.2 | 3.4 | 2.5 | 2.7 | 12.5 | 2.6 | 5.9 | 15.0 | 8.6 | 12.3 | **15.7** | 10.9 | 14.0 |
| 1908-9 | .6 | **.2** | .4 | 3.0 | **.2** | 1.1 | 5.4 | 1.2 | 2.0 | 5.0 | 2.1 | 2.9 | **19.1** | 2.5 | 15.4 | 18.8 | 17.6 | 18.0 |
| 1909-10 | 1.2 | .4 | .8 | 2.4 | 1.0 | 1.5 | 13.3 | 2.1 | 5.5 | 15.1 | 7.2 | 11.5 | 14.2 | 7.7 | 10.7 | 14.7 | 10.6 | 12.4 |
| 1910-11 | .5 | — .4 | — .1 | 1.0 | .0 | .3 | 5.8 | .2 | 1.2 | 10.7 | 2.5 | 5.3 | 16.2 | 1.7 | 7.4 | 17.2 | 10.4 | 15.0 |
| 1911-12 | .5 | .1 | .2 | .8 | .4 | .6 | 1.4 | .5 | .8 | 1.1 | .6 | .8 | **12.0** | .7 | 3.6 | 9.3 | 4.1 | 5.9 |
| 1899-1912 | 6.3 | — .4 | 1.4 | 9.9 | .0 | 2.0 | 16.2 | .2 | 4.1 | 16.3 | .6 | 6.8 | 19.1 | .7 | 11.0 | 19.2 | 3.4 | 13.5 |

| Year. | March. | | | April. | | | May. | | | June. | | | July. | | | August. | | | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | |
| 1899-1900 | 16.0 | 12.5 | 13.5 | 12.2 | 9.8 | 11.3 | 10.8 | 7.5 | 9.7 | 7.4 | 3.3 | 5.3 | 3.2 | 1.0 | 1.9 | 1.0 | **0.5** | 0.7 | ...... |
| 1900-1901 | 17.2 | 12.2 | 14.5 | 11.9 | 10.0 | 10.6 | 12.2 | 10.2 | 11.6 | 10.0 | 4.0 | 6.6 | 3.8 | 1.2 | 2.4 | 1.7 | .5 | .8 | 7.7 |
| 1901-2 | 18.4 | 12.0 | 14.7 | 14.7 | 11.2 | 13.4 | 13.8 | 11.8 | 12.8 | 11.9 | 5.8 | 9.0 | 5.8 | 2.9 | 4.0 | 3.1 | 1.4 | 2.2 | 7.1 |
| 1902-3 | 16.4 | 12.4 | 14.4 | 16.9 | 13.0 | 15.0 | 12.9 | 8.8 | 11.2 | 8.8 | 3.8 | 6.3 | 3.8 | 1.7 | 2.6 | 1.6 | .9 | 1.1 | 8.2 |
| 1903-4 | 19.0 | 16.7 | 17.4 | 17.2 | 15.8 | 16.3 | 15.8 | 14.4 | 15.4 | 14.2 | 7.9 | 11.3 | 7.8 | 4.2 | 5.8 | 5.2 | 3.9 | 4.2 | 9.4 |
| 1904-5 | 17.4 | 13.4 | 15.7 | 17.2 | 13.8 | 15.4 | 14.3 | 12.0 | 13.1 | 11.9 | 7.0 | 9.7 | 6.8 | 3.9 | 5.3 | 3.9 | **2.6** | 3.2 | 9.5 |
| 1905-6 | ...... | ...... | ...... | **18.9** | 15.8 | 16.8 | 16.7 | 13.2 | 15.4 | 16.8 | 13.3 | 15.6 | 13.0 | 6.3 | 9.5 | 8.2 | 4.7 | 6.3 | ...... |
| 1906-7 | **20.2** | 15.6 | 16.6 | 17.2 | 15.9 | 16.7 | 15.7 | 13.7 | 14.8 | 13.6 | 10.8 | 12.6 | 10.6 | 6.0 | 8.2 | 6.0 | 3.4 | 4.5 | 10.4 |
| 1907-8 | 12.6 | 10.7 | 11.9 | 11.2 | 8.8 | 10.1 | 10.5 | 8.6 | 9.4 | 8.4 | 3.9 | 6.2 | 3.9 | 1.4 | 2.4 | 1.3 | **.5** | .8 | 6.7 |
| 1908-9 | 17.5 | 15.4 | 16.5 | 15.6 | 14.3 | 14.8 | 14.2 | 11.6 | 13.1 | 11.5 | 7.6 | 9.9 | 7.5 | 3.3 | 5.2 | 3.2 | 1.2 | 2.1 | 8.4 |
| 1909-10 | **16.1** | 14.3 | 15.3 | 15.3 | 12.2 | 15.7 | 11.8 | 5.4 | 8.7 | 5.3 | 2.2 | 3.4 | 2.1 | .5 | 1.2 | .4 | — .3 | .0 | 7.2 |
| 1910-11 | **17.5** | 10.0 | 15.3 | 16.5 | 14.5 | 15.6 | 14.9 | 13.2 | 14.1 | 13.4 | 9.0 | 12.0 | 8.4 | 2.2 | 4.5 | 2.1 | .4 | 1.0 | 7.6 |
| 1911-12 | 11.1 | 3.6 | 8.1 | 9.7 | 5.1 | 6.3 | 11.4 | 6.8 | 9.5 | 10.8 | 2.6 | 5.8 | 2.4 | — .3 | .7 | — .4 | **—1.2** | — .8 | 3.5 |
| 1899-1912 | 20.2 | 3.6 | 14.5 | 18.9 | 5.1 | 13.7 | 16.7 | 6.8 | 12.2 | 16.8 | 2.2 | 8.7 | 13.0 | — .3 | 4.1 | 8.2 | —1.2 | 2.1 | **7.8** |

TABLE No. 6.—*Highest, lowest, and mean stages for each month and the mean for each year at Sacramento.*

Stages in bold-face type indicate the extremes for each year.
Sacramento is on the Sacramento River, 64 miles above Suisin Bay and 38 miles above Rio Vista. Elevation, −0.5 foot; flood stage, 29 feet.

| Year. | September. | | | October. | | | November. | | | December. | | | January. | | | February. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. |
| 1889-1900 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | **27.0** | 21.7 | 24.4 | 21.4 | 15.5 | 17.9 |
| 1900-1 | 7.9 | **7.6** | 7.8 | 13.5 | **7.6** | 9.5 | 19.5 | 8.8 | 12.0 | 19.5 | 12.0 | 15.2 | 22.7 | 16.0 | 21.5 | **28.2** | 21.0 | 23.5 |
| 1901-2 | 8.5 | **7.2** | 7.6 | 10.7 | 7.5 | 8.2 | 14.6 | 8.1 | 9.4 | 20.5 | 11.6 | 15.4 | 12.0 | 9.8 | 10.8 | 27.6 | 9.8 | 18.8 |
| 1902-3 | 7.9 | **7.2** | 7.5 | 10.3 | **6.9** | 7.7 | 16.9 | 8.1 | 13.1 | 18.1 | 12.6 | 15.9 | 23.2 | 12.6 | 16.5 | 23.2 | 18.7 | 21.1 |
| 1903-4 | 7.3 | **7.0** | 7.1 | 8.7 | **7.0** | 7.5 | 20.5 | 7.3 | 14.1 | 19.6 | 14.3 | 17.1 | 15.8 | 13.3 | 14.4 | **27.9** | 12.8 | 19.2 |
| 1904-5 | 12.0 | 8.2 | 9.1 | 18.0 | 9.2 | 11.7 | 12.0 | 10.4 | 11.0 | 17.0 | 10.6 | 11.7 | 20.8 | 16.6 | 18.7 | **22.0** | 19.8 | 20.9 |
| 1905-6 | 7.0 | **6.3** | 6.6 | 6.7 | 6.4 | 6.5 | 7.4 | 6.5 | 6.7 | 7.8 | 6.9 | 7.1 | 23.0 | 7.0 | 15.2 | 21.5 | 16.1 | 18.7 |
| 1906-7 | 8.8 | 7.6 | 8.0 | 7.6 | **6.8** | 7.1 | 10.3 | 7.0 | 8.0 | 20.5 | 7.3 | 12.5 | 20.6 | 18.2 | 19.4 | **27.2** | 20.5 | 23.3 |
| 1907-8 | 8.5 | 7.5 | 8.0 | 8.0 | 7.3 | 7.5 | 8.4 | 7.5 | 7.8 | 15.3 | 7.7 | 10.3 | 19.3 | 13.2 | 15.9 | **20.4** | 16.4 | 18.9 |
| 1908-9 | 5.6 | **5.3** | 5.5 | 8.3 | **5.3** | 5.9 | 9.3 | 5.8 | 6.6 | 9.6 | 6.8 | 7.5 | **29.6** | 7.2 | 21.6 | 24.0 | 21.1 | 22.6 |
| 1909-10 | 6.4 | 5.5 | 5.9 | 7.0 | 6.0 | 6.4 | 18.7 | 6.7 | 10.8 | 22.0 | 13.1 | 17.3 | 20.0 | 14.0 | 16.8 | 18.9 | 15.7 | 17.4 |
| 1910-11 | 6.3 | **5.1** | 5.5 | 6.2 | 5.3 | 5.7 | 9.4 | 5.7 | 6.5 | 14.0 | 7.4 | 9.5 | **26.4** | 6.9 | 14.3 | 26.9 | 17.5 | 22.8 |
| 1911-12 | 5.9 | 5.5 | 5.7 | 6.0 | 5.6 | 5.8 | 6.7 | 5.7 | 6.0 | 6.2 | 5.7 | 5.9 | 13.9 | 5.8 | 8.1 | 11.2 | 8.6 | 9.8 |
| 1889-1912 | 12.0 | 5.1 | 7.0 | 18.0 | 5.3 | 7.5 | 20.5 | 5.7 | 9.3 | 22.0 | 5.7 | 12.1 | 29.6 | 5.8 | 16.7 | 28.2 | 8.6 | 19.8 |

| Year. | March. | | | April. | | | May. | | | June. | | | July. | | | August. | | | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | |
| 1889-1900 | 23.5 | 17.4 | 21.5 | 22.0 | 18.5 | 20.3 | 19.4 | 16.5 | 18.5 | 16.1 | 11.0 | 13.3 | 10.8 | 8.3 | 9.3 | 8.3 | 7.7 | 7.9 | ...... |
| 1900-1 | 27.3 | 21.3 | 23.5 | 21.0 | 19.1 | 19.8 | 22.2 | 20.1 | 21.2 | 20.2 | 12.4 | 15.9 | 12.3 | 8.5 | 10.1 | 8.5 | 7.7 | 8.0 | 15.7 |
| 1901-2 | **28.2** | 20.5 | 23.3 | 22.4 | 20.0 | 21.4 | 21.8 | 20.8 | 21.3 | 20.9 | 13.6 | 18.1 | 13.3 | 9.6 | 11.0 | 9.7 | 7.9 | 8.6 | 14.5 |
| 1902-3 | 25.1 | 18.3 | 20.1 | **27.6** | 21.0 | 23.8 | 21.5 | 17.3 | 20.2 | 17.9 | 11.7 | 14.7 | 11.7 | 8.2 | 9.5 | 8.0 | 7.2 | 7.6 | 14.8 |
| 1903-4 | 26.3 | 21.8 | 24.2 | 24.0 | 20.8 | 22.1 | 22.2 | 20.5 | 21.3 | 20.9 | 15.8 | 18.8 | 15.6 | 10.5 | 12.6 | 10.3 | 9.0 | 9.7 | 15.7 |
| 1904-5 | 21.9 | 18.0 | 20.0 | 21.7 | 19.6 | 20.6 | 19.6 | 17.5 | 18.6 | 17.3 | 11.5 | 14.8 | 11.3 | 8.2 | 9.6 | 8.1 | **6.9** | 7.4 | 14.5 |
| 1905-6 | 26.1 | 20.9 | 22.9 | **27.4** | 21.4 | 23.6 | 22.2 | 20.5 | 21.6 | 22.9 | 20.5 | 22.2 | 20.5 | 11.7 | 16.3 | 12.0 | 8.8 | 10.4 | 14.8 |
| 1906-7 | 26.9 | 20.4 | 22.7 | 22.3 | 20.3 | 21.0 | 20.1 | 19.2 | 19.6 | 19.8 | 17.8 | 18.7 | 17.8 | 12.0 | 14.9 | 11.8 | 8.4 | 9.8 | 15.4 |
| 1907-8 | 17.5 | 15.8 | 16.8 | 17.2 | 15.2 | 16.3 | 17.1 | 15.3 | 16.2 | 16.0 | 9.9 | 12.6 | 9.7 | 6.6 | 7.8 | 6.4 | 5.6 | 6.0 | 12.0 |
| 1908-9 | 20.9 | 18.6 | 19.8 | 20.1 | 18.6 | 19.3 | 20.3 | 17.5 | 19.1 | 17.9 | 13.2 | 16.3 | 13.2 | 7.9 | 9.9 | 7.9 | 6.2 | 6.8 | 13.4 |
| 1909-10 | **22.8** | 19.0 | 21.0 | 21.8 | 20.2 | 20.9 | 19.9 | 12.5 | 16.4 | 12.4 | 7.4 | 9.4 | 7.1 | 5.8 | 6.5 | 6.2 | **5.3** | 5.6 | 12.9 |
| 1910-11 | 25.1 | 17.1 | 22.3 | 24.5 | 21.9 | 22.8 | 22.0 | 20.5 | 21.3 | 21.5 | 18.0 | 20.5 | 17.0 | 8.4 | 11.9 | 8.2 | 5.7 | 6.8 | 14.2 |
| 1911-12 | 13.9 | 8.4 | 11.5 | 12.0 | 10.2 | 11.2 | **16.7** | 12.2 | 14.9 | 16.3 | 8.5 | 12.3 | 8.3 | 5.2 | 6.4 | 5.4 | **4.1** | 4.7 | 8.5 |
| 1889-1912 | 28.2 | 8.4 | 20.7 | 27.6 | 10.2 | 20.2 | 22.2 | 12.2 | 19.2 | 22.9 | 7.4 | 16.0 | 20.5 | 5.2 | 10.4 | 12.0 | 4.1 | 7.6 | 13.9 |

TABLE NO. 7.—*Highest, lowest, and mean stages for each month and the mean for each year at Oroville.*

Stages in bold-face type indicate the extremes for each year.
Oroville is on the Feather River, 32 miles above its junction with the Yuba at Marysville, and 76 miles above Sacramento. Elevation, 147.4 feet; flood stage, 25 feet.

| Year. | September. | | | October. | | | November. | | | December. | | | January. | | | February. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. |
| 1906-7 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 7.7 | **1.4** | 3.1 | 17.6 | 6.3 | 8.9 |
| 1907-8 | 3.8 | 3.6 | 3.7 | 3.7 | 3.5 | 3.6 | 3.7 | 3.5 | 3.6 | **7.8** | 3.5 | 4.6 | 7.7 | 4.3 | 5.6 | 6.7 | 4.4 | 5.0 |
| 1908-9 | 2.5 | 2.3 | 2.3 | 5.0 | 2.3 | 2.6 | 4.3 | 2.4 | 2.8 | 5.0 | 2.8 | 3.1 | **26.0** | 2.8 | 11.0 | 9.9 | 7.1 | 8.0 |
| 1909-10 | 2.2 | 1.0 | 1.4 | 3.6 | 1.0 | 1.7 | **9.7** | 2.0 | 3.9 | 11.0 | 3.7 | 5.4 | 6.7 | 3.9 | 4.9 | 8.2 | 4.6 | 5.2 |
| 1910-11 | 1.4 | **.5** | .9 | 1.3 | **.5** | .9 | 5.4 | .7 | 1.5 | 6.7 | 1.8 | 2.9 | **13.3** | 1.5 | 4.1 | 9.6 | 4.0 | 5.6 |
| 1911-12 | 1.5 | .9 | 1.0 | 1.5 | .8 | 1.1 | 2.3 | .7 | 1.4 | 1.5 | .9 | 1.2 | **7.1** | 1.3 | 2.7 | 3.2 | 2.0 | 2.5 |
| 1906-1912 | 3.8 | .5 | 1.9 | 5.0 | .5 | 2.0 | 9.7 | .7 | 2.6 | 11.0 | .9 | 3.4 | 26.0 | 1.3 | 5.2 | 17.6 | 2.0 | 5.9 |

| Year. | March. | | | April. | | | May. | | | June. | | | July. | | | August. | | | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | |
| 1906-7 | **28.2** | 5.1 | 10.9 | 12.7 | 10.1 | 10.9 | 10.0 | 8.8 | 9.4 | 9.0 | 6.4 | 7.7 | 6.3 | 4.6 | 5.2 | 4.5 | 3.8 | 4.0 | ...... |
| 1907-8 | 7.0 | 4.7 | 5.8 | 7.4 | 5.6 | 6.6 | 6.9 | 5.7 | 6.2 | 5.7 | 3.9 | 4.9 | 3.8 | 2.8 | 3.2 | 2.8 | **2.4** | 2.5 | 4.6 |
| 1908-9 | 9.0 | 6.4 | 7.1 | 8.8 | 6.5 | 7.5 | 8.2 | 6.5 | 7.2 | 7.0 | 4.5 | 5.9 | 4.3 | 2.3 | 3.1 | 2.2 | **1.5** | 1.8 | 5.2 |
| 1909-10 | 9.0 | 6.4 | 7.4 | 7.0 | 5.9 | 6.6 | 6.0 | 3.4 | 4.9 | 3.2 | 1.7 | 2.2 | 1.7 | **.5** | 1.2 | 1.0 | .6 | .8 | 3.8 |
| 1910-11 | 10.2 | 4.1 | 6.8 | 12.4 | 7.0 | 8.9 | 9.1 | 7.4 | 8.0 | 8.1 | 5.0 | 6.8 | 4.9 | 2.0 | 3.3 | 2.0 | 1.0 | 1.5 | 4.3 |
| 1911-12 | 6.1 | 1.9 | 3.5 | 5.1 | 2.8 | 3.6 | 5.9 | 5.0 | 5.4 | 5.3 | 1.4 | 3.5 | 1.6 | .5 | .9 | .8 | **.0** | .4 | 2.3 |
| 1906-1912 | 28.2 | 1.9 | 6.9 | 12.7 | 2.8 | 7.4 | 10.0 | 3.4 | 6.8 | 9.0 | 1.4 | 5.2 | 6.3 | .5 | 2.8 | 4.5 | .0 | 1.8 | 4.0 |

TABLE No. 8.—*Highest, lowest, and mean stages for each month and the mean for each year at Marysville.*

Stages in bold-face type indicate the extremes for each year.
Marysville is on the Yuba River at its junction with the Feather River, 44 miles above Sacramento. Elevation, 46.8 feet; flood stage, 28 feet.

| Year. | September. | | | October. | | | November. | | | December. | | | January. | | | February. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. |
| 1906-7 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 14.7 | 10.8 | 11.7 | 21.9 | 12.7 | 14.5 |
| 1907-8 | 9.1 | 8.9 | 9.0 | 8.9 | 8.7 | 8.8 | 9.0 | **8.5** | 8.6 | 13.1 | **8.5** | 9.6 | **13.4** | 9.4 | 10.7 | 12.7 | 9.8 | 10.5 |
| 1908-9 | 8.5 | 8.3 | 8.4 | 10.3 | 8.3 | 8.6 | 9.7 | 8.5 | 8.7 | 10.2 | 8.6 | 8.9 | **24.0** | 8.6 | 15.1 | 15.3 | 11.0 | 12.3 |
| 1909-10 | 6.7 | 6.3 | 6.5 | 7.5 | 6.2 | 6.6 | 14.0 | 6.9 | 8.8 | 14.9 | 8.0 | 9.6 | 12.4 | 8.7 | 9.6 | 10.9 | 8.8 | 9.4 |
| 1910-11 | 7.1 | 5.8 | 6.0 | 6.4 | **5.7** | 5.6 | 7.4 | 5.8 | 6.2 | 9.4 | 6.2 | 6.9 | **19.3** | 6.1 | 9.4 | 18.2 | 8.3 | 10.0 |
| 1911-12 | 7.5 | 7.3 | 7.3 | 7.5 | 6.7 | 7.1 | 8.2 | 6.3 | 6.8 | 6.5 | 6.1 | 6.3 | 9.3 | 6.3 | 7.2 | 7.8 | 6.7 | 7.1 |
| 1906-1912 | 9.1 | 5.8 | 7.4 | 10.3 | 5.7 | 7.3 | 14.0 | 5.8 | 7.8 | 14.9 | 6.1 | 8.3 | 24.0 | 6.1 | 10.6 | 21.9 | 6.7 | 10.6 |

| Year. | March. | | | April. | | | May. | | | June. | | | July. | | | August. | | | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | |
| 1906-7 | **23.3** | 12.7 | 14.6 | 15.7 | 13.6 | 14.6 | 14.2 | 13.1 | 13.6 | 14.0 | 11.8 | 12.7 | 11.9 | 9.9 | 10.8 | 9.8 | **9.2** | 9.3 | ...... |
| 1907-8 | 11.6 | 10.3 | 10.9 | 12.5 | 10.4 | 11.4 | 12.9 | 11.0 | 11.8 | 11.3 | 9.7 | 10.6 | 9.7 | 8.8 | 9.2 | 8.8 | **8.5** | 8.6 | 10.0 |
| 1908-9 | 11.9 | 9.9 | 10.7 | 12.0 | 10.2 | 11.0 | 12.3 | 10.3 | 11.3 | 11.7 | 9.3 | 10.4 | 9.2 | 7.1 | 7.9 | 7.1 | **6.7** | 6.8 | 10.0 |
| 1909-10 | **13.9** | 10.3 | 11.2 | 11.5 | 10.7 | 11.1 | 10.7 | 8.8 | 9.7 | 8.9 | 7.0 | 7.7 | 6.9 | 6.2 | 6.5 | 6.2 | **5.8** | 6.0 | 8.6 |
| 1910-11 | 15.5 | 8.4 | 10.6 | 16.0 | 10.9 | 12.4 | 12.7 | 11.3 | 12.0 | 13.1 | 10.5 | 11.8 | 10.3 | 8.1 | 9.2 | 8.0 | 7.4 | 7.7 | 9.0 |
| 1911-12 | 9.8 | 6.7 | 7.9 | 9.5 | 7.2 | 7.8 | 10.0 | 8.8 | 9.5 | **10.1** | 6.9 | 8.4 | 6.8 | 5.8 | 6.1 | 5.8 | **5.5** | 5.6 | 7.3 |
| 1906-1912 | 23.3 | 6.7 | 11.0 | 16.0 | 7.2 | 11.4 | 14.2 | 8.8 | 11.3 | 14.0 | 6.9 | 10.3 | 11.9 | 5.8 | 8.3 | 9.8 | 5.5 | 7.3 | 9.0 |

TABLE NO. 9.—*Highest, lowest, and mean stages for each month and the mean for each year at Folsom.*

Stages in bold-face type indicate the extremes for each year.
Folsom is on the American River 24 miles from its mouth and 25 miles from Sacramento on the Sacramento River. Elevation, 110.6 feet.

| Year. | September. | | | October. | | | November. | | | December. | | | January. | | | February. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. |
| 1906–7 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 9.8 | 3.4 | 4.6 | 19.9 | 6.0 | 8.5 |
| 1907–8 | 3.1 | 3.0 | 3.0 | 3.2 | 2.5 | 2.9 | 3.1 | 2.7 | 2.9 | 8.0 | 2.7 | 3.9 | **9.0** | 3.8 | 4.7 | 5.2 | 3.8 | 4.3 |
| 1908–9 | 2.0 | **1.9** | 1.9 | 5.0 | **1.9** | 2.5 | 4.0 | 2.3 | 2.7 | 3.9 | 2.5 | 3.0 | **24.5** | 2.7 | 10.8 | 13.5 | 7.0 | 8.9 |
| 1909–10 | 2.0 | **1.7** | 1.8 | 3.0 | 1.8 | 2.2 | 15.2 | 2.8 | 4.9 | 15.6 | 4.0 | 6.6 | 11.5 | 4.9 | 6.5 | 7.5 | 5.2 | 6.0 |
| 1910–11 | 2.7 | 1.9 | 2.1 | 2.9 | **1.8** | 2.1 | 4.0 | 2.0 | 2.6 | 8.0 | 2.5 | 3.7 | **19.7** | 2.5 | 7.8 | 14.3 | 5.1 | 7.4 |
| 1911–12 | 2.0 | **.8** | 1.1 | .8 | **.8** | .8 | 2.9 | 1.4 | 2.3 | 2.5 | 2.1 | 2.3 | 5.4 | 2.4 | 3.1 | 3.4 | 2.7 | 3.0 |
| 1906–1912 | 3.1 | .8 | 2.0 | 5.0 | .8 | 2.1 | 15.2 | 1.4 | 3.1 | 15.6 | 2.1 | 3.9 | 24.5 | 2.4 | 6.2 | 19.9 | 2.7 | 6.3 |

| Year. | March. | | | April. | | | May. | | | June. | | | July. | | | August. | | | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | |
| 1906–7 | **26.8** | 5.9 | 10.8 | 12.5 | 9.5 | 11.0 | 12.1 | 8.3 | 10.0 | 11.9 | 7.0 | 9.2 | 9.2 | 4.5 | 6.2 | 4.5 | **3.0** | 3.7 | ...... |
| 1907–8 | 6.3 | 4.2 | 5.3 | 7.5 | 4.8 | 5.9 | 6.7 | 5.1 | 6.0 | 5.6 | 4.1 | 4.9 | 4.1 | 2.2 | 3.2 | 2.7 | **1.9** | 2.2 | 4.1 |
| 1908–9 | 9.3 | 5.8 | 7.0 | 11.0 | 5.8 | 8.3 | 10.6 | 6.1 | 8.5 | 11.5 | 5.5 | 7.6 | 5.4 | 2.9 | 3.9 | 3.1 | 2.0 | 2.4 | 5.6 |
| 1909–10 | **12.9** | 7.1 | 8.5 | 10.5 | 7.0 | 8.7 | 8.4 | 5.4 | 6.6 | 5.5 | 3.4 | 4.1 | 3.4 | 2.1 | 2.5 | 2.0 | 1.9 | 1.9 | 5.0 |
| 1910–11 | 15.1 | 5.1 | 9.0 | 13.2 | 7.6 | 9.9 | 11.5 | 7.6 | 9.4 | 11.9 | 6.6 | 10.1 | 6.1 | 3.1 | 4.7 | 3.0 | 2.0 | 2.5 | 5.9 |
| 1911–12 | 6.3 | 2.8 | 4.0 | 7.7 | 4.1 | 4.7 | 9.3 | 5.9 | 7.4 | **9.6** | 3.9 | 6.0 | 3.8 | 2.3 | 2.9 | 2.3 | 1.4 | 1.8 | 3.3 |
| 1906–1912 | 26.8 | 2.8 | 7.4 | 13.2 | 4.1 | 8.7 | 12.1 | 5.1 | 8.0 | 11.9 | 3.4 | 7.0 | 9.2 | 2.1 | 3.9 | 4.5 | 1.4 | 2.4 | 4.8 |

Kennett is about 3 miles below the mouth of the Pit River and 323 miles above the mouth of the Sacramento. The drainage area above the station is 8,450 square miles. Besides the drainage of the elevated region of the Sacramento, this station also shows the output of the Pit. Kennett is really the starting point of all flood waves that affect the upper Sacramento River.

Red Bluff is 265 miles from the mouth of the River and 58 miles below Kennett. The drainage area above the station is 11,058 square miles. The average fall per mile between Kennett and Red Bluff is 6.6 feet. When the river at Red Bluff is at or near a 10-foot stage a 25-foot stage at Kennett will cause an additional rise at Red Bluff of 10 or 11 feet. It has been closely estimated that under these conditions the Kennett water will reach Red Bluff in between 13 and 14 hours.

Jacinto is 198 miles from the mouth of the river and 67 miles below Red Bluff. The drainage area above the station is about 14,000 square miles. The average fall per mile between Red Bluff and Jacinto is about 2.6 feet. The Red Bluff flood wave will usually reach Jacinto in about 20 hours, and a 10-foot stage at Jacinto will generally be augmented by about 6 feet from a 20-foot head at Red Bluff, eliminating, of course, the output of Stony Creek, which empties into the Sacramento 9 miles above Jacinto.

Colusa is 156 miles from the mouth of the river and 42 miles below Jacinto. The drainage area above the station is 15,943 square miles. The average fall per mile between Jacinto and Colusa is slightly over a foot. The Jacinto station has recently been established in the place of Monroeville, near the mouth of Stony Creek, which has been abandoned. The effect of Stony Creek flood discharge on the river at Jacinto and Colusa will be discussed in connection with the station at St. John on Stony Creek.

Knights Landing is 99 miles above the mouth of the river and 57 miles below Colusa. The drainage area above the station is 16,793 square miles. The average fall per mile between Colusa and Knights Landing is about 0.4 foot. The effect of high water at Colusa on points down the river depends altogether on the condition of the levees and on the amount of water in Colusa, Yolo, and Sutter Basins.

Sacramento City is at the junction of the Sacramento and American Rivers, and is 64 miles from the mouth of the river. It is 35 miles below Knights Landing and 20 miles below the mouth of the Feather River at Vernon. The drainage area above the station is 28,433 square miles. The average fall per mile between Knights Landing and Sacramento is about 0.5 of a foot.

