DEPARTMENT OF THE INTERIOR

WATER-SUPPLY

AND

IRRIGATION PAPERS

OF THE

UNITED STATES GEOLOGICAL SURVEY

No. 68

WASHINGTON
GOVERNMENT PRINTING OFFICE
1902

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

WATER STORAGE

IN THE

TRUCKEE BASIN, CALIFORNIA-NEVADA

BY

L. H. TAYLOR

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DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF HYDROGRAPHY,
Washington, D. C., April 15, 1902.

SIR: I have the honor to transmit herewith a paper prepared by Mr. L. H. Taylor, entitled Water Storage in the Truckee Basin, California-Nevada, and to request that it be published in the series of Water-Supply and Irrigation Papers. It relates to surveys and examinations made by Mr. Taylor, as resident hydrographer of this Survey, and in cooperation with the State of Nevada, in order to ascertain the extent to which the waters of Truckee River can be conserved and utilized in the development of the arid lands of that State. Mr. Taylor shows that by constructing various dams and other hydraulic works a large amount of water which now runs to waste can be saved and conducted out upon vacant public land, furnishing a supply also to some of the lands now in private ownership. This is one of the most important of the interstate irrigation problems which have been carefully examined. The construction of the works described by Mr. Taylor would do much toward increasing the cultivated area and the population of Nevada, and would cause the State to rise rapidly in agricultural rank.

Very respectfully,

F. H. NEWELL,
Hydrographer in Charge.

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

WATER STORAGE IN THE TRUCKEE BASIN, CALIFORNIA-NEVADA.

By L. H. TAYLOR.

LOCATION OF BASIN.

The region drained by Truckee River is embraced between meridians 119° 10′ and 120° 28′ west longitude and parallels 38° 42′ and

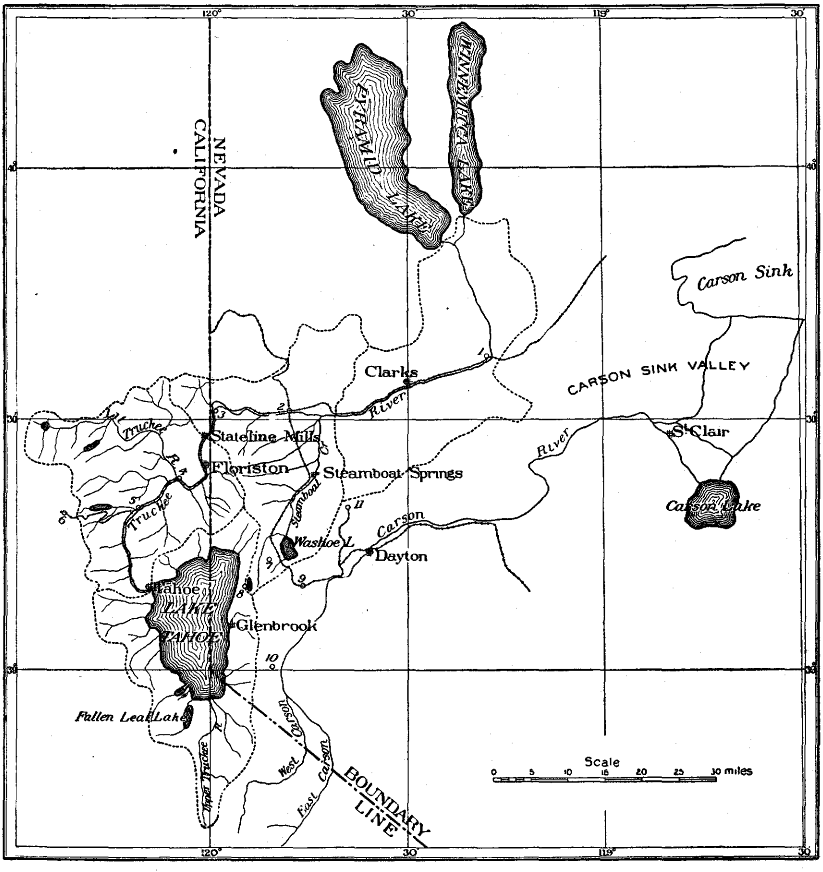


FIG. 1.—Map of the Truckee Basin, showing minor drainage basins and location of rainfall stations.

Rainfall stations:

1. Wadsworth.	4. Boca.	7. Lewers's ranch.	10. Genoa.
2. Reno.	5. Truckee.	8. Marlette Lake.	11. Virginia.
3. Verdi.	6. Summit.	9. Carson.	

40° 20′ north latitude, being partly in the State of California and partly in Nevada. (See map of Truckee Basin, fig. 1.) The upper or western portion of the basin lies immediately east of the summit of the main Sierra Nevada, and embraces a high, forest-clad region ranging in altitude from 5,000 to 11,000 feet above sea level, on which the precipitation, which is mainly in the form of snow, is heavy. The greater part of the area is in the State of California. The eastern or lower part of the basin, which is entirely within the State of Nevada, is essentially different in character, being made up of broad, open valleys and barren hills, distinctly typical of the Great Basin.

The river flows northward and enters Lake Tahoe at an elevation of 6,225 feet above sea level. This lake is the largest body of fresh water at that altitude in the United States, its area being 193 square miles. (A portion of the lake is shown in Pl. I; see also fig. 5, p. 44.) As the boundary line between Nevada and California passes through the lake, a portion of it is in each State. The outlet of the lake is at Tahoe, Cal. After leaving the lake the river has a general northward course until it reaches Verdi, Nev., a short distance from the State line, and about 40 miles from the lake. In this part of its course it receives a number of important tributaries which augment its flow. There are a number of lakes at the headwaters of the branch streams. After passing Verdi the river, entering what has been called the lower portion of the Truckee Basin, flows eastward a distance of 45 miles, passing through the Reno Valley and the Lower Truckee Canyon to Wadsworth, whence it turns northward, flows about 20 miles farther, and discharges into Pyramid and Winnemucca lakes.

PRECIPITATION.

Precipitation records have been kept at eight places within the basin of Truckee River, and at three stations—Virginia, Carson, and Genoa—immediately adjacent to the south and east, as shown in fig. 1. At a majority of these stations, in fact at all except Reno and Lewers's ranch, in the Truckee Basin, the observations were made by the agents and telegraph operators of the Southern Pacific Railroad Company. The records afford the only data available, and probably furnish means approximating the truth.

The following table gives the annual precipitation at all of the stations referred to except Marlette Lake, where observations were made during only twelve months, from July 1, 1894, to June 30, 1895:

PORTION OF LAKE TAHOE.

Annual rainfall, in inches, at ten stations on eastern slope of Sierra Nevada in and adjacent to basin of Truckee River.

Year.	Wads-worth (4,077).*a*	Reno (4,497).*a*	Verdi (4,895).*a*	Boca (5,541).*a*	Truckee (5,819).*a*	Sum-mit (7,017).*a*	Lewers's ranch (5,177).*a*	Genoa (4,824).*a*	Carson (4,670).*a*	Vir-ginia (6,242).*a*
1870	2.30			13.46	23.28	34.29				
1871	4.04	4.86		16.87	36.71	60.60				
1872	0.70	4.11		8.40	27.29	37.90				
1873	1.84	2.75		11.65	26.16	40.95				
1874	4.13	5.70		21.85	35.69	18.85				
1875	3.96	6.06		10.66	27.50	33.86			17.73	
1876	2.27	3.59		17.73	28.85	46.90			9.06	
1877	4.27	5.68		8.89	16.13	26.73				
1878	4.85	6.32		15.81	25.81	32.69				
1879	3.88	4.02		21.08	27.86	73.67				
1880	3.31	6.70		16.79	37.61	64.50			13.10	
1881	5.01	5.89		2.42	21.28	30.95			10.33	
1882	3.56	5.48		21.00	30.50	62.12			11.29	
1883	2.82	3.95		11.30	16.80	23.57			6.95	
1884	4.79	6.17		28.60	43.81	60.47			17.82	
1885	3.59	2.95		8.38	14.91	25.41			11.32	
1886	5.30	4.82		17.60	18.55	41.00			10.93	
1887	6.70	5.78		20.39	25.95	49.97			8.54	
1888	3.78	4.60		11.23	8.85	38.02			7.12	
1889	5.19	6.43	17.87	38.40	19.16	51.42		22.80	12.44	
1890	6.78	9.72	15.63	32.07	39.45	58.83		16.89	13.80	
1891	6.22	10.45		28.10	26.85	26.03	29.00	22.61	18.30	20.41
1892	4.65	11.92	18.33	29.05	31.10	44.70	26.29		14.25	15.91
1893		4.74		27.62	32.54		22.66	15.78	11.42	14.79
1894		7.27		27.64	30.45		25.69	12.50	12.78	19.78
1895	4.51	5.53	20.97	16.47	23.39		20.36	10.45	10.91	
1896	10.28	10.59	23.09	30.50	29.61		30.50		14.64	
1897	7.25	8.00	13.13	26.02	27.33		25.61		13.62	
1898	4.27	6.41	3.91	14.81	12.21	31.46	14.32		6.04	
1899	5.32	8.50	18.06	32.47	33.86	73.80	26.35		9.78	
1900	5.30	7.81	8.97	25.29	17.56	42.52	23.72		10.13	

a Elevation above sea level, in feet.

For the purpose of showing the distribution of rainfall throughout the year the following tables of the monthly precipitation during the last thirteen years at the eleven stations mentioned have been prepared. The tables have been arranged for the twelve months beginning September 1 and ending August 31 of the following year, as the latter date is near the end of the irrigating season and is the time when the streams reach their lowest stage.

Monthly precipitation, in inches, at Wadsworth, Nev.

[Elevation, 4,077 feet.]

Season.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1888-89									0.29	0.24	0.00	0.00	
1889-90	0.00	0.29	0.55	1.16	1.95	0.70	0.28	0.04	1.10	0.00	0.00	0.00	6.07
1890-91	1.55	0.50	0.05	0.61									
1894-95	*a* 0.35	*a* 0.39	*a* 0.57	*a* 0.62	0.75	0.55	0.20	0.20	1.06	0.00	0.05	0.05	*b* 4.79
1895-96	0.05	0.05	0.45	0.10	3.22	0.00	0.22	0.35	0.64	0.00	2.04	1.20	8.30
1896-97	0.41	0.10	2.05	0.05	0.89	2.33	0.23	0.00	0.30	0.20	0.00	0.00	6.56
1897-98	0.25	1.78	0.29	0.98	0.83	0.05	0.60	0.30	1.37	0.00	0.00	0.05	6.50
1898-99	0.18	0.22	0.58	0.09	*a* 1.21	0.30	0.70	0.10	0.42	*a* 0.07	0.10	0.05	*b* 4.02
1899-1900	0.00	0.20	0.10	1.95	0.35	0.25	0.64	1.92	1.12	0.05	0.08	0.00	6.66
1900-1901	0.34	T.	0.50	0.05	0.51	1.18	*a* 0.41	0.30	0.76	0.10	0.00	1.92	6.07
Mean	0.35	0.39	0.57	0.62	1.21	0.67	0.41	0.40	0.77	0.07	0.25	0.36	6.07

a Normal rainfall; record for month is missing.
b Includes the months for which rainfall has been estimated.
T. indicates trace.
Records for missing years are not obtainable.

Monthly precipitation, in inches, at Reno, Nev.

[Elevation, 4,497 feet.]

Season.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1888-89	0.00	0.00	0.99	0.43	0.30	0.25	0.95	0.00	0.17	0.00	0.00	0.00	3.09
1889-90	0.00	0.75	1.10	2.91	4.20	1.75	0.80	0.16	0.31	0.00	0.00	0.16	12.14
1890-91	0.90	0.00	0.00	1.30	0.06	2.69	0.28	0.56	2.72	0.41	*a* 0.15	*a* 0.38	*b* 11.45
1891-92	0.54	*a* 0.31	0.05	1.14	0.58	1.40	0.76	0.09	0.22	1.27	0.00	0.00	*b* 6.36
1892-93	0.07	0.27	4.65	2.61	1.51	1.10	0.58	0.38	0.13	0.00	0.00	0.04	11.34
1893-94	0.24	0.02	0.42	0.32	0.89	1.42	0.22	0.10	0.91	1.06	0.31	0.11	6.02
1894-95	0.19	0.16	0.02	1.88	2.81	0.33	0.07	0.39	0.57	0.00	0.00	0.02	6.44
1895-96	0.24	0.10	0.17	0.83	2.87	0.00	1.15	1.31	1.23	0.00	1.03	0.79	9.71
1896-97	0.93	0.08	0.89	0.31	1.05	2.10	0.72	0.03	1.73	0.20	0.00	0.07	8.11
1897-98	0.02	0.96	0.16	0.87	0.99	1.47	0.65	0.41	0.95	0.00	0.00	0.16	6.64
1898-99	0.31	0.24	0.63	0.60	*a* 1.52	0.65	1.03	0.12	0.41	0.40	0.22	1.37	*b* 7.49
1899-1900	T.	0.72	0.47	1.69	0.50	0.27	0.59	1.75	0.39	1.08	0.18	*a* 0.38	*b* 8.02
1900-1901	0.67	0.44	1.48	0.46	2.48	3.24	0.39	0.32	1.60	T.	T.	1.60	12.68
Mean	0.32	0.31	0.85	1.18	1.52	1.28	0.78	0.43	0.87	0.34	0.15	0.38	8.41

a Normal rainfall; record for month is missing.
b Includes the months for which rainfall has been estimated.
T. indicates trace.

Monthly precipitation, in inches, at Verdi, Nev.

[Elevation, 4,895 feet.]