Much of the flood waters of the Feather River escapes either into Sutter Basin or through breaks on the west side into Yolo Basin, but a sufficient amount reaches Sacramento to cause a decided rise on the gage at that point.

Rio Vista is 26 miles from the mouth of the river and 38 miles below Sacramento City. The drainage area above the station is 30,047 square miles. The station is about 3 miles below the mouth of Steamboat Slough through which the drainage of the Coast Range and the accumulated waters of Yolo Basin are discharged into the Sacramento River.

## TRIBUTARIES OF THE SACRAMENTO.

It would be practically impossible to enumerate all the small watercourses that feed the Sacramento River during periods of heavy rainfall, or even the streams that are kept alive during the rainy season, and no attempt will be made in this paper to name or describe any stream other than those that materially affect the water levels of the main river. The main and tributary streams of both valleys are shown in figure No. 1, frontispiece.

The most important tributaries of the Sacramento flow westward from the Sierra Nevada, the largest of which, named from north to south, are the Pit, Feather, and American Rivers. There are several creeks that run the greater part of the year, chief of which are Battle, Antelope, Mill, Deer, Chico, and Butte. While all of these creeks have heavy discharges in times of heavy rainfall it has not yet been practicable to establish permanent stations on any of them. They are, however, considered in times of floods.

The Pit River rises in the Warner Mountains at an elevation of some 10,000 feet and flows southwestward to its junction with the Sacramento about 3 miles north of Kennett. This river is really the northeastern extension of the Sacramento and some geographers consider the Pit and Sacramento as one stream. The total fall of the Pit is about 6,000 feet. From the mouth of Falls River, at Falls City, to where it joins the Sacramento, a distance of about 87 miles, the Pit is deeply intrenched in rocky canyons. The principal tributaries of the Pit are the McCloud and Falls Rivers, although Montgomery, Hatchet, Hat, Squaw, and Burney Creeks add greatly to its discharge during periods of heavy rainfall. In times of heavy flow the most of the creeks named practically leap into the Pit as roaring cataracts. There is no Weather Bureau gauging station on the Pit River, but, as has been stated, the combined output of the Pit and the upper Sacramento River is measured on the Kennett gauge where a rise of from 15 to 20 feet often occurs in 24 hours.

The precipitation of the Pit River drainage becomes somewhat less as the northeastern end of its watershed is approached, especially in the level portions of Modoc County. It increases in the higher levels of the Warner Mountains, and varies from 20 to 30 inches annually. Some snow falls along the western slopes of the Warner Mountains and occasionally in the plains adjacent to Alturas. Within a radius of 20 to 40 miles adjacent to Kennett, in the lower Pit and upper Sacramento watersheds, the annual precipitation sometimes exceeds 100 inches. In 1909 the rainfall at Kennett for the three months ending with March was 86.42 inches, of which 54.08 inches fell in January and 24.30 in February. The annual precipitation at Kennett for 1909 was 115.92 inches.

The Feather River drains an extensive area south of the Honey Lake drainage basin and empties into the Sacramento at Vernon, 20 miles above Sacramento City. The drainage area above its mouth is something over 7,000 square miles. Its principal tributaries are the Yuba, which joins it near Marysville, and the Bear, which empties into it 17 miles below Marysville and 1 mile above Nicolaus. The output of the Feather River will probably exceed that of any of the tributaries of the Sacramento and is one of the principal streams to be reckoned with in times of flood. It rises on Mount Lassen at an elevation of nearly 10,000 feet and flows southward, being joined in the high Sierra by numerous forks, the chief of which are the North, Middle, and South Forks. The Feather-Yuba drainage includes the western slopes of the Sierra Nevada lying between the Pit and American Basins. The mean annual precipitation in the Feather-Yuba drainage area varies from 20 inches in the valley to 60 or 70 inches in the higher regions; occasionally as much as 100 inches falls. In the higher regions it is mostly in the form of snow, which often remains on the ground until June and sometimes July. On the summit of Mount Lassen the snow rarely ever disappears. From Oroville to its mouth the Feather flows practically parallel with the Sacramento, and during all floods of which there is a record it has overflowed its west bank at a point near Hamilton Bend and discharged its surplus water into a basin lying north of Marysville Buttes, thence into the Sacramento through Butte Slough. This water in 1909 was the deciding factor in the breaking of the levees at Moons Bend on the Sacramento River below Colusa and the flooding of Colusa Basin.

Upon the completion of an enormous dam by the Great Western Power Co. in the lower portion of Big Meadows Valley, that part of the North Fork of the Feather which drains this valley will be changed into a large reservoir that will occupy an area of about 40 square miles. The dam, which will impound about 1,250,000 acre-feet of water, will be 110 feet above the ordinary water level of the valley. As the North Fork of the Feather, besides bearing the drainage of Mount Lassen, is the most extensive watershed of any of the branches of this river, it will be seen that this huge reservoir will exercise a modifying effect on future flood conditions in the main stream. A regular river and rainfall station is maintained at Oroville on the Feather, 32 miles above its confluence with the Yuba and 50 miles from the mouth of the river. The drainage area above the station is 3,100 square miles. The fall between Oroville and the mouth of the Feather is about 2.6 feet per mile. Another regular river and rainfall station has recently been established on the Feather at Nicolaus, 16 miles below the mouth of the Yuba, 1 mile below the mouth of the Bear, and 10 miles above the mouth of the Feather.

The Yuba River rises at an elevation of about 8,000 feet and flows southwestward to its junction with the Feather near Marysville. It is fed by three forks, the North, Middle, and South, which drain the snow fields of the high mountains. A regular river and rainfall station has been maintained for many years at Marysville, which is 26 miles above the mouth of the river. The drainage area above Marysville is 3,540 square miles. In times of flood or heavy rainfall special telegraphic reports are received from Downieville, on the North Fork of the Yuba, about 95 miles above Marysville.

The Bear River drains a small area, not over 300 square miles, between the Yuba and American watersheds. It rises at an elevation of about 5,500 feet and flows southwestward to its junction with the Feather. This stream rises rapidly under the influence of heavy rains or melting snows in the higher regions of its watershed. With the cessation of rain the river quickly subsides and reaches its normal stage in a few hours' time. A special river station has been established on the Bear near Colfax, from which telegraphic reports are received in times of heavy rainfall.

The American River drains that part of the western slopes of the Sierra Nevada lying between the Bear and Yuba on the north and the Cosumnes and Mokelumne on the south. It flows southwestward and joins the Sacramento at the city of Sacramento. The drainage area above its mouth is about 2,000 square miles and its total fall is about 9,000 feet. Like the Feather and Yuba Rivers, the American branches out into numerous forks, all of which tap the snow fields of the high mountain ranges. In the higher part of its basin are numerous small lakes. There are two stations on this stream: One at Folsom, 25 miles above Sacramento, from which reports of river and rainfall are received the year round, and another on the Middle Fork, near East Auburn, from which reports are telegraphed in times of high water or heavy rainfall. It has been estimated that when a stage of 10 feet is reached on the Middle Fork gauge, assuming that all other forks are proportionally high, the main river at Folsom will be augmented by 10 or 11 feet when the gauge at the last-named point is at or near a 10-foot stage. The advance flood wave, starting at Folsom with a 20-foot head, will reach Sacramento city in about six hours. With a 25-foot head at Folsom the swell will be felt at

Sacramento in about five hours. The rate of progress of this stream becomes rapidly less as the water subsides, and at extreme low water the river becomes very sluggish, especially in the vicinity of Sacramento. Between Fair Oaks and Folsom the river is mostly confined within high banks. The American rarely retains a full head of water longer than a few hours after the cessation of rain, and for this reason its flood waves usually pass into the Sacramento before the output of the Feather-Yuba reaches its mouth. However, with a protracted spell of heavy rainfall that is coextensive with the watersheds of the American, Feather, and Yuba Rivers, the American remains at flood stage until the approach of the Feather River output, or such a part thereof as does not escape into the basins on each side of the Sacramento above the mouth of the American. The mean annual precipitation of the American watershed varies from 20 inches in the vicinity of Sacramento to 25 or 30 inches in the foothills. In the higher regions it amounts to 60 or 70 inches, and much of it is in the form of snow. Melting snows in the higher regions affect the American during the first warm days of spring, but this of itself rarely raises the river more than a few feet, and this usually flattens out before reaching Sacramento. The most potent factor in producing floods in the American is the combined influence of heavy rainfall and melting snows in its upper watershed.

Of the western tributaries of the Sacramento or those that flow from the Coast Range, the most important are Stony, Cache, Putah, and Cottonwood Creeks. In addition to these are Clear and Thomas Creeks, streams of small discharges and restricted watersheds.

Cottonwood Creek empties into the Sacramento near the town of Cottonwood. Its numerous small forks rise in the Coast Range at elevations ranging from 4,000 to over 6,000 feet. Although the main stream is east of the Coast Range proper, the total area drained by this creek is something over 900 square miles. The mean annual precipitation ranges from 20 to 25 inches in that part contiguous to the Sacramento River to 50 inches or more in the higher regions, where much of it is in the form of snow. This stream has a heavy discharge during periods of excessive rainfall, but it has not yet been practicable to establish a Weather Bureau river gauge in its watershed.

Stony Creek rises west of the Sacramento River at an elevation of about 5,000 feet and flows northward between the Coast Range proper and the foothills until it breaks through the hills and turns eastward through the plains toward the Sacramento, into which it discharges at a point near Monroeville. Stony Creek is the last southerly watercourse that discharges directly into the Sacramento River. The mean annual precipitation in the watershed of Stony Creek varies from 25 inches in the valley to about 40 inches in its most elevated feeders. Some snow falls in the higher regions, but this form of precipitation is rarely a factor in the flood situation.

The Weather Bureau maintains a regular river and rainfall station at St. John, about 3 miles above the point where the creek joins the Sacramento River, and a special rainfall station is in operation at Stonyford, about 45 miles above St. John, from which heavy rainfall is reported by telegraph. During the summer months the creek in the vicinity of St. John is practically dry, but during the winter months, especially during periods of heavy rainfall it rises rapidly, sometimes carrying away bridges, as was the case during the floods of 1907 and 1909. Stages over 6 feet in the lower reaches of the creek exercise a marked influence on the run-off of the Sacramento between its junction with the Sacramento and Colusa. Records show that stages between 9 and 12 feet on the St. John gauge will raise the river in the vicinity of Colusa from 5 to 7 feet when the Colusa gauge is at or near a 15-foot stage. The distance from the mouth of Stony to Colusa is about 50 miles and the first effect of the Stony flood wave is felt in between 14 and 16 hours, according to the intensity of the wave. The average fall per mile between the mouth of the creek and Colusa is about 2.3 feet. The creek falls rapidly after the cessation of rain and rarely maintains a stage as high as 8 feet for more than a few hours. At 12 feet the creek overflows its banks in the vicinity of St. John.

The United States Reclamation Service has recently completed a large reservoir in the vicinity of Orland, where a sufficient amount of water has been impounded from Stony Creek to irrigate some 14,000 acres.

Cache Creek drains that part of the eastern slope of the Coast Range lying between Stony and Putah Creeks. It rises in Clear Lake and flows southward through Yolo Basin and reaches the Sacramento River through Cache and Steamboat Sloughs a short distance above Rio Vista. Clear Lake has a drainage basin of about 450 square miles.

Putah Creek drainage basin lies between Cache Creek and Napa Valley. It rises in the St. Helena Range and flows southward through Yolo Basin, thence through Cache and Steamboat Sloughs into the Sacramento River.

The mean annual precipitation in the Cache and Putah Creek Basins varies from about 20 inches in Yolo Basin to 50 or 60 inches in the higher regions. Some snow falls in the upper forks of Putah and in the feeders of Clear Lake, although there is no appreciable increase in the run-off of either stream from this form of precipitation.

Both Cache and Putah Creeks have a heavy discharge during periods of heavy rainfall, and their flood waters intensify conditions from Rio Vista to Collinsville and throughout the island districts in the lower Sacramento and San Joaquin Rivers. All water that reaches Yolo Basin, whether from the hills or from the overflow of Colusa Basin, or through weirs and other openings along the west side of the Sacramento River, is borne back into the Sacramento River through the outlets that carry the combined discharge of Cache and Putah Creeks. During the floods of 1907 and 1909 the discharge of the accumulated water of Yolo Basin into the Sacramento River was sufficient to reverse the current of this stream for several miles above the mouth of Steamboat Slough, especially during flood tide.

No Weather Bureau gauges have been established on Cache or Putah Creeks, but arrangements are being made whereby gauge readings may be secured from several points in Yolo Basin during flood periods.

## The San Joaquin Drainage Basin.

The San Joaquin Valley is bounded on the east by the Sierra Nevada, on the south by the Tehachapi Cross Range, on the west by the Coast Range; on the south it merges into the Sacramento Valley in the region of the Mokelumne and Cosumnes Rivers.

The San Joaquin River, the trunk stream of the southern end of the Great Valley, and of the San Joaquin Valley, rises in the elevated regions of the Southern Sierras at a point south of the Yosemite National Park and flows southward to the floor of the valley, thence northwestward to Suisun Bay. Its total length is quoted as 350 miles. The river has been popularly divided into two sections, the upper and lower. The logical point between the divisions is a few miles above Mendota, where the river bends abruptly from a southwesterly to a northwesterly course.

Precipitation in the valley itself, or along the course of the river, ranges from something over 16 inches annually in the vicinity of Stockton to less than 5 inches in the region of Bakersfield. It increases rapidly as the Sierra Nevada are approached. The main water supply, however, of this stream is drawn from melting snows from the high mountain peaks of the Southern Sierra, many of which are almost always covered with snow. For this reason the mean maximum flow generally occurs in May and June, sometimes in July.

Three river and rainfall stations, having uninterrupted records of six years, are maintained on the San Joaquin River proper. Named from south to north they are Friant, Firebaugh, and San Joaquin Bridge

Tables of highest, lowest, and mean stages for each month and the mean for each year follow.

The tabular values are also presented graphically in figures 16 to 22b, inclusive.

*Mean monthly river stages, San Joaquin system.*

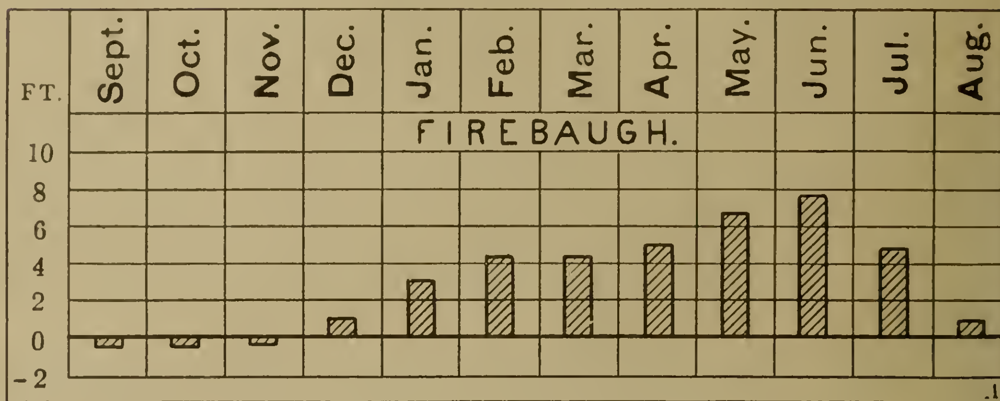



FIG. 16.—Mean monthly river stages.

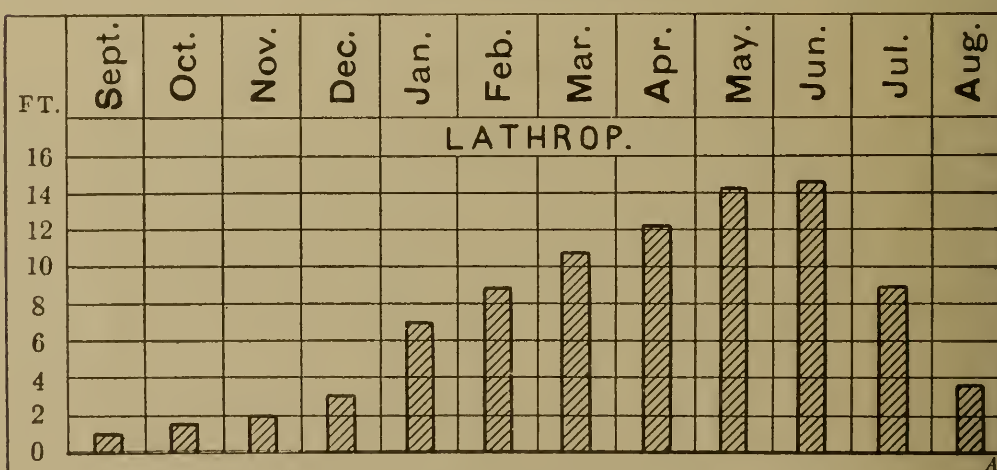



FIG. 16a.—Mean monthly river stages.

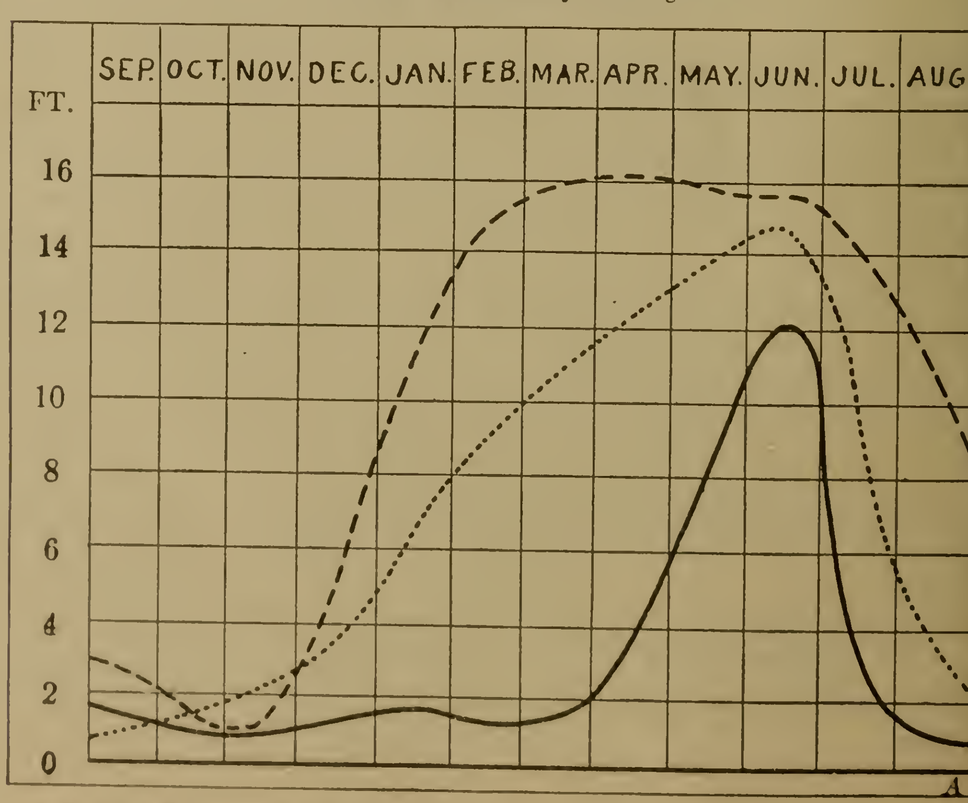



FIG. 17.—Mean monthly river stages, Lathrop, Cal. Broken line, season 1906–7, unusually high; solid line, 1911–12, unusually low; dotted line, mean stages for a 12-year period.

*Highest, lowest, and mean seasonal stages, San Joaquin system.*

(In feet.)

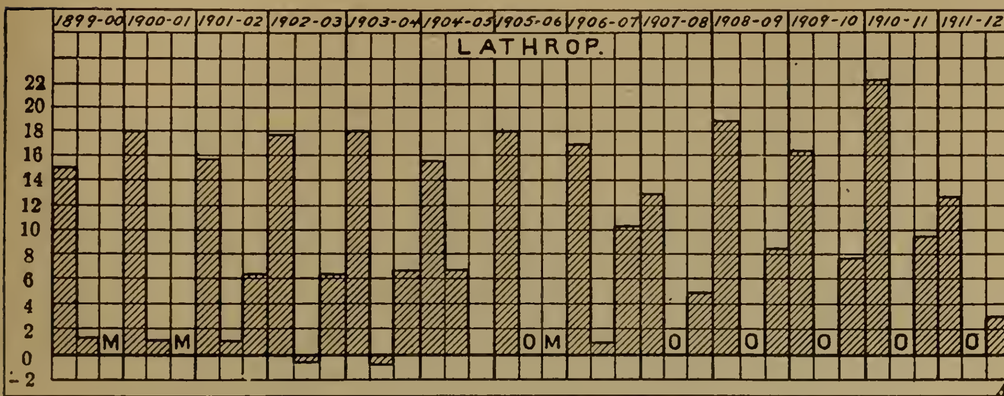



FIG. 18.—Highest, lowest, and mean stages.

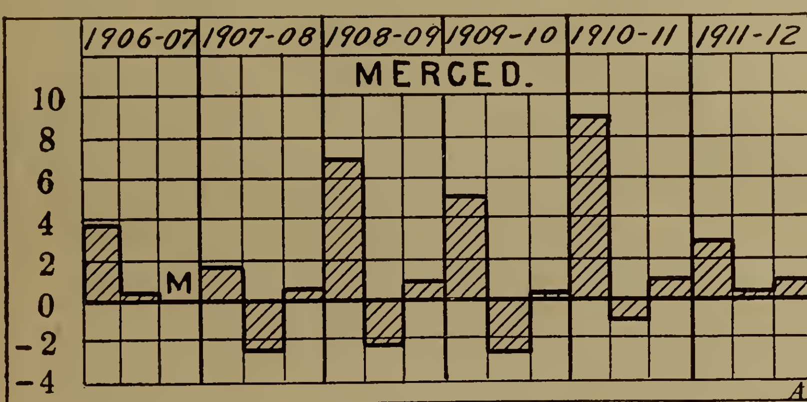



FIG. 19.—Highest, lowest, and mean stages.

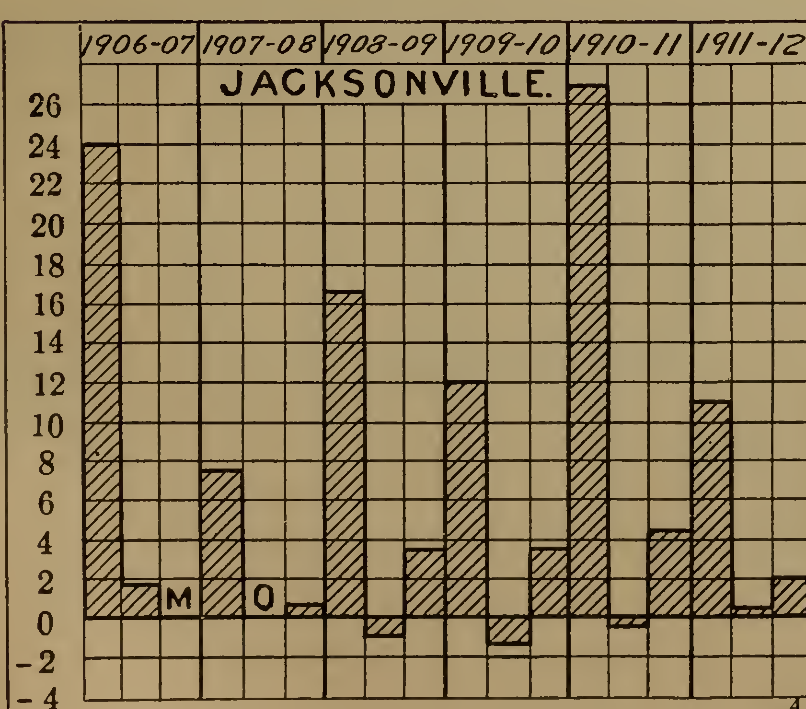



FIG. 20.—Highest, lowest, and mean stages.

*Highest, lowest, and mean seasonal stages, San Joaquin system*—Continued.

(In feet.)

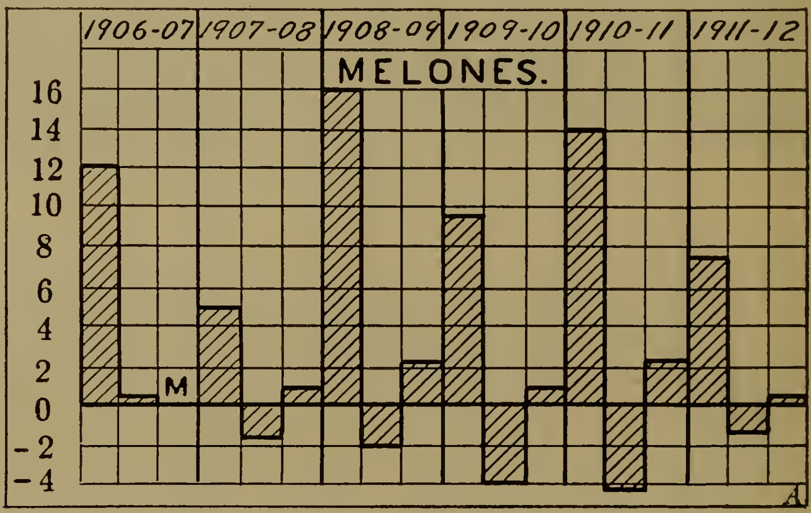



FIG. 20a.—Highest, lowest, and mean stages.

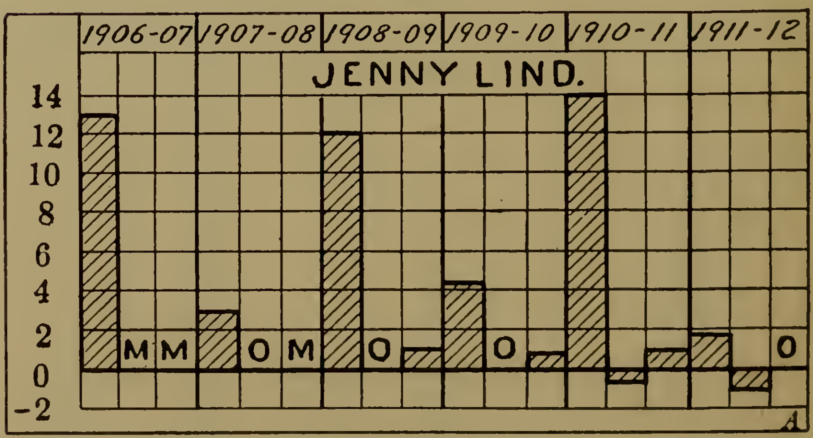



FIG. 20b.—Highest, lowest, and mean stages.

*Highest, lowest, and mean seasonal stages, San Joaquin system*—Continued.

(In feet.)

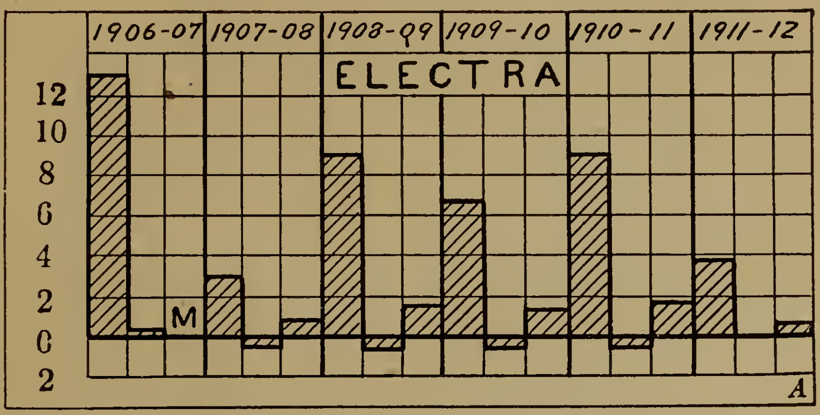



FIG. 21.—Highest, lowest, and mean stages.

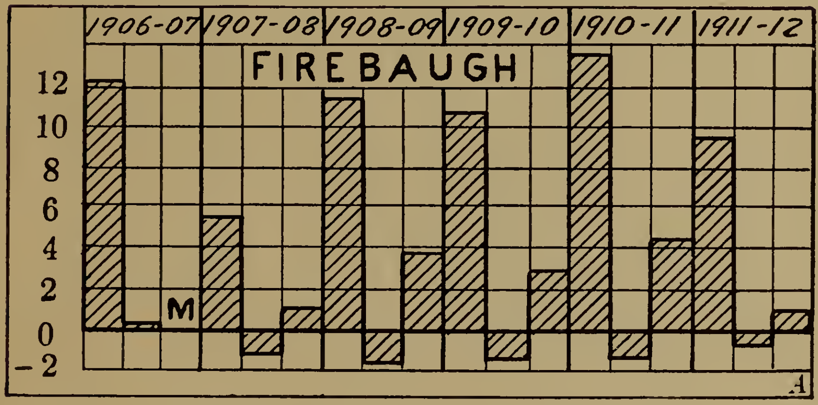



FIG. 22.—Highest, lowest, and mean stages.

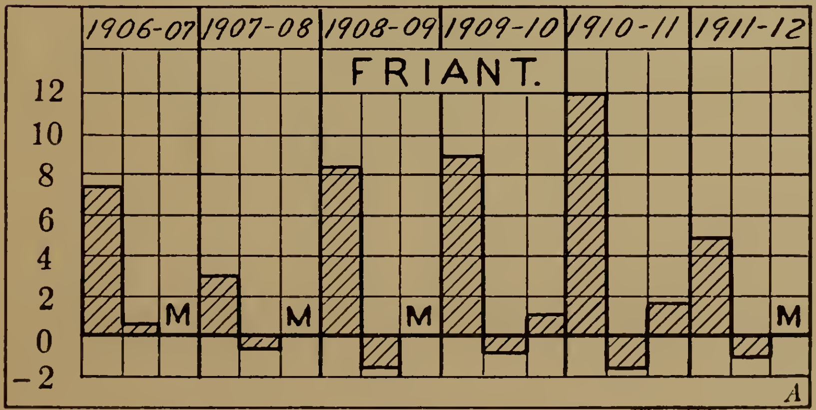



FIG. 22b.—Highest, lowest, and mean stages.

## San Joaquin River System.

Table No. 1.—*Highest, lowest, and mean stages for each month and the mean for each year at Friant.*

Stages in bold-face type indicate the extremes for each year.
Friant is on the San Joaquin River, 203 miles from its mouth, and 43 miles above Firebaugh. Elevation, 355 feet; flood stage, 10 feet.

| Year. | September. | | | October. | | | November. | | | December. | | | January. | | | February. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. |
| 1906-7 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 4.0 | **0.6** | 1.3 | 2.5 | 1.4 | 1.9 |
| 1907-8 | 2.0 | 1.2 | 1.7 | ...... | ...... | ...... | 0.0 | −0.2 | −0.1 | 0.6 | **−0.3** | −0.1 | .9 | .0 | .1 | .9 | .0 | .1 |
| 1908-9 | .2 | .0 | .0 | − 1.3 | **−1.3** | −1.3 | −1.3 | **−1.3** | −1.3 | .0 | .0 | .0 | **8.5** | .0 | 1.9 | 5.3 | .9 | 1.7 |
| 1909-10 | .0 | .0 | .0 | .0 | − .1 | .0 | 1.7 | **−0.6** | .0 | 7.0 | .0 | .9 | **9.0** | .8 | 1.8 | 1.0 | .5 | .7 |
| 1910-11 | 2.3 | −1.0 | − .8 | −1.0 | −1.0 | −1.0 | −1.0 | −1.0 | −1.0 | −1.0 | **−1.3** | −1.2 | **12.0** | **−1.3** | 1.0 | 6.0 | 1.0 | 2.1 |
| 1911-12 | .5 | − .2 | .1 | − .2 | − .6 | − .5 | − .6 | − .6 | − .6 | − .6 | **− .7** | − .6 | − .6 | − .6 | − .6 | − .6 | − .6 | − .6 |
| 1906-12 | 2.3 | −1.0 | .2 | .0 | −1.3 | − .7 | 1.7 | −1.3 | − .6 | 7.0 | −1.3 | − .2 | 12.0 | −1.3 | .9 | 6.0 | − .6 | 1.0 |

| Year. | March. | | | April. | | | May. | | | June. | | | July. | | | August. | | | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | |
| 1906-7 | 7.5 | 1.3 | 3.3 | 5.9 | 2.8 | 4.6 | **7.4** | 4.1 | 5.4 | 8.0 | 3.8 | 5.8 | 6.4 | 3.0 | 4.6 | 3.0 | 2.1 | 2.6 | ...... |
| 1907-8 | 1.5 | .3 | .9 | 3.0 | .3 | 1.4 | **3.2** | .7 | 1.7 | 1.9 | 1.0 | 1.4 | 1.1 | .3 | .6 | 1.3 | .0 | .2 | ...... |
| 1908-9 | 1.7 | .9 | 1.2 | 4.0 | 1.0 | 2.5 | 5.7 | 3.5 | 4.5 | 7.6 | 4.0 | 5.7 | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| 1909-10 | 2.0 | .5 | 1.3 | 4.3 | .7 | 2.6 | 4.0 | 2.4 | 3.4 | 4.1 | 1.3 | 2.0 | 1.3 | − .1 | .3 | − .1 | **−0.6** | − .4 | 1.0 |
| 1910-11 | 6.8 | 1.0 | 2.8 | 4.8 | 2.1 | 3.1 | 6.2 | 3.0 | 4.2 | 7.8 | 3.8 | 6.3 | 6.0 | 2.3 | 4.5 | 2.2 | .5 | 1.3 | 1.8 |
| 1911-12 | .9 | − .6 | − .1 | .8 | − .2 | .3 | 4.6 | .5 | 1.8 | **4.9** | .7 | 2.6 | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| 1906-12 | 7.5 | − .6 | 1.6 | 5.9 | − .2 | 2.4 | 7.4 | .5 | 3.5 | 8.0 | .7 | 4.3 | 6.4 | − .1 | 2.5 | 3.0 | − .6 | .9 | ...... |

TABLE NO. 2.—*Highest, lowest, and mean stages for each month and the mean for each year at Firebaugh.*

Stages in bold-face type indicate the extremes for each year.
Firebaugh is on the San Joaquin River, 160 miles from its mouth and 111 miles above Lathrop. Elevation, 153.5 feet; flood stage, 12 feet.

| Year. | September. | | | October. | | | November. | | | December. | | | January. | | | February. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. |
| 1906-7 | | | | | | | | | | | | | 8.2 | 3.4 | 4.3 | 6.7 | 4.6 | 5.5 |
| 1907-8 | 1.1 | −0.4 | 0.4 | 0.6 | −0.5 | 0.4 | 1.8 | 0.2 | 0.4 | 2.3 | 0.2 | 1.2 | 2.9 | 1.4 | 1.7 | 2.6 | 1.2 | 1.8 |
| 1908-9 | −1.1 | −1.4 | −1.3 | .5 | −1.4 | −1.1 | −1.3 | **−1.5** | −1.4 | − .4 | −1.3 | − .9 | 10.2 | − .5 | 4.2 | 10.1 | 4.4 | 6.4 |
| 1909-10 | − .5 | −1.1 | − .9 | − .8 | **−1.2** | −1.0 | 3.4 | **−1.2** | .4 | 9.2 | 2.3 | 4.2 | **11.0** | 4.6 | 6.4 | 5.0 | 2.5 | 3.6 |
| 1910-11 | 2.0 | **−1.2** | − .8 | − .8 | −1.0 | − .9 | − .8 | −1.0 | − .9 | .8 | −1.0 | − .5 | 8.9 | − .8 | 1.5 | 12.5 | 3.5 | 7.4 |
| 1911-12 | 1.0 | .3 | .7 | 1.6 | .4 | .8 | 1.0 | .4 | .7 | .6 | .3 | .4 | .8 | .3 | .4 | .5 | **− .7** | − .2 |
| 1906-12 | 2.0 | −1.4 | − .4 | 1.6 | −1.4 | − .4 | 3.4 | −1.5 | − .2 | 9.2 | −1.3 | .9 | 11.0 | − .8 | 3.1 | 12.5 | − .7 | 4.1 |

| Year. | March. | | | April. | | | May. | | | June. | | | July. | | | August. | | | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | |
| 1906-7 | 11.5 | 4.7 | 8.1 | 11.4 | 8.1 | 10.1 | 11.5 | 9.8 | 10.9 | **12.5** | 10.5 | 11.5 | 11.8 | 7.2 | 10.3 | 6.6 | **0.5** | 3.4 | ...... |
| 1907-8 | 3.9 | 1.0 | 2.5 | 5.2 | .3 | 2.2 | **5.5** | 1.4 | 3.0 | 4.3 | 1.3 | 2.4 | 1.5 | − .7 | .4 | .8 | **−1.3** | − .5 | 1.3 |
| 1908-9 | 5.4 | 3.2 | 4.2 | 8.4 | 3.1 | 5.7 | 10.6 | 8.1 | 9.5 | **12.5** | 9.2 | 11.7 | 11.6 | 2.2 | 8.0 | 2.1 | − .6 | .2 | 3.8 |
| 1909-10 | 4.9 | 2.4 | 3.7 | 8.4 | 2.8 | 5.7 | 8.4 | 5.6 | 7.4 | 8.7 | 2.0 | 4.8 | 2.1 | −1.1 | .2 | −1.0 | **−1.2** | −1.1 | 2.8 |
| 1910-11 | 11.0 | 3.4 | 7.6 | 9.3 | 5.7 | 7.7 | 10.1 | 6.9 | 8.4 | **13.6** | 9.2 | 11.9 | 12.6 | 6.3 | 10.6 | 5.2 | 1.0 | 2.4 | 4.5 |
| 1911-12 | .5 | **− .7** | − .5 | .8 | − .7 | − .4 | 6.7 | − .7 | 2.6 | **9.6** | 1.7 | 5.9 | 1.7 | − .1 | .5 | − .2 | − .4 | − .2 | .9 |
| 1906-12 | 11.5 | − .7 | 4.3 | 11.4 | − .7 | 5.2 | 11.5 | − .7 | 7.0 | 13.6 | 1.3 | 8.0 | 12.6 | −1.1 | 5.0 | 6.6 | −1.3 | .7 | 2.7 |

TABLE NO. 3.—*Highest, lowest, and mean stages for each month and the mean for each year at Lathrop.*

Stages in bold-face type indicate the extremes for each year.
Lathrop is on the San Joaquin River, 49 miles from its mouth. Elevation, 1.9 feet; flood stage, 17 feet.

| Year. | September. | | | October. | | | November. | | | December. | | | January. | | | February. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. |
| 1899–1900 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 14.7 | 6.8 | 9.8 | 6.4 | 4.7 | 5.5 |
| 1900–1901 | 1.5 | **1.1** | 1.4 | 6.5 | **1.1** | 3.8 | 14.0 | 2.0 | 5.9 | ...... | ...... | ...... | 16.7 | 4.5 | 11.6 | **18.0** | 8.5 | 15.7 |
| 1901–2 | 3.3 | 1.4 | 2.1 | 3.5 | **.7** | 1.5 | 3.9 | 2.8 | 3.3 | 10.0 | 3.2 | 5.5 | 3.7 | 2.2 | 2.8 | 12.4 | 2.0 | 4.4 |
| 1902–3 | 1.0 | .1 | .6 | .6 | **— .3** | .2 | 3.5 | .2 | 1.8 | 5.5 | 1.8 | 3.0 | 15.3 | 1.7 | 3.8 | 14.4 | 5.3 | 7.8 |
| 1903–4 | .8 | — .2 | .2 | .4 | **— .5** | .0 | 5.8 | .0 | 2.0 | 2.1 | .8 | 1.4 | 1.5 | .7 | 1.2 | 16.1 | .8 | 6.4 |
| 1904–5 | 4.2 | **.2** | .9 | 13.2 | 4.6 | 8.3 | 5.7 | 2.7 | 3.7 | 3.3 | 2.0 | 2.6 | 4.9 | 3.0 | 4.0 | 11.0 | 3.9 | 7.3 |
| 1905–6 | .2 | **.0** | .0 | .3 | **.0** | .0 | .4 | **.0** | .1 | .5 | **.0** | .2 | 16.3 | .4 | 6.8 | 12.8 | 4.4 | 7.3 |
| 1906–7 | 5.6 | 1.8 | 3.3 | 2.0 | **.8** | 1.3 | 1.9 | 1.0 | 1.4 | 12.8 | 1.1 | 5.2 | 15.0 | 8.8 | 11.6 | 16.7 | 12.4 | 14.4 |
| 1907–8 | 3.9 | 2.0 | 2.9 | 2.6 | 1.4 | 1.8 | 2.5 | 1.4 | 2.0 | 4.8 | 1.5 | 2.6 | 7.1 | 4.0 | 5.1 | 7.1 | 4.1 | 5.3 |
| 1908–9 | 1.0 | **.0** | .4 | 1.2 | **.0** | .3 | .7 | **.0** | .3 | 1.2 | .3 | .7 | **18.7** | .8 | 10.8 | 18.2 | 15.0 | 16.4 |
| 1909–10 | 2.0 | .4 | 1.4 | 1.9 | **.0** | 1.0 | 9.9 | **.0** | 3.4 | 14.0 | 6.7 | 9.8 | 15.5 | 7.3 | 13.4 | 12.4 | 7.9 | 9.5 |
| 1910–11 | 2.8 | **.0** | .7 | .7 | **.0** | .3 | .8 | **.0** | .4 | 3.3 | .4 | 1.4 | 15.1 | .5 | 6.0 | **22.5** | 10.9 | 15.4 |
| 1911–12 | 2.5 | 1.0 | 1.6 | 1.6 | **.8** | 1.3 | 1.5 | 1.2 | 1.3 | 1.6 | 1.2 | 1.4 | 2.4 | 1.4 | **1.8** | 2.2 | .6 | 1.4 |
| 1899–1912 | 5.6 | — .2 | 1.3 | 13.2 | — .5 | 1.6 | 14.0 | .0 | 2.1 | 14.0 | .0 | 3.1 | 18.7 | .4 | 6.8 | 22.5 | .6 | 9.0 |

| Year. | March. | | | April. | | | May. | | | June. | | | July. | | | August. | | | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | High | Low. | Mean | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | |
| 1899–1900 | 10.0 | 5.1 | 8.3 | 10.7 | 7.4 | 9.0 | **15.2** | 9.2 | 13.3 | 15.2 | 11.0 | 13.9 | 10.6 | 2.0 | 5.4 | 2.0 | **1.3** | 1.7 | ...... |
| 1900–1901 | 16.5 | 12.1 | 14.4 | 14.8 | 9.6 | 12.1 | 17.6 | 14.5 | 16.1 | 17.3 | 15.7 | 16.5 | 16.5 | 11.5 | 14.4 | 11.2 | 3.4 | 7.2 | ...... |
| 1901–2 | 13.2 | 6.2 | 9.8 | 14.4 | 7.3 | 11.8 | **15.7** | 11.8 | 13.9 | **15.8** | 13.3 | 14.9 | 13.2 | 2.9 | 6.8 | 2.9 | .8 | 1.6 | 6.5 |
| 1902–3 | 13.8 | 5.0 | 8.3 | **17.9** | 10.5 | 13.8 | 16.9 | 13.5 | 15.1 | 16.1 | 13.2 | 14.6 | 12.9 | 2.1 | 6.4 | 1.9 | .5 | 1.0 | 6.4 |
| 1903–4 | 16.4 | 10.0 | 13.3 | 16.0 | 12.9 | 14.3 | **18.0** | 12.5 | 16.0 | 17.4 | 13.9 | 16.3 | 13.7 | 4.6 | 8.7 | 5.0 | 1.0 | 2.6 | 6.9 |
| 1904–5 | 14.7 | 6.8 | 10.1 | 12.8 | 9.8 | 10.6 | **15.4** | 10.8 | 13.6 | 15.2 | 12.6 | 14.2 | 12.4 | 2.0 | 6.2 | 2.0 | **.2** | .9 | 6.9 |
| 1905–6 | ...... | ...... | ...... | 17.4 | 15.1 | 15.8 | 17.5 | 15.7 | 16.7 | 17.8 | 16.7 | 17.3 | **17.9** | 15.9 | 17.0 | 15.7 | 6.0 | 12.4 | ...... |
| 1906–7 | 19.2 | 13.0 | 16.0 | 16.5 | 15.5 | 16.0 | 16.3 | 15.4 | 15.8 | **17.0** | 15.1 | 16.1 | 16.2 | 14.2 | 15.2 | 14.0 | 4.0 | 9.1 | 10.4 |
| 1907–8 | 8.9 | 5.0 | 7.2 | 11.6 | 4.8 | 8.0 | **12.9** | 7.3 | 10.0 | 11.3 | 4.6 | 7.9 | 4.5 | 1.2 | 2.8 | 1.0 | **.0** | .7 | 4.7 |
| 1908–9 | 14.7 | 9.8 | 12.2 | 15.7 | 10.6 | 13.2 | 17.2 | 15.3 | 16.3 | 17.9 | 15.6 | 16.9 | 16.4 | 6.8 | 13.2 | 6.3 | 1.5 | 3.0 | 8.6 |
| 1909–10 | 14.9 | 8.0 | 11.6 | 16.5 | 12.1 | 14.0 | **16.6** | 14.0 | 15.3 | 15.8 | 4.3 | 11.0 | 4.1 | .8 | 2.2 | 2.0 | **.0** | 1.0 | 7.8 |
| 1910–11 | 19.3 | 9.6 | 15.8 | 16.7 | 14.5 | 15.7 | 17.0 | 14.7 | 15.8 | 19.2 | 16.4 | 17.8 | 17.7 | 14.2 | 16.1 | 13.8 | 2.3 | 7.0 | 9.4 |
| 1911–12 | 2.8 | .6 | 1.6 | 4.3 | 1.0 | 2.4 | 12.6 | 2.2 | 7.7 | **15.5** | 5.9 | 12.3 | 5.4 | 1.0 | 2.4 | 1.6 | **.0** | .8 | 3.0 |
| 1899–1912 | 19.3 | .6 | 10.7 | 17.9 | 1.0 | 12.1 | 18.0 | 2.2 | 14.3 | 19.2 | 4.3 | 14.6 | 17.9 | .8 | 9.0 | 15.7 | .0 | 3.8 | 7.1 |

TABLE No. 4.—*Highest, lowest, and mean stages for each month and the mean for each year at Merced Falls.*

Stages in bold-face type indicate the extremes for each year.
Merced Falls is on the Merced River, 35 miles from its mouth. Elevation about 321.1 feet. There is no danger from floods.

| Year. | September. | | | October. | | | November. | | | December. | | | January. | | | February. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. |
| 1906–7 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 4.0 | 0.5 | 1.0 | 2.1 | 0.8 | 1.2 |
| 1907–8 | 0.4 | 0.0 | 0.2 | 0.8 | 0.0 | 0.1 | 0.2 | 0.0 | 0.0 | 0.7 | 0.0 | 0.3 | 1.1 | .4 | .5 | .8 | .3 | .4 |
| 1908–9 | .0 | −2.0 | − .8 | .3 | −2.0 | −1.0 | .0 | −2.0 | −1.0 | .0 | **−2.0** | − .9 | **7.1** | − .9 | 1.5 | 4.9 | 1.0 | 1.7 |
| 1909–10 | .2 | **−2.6** | −1.0 | .0 | −2.0 | − .7 | 1.3 | −1.0 | .2 | 4.8 | .4 | .8 | **5.3** | .7 | 1.3 | 1.0 | .7 | .8 |
| 1910–11 | .7 | −1.0 | − .8 | .0 | **−1.0** | − .4 | .2 | **−1.0** | − .5 | .8 | **−1.0** | − .3 | **9.0** | −1.0 | 1.1 | 4.1 | 1.0 | 1.6 |
| 1911–12 | .5 | .4 | .3 | .3 | .3 | .3 | .4 | .3 | .3 | .3 | **.2** | .2 | .5 | .2 | .4 | .4 | .3 | .4 |
| 1906–12 | .7 | −2.6 | − .4 | .8 | −2.0 | − .3 | 1.3 | −2.0 | − .2 | 4.8 | −2.0 | .0 | 9.0 | −1.0 | 1.0 | 4.9 | .3 | 1.0 |

| Year. | March. | | | April. | | | May. | | | June. | | | July. | | | August. | | | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | |
| 1906–7 | **6.0** | 0.9 | 2.5 | 2.9 | 1.7 | 2.4 | 3.5 | 2.1 | 2.7 | 3.8 | 1.6 | 2.7 | 2.8 | 1.0 | 1.7 | 1.2 | **0.4** | 0.7 | ...... |
| 1907–8 | 1.1 | .6 | .8 | **2.0** | .6 | 1.2 | 1.9 | 1.0 | 1.3 | 1.2 | .7 | 1.0 | .7 | .3 | .5 | .5 | **−2.4** | − .4 | 0.5 |
| 1908–9 | 1.4 | .9 | 1.0 | 2.4 | 1.0 | 1.6 | 3.1 | 2.0 | 2.5 | 3.9 | 1.8 | 2.7 | 1.8 | .5 | 1.0 | .5 | .0 | .3 | .7 |
| 1909–10 | 2.1 | .8 | 1.3 | 2.8 | 1.3 | 2.0 | 2.4 | 1.5 | 2.0 | 1.8 | .5 | 1.0 | .5 | .0 | .4 | .0 | −1.0 | − .8 | .3 |
| 1910–11 | 5.2 | 1.4 | 2.5 | 2.8 | 1.7 | 2.1 | 3.5 | 2.0 | 2.5 | 4.0 | 2.4 | 3.3 | 3.0 | 1.0 | 1.9 | 1.0 | .5 | .7 | 1.1 |
| 1911–12 | 1.5 | .3 | .8 | 1.5 | .6 | .9 | 2.8 | .9 | 1.6 | **3.1** | .8 | 1.7 | .7 | .3 | .5 | .3 | .2 | .3 | .5 |
| 1906–12 | 6.0 | .3 | 1.5 | 2.9 | .6 | 1.7 | 3.5 | .9 | 2.1 | 4.0 | .5 | 2.1 | 3.0 | .0 | 1.0 | 1.2 | −2.4 | .1 | **.6** |

Table No. 5.—*Highest, lowest, and mean stages for each month and the mean for each year at Jacksonville.*

Stages in bold-face type indicate the extremes for each year.
Jacksonville is on the Tuolumne River, 64 miles from its mouth. Elevation, 601.7 feet; flood stage, 20 feet.

| Year. | September. | | | October. | | | November. | | | December. | | | January. | | | February. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. |
| 1906-7 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 8.6 | **1.6** | 2.4 | 6.6 | 3.0 | 4.3 |
| 1907-8 | 2.1 | **0.0** | 0.9 | 1.8 | 0.6 | 0.9 | 1.4 | 0.5 | 0.8 | 3.6 | 0.4 | 1.7 | 3.2 | 1.8 | 2.4 | 3.8 | 2.0 | 2.4 |
| 1908-9 | .4 | .2 | .3 | 3.6 | .0 | .5 | 1.0 | .3 | .4 | 1.5 | .5 | .7 | **17.0** | .5 | 5.7 | 9.4 | 3.6 | 5.0 |
| 1909-10 | — .6 | **—1.1** | — .8 | 1.0 | **—1.1** | .5 | 9.0 | 1.0 | 3.1 | **12.0** | 2.0 | 3.9 | 8.0 | 3.0 | 4.2 | 4.6 | 2.4 | 3.1 |
| 1910-11 | 3.4 | **— .2** | .4 | 1.0 | **— .2** | .3 | 1.3 | .0 | .6 | 3.2 | .2 | 1.0 | **27.0** | .2 | 4.4 | 12.0 | 2.8 | 4.7 |
| 1911-12 | 1.4 | .2 | .5 | .2 | .2 | .2 | 1.0 | .2 | .3 | .3 | .2 | .2 | 1.8 | .3 | .6 | .8 | .4 | .6 |
| 1906-12 | 3.4 | —1.1 | .3 | 3.6 | —1.1 | .5 | 9.0 | .0 | 1.0 | 12.0 | .2 | 1.5 | 27.0 | .2 | 3.3 | 12.0 | .4 | 3.4 |

| Year. | March. | | | April. | | | May. | | | June. | | | July. | | | August. | | | An nual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | |
| 1906-7 | **24.0** | 2.8 | 6.8 | 8.2 | 4.6 | 6.5 | 10.2 | 6.2 | 7.7 | 12.0 | 5.6 | 8.6 | 10.2 | 5.0 | 7.5 | 5.2 | 2.2 | 3.3 | ...... |
| 1907-8 | 5.0 | 2.8 | 3.7 | **7.6** | 2.8 | 5.1 | **7.6** | 4.2 | 5.8 | 6.4 | 3.2 | 4.8 | 3.2 | 1.4 | 2.1 | 2.0 | .4 | .9 | 2.6 |
| 1908-9 | 5.6 | 3.4 | 4.0 | 7.6 | 3.6 | 5.9 | 9.0 | 6.1 | 7.8 | 11.9 | 6.9 | 9.2 | 8.0 | 2.1 | 4.4 | 2.0 | **— .6** | .5 | 3.7 |
| 1909-10 | 8.2 | 4.2 | 5.4 | 9.0 | 5.6 | 7.2 | 8.5 | 5.5 | 7.5 | 8.6 | 2.8 | 4.7 | 2.6 | .6 | 1.4 | .6 | .1 | .3 | 3.4 |
| 1910-11 | 12.0 | 4.0 | 6.8 | 8.6 | 5.4 | 7.2 | 10.4 | 6.2 | 7.9 | 13.0 | 7.6 | 10.8 | 10.0 | 4.2 | 7.6 | 4.0 | 1.1 | 2.3 | 4.5 |
| 1911-12 | 3.6 | .4 | 2.0 | 5.4 | 2.4 | 3.2 | 9.8 | 4.4 | 6.7 | **11.0** | 3.6 | 6.9 | 3.0 | 1.0 | 2.4 | .8 | **.1** | .5 | 2.0 |
| 1906-1912 | 24.0 | .4 | 4.8 | 9.0 | 2.4 | 5.8 | 10.4 | 4.2 | 7.2 | 13.0 | 2.8 | 7.5 | 10.2 | .6 | 4.2 | 5.2 | — .6 | 1.3 | 5.2 |

TABLE NO. 6.—*Highest, lowest, and mean stages for each month and the mean for each year at Melones.*

Stages in bold-face type indicate the extremes for each year.
Melones is on the Stanislaus River, 64 miles from its mouth. No danger from floods.

| Year. | September. | | | October. | | | November. | | | December. | | | January. | | | February. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. |
| 1906-7 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 5.2 | 1.0 | 1.7 | 6.0 | 3.4 | 4.1 |
| 1907-8 | 0.2 | -0.2 | 0.0 | -0.2 | -0.3 | -0.3 | -0.1 | -0.6 | -0.3 | 1.1 | -0.6 | 0.4 | 0.7 | - .9 | .1 | .0 | - .9 | - .3 |
| 1908-9 | -1.2 | -1.8 | -1.7 | -1.4 | **-1.9** | -1.6 | -1.0 | **-1.9** | -1.6 | .2 | -1.4 | - .2 | **16.0** | - .5 | 3.8 | 7.0 | 2.5 | 3.7 |
| 1909-10 | -1.9 | -3.6 | -3.2 | - .5 | -2.7 | -1.3 | 9.5 | .5 | 1.9 | 9.4 | .5 | 2.8 | 6.0 | .3 | 2.4 | 3.0 | 1.8 | 2.4 |
| 1910-11 | -3.4 | **-4.1** | -4.0 | -3.9 | -4.0 | -4.0 | -1.5 | -3.9 | -3.2 | .5 | - .7 | .2 | **14.0** | -1.0 | 2.4 | 8.0 | 1.8 | 3.1 |
| 1911-12 | 1.0 | .9 | .9 | .9 | .7 | .8 | .5 | - .1 | .0 | .0 | - .3 | - .1 | 1.2 | - .2 | .0 | .7 | - .5 | .4 |
| 1906-1912 | 1.0 | -4.1 | -1.6 | .9 | -4.0 | -1.3 | 9.5 | -3.9 | - .6 | 9.4 | -1.4 | .6 | 16.0 | -1.0 | 1.7 | 8.0 | - .9 | 2.2 |

| Year. | March. | | | April. | | | May. | | | June. | | | July. | | | August. | | | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | |
| 1906-7 | **12.2** | 3.2 | 6.0 | 5.6 | 3.2 | 4.5 | 6.2 | 4.5 | 5.1 | 7.0 | 5.2 | 6.2 | 6.8 | 2.0 | 4.0 | 2.0 | **0.1** | 1.2 | ...... |
| 1907-8 | 2.3 | - .7 | 1.2 | **4.9** | 1.0 | 2.9 | 4.0 | 2.3 | 2.9 | 2.8 | 2.0 | 2.4 | 2.2 | - .9 | .0 | .4 | **-1.2** | - .8 | 0.7 |
| 1908-9 | 4.0 | 2.3 | 3.0 | 9.0 | 3.0 | 5.6 | 9.1 | 4.5 | 6.8 | 9.5 | 4.2 | 6.4 | 4.5 | 1.0 | 2.7 | 1.0 | -1.6 | - .8 | 2.2 |
| 1909-10 | 8.0 | 3.5 | 5.1 | 7.8 | 4.0 | 6.1 | 6.5 | 4.2 | 5.1 | 5.2 | .2 | 2.3 | .3 | -2.0 | -2.0 | -3.0 | -4.0 | -3.8 | .7 |
| 1910-11 | 8.0 | 1.8 | 5.0 | 9.0 | 4.5 | 6.4 | 10.0 | 5.0 | 7.0 | 10.9 | 5.5 | 8.7 | 6.0 | 1.8 | 3.2 | 1.7 | 1.0 | 1.2 | 2.2 |
| 1911-12 | 1.3 | .0 | .7 | 2.5 | .8 | 1.3 | 6.5 | 1.5 | 4.2 | **7.3** | 1.0 | 3.7 | 1.0 | - .1 | .4 | - .1 | **- .9** | - .6 | .1 |
| 1906-1912 | 12.2 | - .7 | 3.5 | 9.0 | .8 | 4.5 | 10.0 | 1.5 | 5.2 | 10.9 | .2 | 5.0 | 6.8 | -2.0 | 1.4 | 2.0 | -4.0 | - .6 | 1.2 |