Season.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1888-89	------	------	------	------	0.05	0.40	2.98	0.14	3.30	0.01	0.00	0.00	------
1889-90	0.00	1.53	3.43	6.03	9.11	1.74	2.00	0.00	*a* 1.25	*a* 0.24	0.00	0.10	*b* 26.43
1890-91	0.00	0.72	T.	0.33	------	------	------	------	------	------	------	------	------
1894-95	------	------	------	------	10.06	2.20	0.73	1.06	1.10	0.55	0.00	0.07	------
1895-96	1.97	0.00	0.76	2.47	9.40	0.08	2.18	2.46	2.29	0.00	1.11	0.74	23.46
1896-97	1.00	0.18	2.05	1.60	1.35	4.99	2.75	0.00	0.40	0.20	0.00	0.20	14.72
1897-98	0.00	0.45	1.62	1.17	0.50	0.91	0.24	0.10	0.91	0.35	0.00	0.10	6.35
1898-99	0.19	0.05	0.20	0.36	*a* 4.29	0.55	4.60	0.50	1.09	0.03	*a* 0.16	1.60	*b* 13.62
1899-1900	0.00	2.10	0.90	2.05	0.74	0.30	1.35	0.20	0.41	0.75	0.19	0.22	9.21
1900-1901	0.00	1.10	2.75	1.15	3.10	5.40	0.60	0.60	0.50	T.	0.00	0.50	15.70
Mean	0.40	0.77	1.46	1.90	4.29	1.84	1.94	0.56	1.25	0.24	0.16	0.39	15.20

a Normal rainfall; record for month is missing.
b Includes the months for which rainfall has been estimated.
T. indicates trace.
Records for missing years are not obtainable.

Monthly precipitation, in inches, at Boca, Cal.

[Elevation, 5,541 feet.]

Season.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1888-89	0.12	0.00	0.95	1.45	4.25	3.10	1.15	0.10	3.90	0.00	0.00	0.00	15.02
1889-90	0.00	1.50	4.55	19.85	14.60	5.40	5.45	1.28	0.70	0.00	0.00	0.00	53.33
1890-91	0.00	0.70	0.00	3.65	1.25	11.80	2.50	1.70	1.40	0.25	0.05	0.00	23.30
1891-92	0.60	0.00	0.25	8.30	0.70	3.35	1.70	2.70	3.10	0.70	0.00	0.00	21.40
1892-93	0.00	1.50	8.35	6.95	4.55	8.90	4.00	1.90	1.35	0.00	0.00	0.05	37.55
1893-94	0.55	0.25	2.42	3.70	5.10	7.55	0.75	1.00	0.33	T.	0.00	T.	21.65
1894-95	T.	0.61	0.51	11.80	8.36	1.20	0.45	0.70	0.90	T.	0.00	T.	24.53
1895-96	0.97	0.11	0.71	3.07	7.75	0.50	6.30	6.65	3.10	0.25	1.15	0.18	30.44
1896-97	0.35	0.00	2.47	1.80	2.20	6.35	8.35	0.10	0.50	0.40	0.00	0.50	23.02
1897-98	T.	2.10	2.80	2.72	1.55	2.90	2.50	1.30	0.85	1.00	0.00	0.00	17.42
1898-99	0.01	1.28	1.84	1.58	6.80	1.85	7.95	0.85	2.40	0.10	0.00	0.98	27.64
1899-1900	0.00	4.42	2.59	4.53	1.57	0.60	3.52	0.60	1.10	2.67	T.	1.22	22.82
1900-1901	0.66	3.04	5.73	4.58	7.17	6.76	2.24	2.04	1.86	0.00	0.00	0.08	34.16
Mean	0.25	1.19	2.55	5.69	5.07	4.64	3.60	1.61	1.65	0.41	0.09	0.23	26.98

T. indicates trace.

Monthly precipitation, in inches, at Truckee, Cal.

[Elevation, 5,819 feet.]

Season.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1888-89	0.12	0.00	2.38	1.58	0.80	1.40	2.51	1.01	4.51	0.00	0.00	0.00	14.31
1889-90	0.00	3.13	3.29	2.51	16.20	8.90	7.29	0.20	1.44	0.00	0.00	0.22	43.18
1890-91	0.80	0.45	0.00	3.70	1.22	8.36	3.92	2.17	2.90	0.46	0.00	0.00	23.98
1891-92	0.98	0.05	0.45	6.34	2.65	2.80	3.00	2.96	4.20	0.95	0.00	0.00	24.38
1892-93	0.29	0.37	5.73	8.15	5.44	8.02	5.18	3.73	1.79	0.00	0.00	0.00	38.70
1893-94	1.22	0.38	3.96	2.82	8.06	0.73	2.65	2.15	1.05	T.	*a* 0.01	0.00	*b* 23.03
1894-95	0.13	1.12	0.60	13.95	11.73	1.92	1.72	0.50	2.40	0.00	0.00	0.00	34.07
1895-96	1.32	0.34	0.50	2.96	7.07	0.40	4.67	9.36	0.54	0.00	0.15	0.34	27.65
1896-97	0.32	0.40	3.86	2.50	2.35	7.97	9.50	0.30	T.	0.18	0.00	*a* 0.11	*b* 27.49
1897-98	T.	0.55	3.20	3.15	1.05	3.65	2.05	0.25	0.30	0.00	0.00	0.00	14.20
1898-99	0.40	0.06	2.95	1.50	7.80	2.70	9.50	1.10	0.75	0.00	0.00	0.92	27.68
1899-1900	0.00	6.49	2.80	1.80	2.63	0.80	4.20	1.90	0.80	1.01	0.00	0.00	22.43
1900-1901	0.00	1.02	2.50	2.70	5.00	7.97	2.50	1.80	0.70	0.00	0.00	0.00	24.19
Mean	0.43	1.10	2.48	4.14	3.54	4.20	4.36	2.11	1.64	0.20	0.01	0.11	24.42

a Normal rainfall; record for month is missing.
b Includes the months for which rainfall has been estimated.
T. indicates trace.

Monthly precipitation, in inches, at Summit, Cal.

[Elevation, 7,017 feet.]

Season.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1888-89	0.00	0.00	3.37	5.26	1.00	1.50	9.55	1.90	6.30	0.22	0.00	0.00	29.10
1889-90	0.00	5.65	6.80	18.50	19.20	11.60	14.00	0.00	*a* 3.60	0.00	0.00	0.00	*b* 79.35
1890-91	0.00	0.00	0.00	7.40	1.50	1.38	5.10	4.60	1.10	0.00	0.00	0.00	21.08
1891-92	0.10	0.05	0.30	11.90	4.00	3.40	7.40	4.50	6.30	0.20	0.00	0.00	38.15
1892-93	0.00	1.18	3.53	7.06	7.90	*a* 6.14	14.50	9.20	*a* 3.60	0.00	*a* 0.04	0.00	*b* 53.17
1893-94	------	0.30	------	------	------	------	------	------	------	------	------	------	------
1897-98	------	------	------	------	4.00	7.10	5.20	0.80	2.90	0.90	0.04	0.00	------
1898-99	0.15	4.40	2.50	3.60	12.70	5.20	15.75	1.75	3.60	0.70	0.00	1.00	*b* 51.35
1899-1900	0.00	16.05	9.15	7.90	5.25	4.75	8.15	4.80	3.97	0.50	0.25	T.	60.77
1900-1901	0.95	3.50	6.90	3.50	11.30	14.20	4.50	5.50	1.00	0.00	0.00	0.00	51.35
Mean	0.15	3.46	4.07	8.14	7.43	6.14	9.35	3.67	3.60	0.28	0.04	0.11	46.44

a Normal rainfall; record for month is missing.
b Includes the months for which rainfall has been estimated.
T. indicates trace.
Records for missing years are not obtainable.

Monthly precipitation, in inches, at Lewers's ranch, Nevada.

[Elevation, 5,177 feet.]

Season.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1889-90	------	------	------	------	------	------	4.39	0.28	1.04	0.00	0.00	1.42	------
1890-91	1.28	*a* 1.71	0.29	3.55	0.31	9.30	4.65	1.72	3.04	0.19	0.11	0.47	*b* 26.62
1891-92	0.96	0.07	0.72	7.46	0.60	1.92	2.16	2.04	1.69	1.53	0.03	0.00	19.18
1892-93	0.26	0.93	9.62	5.51	4.75	3.67	3.05	1.68	1.22	0.00	0.01	0.00	30.70
1893-94	2.22	0.34	3.81	1.91	5.53	5.39	1.80	0.56	1.86	1.77	0.40	0.09	25.68
1894-95	0.14	2.51	0.36	5.28	7.92	3.08	1.22	0.98	1.56	0.21	0.00	0.10	23.36
1895-96	1.95	0.26	0.01	3.07	10.70	0.30	3.99	3.99	2.83	0.00	0.58	0.94	28.62
1896-97	0.68	0.68	3.70	2.11	2.13	5.35	4.34	0.25	0.20	0.55	0.00	0.43	20.42
1897-98	0.08	4.41	3.66	4.21	0.86	1.75	4.57	1.18	1.07	0.23	0.01	0.27	19.30
1898-99	0.18	1.41	3.39	2.40	*a* 4.17	0.69	8.51	0.65	0.15	0.06	0.01	1.21	*b* 22.83
1899-1900	0.00	2.45	3.41	5.46	0.96	1.13	2.41	4.16	*a* 1.67	*a* 0.46	1.25	0.15	*b* 23.51
1900-1901	0.87	4.06	6.68	2.05	7.93	6.33	1.96	2.20	3.71	0.49	T.	0.75	37.03
Mean	0.78	1.71	3.24	3.91	4.17	3.54	3.34	1.64	1.67	0.46	0.20	0.49	25.15

a Normal rainfall; record for month is missing.
b Includes the months for which rainfall has been estimated.
T. indicates trace.

Monthly precipitation, in inches, at Marlette Lake, Nevada.

[Elevation, 7,800 feet.]

Season.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1893-94											0.30	0.23	
1894-95	0.38	2.22	0.60	8.77	9.10	4.75	3.49	0.95	1.92	0.00			

Records for other years are not obtainable.

Monthly precipitation, in inches, at Virginia, Nev.

[Elevation, 6,242 feet.]

Season.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1890-91					0.31	4.20	2.31	1.27	3.60	0.82	0.20	T.	
1891-92	1.68	T.	0.05	5.97	0.32	0.93	1.64	0.76	1.24	1.15	T.	*a* 0.09	*b* 13.83
1892-93	0.20	1.11	6.06	2.41	2.53	4.74	1.08	1.45	0.82	T.	T.	0.02	20.42
1893-94	1.68	0.10	1.26	1.11	3.54	5.14	1.40	0.46	1.62	3.27	0.32	0.24	20.14
1894-95	0.07	1.00	0.01	2.71									
Mean	0.91	0.55	1.85	3.05	1.67	3.75	1.61	0.98	1.82	1.31	0.13	0.09	17.71

a Normal rainfall; record for month is missing.
b Includes the months for which rainfall has been estimated.
T. indicates trace.
Records for other years are not obtainable.

Monthly precipitation, in inches, at Carson, Nev.

[Elevation, 4,670 feet.]

Season.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1888-89	0.59	0.00	2.00	0.61	0.10	0.27	1.63	0.03	1.91	0.33	0.00	0.00	7.47
1889-90	0.00	1.08	2.47	4.62	5.29	2.39	1.12	0.15	0.43	0.00	0.00	1.13	18.61
1890-91	1.01	0.03	0.01	2.31	0.10	4.18	2.55	1.85	2.80	0.29	0.21	0.00	15.34
1891-92	0.89	0.00	0.00	5.43	0.35	1.39	1.71	0.48	0.54	1.46	0.00	0.02	12.27
1892-93	0.26	0.30	5.85	1.89	3.18	2.42	1.47	1.01	0.37	0.00	0.00	0.11	16.86
1893-94	0.98	0.15	1.49	0.24	2.33	2.83	0.97	0.36	1.07	1.14	0.23	0.05	11.84
1894-95	0.05	0.29	0.22	3.24	4.59	1.96	0.32	0.40	0.73	0.02	0.00	0.04	11.86
1895-96	0.20	0.71	0.56	1.38	4.82	0.10	2.23	1.47	1.06	0.12	0.63	1.30	14.58
1896-97	0.38	0.30	1.53	0.70	1.47	4.17	2.83	0.04	0.20	0.12	0.27	0.34	12.31
1897-98	0.01	1.56	0.88	1.72	0.58	0.95	1.00	0.53	0.32	0.00	0.07	0.25	7.92
1898-99	0.15	0.67	1.39	0.13	*a* 2.09	0.35	2.29	0.30	0.52	0.07	T.	0.47	*b* 8.43
1899-1900	0.00	0.63	1.14	1.92	0.28	0.38	0.88	2.79	0.55	0.59	0.14	0.13	9.43
1900-1901	0.09	1.20	2.41	0.69	2.03	2.93	0.61	0.92	1.68	0.23	0.02	0.44	13.24
Mean	0.36	0.53	1.54	1.91	2.09	1.87	1.51	0.79	0.94	0.34	0.12	0.33	12.33

a Normal rainfall; record for month is missing.
b Includes the months for which rainfall has been estimated.
T. indicates trace.

Monthly precipitation, in inches, at Genoa, Nev.

[Elevation, 4,824 feet.]