TABLE No. 7.—*Highest, lowest, and mean stages for each month and the mean for each year at Jenny Lind.*

Stages in bold-face type indicate the extremes for each year.
Jenny Lind is on the Calaveras River, 28 miles from its month. Flood stage, 10 feet.

| Year. | September. | | | October. | | | November. | | | December. | | | January. | | | February. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. |
| 1906-7 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 5.4 | 1.8 | 2.7 | 5.0 | 1.8 | 2.7 |
| 1907-8 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 1.1 | 0.3 | 0.7 | 2.9 | .7 | 1.2 | **3.0** | .7 | 1.0 |
| 1908-9 | 0.0 | **0.0** | 0.0 | 0.0 | **0.0** | 0.0 | 0.2 | 0.2 | 0.2 | 1.1 | .2 | .6 | **12.0** | .6 | 2.7 | 6.0 | 1.8 | 2.6 |
| 1909-10 | .0 | **.0** | .0 | .1 | **.0** | .0 | 2.6 | .2 | .6 | 2.7 | .4 | 1.4 | **4.2** | .5 | 1.5 | 1.1 | .7 | .9 |
| 1910-11 | .0 | .0 | .0 | .0 | — .2 | — .1 | .0 | — .2 | — .1 | .4 | .0 | .0 | **14.0** | .0 | 2.7 | 5.0 | 1.1 | 2.0 |
| 1911-12 | — .2 | — .4 | — .3 | — .1 | — .2 | — .1 | .0 | — .1 | .0 | .2 | .0 | .1 | 1.5 | .2 | .3 | .5 | .0 | .1 |
| 1906-1912 | .0 | — .4 | — .1 | .1 | — .2 | .0 | 2.6 | — .2 | .2 | 2.7 | .0 | .6 | 14.0 | .0 | 1.8 | 6.0 | .0 | 1.6 |

| Year. | March. | | | April. | | | May. | | | June. | | | July. | | | August. | | | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | |
| 1906-7 | 13.0 | 2.1 | 4.0 | 2.5 | 1.4 | 1.8 | 1.4 | 0.9 | 1.1 | 1.0 | 0.8 | 0.9 | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| 1907-8 | 2.0 | .8 | 1.0 | .9 | .5 | .7 | .5 | .3 | .4 | .3 | .3 | .3 | 0.0 | **0.0** | 0.0 | 0.0 | **0.0** | 0.0 | ...... |
| 1908-9 | 2.2 | 1.6 | 1.7 | 1.8 | .7 | 1.0 | .7 | .2 | .4 | .2 | .2 | .2 | .1 | **.0** | .0 | .0 | **.0** | .0 | 0.8 |
| 1909-10 | 4.2 | .5 | 1.2 | 1.0 | .5 | .7 | .5 | .2 | .3 | .2 | .1 | .2 | .0 | **.0** | .0 | .0 | **.0** | .0 | .6 |
| 1910-11 | 10.5 | 1.0 | 2.5 | 2.5 | .7 | 1.1 | .7 | .3 | .5 | .3 | .0 | .1 | .0 | — .3 | — .2 | — .3 | **— .4** | — .4 | .7 |
| 1911-12 | **1.8** | .0 | .5 | .8 | .1 | .2 | .3 | .0 | .2 | .2 | — .3 | — .1 | — .3 | **— .8** | — .6 | — .7 | **— .8** | — .7 | .0 |
| 1906-1912 | 13.0 | .0 | 1.8 | 2.5 | .1 | .9 | 1.4 | .0 | .5 | 1.0 | — .3 | .3 | .1 | — .8 | — .2 | .0 | — .8 | — .2 | .5 |

TABLE NO. 8.—*Highest, lowest, and mean stages for each month and the mean for each year at Electra.*

Stages in bold-face type indicate the extremes for each year.
Electra is on the Mokelumne River 70 miles from its mouth and 55 miles above its junction with the Cosumnes River. Elevation, 669.8 feet; flood stage, 12 feet.

| Year. | September. | | | October. | | | November. | | | December. | | | January. | | | February. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. |
| 1906-7 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 4.0 | 1.5 | 1.9 | 4.8 | 2.5 | 2.9 |
| 1907-8 | 0.1 | 0.1 | 0.1 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 1.7 | 0.1 | 0.3 | 1.5 | .4 | .7 | .9 | .6 | .6 |
| 1908-9 | − .2 | − .2 | − .2 | 1.0 | − .2 | − .1 | .4 | − .3 | − .1 | .4 | − .3 | .1 | **8.8** | − .1 | 2.6 | 3.8 | 1.6 | 2.3 |
| 1909-10 | .0 | − .2 | − .2 | .1 | .0 | .0 | **7.0** | .0 | 1.3 | 5.0 | 1.5 | 2.2 | 4.0 | 1.2 | 1.5 | 2.0 | 1.2 | 1.5 |
| 1910-11 | − .1 | − .2 | − .2 | .0 | − .2 | − .2 | .5 | − .1 | .1 | 1.0 | .0 | 0.4 | **9.3** | .0 | 1.9 | 5.0 | 1.5 | 2.2 |
| 1911-12 | .2 | .1 | .1 | .3 | .1 | .2 | .5 | .1 | .2 | .3 | .1 | .1 | .9 | .2 | .4 | .4 | .2 | .3 |
| 1906-1912 | .2 | − .2 | − .1 | 1.0 | − .2 | .0 | 7.0 | − .3 | .3 | 5.0 | − .3 | .6 | 9.3 | − .1 | 1.5 | 4.8 | .2 | 1.6 |

| Year. | March. | | | April. | | | May. | | | June. | | | July. | | | August. | | | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | High. | Low. | Mean. | |
| 1906-7 | **13.0** | 2.2 | 4.0 | 3.6 | 2.6 | 3.1 | 3.8 | 2.4 | 3.1 | 4.6 | 2.4 | 3.4 | 3.8 | 1.6 | 2.6 | 1.5 | **0.1** | 0.7 | ...... |
| 1907-8 | 1.2 | .7 | 1.0 | **2.8** | .9 | 1.9 | 2.4 | 1.2 | 1.8 | 2.4 | .7 | 1.6 | .7 | .5 | .5 | .5 | − .2 | − .1 | 0.7 |
| 1908-9 | 2.6 | 1.8 | 2.4 | 3.5 | 2.2 | 2.5 | 4.0 | 3.2 | 3.6 | 4.6 | 3.0 | 3.9 | 3.0 | .1 | .9 | .1 | − .2 | − .1 | 1.5 |
| 1909-10 | 4.0 | 1.4 | 2.6 | 3.8 | 2.2 | 3.0 | 3.6 | 2.8 | 3.2 | 3.1 | .9 | 1.7 | .9 | .0 | .3 | − .1 | − .2 | − .1 | 1.4 |
| 1910-11 | 4.5 | 1.4 | 2.7 | 4.6 | 2.4 | 3.2 | 4.5 | 2.5 | 3.3 | 5.1 | 3.0 | 4.3 | 3.2 | .7 | 2.1 | .6 | .1 | .2 | 1.7 |
| 1911-12 | 1.3 | .2 | .6 | 1.6 | .6 | .9 | 3.7 | 1.5 | 2.5 | **3.8** | .8 | 2.1 | .7 | **.0** | .2 | .0 | **.0** | .0 | .6 |
| 1906-1912 | 13.0 | .2 | 2.2 | 4.6 | .6 | 2.4 | 4.5 | 1.2 | 2.9 | 5.1 | .7 | 2.8 | 3.8 | .0 | 1.1 | 1.5 | − .2 | .1 | 1.2 |

Friant is about 203 miles above the mouth of the river with a drainage area above the station of 1,730 square miles.

Firebaugh is 43 miles below Friant with a drainage area above the station of 11,382 square miles. San Joaquin is 111 miles below Firebaugh and 49 miles above the mouth of the river. The drainage area above the station is 20,887 square miles.

The average fall per mile between Friant and San Joaquin Bridge is about 2 feet; from San Joaquin Bridge to the mouth of the river the fall is only a fraction of a foot per mile.

## Tributaries of Tulare and Buena Vista Lakes.

There are several streams that enter the San Joaquin Valley from the Sierras south of the upper end of the San Joaquin River that are lost in Tulare and Buena Vista Lakes and the adjacent "Tules." They are the Kern, Kaweah, Tule, and Kings Rivers.

The Kern has its source at elevations ranging between 11,000 and 13,000 feet, with a drainage basin quoted as 2,500 square miles. It flows southwestward from the mountains and empties into Buena Vista Lake. During exceptionally high stages in this lake it has been known to escape thence through various sloughs northward into Tulare Lake. While the Kern has a heavy discharge when in flood, and has been known to cause disastrous inundations, much of its normal flow is now diverted in the vicinity of Bakersfield for irrigation purposes.

The mean annual precipitation in the Kern River Basin varies from less than 5 inches in the valley to as much as 50 or 60 inches in the higher regions. Above the 5,000-foot level it is mostly all in the form of snow.

Tule River Basin, north of that of the Kern, starts in the high mountain ranges of the Sierra Nevada at an elevation quoted as 9,000 feet and flows westward toward Tulare Lake, which it sometimes reaches, but the most of its normal flow is now diverted for irrigation purposes in the vicinity of Porterville. Its watershed is small, the total drainage being quoted as 350 square miles.

The Kaweah River flows southwestward from the Great Western Divide and at high stages reaches Tulare Lake. Its greatest elevation is about 12,000 feet, and its drainage basin is about twice that of the Tule. Below the foothills the most of its flow is used for irrigation. Both the Tule and Kaweah are subject to overflow and occasionally some damage is caused from floods in the vicinity of Porterville on the Tule and Visalia on the Kaweah. The mean annual precipitation in the Kaweah and Tule Basins varies from 8 or 10 inches in the valley to 30 or 40 inches in the higher regions. Heavy snow falls in the most elevated regions of both watersheds.

The Weather Bureau has recently established several stations on the Kaweah River, the most important being at Carter's ranch, near Three Rivers.

Kings River drains the western slopes of the Sierras between the Kaweah drainage and that of the upper end of the San Joaquin. It rises at an elevation of nearly 14,000 feet and flows southwestward to a point just north of Tulare Lake, where it separates, one part flowing southward into the lake and the other northward through Kings River Slough into the San Joaquin. This stream, however, has rarely augmented, to any great extent, floods in the upper San Joaquin for the reason that at high stages its greatest discharge follows its southern course to the lake. Its main stream is tapped just below the foothills and a large part of its normal flow is diverted for irrigation purposes. The mean annual precipitation in the Kings River Basin ranges from as much as 60 inches or more in the higher regions to as little as 8 inches in its lower reaches.

All streams lying south of the upper end of the San Joaquin River which have been ponded back by Tulare and Buena Vista Lakes will, no doubt, be used more and more for irrigation purposes as the cultivated area increases, which will ultimately result in the reclaiming of the entire Tulare Lake Basin.

Owing to the fluctuations of the water level of the Tulare Lake considerable interest has, during the past few years, been centered around this section. Although millions of dollars have been lost in farming ventures by the inundation of lands in the vicinity of the lake thought to have become permanently arable, farmers still look forward to the time when the entire basin, or the "Valley of the Tules," as it is sometimes called, will be added to the agricultural assets of the State.

No better description of Tulare Lake itself, and the conditions that have prevailed in that section during the past 10 or 15 years, can be found than that published by the United States Geological Survey in Water-Supply Paper No. 251, which is as follows:

Tulare Lake is a shallow body of water occupying the lowest depression in the Tulare Basin. The lake is rectangular in shape and its greatest length is from northwest to southeast. In November, 1907, when the margin was carefully determined, the lake had an area of 274 square miles, a maximum depth of 12.4 feet, and average length of 20 miles, and a width of 13.5 miles; the water's edge was 3 miles from the town of Corcoran, and the water surface about 12 feet below. The lake reached its greatest height in the summer of 1907, when it had a maximum depth of nearly 14 feet.

For the 25 years preceeding 1898 the lake level was steadily lowered, with only seasonal fluctuations. This lowering was brought about by the development of irrigation in the Tulare Basin, the water used for this purpose being diverted from the streams supplying the lake; but undoubtedly the chief factor in producing the subsidence was light precipitation. During this entire period the precipitation was generally below the normal, particularly during the several years immediately preceding 1898, and in that year the lake became practically dry, and after having partially refilled in 1901, it became completely dry in 1905. As the water receded a constantly increasing area of exceedingly fertile land was uncovered. From time to time this land was leveed on the lake side and cultivated, until, in the early spring of 1906, the entire bed was under cultivation.

On March 15, 1906, the first water reached the lake bed at the mouth of Kings River and began spreading over a large area of bottom land, upon which stood a crop of wheat almost matured. A few days later water from the Kaweah and Tule Rivers reached the lake. Then began a steady rise which rapidly submerged an increasingly large area of wheat fields. On June 1, the water was 7 feet deep, and covered 200 square miles. On June 23, overflow from the Kern Basin cut through the sand ridge from the south and flowed into the lake, which, for a few days afterwards rose at the rate of 0.2 foot per day. On August 4 the water reached its greatest height for the year 1906, and the lake had an area of about 300 square miles and a maximum depth of 12.7 feet. The total rise of the lake in 1906 was 10.8 feet. From this date the lake slowly subsided until December, after which a rise began which continued until July, 1907, when the lake attained a maximum depth of 14 feet. Since that date it has been gradually subsiding.

The lake bed resembles a large flat saucer, the flat, level area in the bottom has an elevation approximately 180 feet above mean sea level and covers about 55 square miles. The lowest point on the crest of the delta ridge to the north is about 27 feet higher than the bottom of the lake. Natural overflow will not occur, therefore, until the lake has a maximum depth of nearly 30 feet and an area of nearly 1,000 square miles.

The lake receives practically all of its water from Kings, Kaweah, and Tule Rivers. The Kings River furnishes the largest quantity. During flood periods about half of the total flow below all diversions enters the lake. Under normal conditions all the water of the Tule River and nearly all of that of the Kaweah River is diverted for irrigation, and only a small quantity of water from these streams reaches the lake. The water from Kern River is stored in Kern Basin, except in years of great run-off. It is said that previous to 1906 no water had reached the lake from Kern River for 25 years. It thus appears that in years of great run-off, like 1906–7, there will always be a flow into the lake. Owing to variations in the overflow, therefore, and in evaporation, which amounts to about 4.5 feet a year, it is probable that the lake will continue to fluctuate very much as in the past, though possibly never reaching very high stages.

## Tributaries of the San Joaquin River.

All of the tributaries of the San Joaquin River rise in the high regions of the Southern Sierra and flow westward. Those which materially affect the flood situation in the floor of the valley take a course nearly parallel with the upper end of the trunk stream and join it at right angles at points below its elbow north of Mendota. Named in their order from south to north, they are the Merced, Tuolumne, Stanislaus, Calaveras, and Mokelumne Rivers. The Fresno and Cowchilla Rivers, while tributary to the San Joaquin, are of no importance so far as the flood situation of the San Joaquin Valley is concerned. The Fresno, however, has a fairly extensive watershed and, under the influence of heavy local rains, has been known to overflow a considerable area directly contiguous to its course; but its rise is practically coincident with the cause, making flood forecasts impracticable.

The Merced River drains an extensive section directly north of the upper end of the San Joaquin and joins the lower section of that stream at a point a few miles east of Newman. The drainage basin of the Merced above the valley is quoted at 1,200 square miles. The most elevated region of its watershed is about 13,000 feet. The Yosemite Valley is wholly within the drainage basin of the Merced River.

A regular river and rainfall station is maintained on the Merced at Merced Falls, 35 miles from the mouth of the river. The drainage basin above the station is about 1,000 square miles. The mean annual precipitation in this basin ranges from 10 to 15 inches in the valley to 20 or 25 inches in the foothills. In the higher regions it amounts to 60 inches or more, much of which is snow, which melts during the latter part of May or the first decade of June, often resulting in freshets in the lower reaches of the river. While the greatest flow of the Merced is in May or June, sometimes in July, should warm weather be delayed, this only takes place in years of normal or heavy snowfall in the mountains. Heavy, warm rains occasionally occur during the winter months, and in March, in which case floods result in some of the sections contiguous to the mouth of the river.

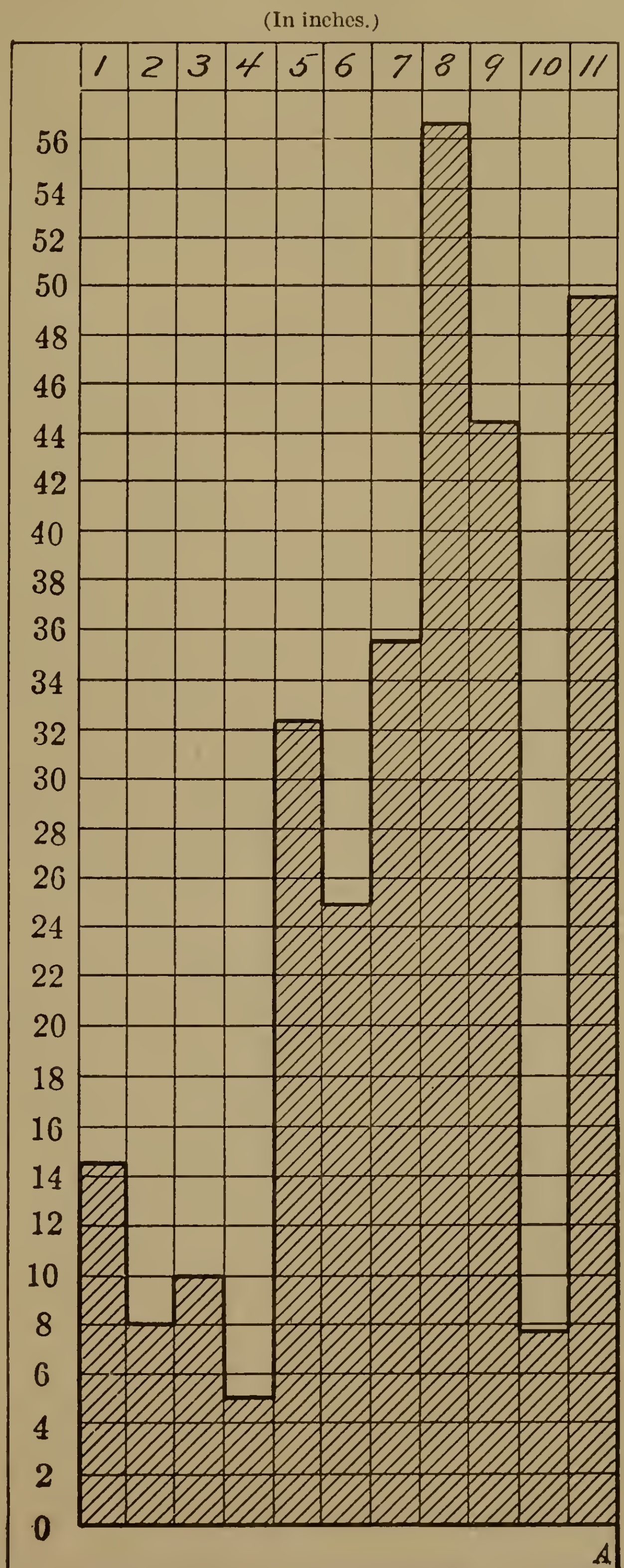



Fig. 15. Normal annual precipitation at 11 stations in the San Joaquin watershed. See page 56.

The Tuolumne River flows southwestward from the high mountains nearly parallel with the Merced whose watershed bounds it on the south. It drains about 1,500 square miles above Woods Creek, one of its most important tributaries. The highest point drained is about 13,000 feet on the North Slope of Mount Lyell. The mean annual precipitation in this watershed varies from about 10 inches in the valley to as much as 60 inches in the higher regions. It decreases rapidly as the floor of the valley is approached. Above the 5,000-foot level it is mostly all in the form of snow, which melts rapidly in the late spring and early summer and contributes to the usual June freshets in the lower San Joaquin Valley. Heavy rains are not uncommon during the winter months, or in March, in which case the river, which has a heavy fall, quickly responds and its flood wave hurries to the San Joaquin, which it joins a short distance west of the town of Modesto.

The stations and altitudes (see fig. 15) are as follows:

| | Elevation (feet). | | Elevation (feet). |
|---|---|---|---|
| 1. Stockton | 23 | 7. Sonora | 1,825 |
| 2. Los Banos | 121 | 8. Summerdale | 2,270 |
| 3. Fresno | 293 | 9. West Point | 2,326 |
| 4. Bakersfield | 394 | 10. Kernville | 2,600 |
| 5. Mokelumne Hill | 1,550 | 11. Crockers | 4,947 |
| 6. Milo | 1,600 | | |

The United States Weather Bureau maintains a regular river and rainfall station at Jacksonville, just below the mouth of Woods Creek, which enables it to make accurate flood forecasts for Modesto and the regions adjacent to the mouth of the river, where a large area is protected by levees. The average fall of the Tuolumne from Hetchy-Hetchy to La Grange, 18 miles below Jacksonville, is 51 feet per mile. Jacksonville is 64 miles from the mouth of the river, and it has been estimated that a flood wave of 25 feet at this station will reach the San Joaquin in 11 to 13 hours, thus giving ample time for an intelligent river forecast for all sections subject to overflow. The greatest and most rapid rise on record for the Tuolumne occurred at Jacksonville between the 29th and 30th of January, 1911, when the river rose from 4.6 to 26 feet in 24 hours. The last-named stage was augmented by another foot rise by 7 a. m., January 31, when the river attained a stage of 27 feet, the highest on record.

The Stanislaus River drains a narrow basin between the Tuolumne and Mokelumne watersheds. The greatest altitude drained is quoted as 11,000 feet. The mean annual precipitation in the watershed of the Stanislaus ranges from 12 to 15 inches in the valley to as much as 50 inches or more in the mountains, where it is mostly as snow. This stream usually carries an increased volume of water during the late spring and early summer, as a result of melting snow, but heavy rains in the foothill sections are not uncommon during the winter months causing floods in its lower reaches. The Stanislaus empties into the San Joaquin about 5 miles below the town of Tuolumne. The Weather Bureau maintains a river and rainfall station on this stream at Melones, 64 miles from the mouth of the river. The drainage basin above the station is about 562 square miles. Owing to the great fall of this stream from its source to its mouth, which is quoted as 70 feet to the mile, high stages in its upper parts usually reach the San Joaquin in about 10 hours, and its flood waves pass down the main stream several hours in advance of those of the Tuolumne and Merced.

The Calaveras River drainage is between that of the Stanislaus and the Mokelumne basins. This stream has the most restricted watershed of any in the San Joaquin Valley north of Kings River, and probably the smallest annual runoff per square mile of any river tributary to the Great Valley, except the Tule, north of Tulare Lake. The highest point drained is between 4,000 and 5,000 feet. The river flows southwestward from the foothills to the little town of Bellota, where it is deflected into a narrow channel known as "Mormon Slough," which empties into Stockton Channel.

The mean annual precipitation in the Calaveras watershed varies from about 16 inches in the vicinity of Stockton to 35 or 40 inches in the higher regions. Some snow falls on the summit of its basin but not in sufficient quantities to materially affect its flow. In fact, this stream is rarely kept alive much later than the 1st of July, after which it is usually dry until the first rains of winter. During the winter months heavy rains sometimes occur and occasionally result in damaging floods in the regions contiguous to Stockton, Bellota, and Linden. Stockton itself, or the greater part thereof, has been rendered practically immune from the ordinary floods of the Calaveras by the construction of a canal which diverts the flood waters of Mormon Slough into the lower Calaveras River, proper, a short distance below Stockton, whence they are carried to the San Joaquin. The flooding of Stockton and the adjacent section in 1909, before the completion of the diverting canal, and the great flood of 1911, when thousands of acres east of Stockton were under water, resulted exclusively from the overflow of the Calaveras. (See fig. 15, "Annual precipitation in San Joaquin Watershed.")

Two river and rainfall stations are in operation on the Calaveras, one at Bellota on Mormon Slough, 17 miles east of Stockton, and one at Jenny Lind, 13 miles above the point where the river flows into the Slough; and a rainfall station is maintained at San Andreas, 26 miles above Jenny Lind. Although the average fall of the Calaveras is nearly 15 feet per mile, and the fall between Bellota and Stockton is about 5 feet per mile, the advance of flood waves has heretofore been greatly retarded by spreading in the vicinity of

Bellota and Linden. With prompt service from river and rainfall stations it is possible to make timely forecasts for the greater part of the area subject to overflow. In fact the Bureau has not yet failed to do this at any time since the establishment of the river service.

Heavy rains in the San Joaquin Valley are usually coextensive with the watersheds of the Upper San Joaquin, Merced, Tuolumne, Stanislaus, and Calaveras Rivers, and result in the passage of four well-defined flood waves down the San Joaquin River, south of Lathrop. The crest of that of the Upper San Joaquin, and the discharge of the North branch of Kings River, usually reach the flat country in the vicinity of Mendota and Firebaugh about the time that those of the Merced, Tuolumne, and Stanislaus reach the lower San Joaquin. Should heavy rains continue, even for a few hours after the above-named streams have attained flood stages, the capacity of the trunk stream becomes overtaxed, and all points subject to overflow between the mouth of the Tuolumne and that of the Calaveras are liable to inundation.

The Mokelumne River flows southwestward from the Sierras and empties into the San Joaquin at a point about 25 miles northwest of Stockton. The greatest elevation drained by this stream is about 10,000 feet. In addition to numerous lakes and small creeks that feed the Mokelumne it has an important tributary in the Cosumnes, which joins it near Thornton, about 6 miles from Walnut Grove on the Sacramento. At flood stage the Cosumnes has a greater discharge than the Mokelumne itself above the point where the two rivers meet. The Cosumnes has the greatest fall of any river in the Great Valley, and is quoted as something over 80 feet per mile. The mean annual precipitation in the Mokelumne-Cosumnes watershed varies from something less than 20 inches in the valley to as much as 60 inches in the high mountain ranges in Alpine and El Dorado Counties.

The Weather Bureau maintains two river and rainfall stations on the Mokelumne; one at Electra, 70 miles from its mouth and 55 miles from its junction with the Cosumnes, and one at Bensons Ferry, a short distance below the point where the two rivers meet. The drainage area above Electra is 537 square miles; that above Bensons Ferry is about 1,200 square miles.

Floods rarely, if ever, occur in the Mokelumne as a direct result of melting snow, but heavy, warm rains during the winter months are liable to cause floods over an extensive area of low country below the mouth of the Cosumnes. During all previous floods of which there is an authentic record, and especially those of 1904, 1907, and 1909, a large area of country in the neighborhoods of Bensons Ferry and Lodi has been flooded. During the 1904 flood many of the levees of the lower Mokelumne were swept away by the waters of the Sacramento, which escaped through what is known as the "Edwards break" and swept southward along the lowlands lying east of and parallel with the Sacramento River. The Edwards break occurred on the 27th of February, 1904, and three or four days later between 40,000 and 50,000 acres were under water between the Sacramento and the Mokelumne Rivers, with an estimated loss of over $1,000,000 in Sacramento and San Joaquin Counties. The loss, however, was greater in the last named county along the South Fork of the Mokelumne.

In the 1907 flood the Mokelumne overflowed its banks above Lodi and Woodbridge, inundating many thousands of acres of land. In 1907 the floods of the Mokelumne were greatly augmented by the waters of the flooded Sacramento, which escaped eastward through a break in the levees near Courtland. It was the added water of the Sacramento River which resulted in the flooding of the Pierson District in 1909.

During the 1909 floods, while the Mokelumne was high, there was only one small break in its levees, which resulted in the inundation of perhaps a thousand acres.

The highest water on record, however, in the Mokelumne occurred in 1911, but all levees which had been strengthened held and there was little damage.

For much of the information regarding the Mokelumne floods the writer is indebted to Mr. Edward H. Barber, of Thornton, Cal.

## Floods in the Sacramento River.

River readings were made at various points in the Sacramento River during the early days, but, until the river service was established by the Weather Bureau, the readings were in most cases indifferently made, and even the best of records were made without regard to any particular datum. The height of flood waters in former days have, however, at some points on the river, been fairly well established by landmarks, which furnish a basis of comparison with stages that have been recorded since the establishment of the service by the Government. Of course, conditions in the old days were vastly different from those that prevail at the present time. Before the settlement of the valley the river during high water roamed at will after it had emerged from its rocky canyons. Protected from the lowlands on either side only by its low banks, which sloped back into the floor of the valley, the river spread over large areas at stages that in these days would be called only moderate. It is believed that many of the "floods" that are associated with the early history of the Sacramento Valley would now pass unnoticed to the bay between levees.

There is, however, ample proof of the fact that there have been some high stages in the Sacramento River in the old days that would probably have been difficult to control even with the levee systems that now protect many of the agricultural districts and some of the smaller towns of the valley.

Regarding the various floods of the Sacramento and American Rivers in the city of Sacramento and its vicinity, history begins with that of 1850–51. Tradition, however, recounts an inundation in 1805, when it is said the entire Sacramento Valley was covered with water, except Marysville Buttes. This tradition was handed down by the Indians and at the time of the first white settlers in this section stories of the "great waters" were still extant.

The History of Sacramento County, by Thompson and West, published in 1880, contains some interesting accounts of the floods in the vicinity of Sacramento from 1850 to 1878. According to this history the flood of 1850 is the first of which there is an authentic record, and it refers to this flood as follows:

> From January 9 to 17, 1850, the entire city of Sacramento was flooded.

In this connection it tells of heavy damage and some loss of life. Of course, the city at that time occupied only a small area, and while the damage was, no doubt, relatively heavy, the probability is that there was little to lose. That this flood was of some intensity is proven by the amount of rain that fell during December, 1849, and January, 1850. It was the flood of 1850 that first suggested the necessity of building levees around the city, and the introduction of this method of protection dates from that year.

The following is taken from the history of Sacramento County:

> On March 7, 1852, another flood occurred at Sacramento, which leveled the most of the levees that had been built for the protection of the city.

During this flood, which must have come from the American River, historians of this section record the destruction of many bridges on this stream, especially those which spanned the South and Middle Forks.

On January 1, 1853, the city of Sacramento was again flooded, the water, according to history, rising to 22 feet above low-water mark. Little damage resulted from this flood, which seems to have subsided quickly, offering evidence of the fact that it came in from the American River.

From 1854 to 1860, inclusive, there are no records of floods in any part of the Sacramento watershed, and the record of precipitation during this period shows no heavy rainfall.

The history previously referred to states that on March 28, 1861, another flood of brief duration occurred on the American River, during which the river was 20 feet above low-water mark. On

December 9, 1861, the American is reported to have risen to 22.7 feet above the low-water mark, resulting in considerable loss.

The greatest and most disastrous flood of which there is any remembrance, and one that seems to have been general throughout the Great Valley, north of Kings River, occurred between January 9 and 12, 1862. The highest water at Sacramento during this flood has been quoted as 24 feet above low water. It has been stated that the American rose 60 feet above low-water mark, but the point


FIG. 44.—High water near Folsom in 1862.

where the measurement was made is not stated. The probability is that the American has been greatly overestimated and the Sacramento has been quoted too low.

According to measurements made in October, 1912, from the attested high-water mark of the 1862 flood made on an old stone stable, near where the Stockton and Coover mill stood on the left bank of the American River a mile and a half above Folsom, the American River at Folsom during that flood would have registered 38.3 feet on the present gage, or 11.5 feet above the 1907 flood.

Judging from all accounts of the 1862 flood it must have been the combined output of the American, Feather, and Yuba Rivers.

The rainfall of December, 1861, and January, 1862, in the vicinity of Sacramento aggregated 23.68 inches, 15.04 inches of which fell in the last-named month. As a result of this unusually heavy rainfall, which was undoubtedly coextensive with the entire Sacramento as well as the San Joaquin watershed, the American River from Folsom to Sacramento City was kept at flood stage until the approach of the Feather-Yuba and upper Sacramento discharge, a condition that had probably never before occurred in this section during its occupation by white settlers. All settlements in both valleys suffered greatly during the great flood of 1862, especially the city of Sacramento, the levee system of which was entirely leveled.

There were three floods in the upper reaches of the Sacramento during the winter of 1861–62. According to Capt. Lee, of Tehama, Cal., who has been connected with the river in various capacities for the past 60 years, and who is still enjoying life at the age of 86 years, the first flood occurred on December 9, 1861, when the river was higher than it had been for many years at all points between Tehama and Red Bluff. According to Capt. Lee, the water was over a foot deep in the streets of Tehama and many thousands of dollars worth of stock was drowned in the vicinity of that town. The second flood occurred on the 29th of December, 1861, following several days of unusually heavy rainfall. Cottonwood Creek was higher than was ever before known; Ludwigs Bridge, that spanned this stream, was carried away. This flood overtopped the banks in the vicinity of Red Bluff and completely inundated Tehama and other settlements along the Sacramento River. The third flood occurred on January 23, 1862, the water reaching the 29-foot mark on the Red Bluff river gage and flooding the warehouse on the east side of the river.

The historians of the Sacramento Valley agree that there were no floods of any importance from January, 1862, to February, 1878, notwithstanding the fact that some heavy rains fell during this interval, notably, November and December, 1864, January, 1866; December, 1867; January, 1868; December, 1871; and January, 1875.

From February 1 to 20, 1878, there were several floods in the Sacramento and American Rivers in the vicinity of Sacramento. On the first-named date the river rose higher than was ever before recorded, 26 feet above low-water mark. Some damage resulted from this flood, caused by the breaking of the levees near Lovdal's ranch, between the city of Sacramento and Sutterville.

The city of Sacramento has remained secure since 1878, notwithstanding the fact that the high stages previously recorded have been exceeded a number of times, notably, as follows: February 4, 1881, 26.6 feet; December 12, 1889, 27 feet; March 4, 1891, 27.6 feet; May 30, 1892, 27.2 feet; December 27, 1892, 28.6 feet; March 22, 1893, 26.5 feet; January 29, 1896, 26.6 feet; February 25, 1901, 28.2 feet; March 1, 1902, 28.2 feet; March 4, 1903, 27.6 feet; February 27, 1904, 26.1 feet; February 7, 1907, 27.2 feet; and January 17, 1909, 29.6 feet, the highest ever recorded.

While, as has been stated, the city of Sacramento itself has not been flooded in recent years, all of the high stages quoted above have resulted more or less seriously at many points up the river, especially in cases where vulnerable levees offered inadequate protection to lands in process of reclamation. For instance, the flood of 1881, is still remembered in the vicinity of Red Bluff and Tehama, where a large area of country was under water, causing heavy damage—loss of stock, destruction of bridges, etc. This flood was the result of heavy rainfall that was, for the most part, confined to the northern end of the valley, over 7 inches of rain having been recorded at Red Bluff during the three days ending January 30, 1881, and torrential rains, according to authentic reports, at points contiguous to the junction of the Sacramento and Pit Rivers.

The two most notable floods of the Sacramento and San Joaquin Valleys, from a pecuniary standpoint, were those of March, 1907, and January, 1909. It is thought that these floods were equally as widespread as was that of 1862, and the losses were, no doubt, far in excess.

In 1907 the land thought to be protected and that under process of reclamation aggregated a greater acreage than at any previous time in the history of the Great Valley. The same may be said of the flood of 1909, as the flood of this year occurred about the time when new levees had replaced those leveled two years previous, and many new reclamation districts besides. During both of these floods many levees were either badly damaged or totally destroyed, large areas rendered useless for immediate cultivation, bridges, both railroad and county, swept away, and many miles of county roads and railroad tracks rendered impassable.

The floods of 1907 and 1909 in the Sacramento and San Joaquin Valleys, and those of 1911 in the Lower San Joaquin Valley are the only inundations of which there is a complete record at all strategic points on the two trunk streams and their main tributaries.

## THE FLOODS OF 1907.

The great floods that prevailed in the rivers of the Sacramento and San Joaquin Valleys during March, 1907, were, of course, the direct results of heavy, warm rains and melting snows that immediately preceded them.

*Table of daily precipitation at selected stations in the Sacramento and San Joaquin watersheds during March, 1907.*

[In this connection see hydrographs, figs. 23 to 27, inclusive, for this period.]

| Date. | Alturas. | Sisson. | Ken-nett. | Duns-muir. | Delta. | Shasta. | Red-ding. | Red Bluff. | Nim-shew. | Quincy. |
|---|---|---|---|---|---|---|---|---|---|---|
| Elevation, feet | 4,460 | 3,555 | 616 | 2,285 | 1,138 | 1,049 | 552 | 307 | 2,500 | 3,400 |
| Mar. 8 | 0.28 | 0.00 | 0.00 | 0.20 | 0.05 | 0.13 | 0.01 | 0.04 | 0.00 | 0.00 |
| Mar. 9 | .05 | .45 | .50 | .66 | 1.10 | .33 | .67 | .69 | 1.49 | .60 |
| Mar. 10 | .05 | .66 | .0 | .30 | 1.90 | 1.14 | .49 | .21 | .33 | .40 |
| Mar. 11 | .25 | .00 | .00 | 2.53 | .90 | .16 | .18 | .06 | 1.45 | .60 |
| Mar. 12 | .00 | .00 | .00 | .00 | .10 | .00 | .00 | .00 | .00 | .20 |
| Mar. 13 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 |
| Mar. 14 | .00 | .00 | .56 | .00 | .00 | .00 | .00 | .00 | .00 | .00 |
| Mar. 15 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .69 | .00 | .00 |
| Mar. 16 | .08 | .00 | .00 | .00 | .00 | .38 | .38 | .65 | 1.40 | .70 |
| Mar. 17 | .55 | .00 | .00 | 2.00 | 1.10 | 1.54 | 1.36 | .62 | 5.54 | 5.30 |
| Mar. 18 | .75 | 3.55 | .00 | 2.87 | 3.50 | 2.25 | .88 | .28 | 4.00 | 6.50 |
| Mar. 19 | .14 | 1.27 | .54 | 2.72 | 3.50 | 1.03 | .11 | .00 | 3.02 | 4.40 |
| Mar. 20 | .15 | 2.25 | 2.44 | 2.00 | 3.10 | .17 | .07 | .01 | 1.17 | 1.75 |
| Mar. 21 | .01 | .60 | 2.00 | .72 | .80 | .51 | .23 | .75 | .43 | .50 |
| Mar. 22 | .05 | .60 | 1.56 | .60 | 1.00 | 2.17 | .19 | .23 | .75 | .60 |
| Mar. 23 | .60 | 2.00 | .82 | .80 | 2.50 | 1.93 | 1.12 | .05 | 2.00 | 3.60 |
| Mar. 24 | .05 | .20 | .82 | .40 | 2.00 | .62 | .11 | .06 | .38 | 1.30 |
| Mar. 25 | .15 | .40 | .08 | 1.20 | .10 | .51 | .09 | .89 | .62 | 1.40 |
| Sum | 3.16 | 12.0 | 9.32 | 18.8 | 21.6 | 12.9 | 5.89 | 5.23 | 22.6 | 27.8 |

| Date. | Chico. | Fruto. | Colusa. | Oro-ville. | Wil-lows. | Nevada City. | Au-burn. | Fol-som. | Sacra-mento. | George-town. |
|---|---|---|---|---|---|---|---|---|---|---|
| Elevation, feet | 189 | 624 | 60 | 147 | 136 | 2,580 | 1,360 | 111 | 71 | 2,650 |
| Mar. 8 | 0.00 | 0.00 | 0.36 | 0.00 | 0.00 | 0.08 | 0.46 | 0.00 | 0.12 | 0.00 |
| Mar. 9 | .93 | .23 | .50 | .30 | .42 | 1.45 | .00 | .24 | .40 | .50 |
| Mar. 10 | .18 | .36 | .10 | .86 | .18 | .51 | 2.35 | .98 | .15 | 2.31 |
| Mar. 11 | .25 | .00 | .00 | .43 | .06 | .96 | .32 | .52 | .06 | .65 |
| Mar. 12 | .02 | .00 | .00 | .22 | .00 | .15 | .00 | .20 | .00 | .75 |
| Mar. 13 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .40 |
| Mar. 14 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | 1.20 |
| Mar. 15 | .00 | .00 | .26 | .33 | .00 | .00 | .00 | .00 | .04 | .40 |
| Mar. 16 | .81 | .22 | .78 | 2.35 | .51 | .91 | .16 | .26 | 1.15 | .30 |
| Mar. 17 | 1.58 | .45 | .14 | 1.10 | .70 | 2.47 | 2.08 | 1.42 | .42 | 3.58 |
| Mar. 18 | .73 | .40 | .46 | 1.44 | .13 | 3.34 | .39 | .10 | 1.74 | 1.08 |
| Mar. 19 | .36 | .30 | .12 | .52 | .05 | 3.63 | 3.11 | 2.08 | .56 | 4.90 |
| Mar. 20 | .35 | .25 | .00 | .08 | .01 | 1.50 | .88 | .60 | .06 | 1.48 |
| Mar. 21 | .22 | .00 | .22 | .30 | .15 | .41 | .36 | .26 | .15 | .76 |
| Mar. 22 | .18 | .00 | 1.02 | 1.32 | .01 | .58 | .44 | .26 | .05 | .91 |
| Mar. 23 | 1.31 | 1.20 | .20 | .48 | .78 | 3.43 | .83 | .68 | 1.46 | 1.78 |
| Mar. 24 | .06 | .00 | .08 | .22 | .15 | .98 | .00 | 1.28 | .25 | 2.55 |
| Mar. 25 | .00 | .30 | .00 | .11 | .00 | .90 | 2.94 | .62 | .01 | 1.85 |
| Sum | 6.98 | 3.71 | 4.24 | 10.1 | 3.15 | 21.3 | 14.3 | 9.50 | 6.62 | 25.4 |

*Daily precipitation at selected stations in the San Joaquin watershed from Mar. 4 to Mar. 23, 1907.*

| Date. | Sanger. | Fire-baugh. | Merced Falls. | Friant. | Yosem-ite. | Jack-son-ville. | Me-lones. | La-throp. | Elec-tra. | Jenny Lind. |
|---|---|---|---|---|---|---|---|---|---|---|
| Elevation, feet | 371 | 154 | 321 | 355 | 3,945 | 602 | 750 | 19 | 670 | ....... |
| Mar. 4 | 0.35 | 0.43 | 0.41 | 0.34 | 0.61 | 0.50 | 1.30 | 0.00 | 0.44 | 0.00 |
| Mar. 5 | .32 | .14 | .20 | .44 | 1.88 | .41 | .24 | .44 | .42 | .62 |
| Mar. 6 | .28 | .05 | .30 | .38 | .25 | .30 | .14 | .00 | .18 | .26 |
| Mar. 7 | .00 | .00 | .00 | .00 | .05 | .26 | .26 | .00 | .04 | .22 |
| Mar. 8 | .04 | .00 | .00 | .00 | .10 | .28 | .00 | .00 | .00 | .00 |
| Mar. 9 | .00 | .00 | .00 | .00 | .01 | 1.46 | .00 | .00 | .00 | .00 |
| Mar. 10 | .00 | .00 | .33 | .38 | 2.15 | 1.52 | 1.98 | .60 | 2.20 | .10 |
| Mar. 11 | .56 | .68 | .60 | .74 | .92 | .28 | 1.92 | .06 | .86 | 1.60 |
| Mar. 12 | .19 | .10 | .10 | .12 | .38 | .00 | .64 | .10 | .86 | .48 |
| Mar. 13 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .16 | .50 |
| Mar. 14 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 |
| Mar. 15 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 |
| Mar. 16 | .00 | .00 | .00 | .00 | 1.40 | .00 | .00 | .00 | .00 | .19 |
| Mar. 17 | .29 | .08 | .20 | .40 | 2.61 | 1.30 | 1.88 | .84 | 1.66 | .70 |
| Mar. 18 | .00 | .00 | .00 | .00 | 2.02 | .01 | .06 | .00 | .26 | .08 |
| Mar. 19 | .10 | .03 | 1.10 | .28 | 1.85 | 2.48 | 2.06 | .80 | 4.56 | 2.00 |
| Mar. 20 | .19 | .00 | .00 | .02 | 1.15 | .08 | .00 | .00 | .44 | .10 |
| Mar. 21 | .16 | .41 | .47 | .00 | .65 | .90 | 1.04 | .00 | 1.00 | .40 |
| Mar. 22 | .16 | .12 | .32 | .36 | .85 | .62 | 1.84 | .48 | .64 | .35 |
| Mar. 23 | .38 | .00 | 1.13 | .06 | .60 | .00 | .00 | .00 | .24 | .46 |
| Sum | 3.02 | 2.04 | 5.16 | 3.52 | 17.5 | 10.4 | 13.4 | 3.32 | 14.0 | 8.60 |

*Hydrographs, Sacramento River system, March, 1907.*

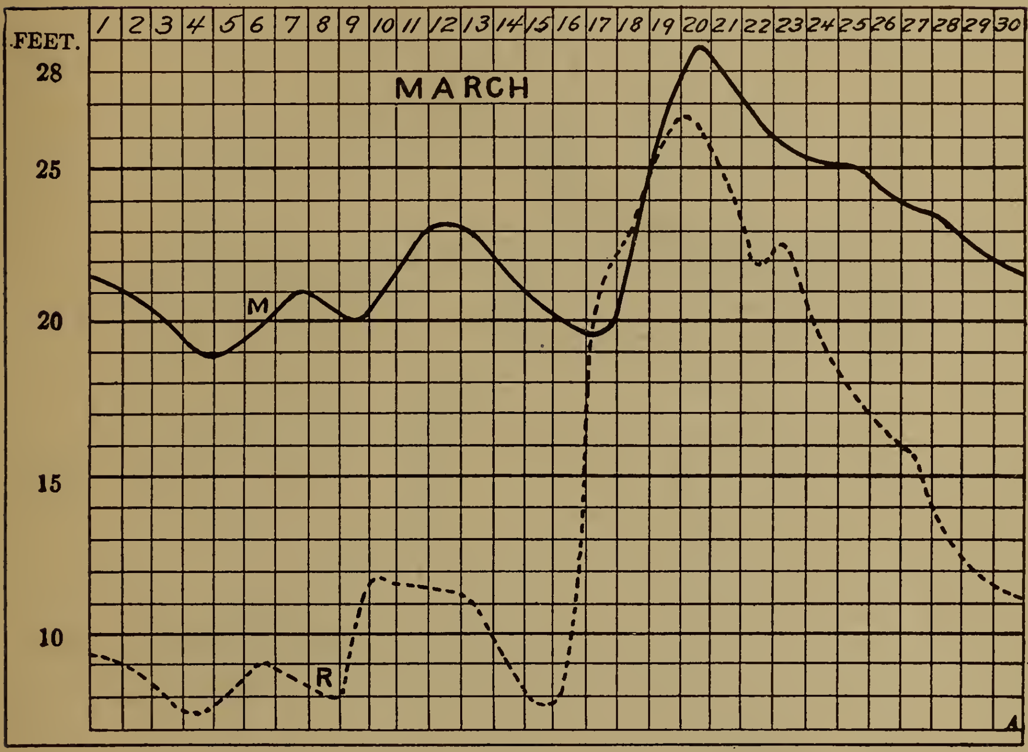



FIG. 23.—Hydrographs, March, 1907. M, Colusa; R, Red Bluff.

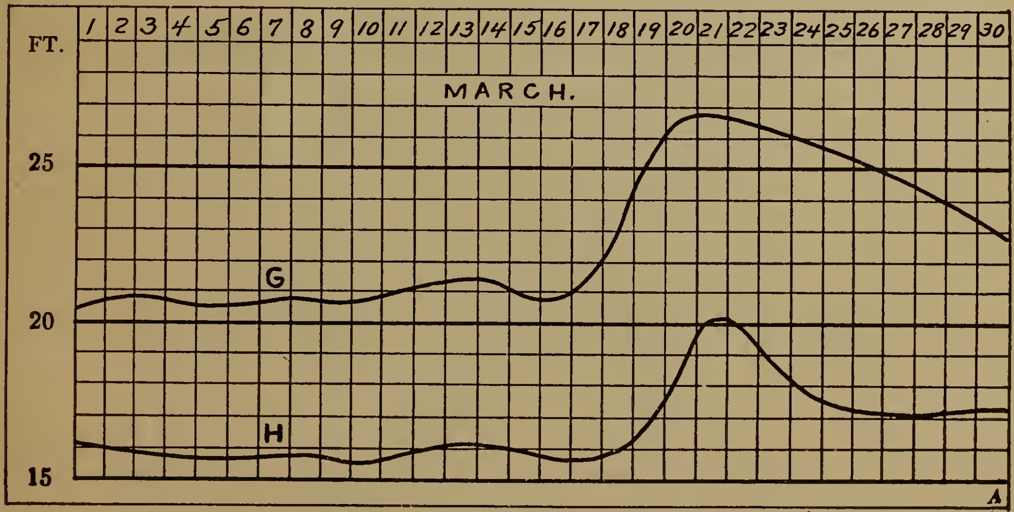



FIG. 24.—Hydrographs. G, Sacramento; H, Knights Landing.

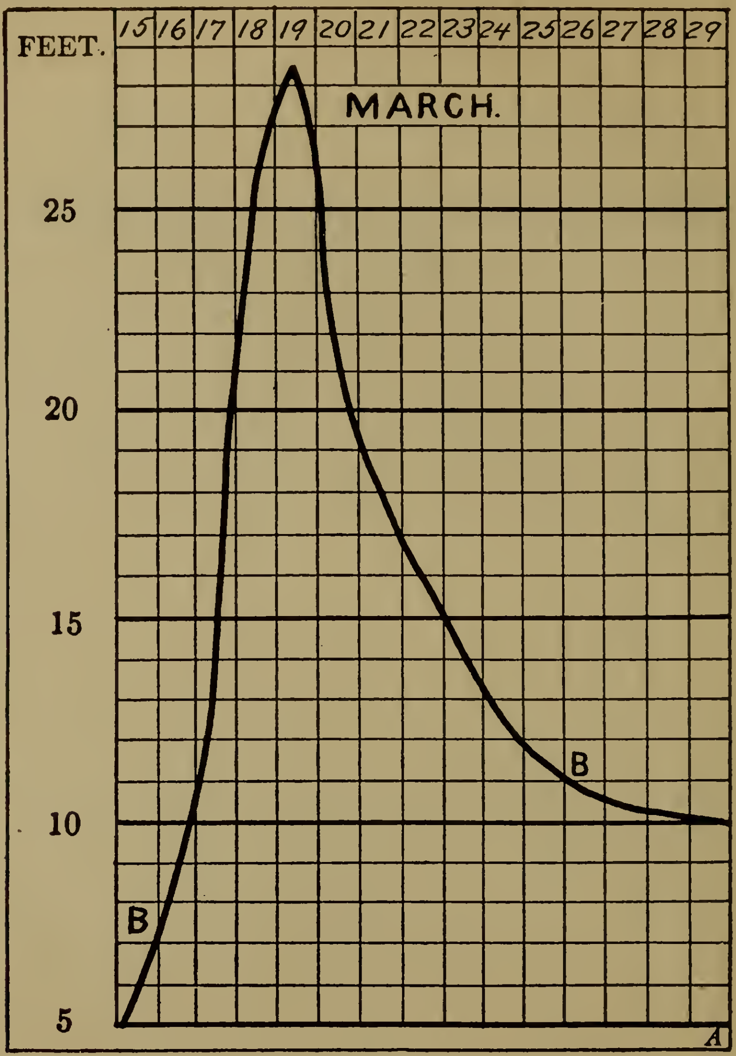



FIG. 25.—Oroville on Feather, March, 1907.

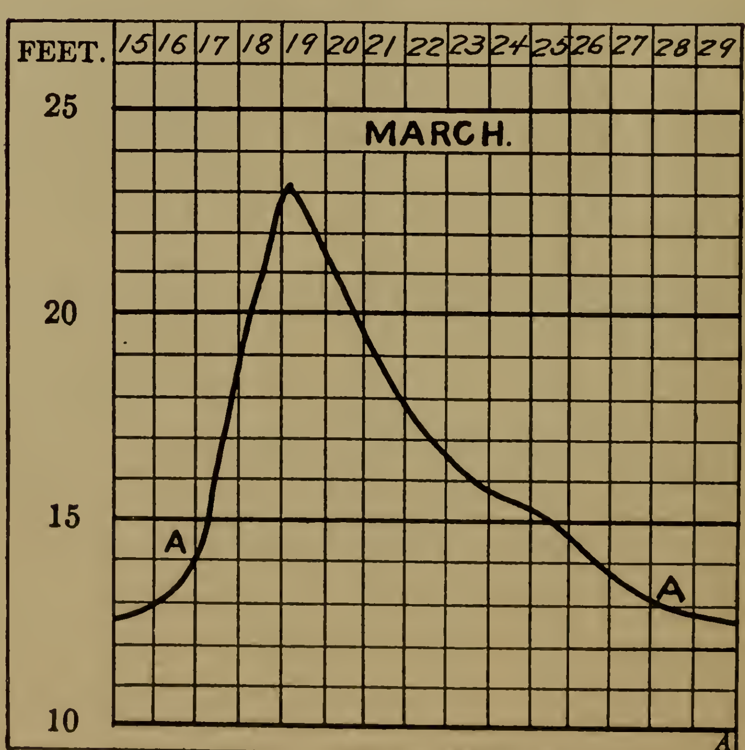



FIG. 26.—Marysville on Yuba, March, 1907.

*Hydrographs, Sacramento River system, March, 1907*—Continued.

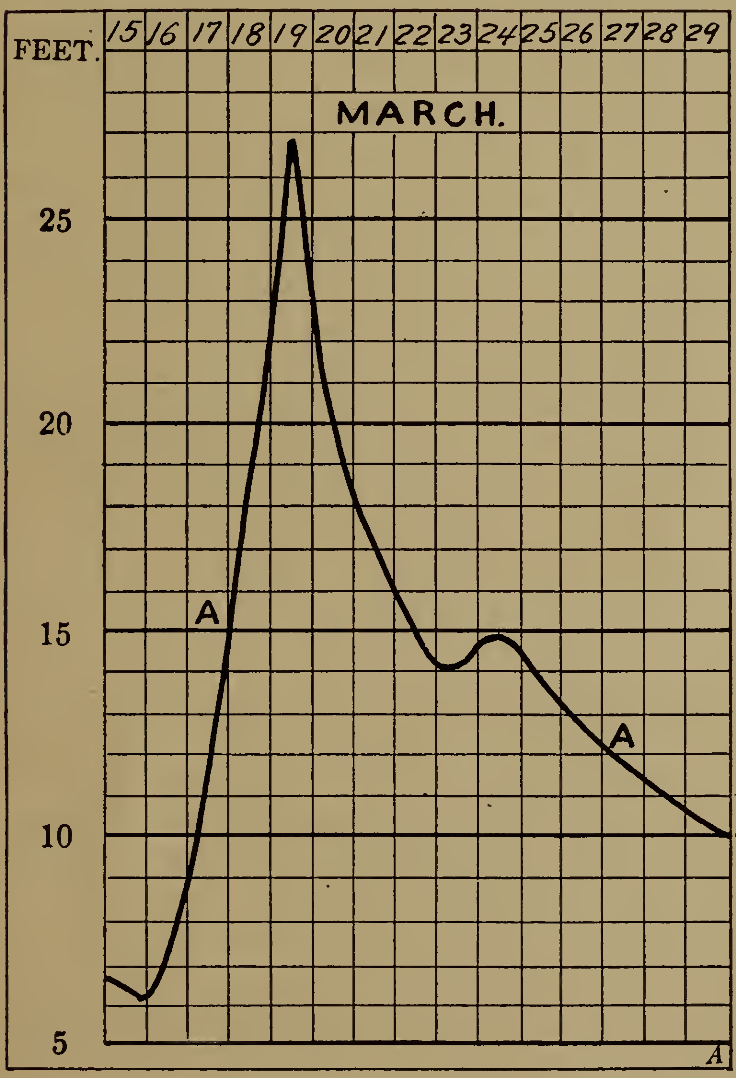



FIG. 27.—Folsom City on American, March, 1907.

Conditions, however, during January and February of that year were largely responsible for the intensity of those in the watershed of the Sacramento. During the first days of January and the first decade of February the occurrence of heavy rains in the headwaters of the Sacramento drainage basin caused rapid rises in all streams, and, in some cases, floods and freshets. There were marked and dangerous rises at Folsom, on the American, on February 2, and at Marysville, on the Yuba, on the 3d, where stages of 21.2 and 22.2 feet, respectively, were recorded. From February 4 to 11, inclusive, high stages were also general in parts of the Sacramento River.

Before the rivers of the Sacramento watershed had recovered from the rains and melting snows of February, and while all flood basins on both sides of the Sacramento were practically full, another period of precipitation occurred between March 4 and 11. This condition resulted in raising the rivers to a point much beyond the stages usually maintained at this time of the year. From March 16 to 20, inclusive, there was another period of precipitation that was coextensive with the entire northern half of the State. At the same time temperatures were much above the seasonal normal in the high foothills and on the flanks of the mountains, which were thickly covered with the accumulated snows of the two preceding months. The effects of the heavy, warm rains and melting snows were almost immediate, and all the main rivers quickly responded to the increased run-off of the mountain feeders. At Kennett, on the Upper Sacramento, the river rose from 6.3 on the 17th to 18 feet on the 18th, and to 25 and 33.2 feet, respectively, on the two succeeding days. At Red Bluff the river rose from 7.9 to 20.7 feet between the 16th and 17th. On the 18th, 19th, and 20th, while the flood waters of the Upper Sacramento and Pitt Rivers were passing, stages of 22.8, 26, and 26.8 feet, respectively, were recorded at Red Bluff. At Colusa the river began rising rapidly during the night of the 17th, and by the morning of the 18th there was a gage reading of 22.7 feet, followed on the 19th and 20th by stages of 26 and 26.8 feet, respectively. The river rose slowly at Knights Landing, as the numerous breaks above tended to flatten out the flood wave before reaching that point. The river was high, however, and continued above the flood stage from the 20th to 24th, inclusive. By the morning of the 17th the river at Sacramento City had already become swollen as a result of the output of the American. On this date a gage reading of 20.9 feet was observed, after which the river rose gradually, averaging about 1 foot per day until the 20th, when it culminated in a stage of 26.9 feet. The breaking of the levees at many points above and below Sacramento checked a further rise at this point, but the river remained above the 26-foot stage for several days. The effects of the Sacramento River flood were first felt at Rio Vista on about the 21st, after which the river at that point rose rapidly until the 24th, when it culminated in a stage of 17 feet, but a high stage was maintained for several days, due to the output of Yolo Basin through the sloughs that drain this basin into the Sacramento River.