Season.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1888-89	*a* 0.51	0.00	0.27	0.65	0.76	0.00	4.45	0.05	1.25	0.07	0.00	0.00	*b* 8.01
1889-90	0.00	2.92	5.45	7.85	6.02	2.33	3.80	0.00	0.70	0.00	0.00	0.15	29.22
1890-91	0.46	*a* 0.73	*a* 2.70	0.00	0.00	4.64	2.95	1.13	3.63	0.00	1.00	0.00	*b* 17.24
1891-92	0.80	0.00	0.00	8.46	*a* 3.38	0.31	2.45	1.35	0.30	*a* 0.02	*a* 0.25	*a* 0.20	*b* 17.54
1892-93	*a* 0.51	*a* 0.73	8.75	*a* 3.02	3.95	1.60	2.13	1.40	*a* 1.13	*a* 0.02	*a* 0.25	0.67	*b* 24.16
1893-94	0.54	0.20	3.44	0.45	2.90	2.82	0.70	0.00	0.42	*a* 0.02	*a* 0.25	0.20	*b* 11.94
1894-95	*a* 0.51	1.23	0.45	3.00	6.65	0.45	0.40	0.25	0.50	0.00	0.00	*a* 0.20	*b* 13.64
1895-96	0.75	0.00	0.53	0.72									
Mean	0.51	0.73	2.70	3.02	3.38	1.74	2.41	0.60	1.13	0.02	0.25	0.20	16.69

a Normal rainfall; record for month is missing.
b Includes the months for which rainfall has been estimated.
Records for other years are not obtainable.

Monthly precipitation at Glenbrook, Nev.

[Elevation, 6,240 feet.]

1901—	Inches.
January 15 to 31	0.60
February	5.10
March	1.23

The records at Reno and Wadsworth, in the lower portion of the basin, are generally applicable to the valley areas, where the water will be chiefly employed for irrigation, and show the need of an artificial supply. The records at the other stations give an idea of the rainfall in the higher portions of the basin, and serve as a basis for estimating the probable run-off from the various portions of the watershed.

The following table shows the increase in precipitation with increase in elevation:

Table showing increase in precipitation with each 100-foot rise in elevation, with Wadsworth, Nev., as a base.

Station.	Length of record.	Elevation.	Elevation above Wadsworth.	Mean precipitation.	Increase in precipitation over Wadsworth.	Constant increase for each 100 feet rise.
	Years.	*Feet.*	*Feet.*	*Inches.*	*Inches.*	*Inches.*
Wadsworth	28	4,077	0	4.48	0	
Reno	29	4,497	420	6.17	1.69	0.40
Verdi	8	4,895	818	16.37	11.89	1.45
Lewers's ranch	9	5,177	1,100	24.53	20.05	1.82
Boca	30	5,541	1,464	20.31	15.83	1.08
Truckee	30	5,819	1,742	26.65	22.17	1.27
Summit	25	7,017	1,940	43.55	39.07	2.01
Marlette Lake	1	7,800	3,723	32.71	28.23	0.76
Virginia	4	6,242	1,165	17.72	13.24	1.14
Carson	22	4,670	593	11.92	7.44	1.25
Genoa	6	4,824	747	16.84	12.36	1.65
Total						12.83
Mean						1.28

In the foregoing table, in computing the mean increase in precipitation per hundred feet rise, the same weight has been given to the record at Marlette Lake, though it covers only twelve months, as to each of the other stations. The reasons for this are: (1) For the period covered by this record the precipitation at most of the stations where observations were made was but slightly above the normal; and (2) the effect upon the mean, which is designed to serve as a basis for estimating the rainfall on various subdivisions of the Truckee Basin, is in the direction of conservatism.

DRAINAGE AREAS.

The map of the Truckee Basin (fig. 1, p. 9) was prepared from the topographic atlas sheets of the United States Geological Survey. The outlines of the various subdivisions of the basin, including the areas directly tributary to reservoir sites which are described in this report, were marked upon the topographic sheets and the areas measured by planimeter.

The following table classifies the basin of the Truckee above Pyramid and Winnemucca lakes into four parts: (1) The area above the outlet to Lake Tahoe, including the lake surface of 193 square miles, which would be tributary to that basin if utilized as a reservoir; (2) intermediate basins, including that of Little Truckee River between Lake Tahoe and Stateline Mills; (3) the area between Stateline Mills and Vista, including Steamboat Creek and Washoe Lake; and (4) the drainage area below Vista:

Drainage areas of Truckee River.

Tahoe Basin, exclusive of Marlette Lake drainage:	Sq. m.	
In California	382	
In Nevada	137	
Total		519
Above Stateline Mills and below Lake Tahoe:		
Squaw Creek	8	
Donner and Cold creeks	31	
Martis Creek	42	
Prosser Creek	56	
Little Truckee River	179	
Juniper Creek	10	
Joe Gray Creek	18	
Alder Creek	18	
Other small tributaries between Lake Tahoe and Stateline Mills	74	
Total		436
Total above Stateline Mills		955
Dog Valley Creek above dam site	16	
Hunter Creek	12	
Steamboat Creek above Steamboat Springs	123	
Other areas between Stateline Mills and Vista	413	
Total		564
Total above Vista		1,519
Total below Vista		611
Total drainage area		2,130
Total in California		790
Total in Nevada		1,340

RUN-OFF AND STREAM FLOW.

During the spring of 1889 measurements of stream flow in the Truckee Basin were begun by the United States Irrigation Survey, a branch of the United States Geological Survey. This season is remembered throughout the State of Nevada as the second and drier of two dry years preceding the winter of 1889 and 1890, known as "the hard winter," from which all subsequent occurrences are dated by the people of the region, who consider it the drier season ever known. During the early part of that year the precipitation at the headwaters of Truckee River was very light, but about the middle of May there was a heavy snowstorm, followed by warm weather, causing floods of short duration, which were followed by unusually low water during the summer and fall. The results of the measurements made by the Irrigation Survey are here given, beginning at the outlet of Lake Tahoe and taking the various tributaries in order:[1]

Discharge measurements of Truckee River at outlet of Lake Tahoe during 1889.

	Sec.-ft.
July 9	136
August 8	75
August 14	56
August 18	49

The maximum for the year is estimated at 170 second-feet.

A stream entering the Truckee from the west about halfway between Lake Tahoe and Truckee, known as Squaw Creek, on June 3, 1889, was discharging 92 second-feet, and on June 22, 1889, 15 second-feet. The creek near Tahoe tollgate was discharging 74 second-feet on June 3, 1889.

Donner Creek is the outlet of Donner Lake. About three-fourths of a mile below the lake it is joined by Cold Creek, which flows in from the south. The following measurements were made during 1889:

Discharge measurements, in second-feet, of Donner and Cold creeks during 1889.

Stream.	June 28.	July 3.	July 6.	July 11.	July 16.	Aug. 7	Aug. 10.	Aug. 17.
Donner Creek		8	5	2	1	0.9	0.2	0.3
Cold Creek	11	10	5	1		1.0	1.0	0.7
Total		18	10	3		1.9	1.2	1.0

More detailed measurements were made of Prosser Creek, the outlet of Twin Valley, and of Little Truckee River, which receives the drainage of Independence and Webber lakes and joins the Truckee at Boca. (See tables of monthly discharge on pages 19 to 22.) Other small tributaries were measured during the year, when they were at about their maximum, except Dog Valley Creek and the second measurement of Martis Creek, the results being as follows:

Discharge measurements of small tributaries of Truckee River during 1889.

Date.	Stream.	Point of measurement.	Discharge.
			Sec.-ft.
June 1	Martis Creek		19
June 22	do		7
May 30	Juniper Creek	Clinton	22
May 31	Joe Gray Creek	Iceland	88
May 31	Alder Creek	Floriston	42
May 22	Dog Valley Creek	Verdi	7

[1] Eleventh Ann. Rept. U. S. Geol. Survey, Pt. II.

Measurements on the main stream were begun in May, 1889, at Essex, Nev., about 12 miles above Reno, the results being as follows:

Discharge measurements of Truckee River at Essex, Nev., during 1889.

	Sec.-ft.
May 20	2,330
May 21	2,570
May 22	2,510
May 29	1,716
June 20	350

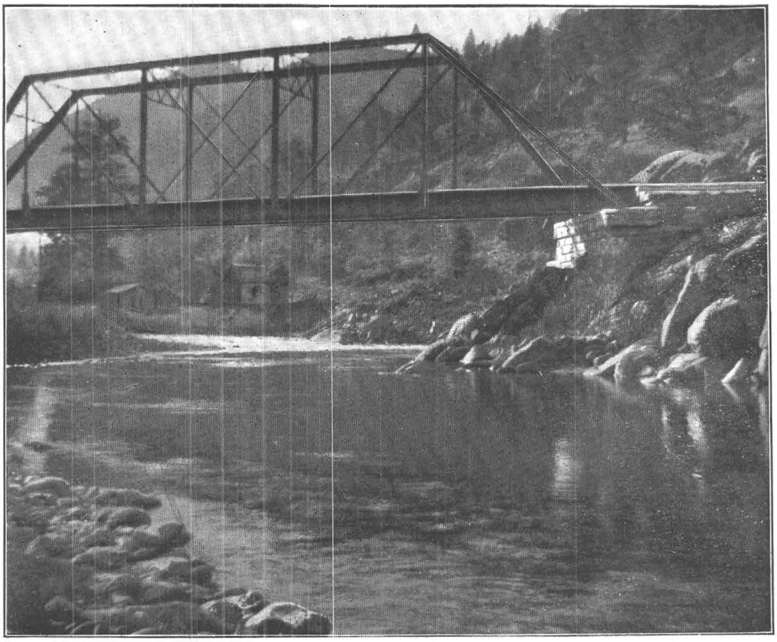
The maximum flow for the year was on May 21. The mean for the last ten days of May was 2,134 second-feet, for June 771 second-feet, for July 278 second-feet, and for August and September 200 second-feet; the latter results, however, are doubtful. In the spring of 1890 the Essex station was abandoned and gagings were made a mile below Boca, also at Laughton's, 6 miles above Reno, and at Vista, 8 miles east of Reno.

On July 3, 1895, the United States Geological Survey began keeping a record of the flow of Truckee River where it issues from Lake Tahoe,[1] for the purpose of obtaining data regarding the value of that lake for storage purposes, it being certain that the volume of water flowing out of the lake from year to year would be the amount yielded by the watershed, less evaporation, and consequently the quantity available for storage. Unfortunately lack of funds necessitated the discontinuance of these observations. While the conditions were not the most favorable for accurate measurements, the results exhibited in the following tables of monthly stream discharge approximate the truth.

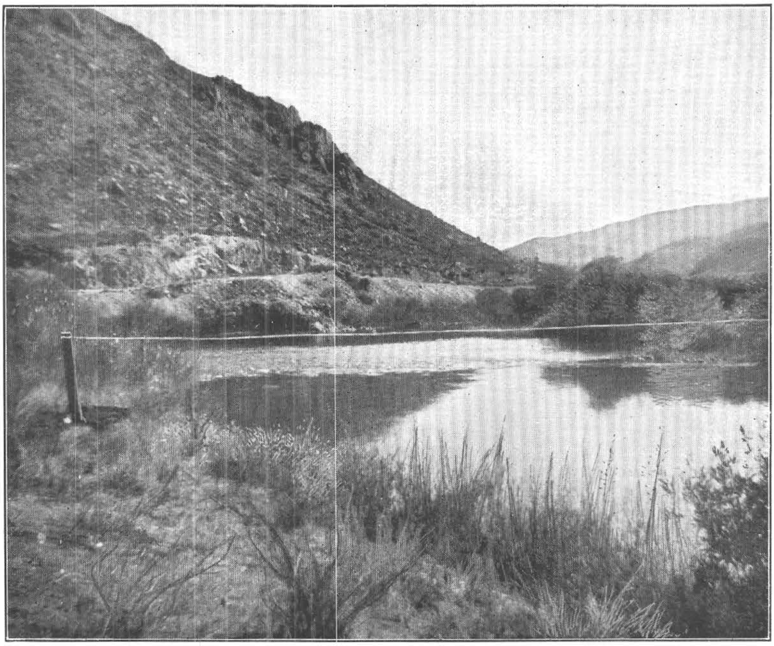
In the month of August, 1899, a station was established on Truckee River at Vista (see Pl. II, *B*), below the Truckee Meadows, for the purpose of measuring the stream discharge at that point; and in the following month a similar station was established at Stateline Mills (see Pl. II, *A*), above all the irrigating canals diverting water from the river. Observations at these stations have been made daily up to December 31, 1901. On May 31, 1900, measurements of the flow of Steamboat Creek, the outlet of the Washoe Lake basin, were begun at Steamboat Springs, where the stream enters the Reno Valley.

During the early part of the year 1900 the outlet of Lake Tahoe into Truckee River was kept closed, but from the time the gates in the dam there were opened, in the latter part of June, a daily record of the outflow has been kept, the results of which are given, as are those of the gagings at the three other stations mentioned in the accompanying tables (pages 22 to 31). The tables also give the run-off in acre-feet, in second-feet per square mile of drainage area, and in depth in inches for each month.

[1] Bull. U. S. Geol. Survey No. 140.



A. TRUCKEE RIVER AT STATELINE MILLS, CALIFORNIA.



B. TRUCKEE RIVER AT VISTA, NEV., GAGING STATION.

Estimated monthly discharge of Truckee River at Tahoe, Cal.

[Drainage area, 519 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1895.						
July	1,185	442	914	56,200	1.761	1.897
August	441	393	425	26,111	0.819	0.943
September	392	357	374	22,244	0.721	0.803
October	496	344	415	25,538	0.800	0.923
November	471	408	437	26,002	0.842	0.940
December	253	246	250	15,388	0.482	0.556
1896.						
January	293	244	262	16,102	0.500	0.582
February	292	288	290	16,677	0.560	0.602
1900.						
June	236	0	52	3,106	0.101	0.112
July	260	0	214	13,131	0.412	0.474
August	260	211	232	14,261	0.447	0.532
September	224	177	196	11,667	0.378	0.434
October	177	155	159	9,781	0.307	0.364
November	200	0	135	8,047	0.261	0.291
December	99	0	81	4,981	0.156	0.180
1901.						
January	117	85	102	6,262	0.196	0.226
February	117	30	81	4,502	0.156	0.163
March	30	30	30	1,845	0.058	0.067
April	30	0	9	565	0.018	0.020
May	0	0	0	0	0	0
June	178	0	30	1,765	0.058	0.064
July	293	156	225	13,809	0.433	0.499
August	555	293	419	25,760	0.807	0.931
September	390	117	326	19,395	0.628	0.701
October	308	251	282	17,308	0.542	0.625
November	293	189	247	14,678	0.475	0.530
December	189	100	111	6,841	0.214	0.247
The year	555	0	155	112,730	0.299	4.073

Estimated monthly discharge of Truckee River at Stateline Mills, Cal.

[Drainage area, 955 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1899.						
September 7 to 30	338	267	276	16,423	0.288	0.322
October	628	267	330	20,273	0.345	0.398
November	1,562	267	570	33,894	0.596	0.665
December	301	235	267	16,429	0.280	0.323
1900.						
January	421	267	376	23,100	0.393	0.453
February	338	235	291	16,187	0.310	0.318
March	1,171	267	810	49,833	0.849	0.978
April	1,429	741	927	55,133	0.970	1.084
May	1,840	1,235	1,529	94,023	1.601	1.846
June	1,429	301	966	57,496	1.012	1.129
July	520	379	441	27,101	0.462	0.532
August	470	338	373	22,929	0.390	0.451
September	470	180	344	20,470	0.360	0.402
October	921	206	462	28,426	0.484	0.558
November	921	301	463	27,573	0.485	0.541
December	1,171	180	380	23,346	0.280	0.323
The year	1,840	180	614	445,617	0.633	8.615
1901.						
January	559	230	314	19,308	0.329	0.379
February	3,435	247	1,082	60,092	1.133	1.176
March	2,280	732	1,280	78,706	1.340	1.544
April	2,505	613	1,476	87,829	1.545	1.728
May	4,370	1,508	2,478	152,370	2.595	2.992
June	2,505	989	1,595	94,910	1.670	1.862
July	1,194	421	686	42,181	0.718	0.823
August	795	349	486	29,884	0.509	0.588
September	559	247	472	28,086	0.494	0.552
October	559	247	470	28,900	0.492	0.566
November	613	383	469	27,908	0.491	0.549
December	1,194	247	445	27,347	0.466	0.53[illegible]
The year	4,370	230	938	677,521	0.982	13.300

Estimated monthly discharge of Truckee River near Vista, Nev.

[Drainage area, 1,519 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1890.						
April 26 to 30	5,610	3,730	4,496	267,512	2.96	3.30
May	7,510	3,200	5,990	368,385	3.94	4.55
June	6,710	3,115	4,162	247,639	2.74	3.06
July	3,730	1,185	2,198	135,177	1.45	1.67
August	1,152	750	952	58,548	0.63	0.72
September	825	570	682	40,579	0.45	0.50
October	1,030	490	742	45,633	0.49	0.56
November	825	400	765	45,517	0.50	0.56
December			*a* 750	46,125	0.49	0.57
1891.						
January			*a* 700	43,050	0.46	0.54
February			*a* 650	36,075	0.43	0.44
March			*a* 650	39,975	0.43	0.50
April 26 to 30	3,115	570	1,523	90,618	1.00	1.12
May	3,285	1,990	2,765	170,047	1.79	2.10
June	2,730	1,280	1,905	113,347	1.25	1.39
July			945	58,108	0.62	0.72
August			485	27,423	0.32	0.37
September			558	33,165	0.36	0.41
October			561	34,696	0.37	0.43
November			503	29,929	0.33	0.37
December			508	32,137	0.31	0.39
The year			980	708,570	0.64	8.78
1892.						
January			593	36,064	0.39	0.45
February			505	29,048	0.33	0.36
March			723	44,467	0.48	0.56
April			854	50,813	0.56	0.63
May			937	59,616	0.62	0.71
1899.						
August, 18 to 31	188	74	114			
September	188	74	152	9,073	0.100	0.111
October	1,066	144	378	23,251	0.249	0.287
November	1,123	355	516	30,713	0.340	0.379
December	709	331	456	28,019	0.300	0.346
1900.						
January	1,210	380	479	29,445	0.315	0.363
February	529	380	426	23,671	0.281	0.292
March	1,094	454	857	52,668	0.564	0.650
April	1,239	479	756	44,982	0.498	0.555
May	1,477	843	1,257	77,289	0.827	0.954
June	1,239	259	709	42,201	0.467	0.521
July	307	74	110	6,746	0.072	0.083
August	283	61	122	7,513	0.080	0.093
September	283	105	192	11,449	0.127	0.141
October	1,123	258	430	26,456	0.283	0.326
November	1,298	331	566	33,660	0.372	0.415
December	1,268	429	554	34,049	0.364	0.420
The year	1,477	61	538	390,129	0.354	4.813
1901.						
January	1,505	418	661	40,644	0.435	0.502
February	4,213	418	1,486	82,529	0.978	1.019
March	2,209	938	1,328	81,657	0.874	1.008
April	1,942	747	1,380	82,117	0.908	1.014
May	4,213	1,410	2,145	131,894	1.412	1.628
June	1,942	854	1,263	75,155	0.831	0.928
July	995	146	425	26,133	0.280	0.323
August	492	128	315	19,369	0.207	0.227
September	467	251	329	19,577	0.217	0.242
October	720	370	477	29,330	0.314	0.362
November	882	467	557	33,144	0.367	0.409
December	1,287	322	510	31,357	0.336	0.387
The year	4,213	123	906	652,906	0.597	8.049

a Estimated.

Estimated monthly discharge of Steamboat Creek at Steamboat Springs, Nev.

[Drainage area, 123 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square. mile.	Depth in inches.
1900.						
May 30 and 31	23.4	23.4	23.4			
June	50.0	4.0	25.0	1,497	0.205	0.228
July	14.0	5.0	7.3	448	0.059	0.068
August	4.0	2.0	3.0	174	0.023	0.026
September	4.0	1.0	2.5	147	0.020	0.023
October	14.0	2.0	5.4	333	0.044	0.051
November	75.0	8.0	11.4	670	0.093	0.103
December	14.0	8.0	8.2	506	0.066	0.077
1901.						
January	56.0	3.0	7.6	467	0.061	0.071
February	72.0	3.0	15.6	866	0.126	0.132
March	20.5	5.0	10.8	664	0.087	0.101
April	11.5	3.0	7.7	458	0.062	0.069
May	29.5	11.5	21.4	1,316	0.174	0.200
June	39.0	17.0	29.6	1,761	0.240	0.268

Estimated monthly discharge of Prosser Creek near Boca, Cal.

[Drainage area, 56 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1889.						
April			*a* 100	5,950	1.79	2.00
May			259	15,900	4.62	5.34
June			110	6,540	1.96	2.20
July			17	1,050	0.31	0.35
August			3	185	0.06	0.06
September			2	123	0.04	0.04
December						9.99
1890.						
May 19 to 31	1,230	615	817	50,245	14.45	16.34
June			580	34,510	10.40	11.67
July	865	120	382	23,493	6.82	7.86
August	120	75	102	6,273	1.82	2.10

a Estimated.

Estimated monthly discharge of Little Truckee River near Boca, Cal.

[Drainage area, 179 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1890.						
April	2,646	276	958	57,066	5.36	5.90
May	2,867	1,000	1,998	122,914	11.15	12.85
June	1,840	1,005	1,491	89,438	8.33	9.36
July	1,330	295	749	45,975	4.18	4.81
August	390	110	200	12,300	1.12	1.28
September	150	87	97	5,771	0.54	0.60
October	108	70	86	5,289	0.48	0.55

Estimated monthly discharge of Truckee River near Boca, Cal.

[Drainage area, 902 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1890.						
March 24 to 31	755	545	637	39,175	0.71	0.81
April	5,716	580	2,751	163,684	3.05	3.40
May	7,172	2,908	5,275	324,412	5.85	6.74
June	5,092	2,596	4,291	255,314	4.76	5.30
July	2,596	930	1,870	115,005	2.07	2.39
August	920	510	736	45,264	0.82	0.94
September	580	495	513	30,523	0.57	0.63
October	660	490	555	34,132	0.62	0.71

Estimated monthly discharge of Truckee River near Essex, Nev.

[Drainage area, 991 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1889.						
May			*a* 2,314	131,241	2.15	2.48
June			771	45,874	0.78	0.87
July			278	17,097	0.28	0.32
August			*a* 200	12,300	0.20	0.23
September			*a* 200	11,900	0.20	0.22

a Estimated.

At Vista observations of the flow of Truckee River were carried on during fifty-five months extending through six years. During four of the years records were kept for the months of January, February, March, June, and July, while for the remaining months observations were made during five years. The results of the observations for several months of the years 1890 and 1891 are claimed to be only rough approximations, so, while the record is not sufficient to show the normal discharge of the river at Vista, the following table, compiled from the data already given, is of value in connection with the study of irrigation possibilities farther down the stream:

Estimated mean monthly, annual, and mean annual discharge of Truckee River at Vista, Nev.

[Drainage area, 1,519 square miles.]

	Jan.	Feb.	Mar.	Apr.	May.	June.
DISCHARGE IN SECOND-FEET.						
1890				4,496	5,990	4,162
1891	*a* 700	*a* 650	*a* 650	1,523	2,765	1,905
1892	593	505	723	854	937	
1899						
1900	479	426	857	756	1,257	709
1901	661	1,486	1,328	1,380	2,145	1,263
Mean	608	767	890	1,802	2,619	2,010
RUN-OFF.						
Run-off, second-feet per square mile	0.400	0.505	0.586	1.186	1.724	1.323
Run-off in inches	0.461	0.526	0.676	1.324	1.988	1.476
Acre-feet	37,385	42,598	54,725	107,228	161,038	119,560

Estimated mean monthly, annual, and mean annual discharge of Truckee River at Vista, Nev.—Continued.

	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
DISCHARGE IN SECOND-FEET.							
1890	2,198	952	682	742	765	a 750	----------
1891	945	485	558	561	503	508	979
1892	----------	----------	----------	----------	----------	----------	----------
1899	----------	114	152	373	516	546	----------
1900	110	122	192	430	566	554	538
1901	425	315	329	477	557	510	906
Mean	920	398	383	517	581	556	1,004
RUN-OFF.							
Run-off, second-feet per square mile	0.606	0.262	0.252	0.340	0.382	0.366	0.661
Run-off in inches	0.698	0.302	0.281	0.392	0.427	0.422	8.973
Acre-feet	56,569	24,472	22,780	31,790	34,572	34,188	726,950

a Approximate.

The following tables show the daily mean discharge of Truckee River at the three stations where observations have been carried on by the United States Geological Survey during the years 1895, 1896, 1899, 1900, and 1901.

Daily mean discharge, in second-feet, of Truckee River at Tahoe, Cal., for 1895

[Drainage area, 519 square miles; observer, P. Wehrman.]

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	----------	441	392	357	471	253
2	----------	439	391	356	466	253
3	1,180	438	390	356	463	252
4	1,180	437	389	355	460	251
5	1,180	436	387	353	459	251
6	1,180	435	384	352	456	251
7	1,185	435	381	350	454	250
8	1,185	434	379	349	451	250
9	1,185	434	377	348	450	249
10	1,185	434	374	347	447	249
11	1,180	433	377	347	445	249
12	1,180	432	381	346	442	249
13	1,180	432	379	345	441	248
14	1,180	431	377	344	438	248
15	1,180	430	376	434	435	248
16	1,180	430	376	432	432	247
17	1,178	429	374	430	429	246
18	1,175	427	373	429	428	248
19	1,167	426	372	426	427	249
20	1,159	425	371	496	426	251
21	266	424	371	494	424	253
22	587	423	368	493	423	253
23	587	422	364	490	423	253
24	585	422	361	488	421	253
25	585	416	360	486	420	253
26	448	409	359	483	419	252
27	447	403	359	482	416	251
28	446	400	358	480	414	251
29	445	399	358	478	411	250
30	444	395	357	475	408	249
31	442	393	----------	474	----------	248
Total	26,511	13,164	11,215	12,875	13,109	7,758
Mean	914.2	425	374	415	437	250
Run-off per square mile	1.761	0.819	0.721	0.800	0.800	0.842
Run-off in inches	1.897	0.943	0.803	0.923	0.940	0.556
Total in acre-feet	56,200	26,110	22,243	25,537	26,002	15,387

Estimated daily discharge, in second-feet, of Truckee River at Tahoe, Cal., for 1896.

[Observer, P. Wehrman.]

Day.	Jan.	Feb.	Day.	Jan.	Feb.	Day.	Jan.	Feb.
1	248	292	15	244	290	29	293	290
2	248	292	16	245	290	30	293	------
3	247	292	17	246	290	31	292	------
4	246	291	18	253	290			
5	246	291	19	264	289	Total	8,118	8,408
6	246	291	20	271	289			
7	246	291	21	276	289	Mean	262	290
8	245	291	22	281	288	Run-off per		
9	245	290	23	284	288	square mile	0.50	0.56
10	245	290	24	284	288	Run-off in		
11	245	290	25	284	289	inches	0.582	0.602
12	245	290	26	286	289			
13	544	290	27	290	289	Total in		
14	244	290	28	292	289	acre-feet	16,102	16,677

Estimated daily discharge, in second-feet, of Truckee River at Tahoe, Cal., for 1900.