The American at Folsom began rising on the night of the 16th, and by the morning of the 17th had risen from 6.2 to 12 feet. On the 18th it had risen to 18.6 feet, and by 7 a. m. of the 19th had reached the unusually high stage of 26.8, the highest ever recorded, except during the flood of 1862.

Coincident with the rise of the American, the Feather and Yuba Rivers rose rapidly. At Marysville, on the Yuba, the river rose from 14.1 to 20.1 feet from the 17th to 18th, and by the morning of the 19th had reached a stage of 23.3 feet, the highest observed.

At Oroville, on the Feather, the river rose from 5.1 to 11.6 feet during the 24 hours ending at 7 a. m. of the 17th. On the morning of the 18th it had risen to 23.6, and at 7 a. m. of the 19th the gage showed 28.2 feet, the crest of the flood at that point. As has been stated in another part of this paper, the flood waters of the Feather escaped through breaks in the levees at Hamilton Bend and rushed westward across country between Biggs and Gridley, thence through the lowlands north of Marysville Buttes and into the Sacramento River by way of Butte Slough.

While the floods were raging in the Sacramento Valley, like conditions were occurring in all sections of the San Joaquin north of the Tuolumne. The Tuolumne at Jacksonville reached a stage of 24 feet on the 19th, and a high stage was maintained on this stream from the mouth of Woods Creek to its mouth until the 21st, after which it fell sharply. The Stanislaus rose briskly from the 16th to the 21st, culminating at a stage of 12.2 feet, the highest on record. It remained at a high stage until the 26th. The Calaveras rose from 4.3 to 13 feet between 7 a. m. of the 16th and the corresponding hour of the 17th, and rushed into Mormon Slough at the rate of some 10 miles an hour and thence overflowing a large area of country. The Mokelumne rose from 8 to 13 feet during the 24 hours ending at 7 a. m. of the 19th. Below Bensons Ferry the flood waters of this stream were reenforced by a heavy swell from the Cosumnes. The combined run-off of the two rivers resulted in flooding something over 15,000 acres of land above Lodi. While the Mokelumne flood was at its worst, conditions were intensified by the breaking of the east side Sacramento levees near Courtland, through which the Sacramento River flood waters rushed into the lower Mokelumne Basin.

The San Joaquin River itself was at or above the flood stage from Mendota to the mouth of the river from the 19th to near the close of the month; this was especially so below Lathrop, where the highest stage on record, 19.2 feet, was recorded on the 20th. From about the 21st to the 28th the greatest damage was done in the delta lands of both trunk streams. (See list of islands and other tracts that were flooded, p. 91.)

## FLOODS IN THE SACRAMENTO AND SAN JOAQUIN VALLEYS, 1909.

There were a series of floods in the central valleys of California from January 14 to 25, inclusive, and during the first decade of February, 1909. Those during the first-named period equaled in intensity the floods of 1907.

The first dangerous condition noted in connection with the 1909 floods was the heavy rainfall throughout the San Joaquin Valley on the 13th of January, and especially in the headwaters of the Calaveras River.

*Table of daily precipitation at selected stations in the Sacramento watershed from Jan. 1 to 31, 1909.*

[See hydrographs, figs. 28 to 40, for this period.]

| Date. | Alturas. | Sisson. | Kennett. | Dunsmuir. | Shasta. | Redding. | Red Bluff. | Quincy. | Chico. |
|---|---|---|---|---|---|---|---|---|---|
| Elevation...............feet.. | 4,460 | 3,555 | 616 | 2,285 | 1,049 | 552 | 307 | 3,400 | 189 |
| Jan. 1 | 0.01 | 1.25 | 1.22 | 1.74 | 0.84 | 1.25 | 1.04 | 1.02 | 0.90 |
| Jan. 2 | .05 | 1.24 | 1.74 | 1.55 | .93 | .85 | .17 | 2.43 | .79 |
| Jan. 3 | .08 | .00 | 3.20 | 1.96 | .48 | .39 | .08 | 1.37 | .82 |
| Jan. 4 | .00 | .90 | .04 | .16 | .38 | .23 | .73 | .00 | .08 |
| Jan. 5 | .36 | 1.19 | 1.20 | 1.14 | 2.32 | 2.24 | 2.00 | 2.58 | 1.60 |
| Jan. 6 | .18 | .89 | 2.90 | 2.05 | 2.04 | 1.53 | .00 | 1.35 | 1.07 |
| Jan. 7 | .30 | 1.86 | 3.10 | 2.02 | 3.87 | 1.07 | .71 | 1.96 | .32 |
| Jan. 8 | .60 | .15 | 3.04 | 2.64 | 2.68 | 2.43 | .34 | 3.10 | 1.25 |
| Jan. 9 | .70 | .00 | 1.24 | .63 | .08 | .00 | .00 | .54 | .00 |
| Jan. 10 | .00 | .00 | .00 | .00 | .54 | .00 | .00 | .00 | .00 |
| Jan. 11 | .00 | .00 | .00 | .00 | .67 | .00 | .00 | .00 | .00 |
| Jan. 12 | .00 | .02 | .00 | .00 | .34 | .11 | .29 | .10 | .04 |
| Jan. 13 | .11 | .62 | .50 | .50 | 1.40 | .73 | .23 | 1.48 | .48 |
| Jan. 14 | .69 | .65 | 3.00 | 1.84 | 1.87 | 1.65 | 1.42 | 3.20 | .28 |
| Jan. 15 | .17 | 1.22 | 2.68 | 1.56 | .91 | 2.11 | 1.36 | 2.77 | 1.12 |
| Jan. 16 | .17 | .31 | 8.90 | 3.00 | .71 | .51 | .10 | 1.90 | .44 |
| Jan. 17 | .30 | .08 | .54 | .80 | 2.04 | .94 | .06 | .35 | .15 |
| Jan. 18 | .07 | .33 | 1.04 | .49 | 1.30 | .04 | .02 | .17 | .10 |
| Jan. 19 | .04 | 1.28 | .90 | 1.00 | 2.13 | .93 | .04 | 1.10 | .50 |
| Jan. 20 | .05 | 2.25 | 2.42 | 2.49 | 2.94 | .77 | .69 | 2.45 | .70 |
| Jan. 21 | .40 | .65 | .60 | 2.45 | 1.60 | .22 | .12 | 1.77 | .46 |
| Jan. 22 | .17 | .10 | 1.10 | .48 | 1.17 | .07 | .04 | .81 | .10 |
| Jan. 23 | .00 | .60 | .06 | .15 | .97 | .17 | .08 | 1.09 | .00 |
| Jan. 24 | .00 | 2.40 | .50 | 1.10 | 2.28 | 3.45 | 1.43 | .80 | .75 |
| Jan. 25 | .01 | .60 | .50 | 1.30 | .08 | 1.20 | 1.49 | .83 | .59 |
| Jan. 26 | .00 | .00 | 3.10 | .30 | .15 | .76 | .47 | .45 | .80 |
| Jan. 27 | .01 | .00 | .30 | .00 | .00 | .00 | .00 | .00 | .05 |
| Jan. 28 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .05 | .00 |
| Jan. 29 | .00 | .00 | .00 | .00 | .68 | .00 | .00 | .00 | .00 |
| Jan. 30 | .00 | 1.30 | .86 | .30 | .18 | .58 | .37 | .50 | .89 |
| Jan. 31 | .00 | .83 | 4.00 | .95 | .38 | .05 | .14 | 1.00 | .10 |
| Sum | 4.47 | 20.72 | 54.08 | 32.60 | 35.96 | 24.28 | 13.42 | 35.17 | 14.38 |

*Table of daily precipitation at selected stations in the Sacramento watershed from Jan. 1 to 31, 1909*—Continued.

| Date. | Fruto. | Colusa. | Oroville. | Willows. | Nevada City. | Auburn. | Folsom. | Sacramento. | Georgetown. |
|---|---|---|---|---|---|---|---|---|---|
| Elevation.................feet.. | 624 | 60 | 147 | 136 | 2,580 | 1,360 | 111 | 71 | 2,650 |
| Jan. 1 | 0.90 | 0.16 | 0.54 | 0.71 | 0.80 | 0.42 | 0.44 | 0.39 | 0.90 |
| Jan. 2 | .33 | .52 | 1.00 | .12 | .55 | .20 | .00 | .28 | .09 |
| Jan. 3 | .60 | .00 | 1.26 | .48 | 1.57 | .62 | .44 | .05 | .91 |
| Jan. 4 | .00 | .40 | .00 | .08 | .02 | .00 | .00 | .21 | .00 |
| Jan. 5 | .70 | 1.04 | .68 | 1.10 | .97 | .41 | .26 | .34 | .62 |
| Jan. 6 | 1.05 | .06 | 1.54 | .74 | 1.79 | 1.45 | .26 | .35 | 1.87 |
| Jan. 7 | .00 | .62 | .06 | .13 | 1.02 | .23 | .20 | .06 | .50 |
| Jan. 8 | .50 | .04 | 1.40 | .65 | 3.45 | 1.28 | .92 | 1.05 | 2.40 |
| Jan. 9 | .20 | .00 | .10 | .05 | 1.10 | 1.59 | .98 | .06 | 3.28 |
| Jan. 10 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .10 |
| Jan. 11 | .00 | .06 | .00 | .00 | .05 | .00 | .00 | .04 | .00 |
| Jan. 12 | .00 | .22 | .01 | .13 | .19 | .18 | .00 | .65 | .26 |
| Jan. 13 | .20 | .18 | .76 | .16 | 2.92 | 2.40 | 1.34 | .37 | 4.12 |
| Jan. 14 | .20 | .68 | .58 | .28 | 4.48 | 2.95 | .94 | 1.28 | 6.05 |
| Jan. 15 | .40 | .50 | .70 | .74 | 3.26 | 3.20 | 2.10 | 1.03 | 5.56 |
| Jan. 16 | .80 | .00 | 1.45 | .70 | 1.62 | 2.00 | 1.60 | .32 | 2.94 |
| Jan. 17 | .00 | .04 | .02 | .00 | .31 | .00 | .00 | .12 | .28 |
| Jan. 18 | .00 | .06 | .40 | .00 | .49 | .70 | .30 | .00 | .84 |
| Jan. 19 | .00 | .12 | .24 | .17 | .52 | .08 | .00 | .29 | .04 |
| Jan. 20 | .20 | .58 | .48 | .51 | 2.31 | 1.20 | .58 | 1.20 | 1.62 |
| Jan. 21 | .65 | .16 | .85 | .30 | 1.68 | 1.28 | 1.28 | .41 | 2.70 |
| Jan. 22 | .15 | .00 | .34 | .08 | .50 | 1.68 | .32 | .15 | .69 |
| Jan. 23 | .00 | .06 | .01 | .01 | .38 | .29 | .12 | .00 | .61 |
| Jan. 24 | .30 | .52 | .00 | .76 | .18 | .00 | .02 | .44 | .26 |
| Jan. 25 | .65 | .68 | .34 | .21 | .64 | .42 | .44 | .12 | .60 |
| Jan. 26 | 3.30 | .18 | .42 | .87 | .09 | .08 | .10 | .12 | .04 |
| Jan. 27 | .10 | .00 | .08 | .08 | .13 | .42 | .22 | .05 | .35 |
| Jan. 28 | .20 | .00 | .01 | .02 | .01 | .00 | .00 | .00 | .02 |
| Jan. 29 | .00 | .14 | .00 | .00 | .00 | .00 | .00 | .00 | .00 |
| Jan. 30 | .30 | .24 | .00 | .27 | .81 | .00 | .00 | .27 | .00 |
| Jan. 31 | .00 | .00 | .00 | .02 | .01 | .00 | .48 | .00 | .71 |
| Sum | 11.73 | 7.26 | 13.27 | 9.37 | 31.85 | 23.08 | 13.94 | 9.65 | 38.36 |

*Daily precipitation at selected stations in the San Joaquin watershed from Jan. 9 to Jan. 27, 1909.*

[See flood charts for this period.]

| Date. | Sanger. | Firebaugh. | North Fork. | Merced Falls. | Friant. | Yosemite. | Jacksonville. | Melones. | Lathrop. | Electra. | Jenny Lind. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Elevation.................feet.. | 371 | 154 | 3,000 | 321 | 355 | 3,945 | 602 | 750 | 19 | 670 | ...... |
| Jan. 9 | 0.00 | 0.14 | 0.78 | 0.24 | 0.42 | 1.78 | 1.92 | 1.96 | 0.52 | 1.54 | 0.00 |
| Jan. 10 | .00 | .00 | .20 | .00 | .10 | .00 | .12 | .00 | .00 | .00 | .00 |
| Jan. 11 | .24 | .00 | .00 | .26 | .00 | .00 | .00 | .00 | .00 | .00 | .30 |
| Jan. 12 | 1.68 | .34 | .95 | 1.65 | .38 | .77 | .16 | .16 | .32 | .18 | 1.08 |
| Jan. 13 | 2.16 | .43 | 4.43 | .74 | 1.86 | 3.47 | 2.90 | 2.12 | .54 | 2.56 | 1.60 |
| Jan. 14 | .50 | .06 | 4.42 | .49 | .88 | 3.17 | 1.76 | 4.56 | .24 | 2.60 | .68 |
| Jan. 15 | .00 | .00 | .61 | .17 | .12 | .49 | .36 | .56 | .04 | 1.08 | .24 |
| Jan. 16 | .00 | .00 | .05 | .00 | .00 | .67 | .32 | .58 | .29 | .42 | .16 |
| Jan. 17 | .00 | .00 | .10 | .00 | .00 | .07 | .04 | .12 | .00 | .22 | .00 |
| Jan. 18 | .00 | .00 | .00 | 00 | 00 | .00 | .00 | .06 | .00 | .58 | .00 |
| Jan. 19 | .00 | .60 | .00 | .22 | .00 | .00 | .00 | .00 | .00 | .00 | .55 |
| Jan. 20 | .00 | .16 | .58 | .79 | .34 | .79 | .04 | .70 | .33 | .76 | .54 |
| Jan. 21 | .94 | .49 | 4.04 | .35 | .96 | 4.18 | 1.56 | 2.10 | 2.30 | 1.64 | 2.00 |
| Jan. 22 | .00 | .00 | 1.50 | .40 | .26 | 1.68 | .60 | 1.04 | .18 | .82 | .50 |
| Jan. 23 | .00 | .17 | .30 | .00 | .26 | .78 | .70 | .70 | .12 | .50 | .15 |
| Jan. 24 | .00 | .00 | .03 | .68 | .00 | .00 | .00 | .01 | .00 | .06 | .70 |
| Jan. 25 | .00 | .05 | .47 | .74 | 18 | .75 | .96 | .86 | .08 | .64 | .70 |
| Jan. 26 | .00 | .75 | .09 | .70 | .22 | .60 | .76 | 1.08 | .20 | .30 | .30 |
| Jan. 27 | .00 | .79 | .52 | .00 | .46 | .64 | .70 | .62 | .03 | .42 | .00 |
| Sum | 5.52 | 3.38 | 19.1 | 7.43 | 6.44 | 19.8 | 12.9 | 17.2 | 5.19 | 14.3 | 9.50 |

*Hydrographs, Sacramento River system, March, 1907, and January, 1909.*

*Kennett, Cal.*

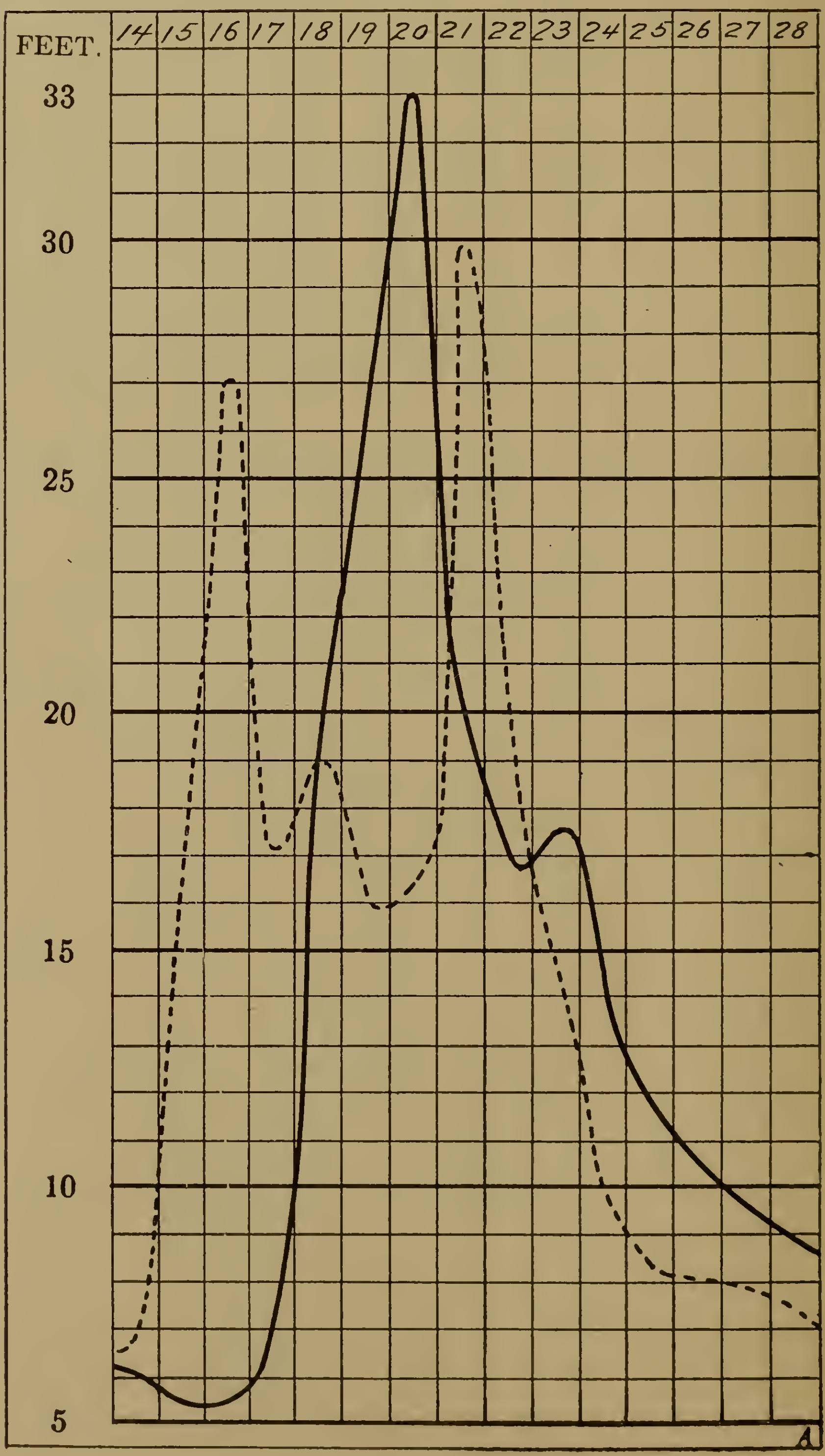



FIG. 28.—Solid line, March, 1907; dotted line, January, 1909.

*Hydrographs, Sacramento River system, January, 1909.*

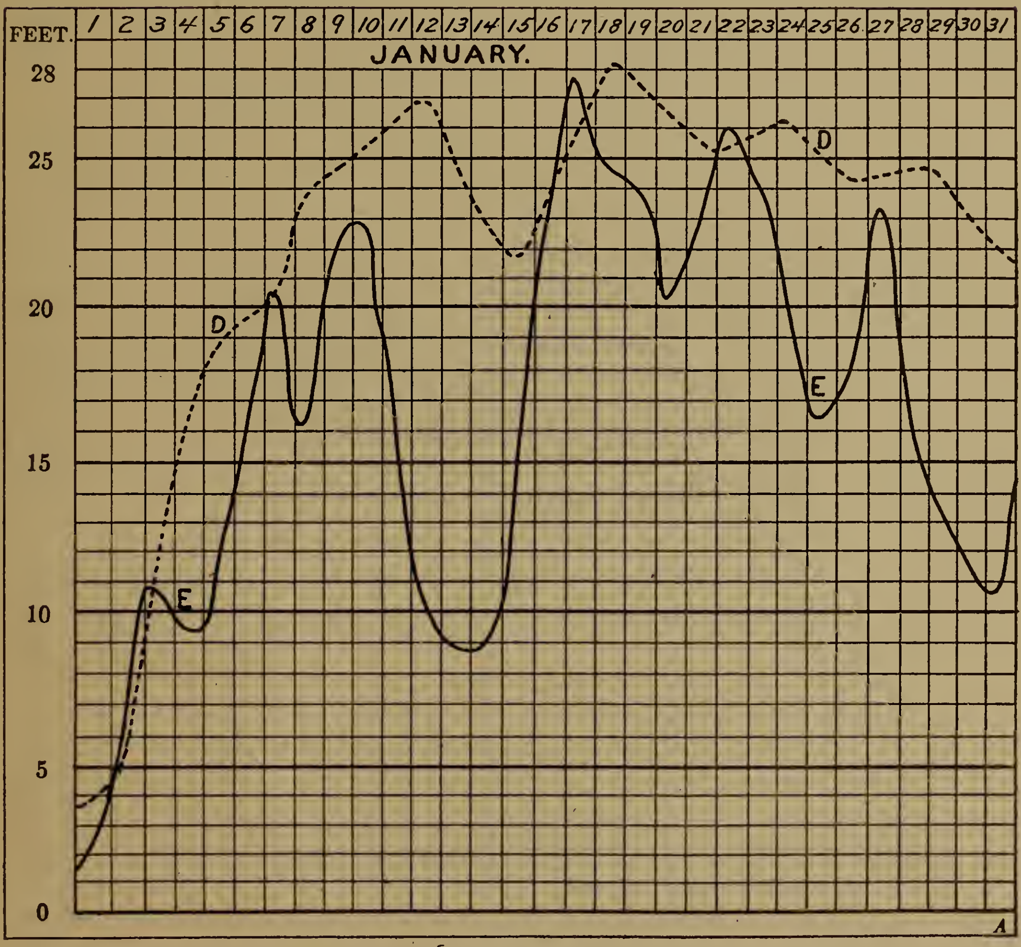



FIG. 29.—Hydrographs, January, 1909. D, Colusa; E, Red Bluff.

*Hydrographs, Sacramento River system, January, 1909*—Continued.

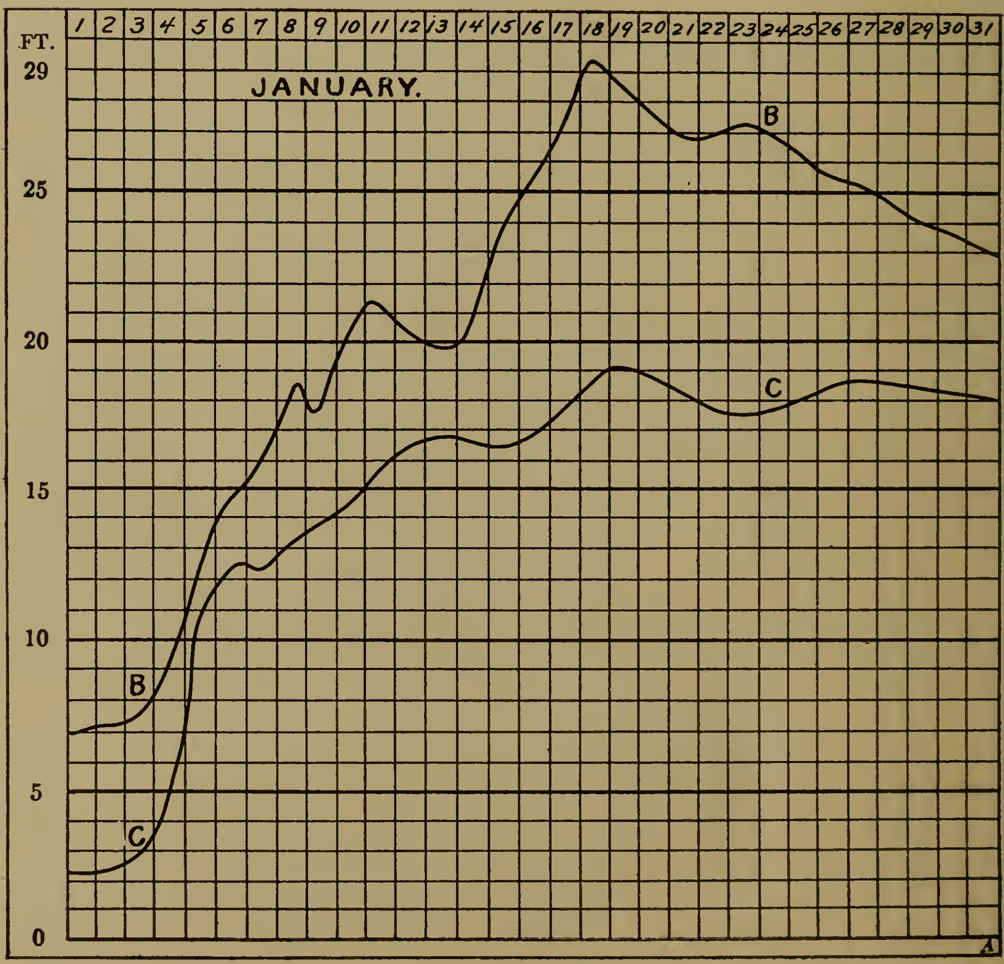



FIG. 30.—Hydrographs, Sacramento River, January, 1909. B, Sacramento; C, Knights Landing.

*Hydrographs, Sacramento River system, January, 1909*—Continued.

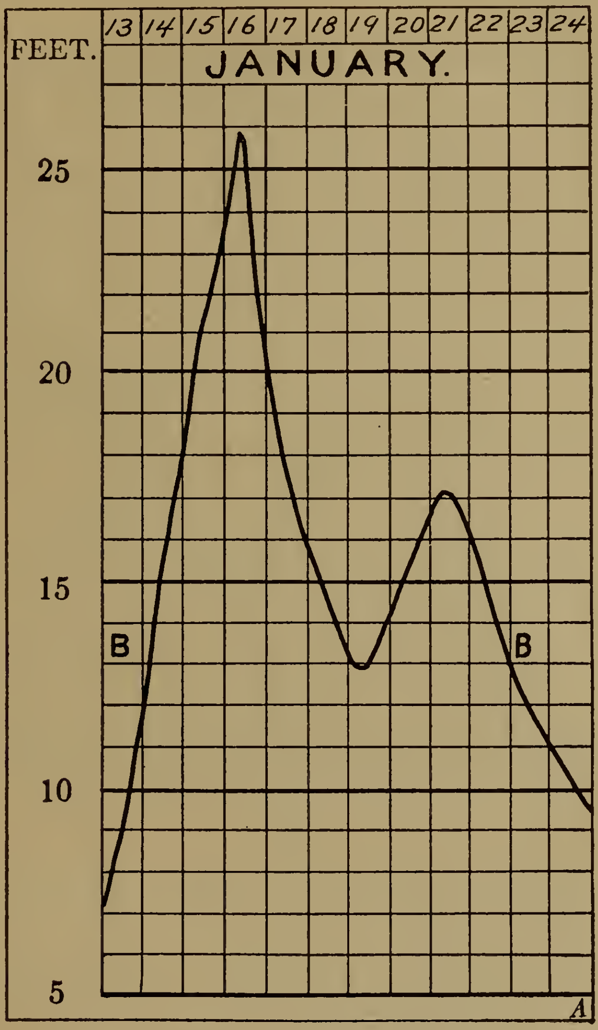



FIG. 31.—Hydrograph, Oroville on Feather.

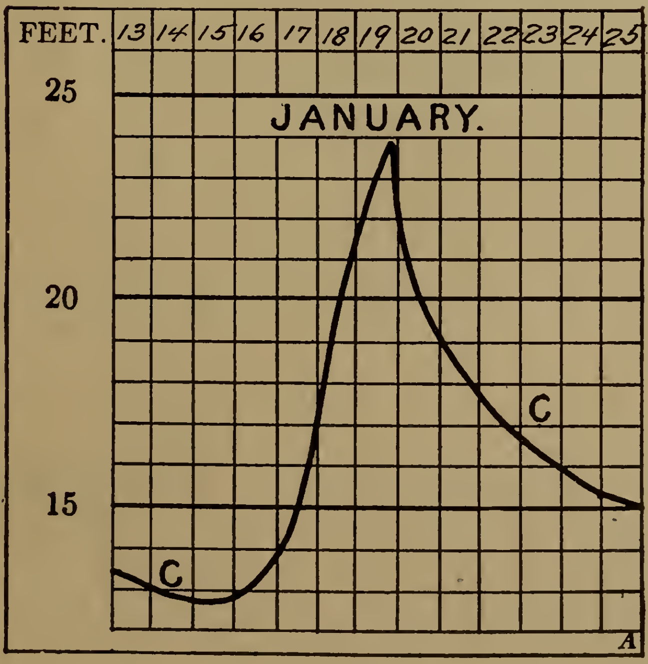



FIG. 32.—Hydrograph, January, 1909, Marysville on Yuba.

*Hydrographs, Sacramento and San Joaquin River systems.*

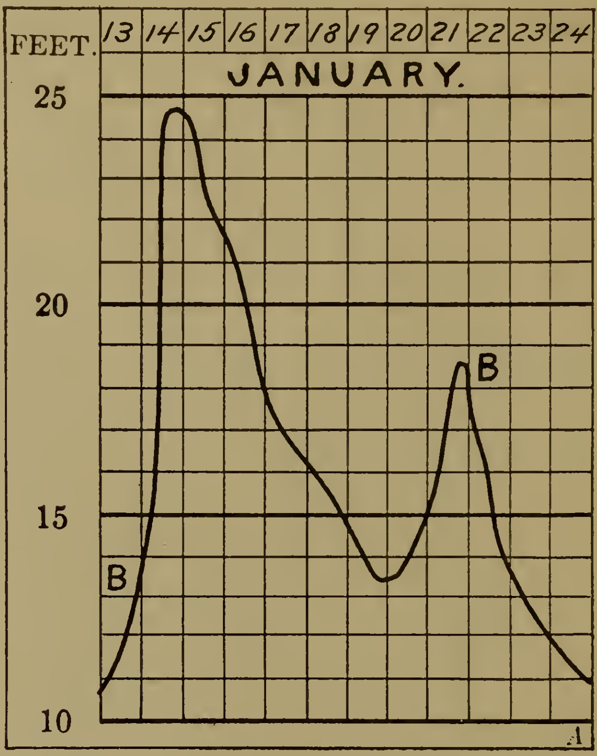



FIG. 33.—Hydrograph, Folsom on American, 1909.

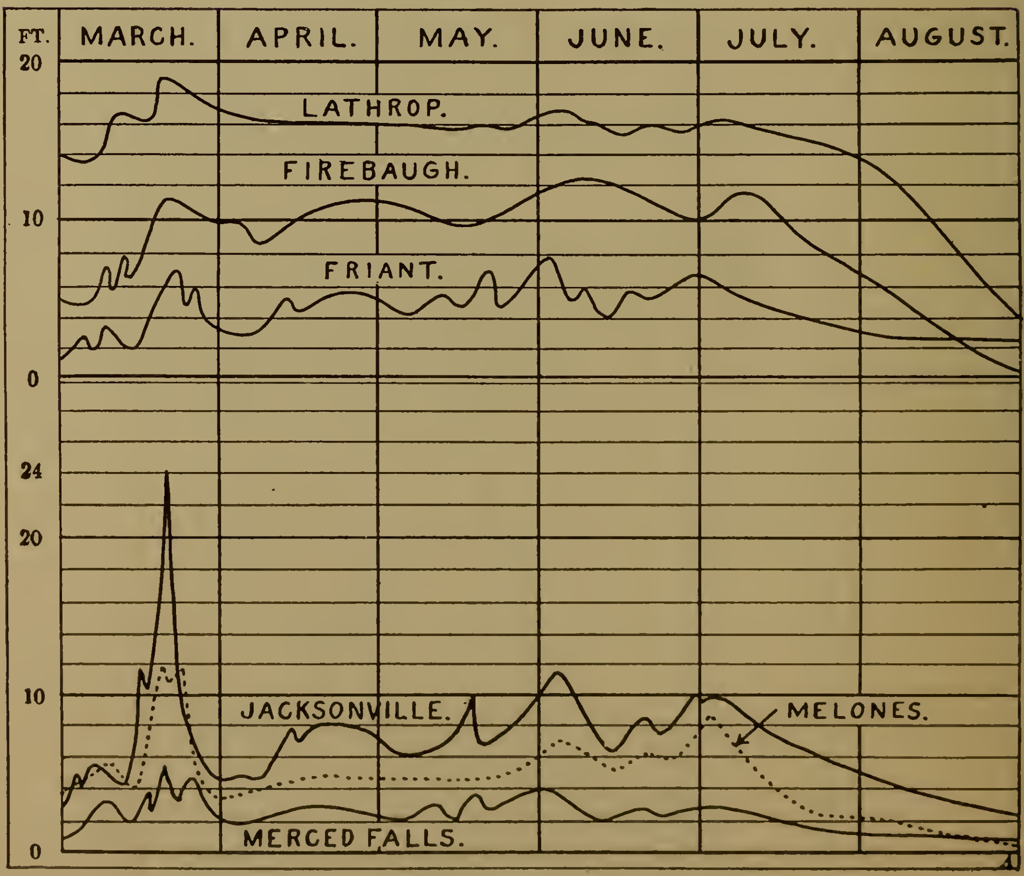



FIG. 34.—Hydrographs, San Joaquin River system, spring freshet, 1907.

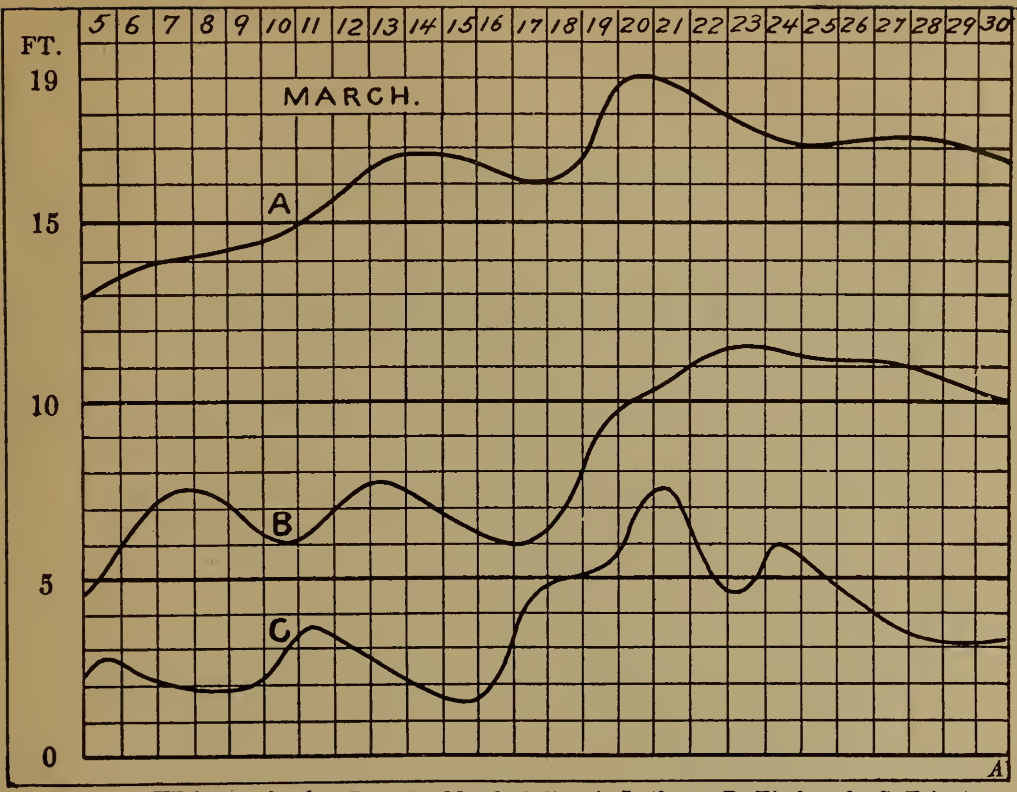



FIG. 35.—Hydrographs, San Joaquin, March, 1907. A, Lathrop; B, Firebaugh; C, Friant.

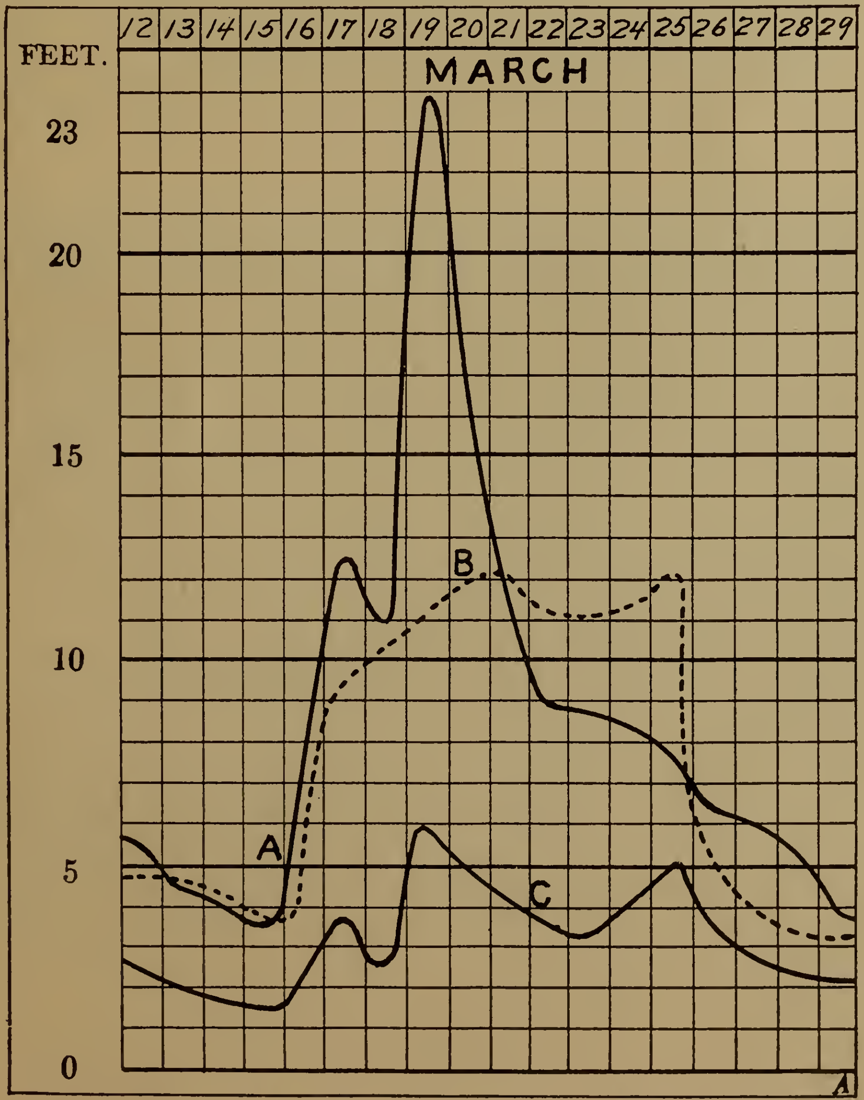



FIG. 36.—Hydrographs, March, 1907. A, Jacksonville; B, Melones; C, Merced Falls.

*Hydrographs, San Joaquin system.*

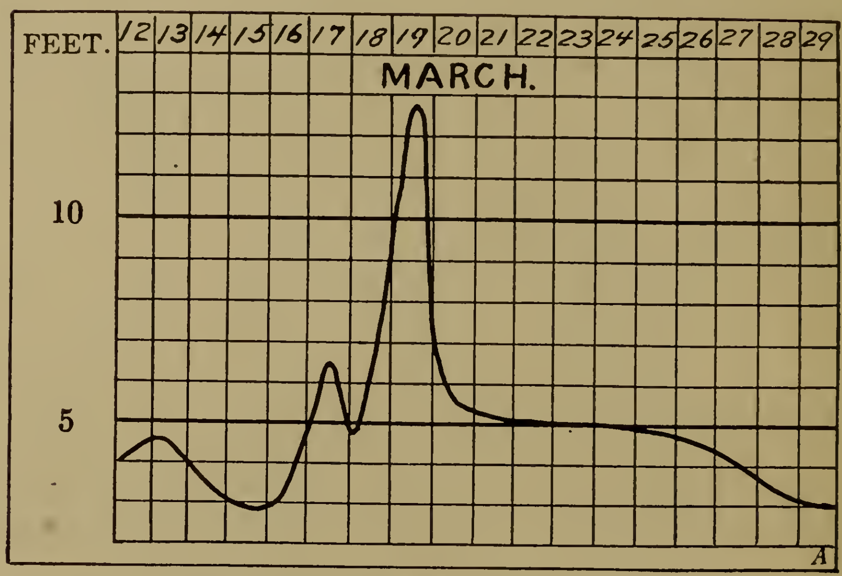



FIG. 37.—Hydrograph, March, 1907. Jenny Lind.

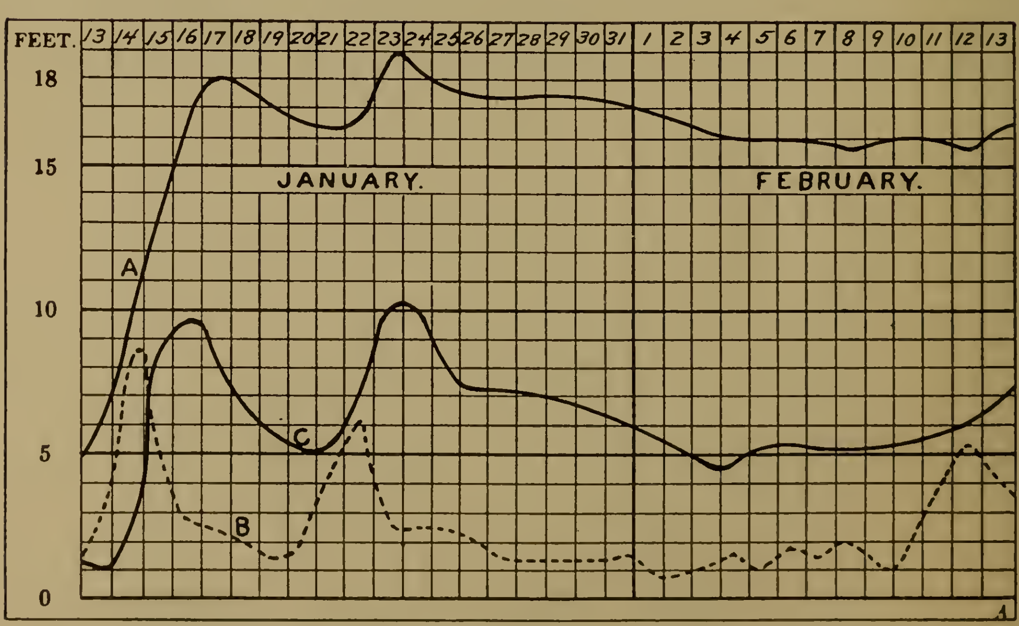



FIG. 38.—Hydrographs, San Joaquin, flood of 1909. A, Lathrop; B, Friant; C, Firebaugh.

*Hydrographs, San Joaquin flood, January, 1909.*

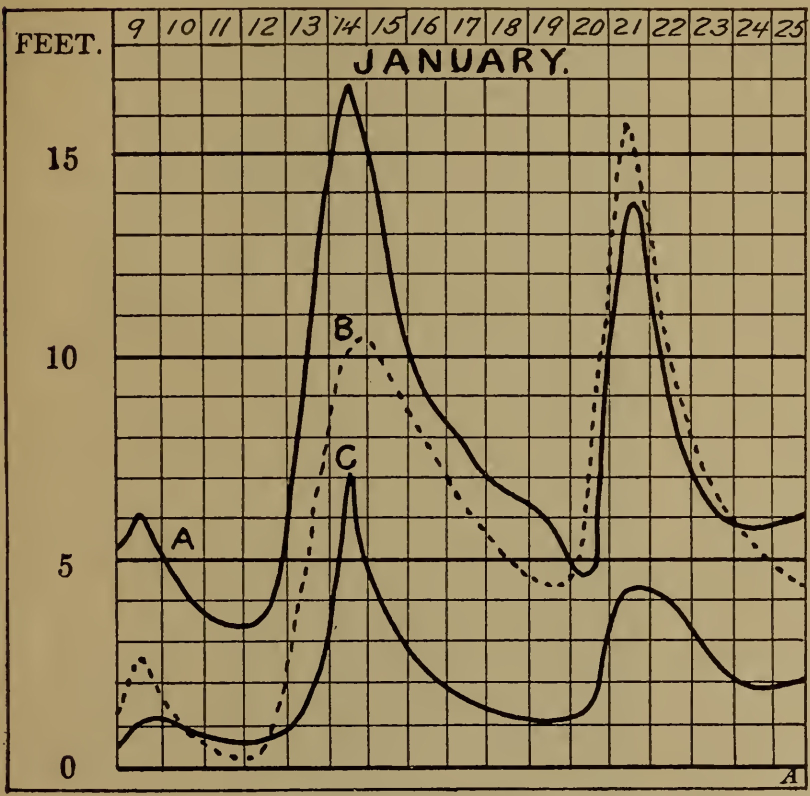



FIG. 39.—A, Jacksonville; B, Melones; C, Merced Falls.

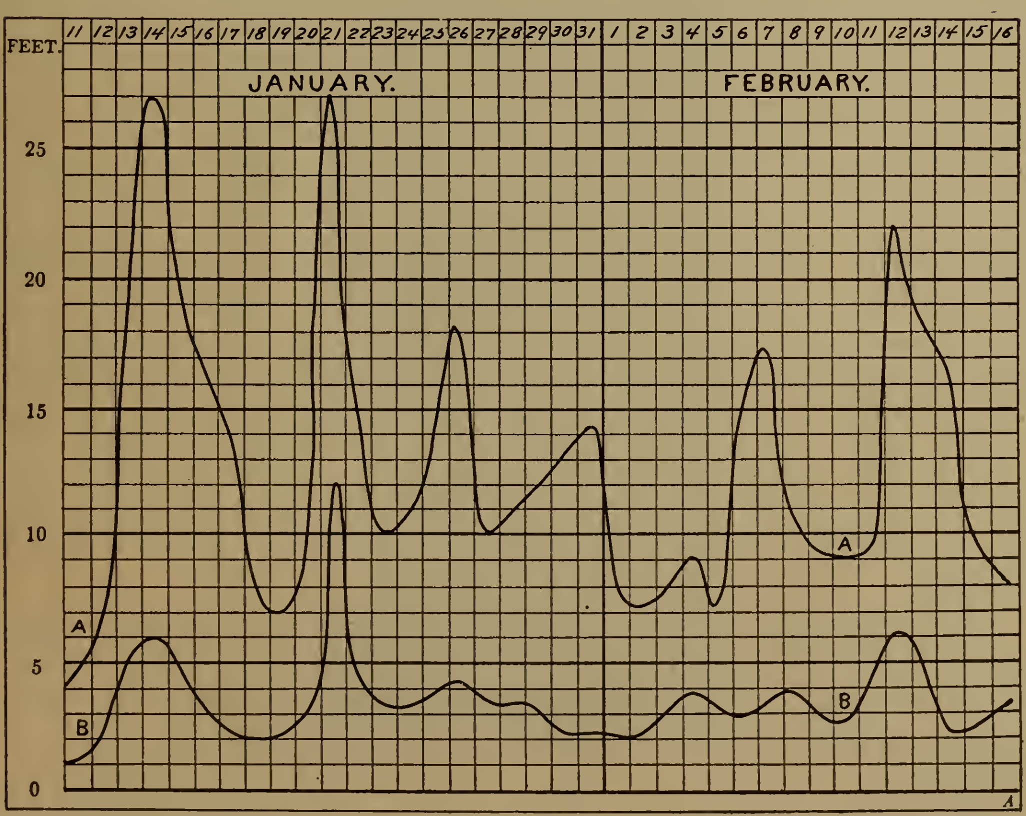



FIG. 40.—Hydrographs San Joaquin flood, January and February, 1909. A, Bellota; B, Jenny Lind.

This table, in addition to its value in connection with flood reports of this period, is of interest in showing the daily precipitation in the Sacramento watershed during an exceptionally wet month.

At Bellota, where the Calaveras is led into Mormon Slough, the river rose from 5 to 20 feet from the 12th to the 13th, and on the 12th reached a stage of 27 feet, the highest ever recorded at that point, resulting in serious floods over a large territory contiguous to Stockton, besides flooding portions of the city itself. All rivers in the San Joaquin watershed rose beyond their flood stages between the 14th and 15th and the San Joaquin itself, below the mouth of the Tuolumne, remained above the danger point until near the end of the month.

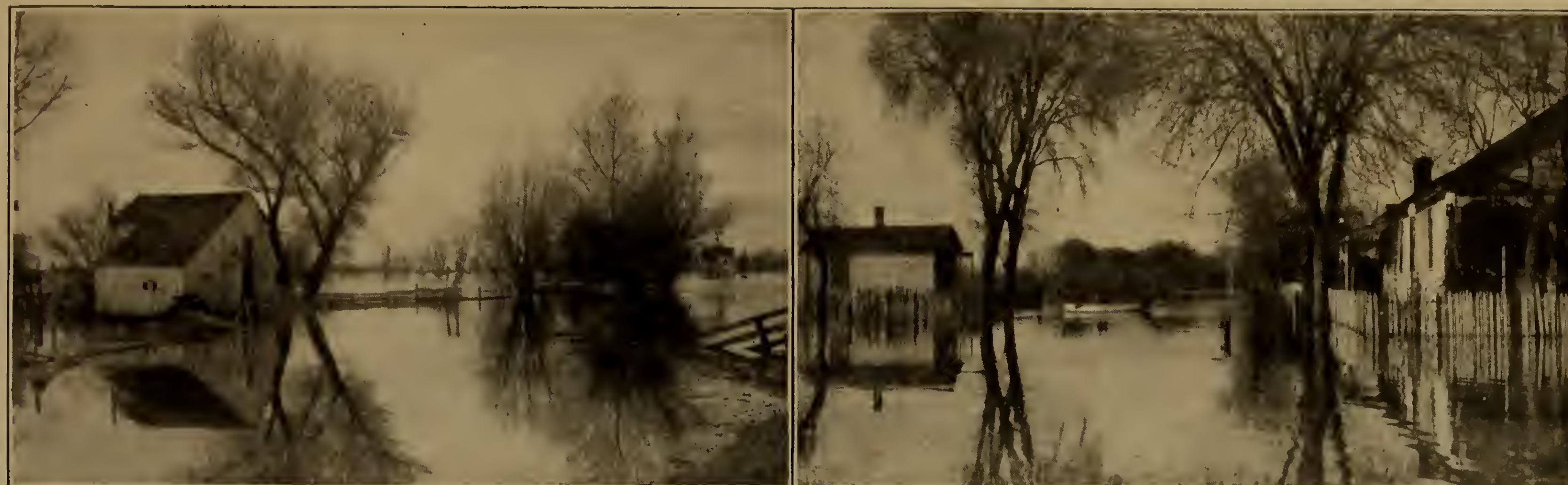
On the 14th of January the situation in the Sacramento Valley in connection with the great floods that occurred later first became serious. In order that conditions in the valley at this time be understood, it may be stated that the first abnormal swell of the season occurred between Colusa and Sacramento City between the 8th and 11th of January. The southern edge of this swell had barely passed the last-named point before the American River, under the influence of heavy rains and melting snows in the large area drained by its numerous feeders, rose 13 feet in a night, and on the morning of the 14th was carrying stages ranging from 15 feet a few miles above its mouth to 24 feet near its first fork, a few miles above Folsom. During the early morning of the 15th the full force of the American flood wave reached the Sacramento River with a volume sufficient to dislodge some of the bridges that spanned the American near Sacramento. The gauge at Sacramento registered 24.9 feet at 7 a. m. of the 15th, but a higher reading must have occurred sometime between midnight and 4 a. m., or during the period of the passing of the American wave. The Sacramento continued to rise at Sacramento City until 12.30 a. m. of the 17th, when it reached a stage of 29.6 feet. This is the highest stage of which there is an authentic record. In the meanwhile the heavy rains throughout the drainage basins of both watersheds had swollen all watercourses beyond their carrying capacities, and many points on the main rivers were being flooded.

On January 16, it was estimated that the Sacramento River was carrying a flood wave from 1 to 2 feet above what may be termed the "danger point" from Red Bluff to Courtland, a distance of over 200 miles.

By the morning of the 17th the Sacramento River between Sacramento and Walnut Grove felt the relief afforded by the escaping waters through breaks in the west side levees, but the flooded area above, especially in the vicinity of Monroeville and St. John, was increasing. By 8 a. m. of this date the town of Broderick, just across the river from Sacramento, had mostly become inundated from the back water of Yolo Basin.

Courtesy Great West.

FIG. 45.—WRECK OF WESTERN PACIFIC BRIDGE OVER AMERICAN RIVER, JANUARY, 1909.



Courtesy Great West.

FIG. 46.—FLOOD SCENE, 1909, IN YOLO BASIN, OPPOSITE SACRAMENTO.

Courtesy Great West.

FIG. 47.—TRACKS OF SOUTHERN PACIFIC RAILWAY CO. IN YOLO BASIN OPPOSITE SACRAMENTO—FLOOD OF 1909.

On the 18th the river at Sacramento had subsided to 28 feet, but by night of this date the flood waters of the Sacramento and those of the San Joaquin were rapidly approaching the delta. By the 19th the great volume of water that had accumulated in Yolo Basin began finding its way back into the Sacramento through Steamboat Slough and thence into the Lower San Joaquin through the various sloughs that connect the two rivers in the vicinity of the Lower Islands, so called.

From the 19th to the 27th inclusive flood conditions prevailed throughout all districts contiguous to the junction of the Sacramento and San Joaquin Rivers, and during this period many agricultural tracts and islands were either partly or wholly flooded. (See list of lands flooded in the "Island districts," p. 91.)

The January flood had barely subsided before heavy rains in the upper Sacramento Valley resulted in damaging floods in the valley north of Colusa. On February 3, all low lands lying between Tehama and Hamilton were under water, and the river between Redding and Monroeville, a distance of 99 miles, was carrying more water than during the floods of March, 1907, or those of January, 1909. In the vicinity of St. John, Monroeville, and Hamilton and thence eastward nearly to the town of Chico, it was estimated that fully 100,000 acres of land were submerged. Tehama was almost completely flooded, there being nearly 10 feet of water in some of the lower sections of the town.

There was little effect of the upper Sacramento flood felt below Colusa on account of the fact that the river flowed freely into the various basins through the breaks caused by the floods of the preceding month. Yolo Basin, however, was fuller than at any time during the previous floods, and it has been stated that the discharge of this sink into the Sacramento River above Rio Vista was sufficient to reverse the current of the Sacramento for a considerable distance above the mouth of Steamboat Slough.

From many reports that have been received from all sections covered by the floods those of 1909 were the most general and widespread of any previous inundations. They were as disastrous as any previous flood of which there is an authentic history, and probably more so, for the reason that, in addition to the large number of old levees broken, there were many new districts in process of reclamation which were inadequately protected by levees not yet completed. It has been estimated that over 300,000 acres of land were, at various times flooded during the January and February floods of 1909. The map reproduced in this bulletin as figure 48, p. 90, through the courtesy of the Great West, from data furnished by the bureau, shows approximately the area that was flooded in the Sacramento Valley during the floods of 1907 and 1909.

## THE FLOODS OF JANUARY AND FEBRUARY, 1911.

On January 30, 1911, heavy, warm rains began falling in the headwaters of the tributaries of the San Joaquin, which resulted in the greatest flood in the history of the Lower San Joaquin Valley.

*Daily precipitation at selected stations in the San Joaquin watersheds Jan. 20 to Jan. 31, 1911.*

[See hydrographs, figs. 41 to 43, for this period.]

| Date. | Firebaugh. | North Fork. | Merced Falls. | Friant. | Yosemite | Jacksonville. | Melones. | Lathrop. | Electra. | Jenny Lind. |
|---|---|---|---|---|---|---|---|---|---|---|
| Elevation..... feet.. | 154 | 3,000 | 321 | 355 | 3,945 | 602 | 750 | 19 | 670 | ........ |
| Jan. 20 | 0.36 | 0.85 | 0.17 | 0.05 | 0.40 | 0.44 | 1.10 | 0.36 | 1.26 | 0.94 |
| Jan. 21 | .00 | .23 | .91 | .34 | .04 | 1.30 | 1.34 | .72 | 1.34 | .00 |
| Jan. 22 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 |
| Jan. 23 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 |
| Jan. 24 | .40 | 3.20 | .74 | .64 | .90 | 1.04 | 1.28 | .74 | 1.46 | 1.16 |
| Jan. 25 | .34 | 2.60 | .77 | 1.28 | .79 | 2.20 | 2.00 | .82 | 1.60 | .82 |
| Jan. 26 | .00 | .00 | .04 | .12 | .00 | .32 | .26 | .12 | .82 | .46 |
| Jan. 27 | .00 | .00 | .04 | .00 | .00 | .10 | .22 | .12 | .62 | .04 |
| Jan. 28 | .00 | .35 | .05 | .02 | .27 | .20 | .46 | .00 | .22 | .20 |
| Jan. 29 | .18 | 2.12 | .17 | .20 | .48 | .46 | .36 | .32 | .44 | .40 |
| Jan. 30 | 1.20 | 2.86 | 2.73 | 1.84 | 1.20 | 3.50 | 4.40 | .92 | 3.42 | 2.40 |
| Jan. 31 | .60 | 1.57 | 2.30 | 1.08 | .06 | 3.06 | 3.02 | .55 | 2.80 | 1.62 |
| Sum | 3.08 | 13.8 | 7.92 | 5.57 | 4.14 | 12.6 | 14.4 | 4.67 | 14.0 | 8.04 |

About 24 hours after the beginning of the rains the flood waters of the Merced, Stanislaus, and Tuolumne Rivers had practically reached the main stream, and three flood waves of great intensity began moving down the San Joaquin. The combined force of these waves reached the lowlands in the vicinity of Lathrop and San Joaquin Bridge during the day of February 1, and by night of this date many thousands of acres of land became flooded. Many head of stock were drowned between Mendota and Lathrop, and in the vicinity of San Joaquin Bridge there were many residences either washed away or else undermined. It has been estimated that ten thousand or more acres were under water between Firebaugh and Lathrop. By the morning of February 2 the flood waters had spread over a large territory between Lathrop and Roberts Island, destroying a number of levees and inundating several thousand acres of reclaimed land. In the meanwhile the Mokelumne had poured its flood waters into the lowlands, doing considerable damage. During this flood the Calaveras overflowed its banks after reaching Mormon Slough and flooded several thousand acres of land between Bellota and Stockton. The city itself was probably saved from one of the most disastrous floods in its history by a diverting canal, which deflected the water of Mormon Slough and carried it down into the Calaveras proper below Stockton. It has been conservatively estimated that fully 75,000 acres of land were overflowed in the San Joaquin Valley between Stockton and Mendota and in the vicinity of Bellota and Linden during the floods of January and February, 1911.