[Observer, J. U. Haley.]

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	------	------	260	211	177	155	0
2	------	236	260	211	165	155	99
3	------	236	260	200	165	155	99
4	------	0	248	200	165	155	72
5	------	236	260	200	177	155	72
6	------	236	248	200	177	155	99
7	------	236	248	224	165	155	99
8	------	0	248	211	165	155	99
9	------	236	236	211	165	155	99
10	------	236	236	211	155	155	99
11	------	236	236	200	155	155	99
12	------	236	236	200	155	155	99
13	------	236	236	200	155	155	99
14	------	236	236	200	155	155	99
15	------	92	236	200	155	155	99
16	------	248	236	188	155	155	99
17	92	236	236	177	155	155	72
18	92	248	236	211	155	155	72
19	92	236	224	200	155	155	72
20	92	248	236	211	155	155	72
21	------	248	224	200	155	177	72
22	99	248	224	200	155	200	72
23	------	248	224	177	155	116	72
24	------	248	224	177	155	116	72
25	155	248	224	177	155	116	72
26	------	248	224	177	155	116	72
27	236	236	224	177	155	116	72
28	236	236	224	177	155	0	72
29	236	248	224	177	155	0	72
30	236	248	211	177	155	0	72
31	------	260	211	------	155	------	72
Total	1,562	6,620	1,190	5,882	4,931	4,057	2,511
Mean	52.2	214	231.9	196.1	159.1	135.23	81
Run-off per square mile	0.106	0.474	0.532	0.434	0.364	0.291	0.156
Run-off in inches	0.101	0.412	0.447	0.378	0.307	0.261	0.180
Total in acre-feet	3,106	13,131	14,261.4	11,666.9	9,780.6	8,047.06	4,980.6

Estimated daily discharge, in second-feet, of Truckee River at Tahoe, Cal., for 1901.

[Observer, J. U. Haley.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	85	100	30	30	------	------	178	293	390	293	293	189
2	85	100	30	30	------	------	178	293	390	293	279	126
3	85	100	30	30	------	------	178	293	390	293	279	126
4	100	100	30	30	------	------	178	293	390	293	279	126
5	100	100	30	30	------	------	178	339	390	293	279	126
6	100	100	30	30	------	------	178	339	390	293	279	126
7	100	117	30	36	------	------	178	407	372	279	279	126
8	100	117	30	36	------	------	156	407	372	251	279	126
9	100	117	30	36	------	------	156	407	372	308	279	126
10	117	100	30	36	------	------	178	531	372	308	279	126
11	117	100	30	36	------	------	178	555	372	293	279	126
12	117	117	30	36	------	------	189	555	323	000	279	100
13	117	117	30	36	------	------	189	555	323	293	279	100
14	117	117	30	------	------	------	189	555	117	293	279	100
15	117	117	30	------	------	------	189	555	225	293	279	100
16	100	117	30	------	------	------	189	555	308	279	279	100
17	100	117	30	------	------	------	189	555	308	279	279	100
18	100	117	30	------	------	------	189	555	308	279	279	100
19	100	30	30	------	------	------	279	390	308	279	279	100
20	100	30	30	------	------	------	279	390	308	279	189	100
21	100	30	30	------	------	------	279	390	308	279	189	100
22	100	30	30	------	------	------	279	265	308	279	189	100
23	100	30	30	------	------	------	279	390	308	308	189	100
24	100	30	30	------	------	------	279	390	308	308	189	100
25	100	30	30	------	------	------	293	390	308	308	189	100
26	100	30	30	------	------	178	293	390	308	308	189	100
27	100	30	30	------	------	178	293	390	308	293	189	100
28	100	------	30	------	------	178	293	390	308	293	189	100
29	100	------	30	------	------	178	293	390	293	293	189	100
30	100	------	30	------	------	178	293	390	293	293	189	100
31	100	------	30	------	------	------	293	390	------	293	------	100
Total	3,157	2,270	930	432	000	890	6,962	12,987	9,778	8,726	7,400	3,449
Mean	102	81	30	14	000	30	225	419	326	282	247	111
Run-off per square mile	0.196	0.156	0.058	0.027	000	0.058	0.499	0.931	0.701	0.625	0.530	0.247
Run-off in inches	0.226	0.163	0.067	0.030	000	0.064	0.433	0.807	0.628	0.542	0.475	0.214
Total in acre-feet	6,262	4,502	1,845	833	000	1,765	13,809	25,760	19,395	17,308	14,678	6,841

Estimated daily discharge, in second-feet, of the Truckee River at Stateline Mills, California, for 1899.

[Drainage area, 955 square miles; observer, H. A. Grant.]

Day.	Sept.	Oct.	Nov.	Dec
1		267	338	267
2		267	338	267
3		267	301	267
4		267	301	267
5		267	301	267
6		267	573	235
7	301	267	684	235
8	301	267	921	235
9	267	267	1,299	267
10	267	267	1,429	267
11	267	267	1,562	267
12	267	301	1,108	267
13	267	301	800	301
14	267	301	628	301
15	267	267	741	301
16	338	267	628	267
17	301	267	628	267
18	267	267	520	267
19	267	267	520	267
20	267	470	423	267
21	267	520	379	267
22	267	628	338	267
23	267	520	301	267
24	301	470	301	267
25	267	423	301	267
26	267	379	301	267
27	267	338	301	267
28	267	301	301	267
29	267	301	267	267
30	267	338	267	267
31		338		267
Total	6,615	10,221	17,088	8,283
Mean	275.6	329.7	569.6	267.2
Run-off per square mile	0.289	0.345	0.596	0.280
Run-off in inches	0.32	0.398	0.665	0.323
Total in acre-feet	16,400	20,273.35	33,894.05	16,429.33

Estimated daily discharge, in second-feet, of Truckee River at Stateline Mills, California, for 1900.

[Observer, H. A. Grant.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.
1	267	267	301	1,045	1,429	1,235
2	301	267	267	921	1,429	1,235
3	684	267	267	800	1,299	1,171
4	921	267	301	800	1,429	1,171
5	684	267	301	921	1,630	1,108
6	628	235	301	921	1,429	1,235
7	423	235	423	921	1,495	1,235
8	338	235	470	741	1,630	1,429
9	301	235	573	741	1,699	1,429
10	301	235	573	800	1,840	1,235
11	301	235	573	800	1,840	1,235
12	301	267	741	1,045	1,429	1,171
13	338	301	800	1,171	1,299	1,429
14	423	301	1,045	1,171	1,299	1,235
15	379	301	1,171	921	1,630	921
16	379	301	1,045	921	1,699	921
17	379	301	1,045	921	1,699	921
18	379	301	921	860	1,769	921
19	379	301	1,045	800	1,769	860
20	379	338	1,045	741	1,840	800
21	301	338	1,171	741	1,699	800
22	301	338	1,108	1,108	1,769	741
23	267	338	1,045	860	1,699	800
24	267	338	1,045	800	1,429	301
25	267	338	1,045	983	1,429	628
26	267	338	1,171	1,108	1,429	628
27	267	338	1,171	860	1,299	573
28	267	338	1,045	800	1,299	573
29	267		1,045	1,045	1,299	573
30	267		1,045	1,429	1,235	573
31	267		1,045		1,235	
Total	11,490	8,161	25,124	27,796	47,403	28,987
Mean	370.7	291.46	810.45	926.53	1,529.13	966.23
Run-off per square mile	0.453	0.318	0.978	1.084	1.846	1.129
Run-off in inches	0.393	0.310	0.849	0.970	1.601	1.012
Total in acre-feet	23,099.84	16,187.34	49,833.45	55,133.37	94,023.85	57,495.71

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	520	338	470	423	423	180
2	520	338	301	301	301	180
3	520	338	235	338	301	180
4	470	338	470	338	470	235
5	470	338	379	379	470	235
6	470	338	423	379	470	235
7	470	338	379	423	628	301
8	470	338	338	379	520	301
9	470	338	338	379	470	379
10	470	338	338	338	470	379
11	470	338	338	301	470	379
12	470	338	379	301	470	379
13	470	338	379	301	470	379
14	470	338	423	301	423	301
15	470	338	423	301	379	301
16	470	338	423	423	379	301
17	423	338	423	206	379	301
18	379	338	423	301	379	301
19	379	379	423	423	379	301
20	423	379	423	921	379	1,171
21	423	379	338	860	520	800
22	423	470	301	800	921	800
23	423	470	301	741	800	741
24	423	470	180	741	684	301
25	423	470	180	684	520	379
26	379	301	180	684	520	379
27	379	379	301	628	423	301
28	379	379	206	628	301	301
29	379	470	267	470	301	301
30	379	470	338	301	301	379
31	379	470		338		301
Total	13,663	11,560	10,320	14,331	13,901	11,770
Mean	440.74	372.9	344	462.3	463.37	379.7
Run-off per square mile	0.532	0.451	0.402	0.558	0.541	0.458
Run-off in inches	0.462	0.390	0.360	0.484	0.485	0.397
Total in acre-feet	27,100.56	22,929.26	20,469.72	28,425.54	27,572.63	23,345.8

Estimated daily discharge, in second-feet, of Truckee River at Stateline Mills, Cal., for 1901.

[Observer, W. A. Pennell.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.
1	292	247	2,069	859	1,870	2,173
2	292	247	2,280	1,123	1,594	2,391
3	383	268	1,775	924	1,508	2,505
4	421	268	1,775	732	1,594	2,391
5	559	247	1,775	989	1,775	2,173
6	247	268	1,775	732	2,173	2,069
7	349	292	1,870	732	2,623	2,173
8	319	292	1,594	732	2,623	2,173
9	319	268	1,683	732	2,745	1,870
10	319	247	1,425	613	2,391	1,594
11	319	268	1,345	732	2,623	1,425
12	383	247	1,194	1,123	4,370	1,345
13	292	292	1,055	613	4,153	1,268
14	268	292	859	1,425	4,153	1,123
15	292	319	989	1,683	3,768	1,268
16	292	319	989	1,683	3,768	1,345
17	268	989	989	1,594	3,953	1,268
18	268	1,194	732	1,870	4,153	1,425
19	292	1,194	924	1,968	3,002	1,508
20	268	3,002	989	2,173	2,505	1,508
21	319	3,435	989	2,173	2,069	1,508
22	319	1,968	1,268	2,173	1,775	1,508
23	292	2,623	1,194	1,968	1,683	1,508
24	292	2,391	1,123	1,968	1,683	1,345
25	319	2,173	1,123	2,505	1,683	1,123
26	292	2,280	1,194	2,280	1,683	1,055
27	292	2,391	1,123	1,968	1,594	989
28	319	2,280	1,055	2,069	1,775	1,194
29	349		859	2,173	1,683	1,268
30	268		795	1,968	1,870	1,345
31	230		859		1,968	
Total	9,733	30,301	39,668	44,277	76,810	47,838
Mean	314	1,082	1,280	1,476	2,478	1,595
Run-off per square mile	0.329	1.133	1.340	1.545	2.595	1.670
Run-off in inches	0.379	1.176	1.544	1.728	2.992	1.862
Total in acre-feet	19,308	60,092	78,706	87,829	152,370	94,910

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1,194	463	463	463	559	613
2	1,194	509	509	463	509	613
3	1,123	421	509	509	383	1,055
4	924	383	509	509	421	1,194
5	732	349	559	509	463	795
6	732	463	509	463	509	859
7	732	509	509	463	463	613
8	671	509	383	463	463	509
9	671	421	383	509	463	509
10	732	463	509	559	421	463
11	671	421	509	559	463	349
12	671	421	509	463	463	292
13	732	421	559	247	509	268
14	671	421	421	463	463	383
15	671	421	247	463	463	319
16	613	383	349	463	463	292
17	617	732	463	421	421	292
18	613	795	463	421	463	292
19	559	795	463	463	463	319
20	613	509	509	292	463	292
21	509	509	463	421	463	268
22	613	383	463	421	421	349
23	613	421	463	421	421	383
24	613	463	509	421	421	383
25	613	509	559	463	463	319
26	613	463	463	463	509	247
27	559	509	463	559	463	292
28	463	559	463	559	463	292
29	613	463	463	559	559	292
30	509	463	509	559	613	349
31	421	509		559		292
Total	21,275	15,060	14,152	14,570	14,084	13,787
Mean	686	486	472	470	469	445
Run-off per square mile	0.828	0.588	0.552	0.566	0.549	0.536
Run-off in inches	0.718	0.509	0.494	0.492	0.491	0.466
Total in acre-feet	42,181	29,884	28,086	28,900	27,908	27,347

Estimated daily discharge, in second-feet, of Truckee River at Vista, Nev., for 1899.

[Drainage area, 1,519 square miles; observer, Sam Nelson.]

Day	Aug.	Sept.	Oct.	Nov.	Dec.
1	----------	89	144	429	355
2	----------	74	166	429	331
3	----------	105	166	380	380
4	----------	105	166	380	404
5	----------	105	166	380	380
6	----------	105	166	380	380
7	----------	105	166	429	380
8	----------	105	166	429	331
9	----------	119	166	479	331
10	----------	144	166	479	380
11	----------	119	166	580	380
12	----------	144	235	1,123	631
13	----------	144	331	953	529
14	----------	119	380	683	478
15	----------	166	331	683	709
16	----------	188	331	898	631
17	----------	166	380	843	529
18	105	144	380	683	478
19	144	144	331	631	478
20	188	144	331	529	478
21	105	144	1,066	479	380
22	144	144	898	429	380
23	105	144	580	380	380
24	144	144	529	429	404
25	119	144	479	429	404
26	105	144	479	429	404
27	105	144	479	429	429
28	74	144	479	380	529
29	89	144	479	355	683
30	89	144	479	355	580
31	74	----------	429	----------	580
Total	1,590	4,574	11,722	15,484	14,126
Mean	113.6	152.47	378.13	516.13	455.68
Run-off per square mile	----------	0.100	0.249	0.340	0.300
Run-off in inches	----------	0.111	0.287	0.379	0.346
Total in acre-feet	----------	9,072.53	23,250.59	30,712.51	28,019.3

Estimated daily discharge, in second-feet, of Truckee River at Vista, Nev., for 1900.