*Hydrographs, San Joaquin flood, January–February, 1911.*

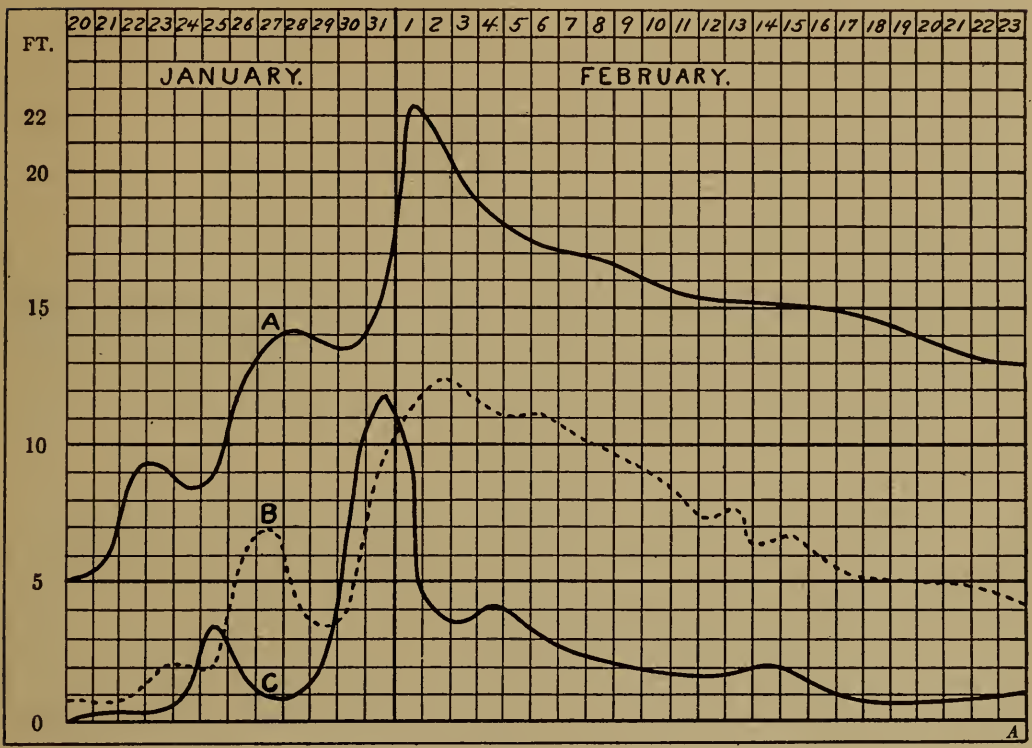



FIG. 41.—Hydrographs San Joaquin flood, 1911. A, Lathrop; B, Firebaugh; C, Friant.

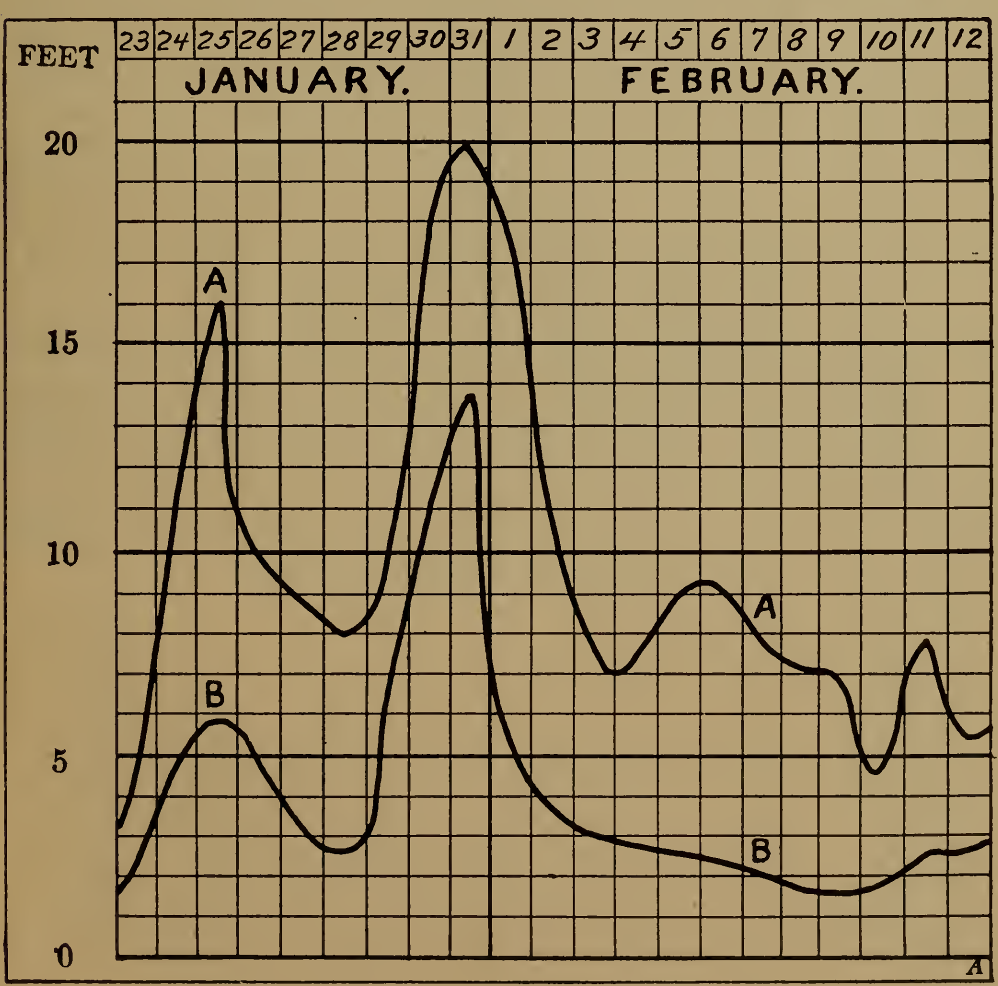



FIG. 42.—Hydrographs, January and February, 1911. A, Bellota; B, Jenny Lind.

*Hydrographs, San Joaquin flood, January–February, 1911*—Continued.

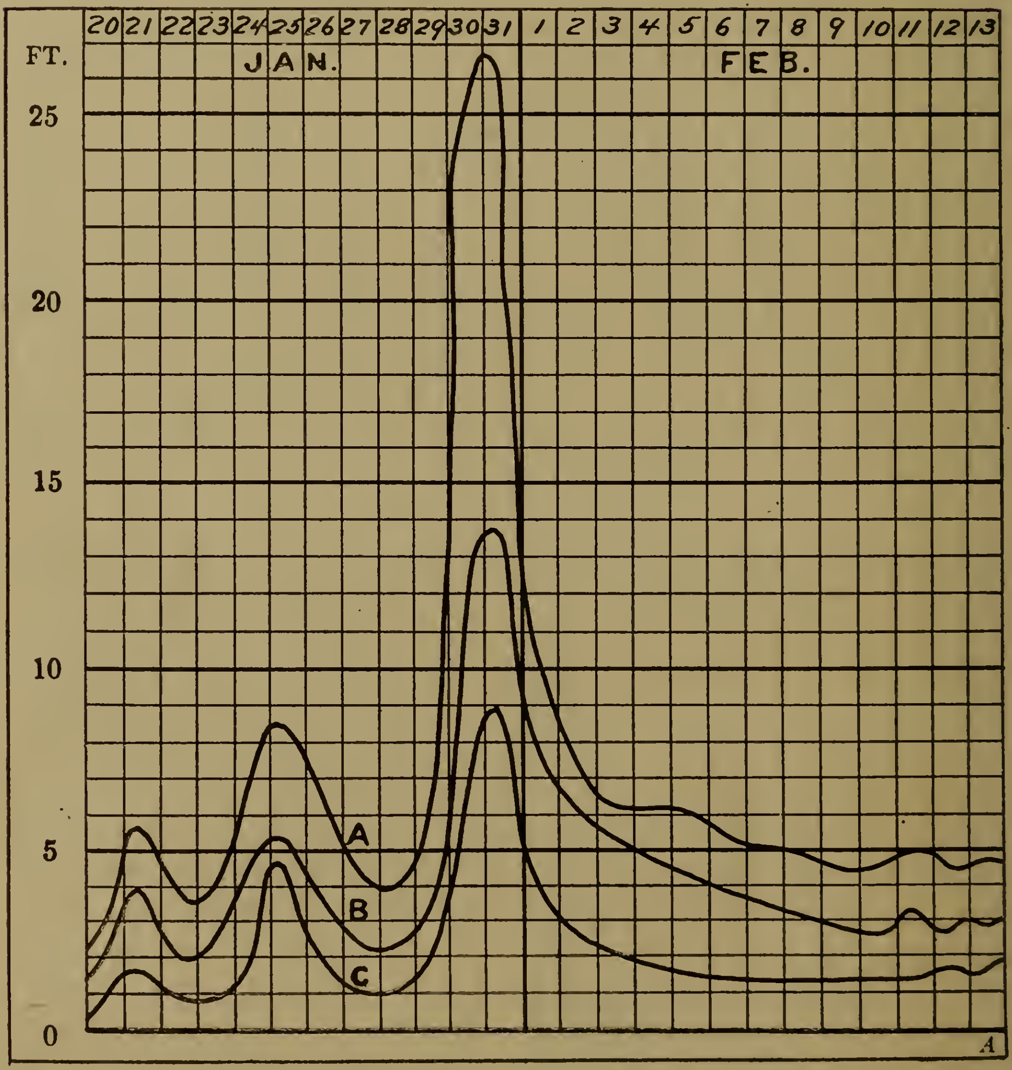



FIG. 43.—A, Jacksonville; B, Melones; C, Merced Falls.

River conditions in the Sacramento Valley again became critical in March, 1911, and a stage of 27.4 feet was recorded at Colusa on the 9th of that month. Heavy rains in the foothills that form the western boundary of Colusa Basin resulted in what is known as the "Trough" of this basin, reaching the highest stage ever before known. The water in this trough continued to menace the back levees that protected it from the foothill drainage, and finally, on April 25, 1911, those which protected reclamation No. 108 gave way, flooding 25,000 acres of land, the most of which was planted to grain, the entire crop being destroyed.

From April, 1911, to January 28, 1912, the date of this report, there have been no floods in the central valleys of California.

### WARNINGS.

During all the floods that occurred in 1907, 1909, and 1911 the Weather Bureau issued warnings to every point involved from 12 hours to as much as 3 days in advance of the approach of the flood waters. Advices from the bureau regarding the great floods that prevailed in the delta lands of the Sacramento and San Joaquin Rivers in 1907 and 1909 not only indicated the intensity of the floods, but timed their approach within a couple of hours three days in advance.

The table below shows approximately the losses that were sustained in the Sacramento and San Joaquin Valleys during the floods of 1904, 1907, 1909, and 1911, and the amount that was saved by reason of the warnings that were issued by the Weather Bureau during those of 1907, 1909, and 1911.

### Losses in the Central Valleys of California During the Floods of 1904, 1907, and 1909.

From reliable reports, and from data which have been gathered from time to time during the past four years, it is estimated that losses due to floods in the drainage basins of the Sacramento and San Joaquin Valleys during the floods noted above aggregate over $10,000,000.

The losses have been divided as follows:

| | |
|---|---|
| Buildings | $200,000 |
| Lumber | 75,000 |
| Levees | 3,500,000 |
| Stock | 200,000 |
| County roads | 1,000,000 |
| County bridges | 900,000 |
| Railroads, including roadbeds and bridges | 2,000,000 |
| Crops destroyed | 1,250,000 |
| Damage to lands by erosion | 500,000 |
| Losses sustained by suspension of business | 200,000 |
| From all other causes | 500,000 |
| Total | 10,325,000 |

The amount saved during the floods of 1907 and 1909 by reason of the timely warnings that were issued by the Weather Bureau aggregate close to $2,000,000. This amount is quoted from estimates that have been received from all sections covered by the floods. It has been admitted that the amount saved would have been much greater had the warnings been heeded in all cases.

### THE FLOOD PLANE OF THE SACRAMENTO RIVER.

In studying the tables of high stages in the Sacramento River at Sacramento City and at other points in the Sacramento Valley, it will be noted that the flood plane has become higher each year; that since the high water of 1850 almost each succeeding flood has been higher than that of its predecessor. In fact, the expression so often heard among river men to the effect that the rivers are rising higher each year has, up to the flood of 1909, become a recognized fact.

The ever-increasing flood plane in the Sacramento River at all points above the mouth of the Feather is, no doubt, due (1) to the increased height and strength of the levees along the river banks, and (2) the constant enlargement of reclamation areas. Both of these causes have, at most points, restricted the natural bed of the river to a channel at no time wide enough to carry its discharge under extreme conditions. The same may be said of the Lower Sacramento, American, Feather, Bear, and Yuba Rivers, except that the predominating cause in the raising of the high-water plane in these streams is the amount of mining débris that has been deposited in their beds. Until March 1, 1893, when a law was passed restricting hydraulic mining, millions of cubic yards of débris were annually being dumped into the upper reaches of these rivers; and, as it slowly found its way downstream, the finer particles advancing at moderate stages and the coarser and heavier matter moving farther and farther down with each succeeding high water or freshet, it not only became a serious menace to the agricultural lands on both sides of the rivers by causing overflows at moderate stages, but affected the navigability of the lower Sacramento River and for a time practically eliminated the Feather River from its mouth to its junction with the Yuba as a navigable stream.

According to notes kindly furnished by Mr. W. T. Ellis, jr., member of the State reclamation board, and for many years president of the Marysville Levee Commission, both the Feather and Yuba Rivers were navigable for a considerable distance above Marysville in the early days of the State's history. This is evidenced by the fact that in 1849 the steamer *Linda* came around the Horn from an Atlantic port and made a trip up the Yuba for a distance of 4 miles above Marysville. In notes, also furnished by Mr. Ellis, it is stated that the steamer *Phoenix* made a trip up the Yuba as far as Owsleys Bar in 1854. In fact, it is a matter of authentic record that before the Feather and Yuba were filled with mining débris Marysville was the natural distributing point for the northern mining section of the State. It is of record at Marysville that on August 27, 1850, there were 24 sailing vessels in the "port" of Marysville, and on August 22, 1851, there arrived at Marysville 7 steamers with full cargoes. In the news columns of the Sacramento Bee of February 16, 1862, it is noted that the steamer *Defiance* made several trips to Oroville with freight during the months of January and February, 1862.

As an illustration of the depth of the bed of the river at Marysville before the filling in by mining débris, Mr. Ellis states that it is a matter of record that during the great flood of 1861–62, when almost the entire Sacramento Valley was inundated, including the city of Sacramento, the flood waters did not reach what was then and is still the main business portion of Marysville. While there are no records of the discharge of the flood waters at that time, they were, no doubt, much greater than those of 1907. It is of record that the rainfall at Nevada City during the winter of 1861–62 was 115 inches, and assuming that the same amount occurred at corresponding elevations in the Feather-Yuba watershed, makes it almost certain that the discharge of 1861–62 was far in excess of the 1907 and 1909 floods, when Marysville experienced considerable difficulty in protecting itself from overflow.

According to reports of engineers during the first 20 years of unrestricted hydraulic mining, from 1849 to 1869, the low-water plane of the Sacramento River at Sacramento City was raised 2.9 feet; that during the next 10 years, 1869 to 1879, the rise of this plane was doubled. Some engineers claim that the low-water plane from 1849 to 1900 was raised fully 7 feet. Col. Mendell, in his report, states that as a consequence of the elevation of the bed of the Sacramento River the tidal influence which in 1849 extended up as high as the mouth of the Feather, 25 miles above Sacramento, and was quite 2 feet at Sacramento, is now no longer noticeable above Hancock Shoals, 9 miles below Sacramento.

Capt. Thomas H. Jackson, United States Corps of Engineers, in connection with his examination and survey of the Sacramento River from its mouth to the Feather in 1908, states as follows:

> A comparison of this survey with that of 1895–96 shows that the river is improving as a navigable channel; that it is recovering from the effects of hydraulic mining. It is estimated that the river bed for a distance of 14 miles below Sacramento has lowered 2 feet within the past 12 years. The American and Feather Rivers, however, are still full of débris, and the effect of the sand deposits in the American River on the Sacramento River are noticeable for a considerable distance below the mouth of that river, and the fact that these two rivers contain probably more than 500,000,000 cubic yards of material, all of which must eventually pass down the Sacramento River to Suisun Bay, must be borne in mind in any consideration of the improvement of the river.

It is quite evident, however, that there has been a further improvement in the bed of the Sacramento River in the vicinity of Sacramento City and, no doubt, for some distance below, since the floods of 1909, as during the low-water period of 1910 it was noted that the tides extended quite to the mouth of the American River, and at times swelled the Sacramento River in the vicinity of Sacramento City as much as 0.4 foot. During August and September, 1912, when the river at Sacramento probably reached the lowest point in the history of the city, tides exceeding 1 foot were noted.

## Flood Basins of the Sacramento River.

Numerous basins on both sides of the Sacramento River have at all times exercised a modifying influence on the floods in this stream by freely admitting the overflow, either through weirs constructed for this purpose or through breaks in the levees. On the east side of the river are four distinct depressions known as Butte, Sutter, American, and Sacramento Basins. In a report of the commissioner of public works to the governor of California in 1894, which report is quoted in a paper before the American Society of Engineers, by W. B. Clapp and others, the following areas and capacities of these basins are given: Butte Basin is north of Marysville Butte and has an area of from 30 to 150 square miles, depending upon the river stage, and a capacity of 460,000 acre-feet at flood stages. It discharges through Butte Slough into Sutter Basin. Sutter Basin is south of Marysville Butte and north of the Feather River. It has an area of 138 square miles and a capacity of 890,000 acre-feet at flood stages. It discharges through sloughs into the Sacramento River above the mouth of the Feather. The American flood basin is south of the Feather and north of the American. It has an area of 110 square miles and a capacity of 571,000 acre-feet at flood stage. It discharges into the Sacramento River north of the city of Sacramento. This basin is of considerable depth at its lowest point, and even during the extreme low water of 1912 contained a large amount of water. At the present time practically all of the American Basin is being leveed with a view to its complete reclamation, and it is expected that it will eventually be eliminated as a flood basin. The Sacramento Basin, so-called, is a narrow depression south of the American and extends thence southward nearly to Walnut Grove. Its area and capacity have not been determined. In fact this basin, if such it may be called, has long ago been reclaimed although its lower or southern end is liable to overflow from the Mokelumne River, when this stream is out of bank, and from the Sacramento in the event that its east side levees give way. Yolo Basin, on the west side of the Sacramento River, was originally one unbroken depression extending from Stony Creek on the north to the mouth of Cache Slough on the south, but it is now divided into two well-defined basins by a ridge that was formed by overbank flow and sediment deposit from the original channel of Cache Creek, which at one time discharged direct into the Sacramento River. This ridge terminates just north of Knights Landing and extends back toward the foothills. North of this ridge is now known as Colusa Basin and south of it is Yolo Basin. Quoting from the Report of Public Works in 1894, Yolo Basin is 50 miles long and 7 miles wide with a capacity of 1,115,000 acre-feet. It discharges into Cache Creek and thence into the Sacramento River through Steamboat Slough.

Colusa Basin is some 45 miles long and from 2 to 7 miles wide, with a capacity of 690,000 acre-feet at flood stage. Until within the past few years Colusa Basin discharged into the Sacramento through Sycamore Slough, but the various processes of reclamation have altogether altered flood conditions both with regard to the water that flows in from the western hills and that from the river. A back levee protects the basin from the hill water and a canal between this levee and the hills now carries the hill drainage into the Sacramento near a point where the lower Sycamore Slough once joined the river at Knights Landing. During the floods of 1907 and 1909 the water that escaped into Colusa Basin from the Sacramento side, where many levees broke, flowed over Knights Landing Ridge into the Yolo Basin. Colusa Basin has, however, been almost entirely if not quite reclaimed and has practically been eliminated as a flood basin. Plans have been made for the cutting of Knights Landing Ridge which, in connection with the west side canal, will make a branch river to which all hill streams will be tributary, leading them down into and eventually through Yolo Basin.

During the 1907 and 1909 floods the protecting levees on the west side of the Feather River, about opposite Marysville Butte, were destroyed by an enormous rush of water which flowed overbank at Hamilton Bend. This water came across the plains to the north of the buttes with such force and volume as to rush directly across the flooded Sacramento River, and after tearing out the west side levees it continued down through Colusa Basin, leaving destruction in its wake. During the 1907 flood the water in Colusa Basin was level with the crest of Knights Landing Ridge, but in 1909, according to measurements made by Mr. G. B. Herington, consulting engineer, Sacramento, Cal., it flowed 4 feet deep over the ridge into Yolo Basin. It was the backwater from this overflow that flooded Knights Landing during the 1909 flood and that kept that town under water for about 41 days. Massive levees have now replaced those that were demolished at Hamilton Bend, and it is not thought that Colusa Basin will again be menaced by the Feather River. (For map of overflowed region, see fig. 48, p. 90.)

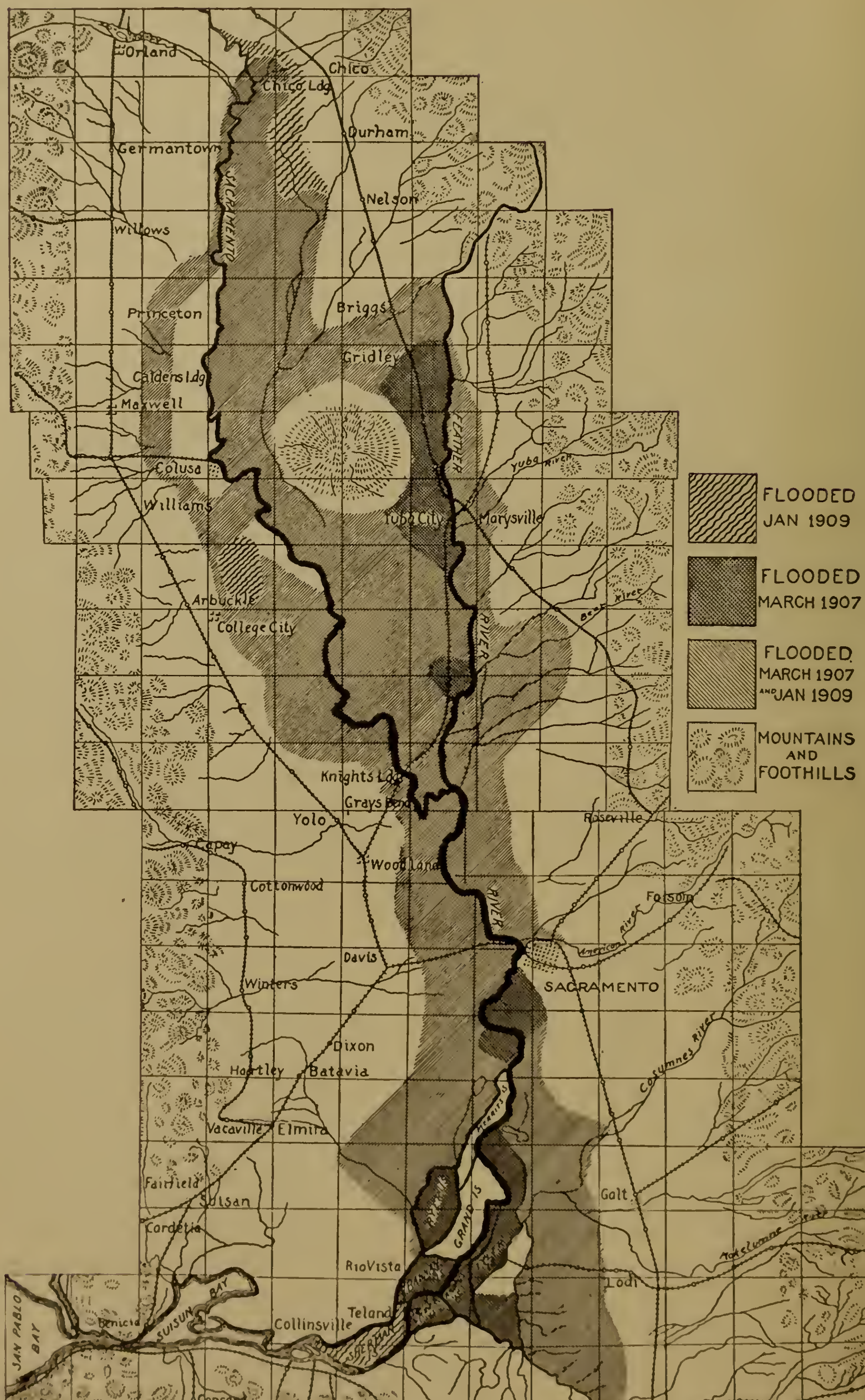



Fig. 48.—Inundated region in Sacramento Valley.

## Delta Lands of the Sacramento and San Joaquin.

In the lower reaches of the Sacramento and San Joaquin Rivers are numerous low tracts of land and many islands, all of which have been built up by silt from both streams. Some of the islands are composed of a combination of silt and peat. The reclamation of these lands, which are the most productive on earth, has necessitated the erection of levees not only strong enough to withstand a long siege of high water, but also to resist the action of winds and tides, both of which are strong factors during periods of high water.

On account of the numerous islands that are separated from the mainland and the many tracts that are dissected by sloughs and other waterways, and the wide range of tides in the lower districts, no Weather Bureau gages have been established in the delta below Rio Vista. Mr. W. E. Meek, a prominent citizen of Antioch, with large agricultural interests in the island districts, made measurements in parts of the lower San Joaquin River during the floods of 1907, 1909, and 1911.

In comparing the floods in the delta of 1907 and 1909, Mr. Meek states that the highest water reached in 1907 was exceeded by that of 1909 in all of the lower districts. In the San Joaquin River above Stockton, however, the crest of the 1907 flood was about 0.5 of a foot higher. During the 1911 floods the water in the lower San Joaquin between Stockton and Mendota was between 2 and 3 feet higher than ever before recorded. But, as stated by Mr. Meek, it did not come within 18 inches as high in 1911 as it did in 1909 on the following-named islands: Andrus, Bradford, Jersey, Sherman, and Twitchel.

The following-named lands in the delta were flooded in 1907: Andrus Island,[a] Bethel tract,[a] Bouldin Island,[a] Brannan Island, Burke tract, Byron tract, Clifton Court tract, Coney Island, Elmwood tract, Franks tract, Jersey Island,[a] lower Jones tract, Lower Sherman Island,[a] Moss tract, Ridge tract, Ryer Island, Sargent Burnhardt tract, Statin Island, Stone tract, Terminus District, Twitchel Island,[a] Tyler Island, Venice Island,[a] Victoria Island, and Webber tract, aggregating 130,744 acres.

## Conclusion.

During the past few years large interests have recognized the ultimate value of all reclaimable lands in the central valleys of California. In the Sacramento Valley especially millions of dollars are now being applied to the work of reclaiming the various flood basins heretofore considered as waste land. According to the Report on the Control of Floods in the River Systems of the Sacramento and San Joaquin Valleys, published in 1911, there are 48 reclamation

[a] Also flooded in 1909.

districts in the Sacramento Valley itself. Reports on 41 of these districts, with an area of 217,904 acres, showed on July 1, 1909, that 205,423 acres have been completely reclaimed and 99,376 acres partly reclaimed by the construction of 521 miles of levees. To these figures should now be added nearly 200,000 acres, as since 1909 the reclamation of Colusa Basin has been practically completed, about 12,000 acres on the west side of the river opposite Sacramento City have been reclaimed, 90,000 acres, comprising the American Basin and other low lands east of the Sacramento and between the Bear and American Rivers, are in process of reclamation, and tentative plans are afoot for the reclaiming of 60,000 acres within Sutter Basin.

Immense levees, practically impregnable, now skirt the Feather River from Vernon to a point near Marysville, and on the south side of the Bear River from its mouth to a point near Wheatland. These levees will not only confine the flood waters of the Bear and Feather Rivers, but will result in a reduction of the time it formerly took them to reach the main stream.

During the floods of 1907 and 1909 the overflow waters of the Feather, Yuba, and Bear Rivers escaped freely into Butte, Sutter, and American Basins, which not only tended to flatten out the flood wave of the Feather River below the mouth of the Bear, but delayed its approach to the mouth of the American River until the crest of the flood wave of this stream had passed into the Sacramento below Sacramento City.

Under present conditions it is estimated that flood water in the lower Feather River will reach the mouth of the American at least two hours earlier than heretofore, provided, of course, that it is not drawn off into Yolo Basin either by the breaking of the west side Sacramento River levees or through artificial by-passes of sufficient width and capacity to materially lower the water level in the main stream.

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