[Observer, Sam Nelson.]

Day.	Jan.	Feb.	Mar.	Apr	May.	June.
1	504	429	454	898	1,417	789
2	479	429	479	953	1,417	898
3	1,210	429	479	898	1,477	843
4	1,094	380	479	789	1,298	1,152
5	816	380	479	789	1,123	898
6	683	404	529	736	1,417	898
7	657	429	580	736	1,447	898
8	631	429	657	736	1,477	1,239
9	479	380	762	683	1,387	981
10	479	380	789	631	1,477	898
11	529	429	816	631	1,477	870
12	529	429	843	631	1,477	870
13	580	454	925	580	1,009	898
14	529	454	1,009	529	981	1,123
15	554	479	1,009	529	1,210	843
16	529	504	1,009	529	1,447	736
17	504	529	1,066	479	1,357	631
18	479	380	1,066	479	1,268	631
19	479	380	1,066	479	1,357	529
20	479	380	1,066	529	1,447	580
21	479	429	1,094	1,239	1,327	504
22	504	429	1,094	1,239	1,327	454
23	479	454	1,066	843	1,268	429
24	429	454	1,009	789	1,123	429
25	429	429	1,009	789	1,037	429
26	429	429	1,009	789	1,009	404
27	380	429	953	843	1,066	404
28	380	454	953	898	981	404
29	380		953	843	1,009	259
30	429		953	1,123	1,009	355
31	404		898		843	
Total	14,845	11,934	26,553	22,678	38,966	21,276
Mean	478.87	426.21	856.55	755.93	1,256.97	709.2
Run-off per square mile	0.315	0.281	0.564	0.489	0.827	0.467
Run-off in inches	0.363	0.292	0.650	0.555	0.954	0.521
Total in acre-feet	29,445.06	23,671.09	52,667.88	44,981.8	77,289.06	42,200.94

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	307	61	144	166	479	529
2	259	61	105	258	504	580
3	188	74	144	283	529	504
4	188	61	283	331	331	479
5	188	74	283	454	360	529
6	188	48	283	454	380	529
7	166	61	211	429	404	429
8	144	61	188	429	429	504
9	144	61	188	429	429	504
10	105	74	166	283	479	479
11	105	74	144	331	479	479
12	105	74	188	360	479	479
13	74	74	235	380	479	479
14	74	105	166	331	429	429
15	90	125	188	331	479	479
16	74	144	188	360	580	479
17	105	125	235	380	529	479
18	74	74	188	454	529	429
19	48	188	188	429	504	504
20	38	144	259	1,123	529	554
21	38	144	235	580	1,123	1,268
22	38	211	188	580	1,298	1,123
23	48	235	188	554	1,066	736
24	144	235	144	504	736	580
25	74	283	144	479	631	479
26	90	188	144	454	709	605
27	74	188	144	454	580	529
28	74	144	235	380	529	429
29	48	105	188	429	479	504
30	48	144	188	454	479	504
31	61	144		454		683
Total	3,401	3,788	5,772	13,338	16,970	17,166
Mean	109.71	122.19	192.4	430.3	565.7	553.7
Run-off per square mile	0.072	0.080	0.127	0.283	0.372	0.364
Run-off in inches	0.083	0.093	0.141	0.326	0.415	0.420
Total in acre-feet	6,745.88	7,513.4	11,448.65	26,456	33,660	34,048.76

Estimated daily discharge, in second-feet, of Truckee River at Vista, Nev., for 1901.

[Observer, Sam Nelson.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.
1	854	442	2,209	938	1,666	1,871
2	854	467	2,015	1,110	1,601	1,942
3	1,505	467	2,052	995	1,473	1,942
4	1,348	467	1,836	1,081	1,473	1,871
5	1,257	418	1,871	938	1,473	1,733
6	1,227	492	1,733	910	1,601	1,537
7	1,052	442	1,666	882	1,942	1,733
8	694	467	1,801	882	1,942	1,733
9	617	418	1,537	747	2,537	1,666
10	617	467	1,473	747	2,537	1,110
11	617	442	1,168	854	4,213	1,168
12	668	467	1,197	938	3,640	1,168
13	541	467	1,473	1,110	3,251	1,168
14	541	467	1,052	1,348	3,539	1,110
15	541	467	1,052	1,537	3,011	1,052
16	467	1,537	1,081	1,634	3,165	967
17	442	2,385	967	1,634	2,537	967
18	418	1,871	967	1,666	2,168	967
19	418	1,871	995	1,733	2,168	1,197
20	467	1,906	938	1,942	2,168	1,110
21	541	3,748	1,052	1,733	2,090	1,024
22	541	4,213	1,081	1,871	1,666	1,110
23	442	2,780	1,287	1,733	1,537	1,110
24	442	2,652	1,110	1,733	1,410	1,024
25	516	2,780	1,168	1,733	1,410	854
26	492	3,079	1,227	1,942	1,410	854
27	418	2,922	1,110	1,871	1,442	1,024
28	467	3,079	1,081	1,733	1,871	967
29	541		995	1,801	1,906	910
30	516		967	1,634	1,906	995
31	442		995		1,733	
Total	20,503	41,680	41,156	41,410	66,486	37,884
Mean	661	1,486	1,328	1,380	2,145	1,263
Run-off per square mile	0.435	0.978	0.874	0.908	1.412	0.831
Run-off in inches	0.502	1.019	1.008	1.014	1.628	0.928
Total in acre-feet	40,644	82,529	81,657	82,117	131,894	75,155

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	910	207	274	418	566	720
2	995	185	322	418	566	720
3	668	251	322	418	566	773
4	720	274	322	467	566	882
5	747	492	322	442	566	1,287
6	694	418	322	467	566	720
7	516	346	322	442	566	566
8	492	370	298	467	516	566
9	492	274	322	418	516	566
10	541	228	298	442	516	566
11	492	146	298	566	516	566
12	643	185	274	516	516	418
13	566	251	274	467	516	418
14	467	346	274	442	516	467
15	370	128	251	418	541	442
16	370	492	274	467	516	418
17	346	492	346	442	541	370
18	394	492	274	467	516	370
19	346	492	274	442	516	370
20	346	492	274	467	541	418
21	146	346	274	467	541	418
22	166	346	274	370	541	418
23	166	346	274	370	541	442
24	185	322	467	418	467	370
25	185	322	467	467	541	370
26	185	228	467	467	617	370
27	228	251	467	492	541	370
28	185	298	418	720	566	370
29	228	251	418	668	882	418
30	207	228	418	643	720	418
31	185	274		617		322
Total	13,181	9,773	9,881	14,792	16,702	15,809
Mean	425	315	329	477	557	510
Run-off per square mile	0.323	0.227	0.242	0.362	0.409	0.387
Run-off in inches	0.280	0.207	0.217	0.314	0.367	0.336
Total in acre-feet	26,133	19,369	19,577	29,330	33,144	31,357

The observations have not extended over a sufficient period to show the mean flow of the streams, but the data are of special value, for, having been collected during extremely dry seasons (the years 1898, 1899, and 1900 were years of exceedingly small water supply on Truckee River), they show very nearly the minimum run-off from the watersheds.

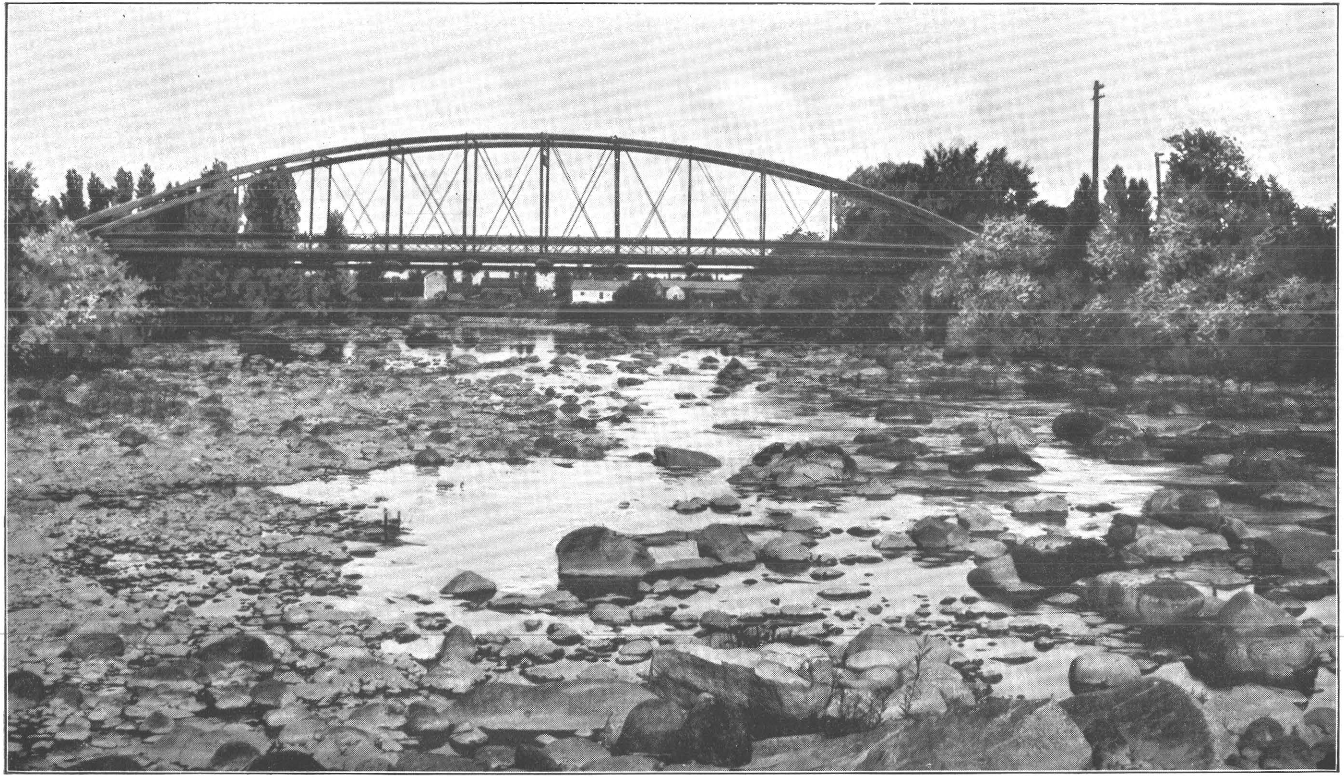
The discharge measurements at Vista, taken in connection with those at Stateline Mills and with the measurements of the irrigating ditches which have been made during the season of 1900, with the knowledge that during August and part of September, 1899, and a considerable portion of July and August, 1900, the entire flow of Truckee River was being diverted above, furnish a basis for estimating the volume of the seepage or return water from irrigation in the Reno Valley.

Besides the measurements and observations made at the regular stations mentioned, the results of which are given in the foregoing tables, a number of measurements of the principal tributaries of Truckee River were made with a view to estimating the relative run-off from different portions of the basin. The results of these measurements, in order downstream, are as follows:

Discharge measurements of tributaries of Truckee River.

Date.	Stream.	Point of measurement.	Discharge.
1900.			*Sec.-ft.*
June 16	Deer Creek		25.19
June 5	Squaw Creek		81.39
June 16	do		46.01
September 14	do		2.76
May 16	Donner Creek	Near Donner Lake	127.8
May 29	do	do	73.42
July 13	do	do	1.09
August 20	do	do	69.00
September 13	do	do	19.19
May 21	do	Near Truckee River	324.48
June 3	do	do	126.97
June 12	do	do	98.89
July 13	do	do	14.69
September 13	Cold Creek		1.35
May 21	Martis Creek		24.51
June 4	do		17.52
September 14	do		8.54
June 3	Truckee River	One-half mile below Truckee	364.00
June 12	do	do	264.00
June 4	Prosser Creek	At mouth	145.112
July 27	do		24.67
September 9	do		9.54
May 19	Little Truckee River	At Boca	*a* 600.00
June 6	do	do	492.00
August 16	do	do	8.94
September 15	do	do	27.14
June 6	Juniper Creek		*a* 30.00
September 15	do		1.33
May 19	Joe Gray Creek		*a* 30.00
July 28	do		20.28
September 15	do		12.28
May 19	Alder Creek		*a* 30.00
July 25	do		12.63
September 10	do		10.29
July 26	Dog Valley Creek		0.40
September 10	do		0.79
June 7	Hunter Creek		40.7
September 12	do		5.93

a Estimated.



TRUCKEE RIVER AT RENO, NEV., DURING LOW WATER IN JULY, 1900.

In the early part of May, 1900, measurements were also made of the principal streams flowing into Lake Tahoe, with results as follows:

Discharge measurements of streams flowing into Lake Tahoe.

Date.	Stream.	Discharge.
1900.		Sec.-ft.
May 5	Ward Creek	147
May 6	Blackwood Creek	140
Do	Three small streams between Idlewild and McKinneys	a12
Do	McKinney Creek	105
May 7	General Creek	100
Do	Meiggs Creek	130
May 7–8	Five small streams between Meiggs Creek and Emerald Bay	a12
May 8	Emerald Bay Creek	60
Do	Cascade Creek	30
Do	Taylor Creek	160
May 9	Upper Truckee River	350
May 10	Ten small streams between Bijou and Glenbrook in Nevada	a15

a Estimated.

Owing to severe wind storms, making it impossible to go on the lake in a small boat, it was not practicable to measure the streams entering from the east and north between Glenbrook and Tahoe, though some of them were discharging considerable water.

During August and September, 1901, another series of measurements of the various streams emptying into the lake was made, with the object of checking as closely as practicable the measured evaporation from the lake surface. Following are the results of these measurements, beginning with the first stream south of the lake outlet and following in regular order around the lake from right to left:

Discharge measurements of streams flowing into Lake Tahoe.

Date.	Stream.	Discharge.	Date.	Stream.	Discharge.
1901.		Sec.-ft.	1901.		Sec.-ft.
August 19	Ward Creek	3.20	September 10	Unnamed creek	a0.15
September 8	do	1.72	August 23	do	a0.20
August 19	Blackwood Creek	3.91	September 10	do	a0.20
September 8	do	2.99	August 23	do	a0.20
August 20	McKinney Creek	0.89	September 10	do	a0.15
September 8	do	0.65	August 24	Glenbrook Creek	0.38
August 21	General Creek	1.50	September 10	do	0.40
September 8	do	1.08	Do	Spooner Creek	0.91
August 21	Meiggs Creek	1.29	Do	Unnamed creek	a0.80
September 8	do	a0.04	August 27	do	0.71
August 21	Unnamed creek	0.85	September 11	do	a0.50
September 8	do	0.42	August 27	do	2.00
August 22	Rubicon Creek	2.23	September 11	do	2.46
September 8	do	1.90	August 27	do	2.80
August 22	Unnamed creek	a0.50	September 11	do	2.54
September 9	do	a0.40	August 27	do	a0.20
August 22	Emerald Creek	5.76	September 11	do	a0.20
September 9	do	1.24	August 27	do	1.52
August 22	Cascade Creek	2.37	September 11	do	1.04
September 9	do	0.80	August 27	do	1.14
August 22	Taylor Creek	8.64	September 11	do	0.53
September 9	do	3.33	August 27	do	a0.60
August 22	Upper Truckee River	47.12	September 11	do	a0.40
September 9	do	35.14	August 26	Hot Springs Creek	1.90
August 22	Trout Creek	32.76	September 11	do	1.26
September 9	do	23.37	August 25	Unnamed creek	a0.20
August 23	Unnamed creek	a0.10	September 7	do	a0.20
September 10	do	a0.06	August 25	do	1.34
August 23	do	a0.20	September 5	do	0.82

a Estimated.

EVAPORATION.

Evaporation has received less attention than any other subject bearing upon water supply in the West, and as a consequence it is a factor of great uncertainty.

On May 17, 1900, a galvanized-iron tank 2 feet square and 2 feet in depth was placed in Lake Tahoe at its outlet, where it was protected from the heavy waves of the lake, for the purpose of measuring the evaporation from the lake surface. A finely divided scale was placed in the tank, and daily readings were taken about the same hour each day by Mr. J. U. Haley, general freight and passenger agent of the Lake Tahoe Railway and Transportation Company. The tank was at all times kept filled to within 1 or 2 inches of the top, and was floated by means of a timber frame, which also served as a protection from waves and drift, so that the water level inside and outside was about the same. The depth of water in which the tank was anchored was about 6 feet, and the water in the tank was fully exposed to wind and sun. The following table gives the monthly evaporation from May 17, 1900, to December 31, 1901, with the exception of the month of July of the latter year, when no record was kept, the tank having been damaged:

Evaporation in Lake Tahoe at Tahoe, Cal.

Month.	1900.	1901.	Month.	1900.	1901.
	Inches.	*Inches.*		*Inches.*	*Inches.*
January		0.84	July	4.00	(*a*)
February		0.70	August	5.15	6.50
March		0.77	September	3.10	4.12
April		1.25	October	2.15	2.65
May 17 to 31	1.83	2.42	November	1.38	2.09
June	3.80	3.35	December	1.33	1.44

a No record.

As has been stated, during a portion of the months of August and September, 1901 (from August 19 to September 18, inclusive), a series of measurements of all of the streams discharging into Lake Tahoe was undertaken, with a view to checking the evaporation records kept at Tahoe. Two measurements were made of each stream. At the same time a careful record of the outflow from the lake was kept and daily observations of evaporation were made.

For the purpose of approximating the mean discharge of the various affluents during that period the mean of the two measurements of each stream was taken, this being deemed proper under the conditions, and the sum of the means was assumed to be the mean daily inflow to the lake. The following table gives the results of this study:

Results of hydrographic investigations at Lake Tahoe from August 19 to September 18, inclusive, 1901.

Inflow:		
Mean daily discharge of streams into lake	second-feet	106.04
Total addition to lake supply	acre-feet	6,310
Equivalent depth on lake surface	inches	0.606
Outflow:		
Mean daily discharge through Truckee River	second-feet	356.68
Total outflow from lake	acre-feet	21,931
Equivalent depth on lake surface	inches	2.105
Net outflow:		
Total outflow less total inflow	acre-feet	15,621
Equivalent depth on lake surface	inches	1.50
Total measured evaporation	do	5.71
Net reduction of lake level	do	7.21
Observed reduction of lake level, fixed gage	do	7.20

During the period over which these observations extended there were no rains which could interfere with their accuracy. It is therefore believed that the observed evaporation at Lake Tahoe since May 17, 1900, will very closely approximate the actual loss from the lake surface from that source, as well as the probable evaporation in other lakes or in storage reservoirs situated at about 6,000 feet altitude in this portion of the Sierras during the period over which the record extends. Of course, evaporation is not constant from year to year, but the variation should not be great in this region, and as the summer of 1900 and the summer and fall of 1901 were unusually dry and windy, the evaporation during that period can probably safely be considered a maximum.

During the year 1894, from May 11 to November 30, the writer conducted a series of observations at Reno, Nev., with a view to determining approximately the depth of evaporation at that place. For this purpose a small galvanized-iron tank, 18 inches square and 18 inches deep, was sunk in the ground until the rim was but half an inch above the surface. This was at all times kept filled to within less than 1 inch of the top, and was so placed that it was fully exposed to sun and wind. The earth immediately around the tank was kept wet. The results are believed to be a fairly close approximation to the loss that would occur in a lake, reservoir, or canal at Reno; and since the conditions influencing evaporation—temperature, humidity of atmosphere, winds, etc.—over the lower portion of Truckee Basin are nearly identical with those at Reno, they should be roughly applicable to other points in that portion of the basin. In estimating the evaporation from proposed storage reservoirs or canals, however, conservative judgment would dictate the addition of a liberal percentage for safety, especially since the results are for only a part of one season.

Evaporation from tank in earth at Reno, Nev., during 1894.

	Depth in inches.
May 11 to 31	2.80
June	5.35
July	8.45
August	9.12
September	7.44
October	4.31
November	2.75
Total	40.22

If the evaporation during the remaining five months of the year amounts to 12.78 inches in depth, or an average of about 2½ inches a month, which would appear from the foregoing table to be a fair estimate, the total for the year would amount to 53 inches.

It is possible that the evaporation from the surface of Pyramid and Winnemucca lakes may be a trifle greater than this, though a comparison of the following data with the results of discharge measurements of Truckee River at Vista, remembering that the run-off from the portion of the drainage area below that place is merely nominal and that the precipitation at the lakes is probably less than 6 inches, would indicate the reverse.

Estimated evaporation from Pyramid and Winnemucca lakes, based on observations at Reno, Nev., in 1894.

Depth of annual evaporation	inches	53
Combined area of lakes	square miles	345
Total evaporation	acre-feet	975,200

To compensate for this loss and maintain the water-surface level in the lakes would require a mean annual inflow of 1,347 cubic feet per second.

Comparison with the results of measurements given in the table of estimated mean monthly, annual, and mean annual discharge of Truckee River at Vista (pages 22–23) would indicate that the mean annual evaporation is less than the foregoing estimate, or that the normal run-off from the Truckee Basin is greater than indicated in the table referred to.

INVESTIGATIONS OF 1889 AND 1890.

RESERVOIR SITES.

During the years 1889 and 1890 surveys were made to ascertain the most feasible and economical mode of utilizing the waters of Truckee River, and the results of the field examinations were reported upon by Mr William Ham. Hall, supervising engineer.[1] Surveys were made

[1] Eleventh and Twelfth Ann. Repts. U. S. Geol. Survey, Pt. II, and Thirteenth Ann. Rept., Pt. III.

of the reservoir sites enumerated in the table on page 38, and the reports included a discussion of the mode of diverting and utilizing the waters.

Two projects for the utilization of the waters of Lake Tahoe were investigated. The first contemplated driving a tunnel through the Tahoe Range from what is known as Boundary Bay, in the southeastern part of the lake, near the Nevada-California boundary line, to Haines Creek Canyon, on the west side of Carson Valley, a distance of 17,331 feet, and tapping the lake 20 feet below the low-water plane. The second project had in view the construction of a dam in the lake outlet at Tahoe, for the purpose of raising the lake surface and drawing off the surplus water through Truckee River for use along that stream.

Two projects for water storage in the Donner Lake basin were also considered and estimated upon. One of these provided for storage in the lake alone, by means of raising, and closing a gap in, an ancient glacial moraine immediately below and to the east of the lake, thus raising its surface 20 feet above low-water plane and impounding 22,205 acre-feet of water, the surface area of the reservoir being 1,337 acres. The other contemplated the construction of two dams, 98 and 33 feet in height, respectively, and impounding the waters of the Donner Lake and the Cold Creek basins. This reservoir would have a surface area of 2,006 acres and a storage capacity of 42,827 acre-feet. The cost of the first project was estimated at $54,810 and of the second project at $279,245. No provision was made in these estimates for cost of rights of way and damages to property, which in the case of the second and larger reservoir would be very great, as the track of the Central Pacific Railroad would have to be removed for a considerable distance.

At Independence Lake it was proposed to build a dam across the outlet channel about 1,800 feet below the lake, the dam to have a maximum height of 40 feet, raising the lake surface 25 feet above ordinary low water and impounding 23,707 acre-feet over a total area of 984 acres. The estimated cost of the dam alone was $56,844.

The Webber Lake reservoir was to be formed by means of a dam having a maximum height of 30 feet, estimated to cost, exclusive of rights of way and damages, $23,927, if built of earth. This dam would raise the lake level 20 feet, flooding a total area, including lake surface, of 778 acres and impounding 11,152 acre-feet.

Estimates were made of the cost of the dams for the Lower Truckee reservoirs (Nos. 1 and 2), but since they did not include rights of way and cost of moving the track of the Central Pacific Railroad, which traverses both sites, they are not quoted.

The following table gives the areas, storage capacities, and heights of dams for each of the reservoirs surveyed and reported upon:

Reservoir sites surveyed in 1889 and 1890.

Name of reservoir.	Height of dam.	Area.	Capacity.
	Feet.	*Acres.*	*Acre-feet.*
Tahoe	(*a*)	(*a*)	(*a*)
Donner Lake	26	1,337	22,205
Donner-Cold Creek	98 and 33	2,006	42,827
Independence Lake	40	984	23,707
Webber Lake	30	778	11,152
Squaw Valley	16	225	1,350
Truckee reservoir	70	206	(*a*)
Little Truckee	60	450	10,100
Stampede Valley	50	120	2,250
Twin Valley	30	310	3,480
Boca reservoir	50	350	6,500
Monument Peak	80	160	4,800
Grass Lake	30	350	4,000
Lower Truckee No. 1	50	400	7,500
Lower Truckee No. 2	60	395	7,400

a Not reported.

CANAL ROUTES.

The following canal routes were also surveyed:[1]

(1) Commencing about 20 feet below the top of the proposed Truckee reservoir dam, a little less than a mile above the town of Truckee, survey was made of a canal line on the south side of the river to command the lands extending from immediately below Truckee into Martis Valley. This line was run on a grade of 0.4 foot to 1,000 feet, and was extended 74,400 feet. No data as to the amount of land commanded are supplied, nor are any estimates of cost furnished.

(2) A canal line was surveyed from a point in the gap traversed by the wagon road to the northwest of the town of Truckee and about 2 miles east of Donner Lake, extending around to the north of Truckee, to command lands lying between Truckee River and Prosser Creek. The grade elevation of the head of this canal line was 30 feet below the proposed high-water plane of the projected Donner Lake reservoir. It was run to Prosser Creek, a distance of 29,000 feet, on a grade of 0.2 foot to 1,000 feet.

(3) Surveys were made for canals to divert water to the lands in the neighborhood of Reno, but no report of the results of these surveys was made.

(4) *Lower Truckee canals.*—Canal surveys were also made from the dam sites of the proposed Lower Truckee reservoirs (Nos. 1 and 2).[2] In each case the lines were run from points near the tops of the proposed dams. Line No. 1 was started on the south side of the river about 4¾ miles above the town of Wadsworth, and extended a total

[1] Eleventh Ann. Rept. U. S. Geol. Survey, Pt. II.
[2] Thirteenth Ann. Rept. U. S. Geol. Survey, Pt. III.

length of 50,700 feet, or to the commencement of Warm Springs Valley, 5½ miles past that town, commanding about 10,500 acres of land. Line No. 2 was started a few feet below the crest of the proposed dam for Lower Truckee reservoir No. 1, being at about 100 feet greater elevation than the head of line No. 1 and about 10½ miles above the town of Wadsworth, and was run along the mountain side south of the river to a point just above the town, thence was swung around to the south, commanding a wide valley and mesa country to the eastward. It was continued a distance of 90,000 feet, far enough to establish the fact that it could be carried into the Lower Carson or Carson Sink Valley. From the main line a branch was surveyed from just below the head of canal line No. 1, with the object of crossing Truckee River by pressure pipes. This line was carried northward, on a grade of 1 foot to the mile, a distance of 45,000 feet, to command lands on the high plateau north of Wadsworth. The main canal would command more than 100,000 acres of good land east of Wadsworth and in the Carson Sink Valley. It was given a grade of 1½ feet to the mile and a cross section of 200 square feet, making its capacity about 600 second-feet.

INVESTIGATIONS OF 1900-1901.

RESERVOIR SITES.

In the latter part of April, 1899, the writer, acting under instructions from Mr. F. H. Newell, chief of the division of hydrography of the United States Geological Survey, began a general study of the basin of Truckee River for the purpose of ascertaining its water supply and the extent to and the means by which it can be utilized for irrigation and other purposes.

Previous investigations had established the fact that in order to use the water of the Truckee to the fullest extent and the best advantage it would be necessary to construct storage reservoirs for the purpose of conserving the flood waters, thus regulating and controlling the stream flow. This was more fully demonstrated by the results of measurements made during the years 1899 and 1900, as will be seen by reference to the tables of stream measurements and discharge.

A general study of the various storage sites known to exist within the Truckee Basin was begun, with a view to ascertaining the volume of the run-off from the drainage area tributary to each and the extent to which it might economically be impounded.

In pursuing these investigations recourse was had to the precipitation data collected by the United States Signal Service and the Weather Bureau (the results being given on previous pages of this report), numerous stream measurements were made, and a number of the reservoir sites (including most of those surveyed in 1889 and 1890 and three new ones) were examined, some of them instrumentally and others only superficially. It was not practicable, however, to give to these the careful, detailed examination requisite to supply data for working plans for the dams required, upon which final estimates of capacity and cost might be based. The estimates given are merely preliminary in character, though where doubtful they are believed to be on the side of safety.

Following is a list of the reservoirs considered worthy of construction and upon which estimates have been made:

Practicable reservoir sites in the Truckee Basin.

	Date of survey.
Lake Tahoe	1889-90 and 1900
Donner Lake	1889-90 and 1900
Independence Lake	1889-90 and 1900
Twin Valley	1889-90 and 1900
Little Truckee	1889-90 and 1900
Henness Pass Valley	1900
Dog Valley	1900

The waters which would be impounded in each of the foregoing reservoirs would be permitted to flow through their natural channels into the main Truckee River, there to be employed for the purpose of developing power for industrial uses, or to be diverted for the irrigation of the arable lands in the valleys in and adjacent to the lower portion of the Truckee Basin, where they could most economically and profitably be used.

IMPRACTICABLE SITES.

The Monument Peak and Grass Lake sites, in the Tahoe Basin, were not considered, for the reason that the waters which might be impounded there could be used only in the high, cold lake valley, where forage plants only can profitably be grown; and since, in order to convey them to the lower valleys of the Truckee Basin, they must pass through Lake Tahoe, it would be more economical to store them in the latter lake.

The Truckee reservoir, never an economical project, can no longer be considered, on account of the recent construction, through the entire length of the site, of the railroad from Truckee to Tahoe.

The site at Stampede Valley (reservoir No. 35 of the survey of 1889-90) is also partly traversed by a railroad. However, if that were not the fact, the cost of its utilization would be disproportionate to the storage capacity.

As already stated, the Lower Truckee reservoirs (Nos. 1 and 2) could not be considered, because they are traversed by the Central Pacific Railroad, which would make the cost of utilization prohibitory.

Consideration of Webber Lake as a storage site was abandoned for the following reasons: (1) The water which would be impounded can be more economically stored in the Little Truckee and the Henness Pass Valley reservoirs, to which they are also tributary; and (2) its

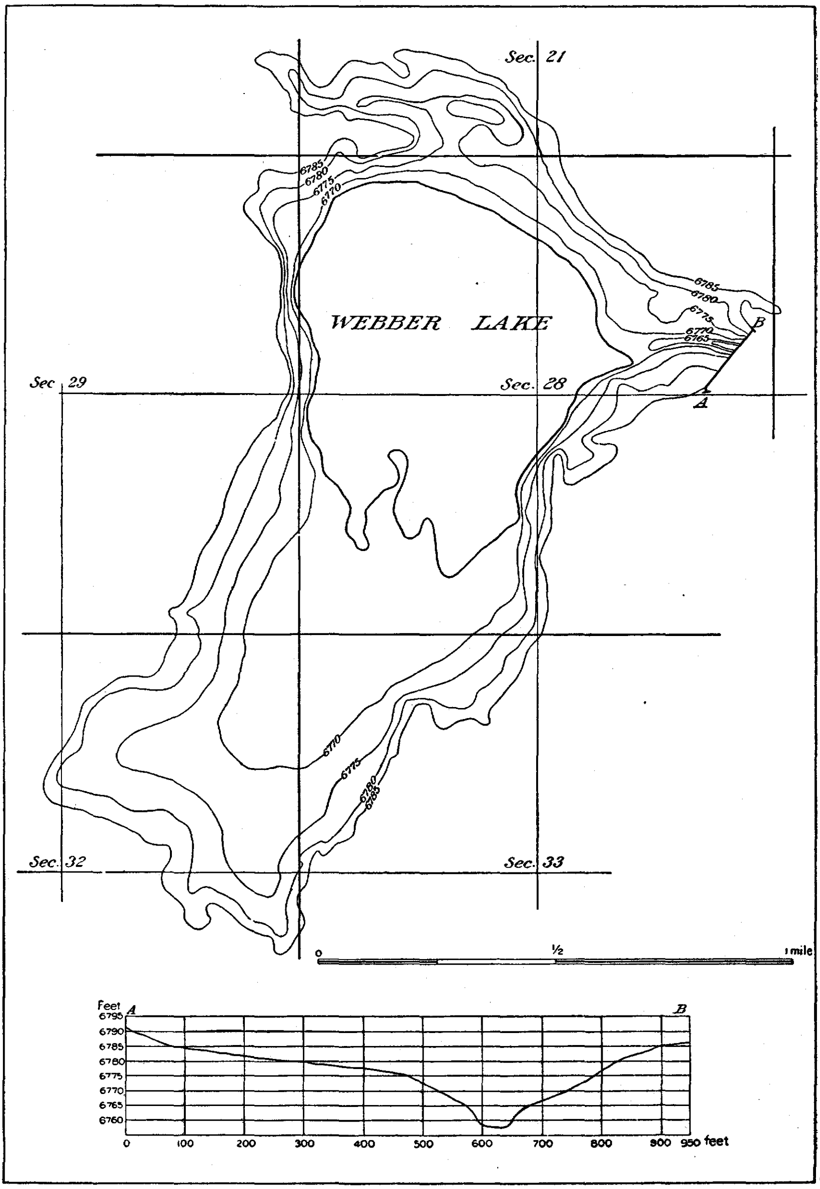


FIG. 2.—Contour map of Webber Lake and profile of dam site. The site occupies portions of secs. 21, 28, 29, 32, and 33 in T. 19 N., R. 14 E., M. D. M.

construction would involve the destruction of considerable private property, necessitating large expenses for damages, and it is deemed better, as a broad public policy, to incur expense for construction rather than destruction, especially if it be practicable to accomplish the former without the latter. A contour map of Webber Lake and a profile of the dam site are shown in fig. 2 (p. 41).

The Squaw Valley site (see figs. 3 and 4), although calling for but

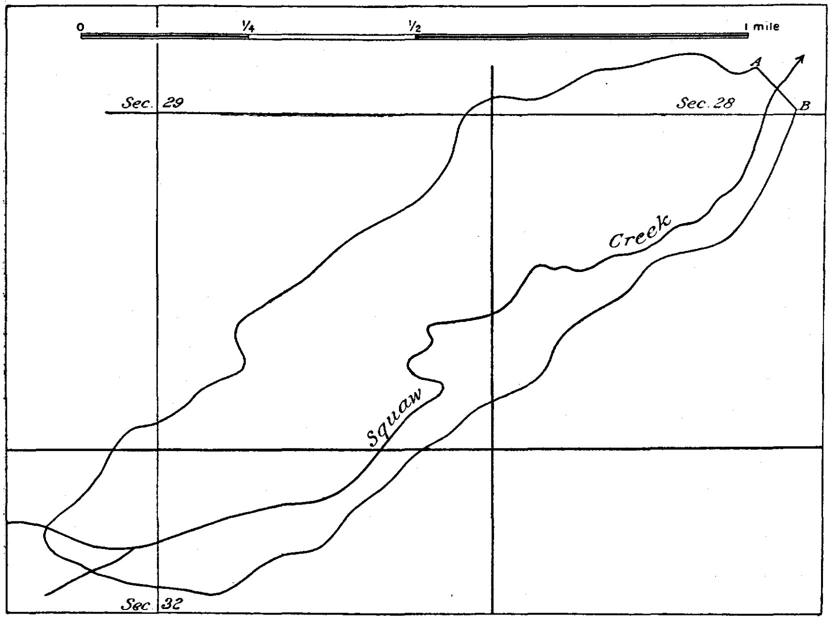


FIG. 3.—Map of Squaw Valley reservoir site. The site occupies portions of secs. 28, 29, and 32 in T. 16 N., R. 16 E., M. D. M.

a nominal outlay for construction, will, by reason of its small capacity, involve too great an expense, relatively, for watchmen, maintenance, etc., to justify its inclusion in a general water-storage project.

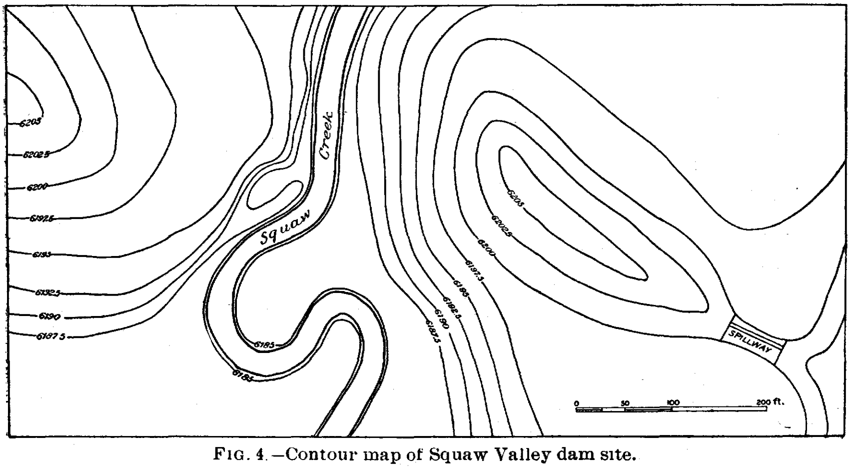


FIG. 4.—Contour map of Squaw Valley dam site.

The Boca reservoir project is abandoned on account of relatively high cost and the introduction of the silt problem, the solution of which is both difficult and expensive, and also on account of some uncertainty as to the water supply.

A. DAM IN TRUCKEE RIVER AT LAKE TAHOE.

B. VIEW LOOKING EAST FROM HEAD OF EMERALD BAY, LAKE TAHOE.

On Martis Creek, 4 miles east of the town of Truckee, is a site with an ample water supply, but examination has demonstrated that it would be too expensive in proportion to its storage capacity.

In Little Valley, to the west of Washoe Lake and immediately east of the crest of the Tahoe mountain range, is a very good site, having a capacity of about 6,500 acre-feet, where the cost of construction would not be great. However, the water stored would be employed only to increase, and insure in dry seasons, the supply for lands now under irrigation in the Washoe Valley, and would have no bearing upon the general project of reclamation of arid lands in the Truckee Basin.

At Sardine Valley, about 9 miles north of Boca, in the basin of Little Truckee River, is a very good reservoir site, where about 16,000 acre-feet of water could be stored, but unfortunately a railroad has recently been built through it, and the cost of its removal would be greater than the value of the water for many years to come.

LAKE TAHOE.

Lake Tahoe (shown in Pl. I and in fig. 5) is the greatest natural lake of the Sierra Nevada and one of the largest mountain lakes in America. Its maximum length from north to south is 21½ miles and its extreme width from east to west 12 miles. Its area is 193 square miles and its altitude above sea level about 6,225 feet at mean low stage. Its greatest depth is about 2,000 feet. The tributary watershed, including its own surface and excluding the drainage area of Marlette Lake, whose waters are diverted from the basin for the supply of Virginia, Nev., is 519 square miles. Its natural outlet is Truckee River, which leaves the lake at Tahoe.

The boundary line between the States of California and Nevada passes through the lake, leaving about two-thirds of its area in the former State and one-third in the latter State. With the exception of Lake Valley, at its southern end, almost the entire watershed is composed of rugged, precipitous mountains, which rise from 1,500 to 4,700 feet above its surface and generally descend abruptly to the water's edge. Originally these mountains were densely timbered, but during recent years those to the east of the lake have been almost denuded of their forests for lumber and fuel.

In the channel of Truckee River, about 500 feet back from the lake, is a crib dam of timber and stone (see Pl. IV, *A*), which for the last twenty years or more has been controlled by the Truckee Lumber Company, which has used the lake waters for flushing logs down the river and for supplying power to its sawmills at Truckee when the natural flow of the stream is insufficient for those purposes. For the last five years the waters have not been employed for flushing logs, but they are still used for power purposes. The dam has three openings, with 10.7, 10.5, and 9.3 feet clear width, which are closed by timber gates. The two wider openings have in the center vertical posts 8 inches in width, which have been deducted in the

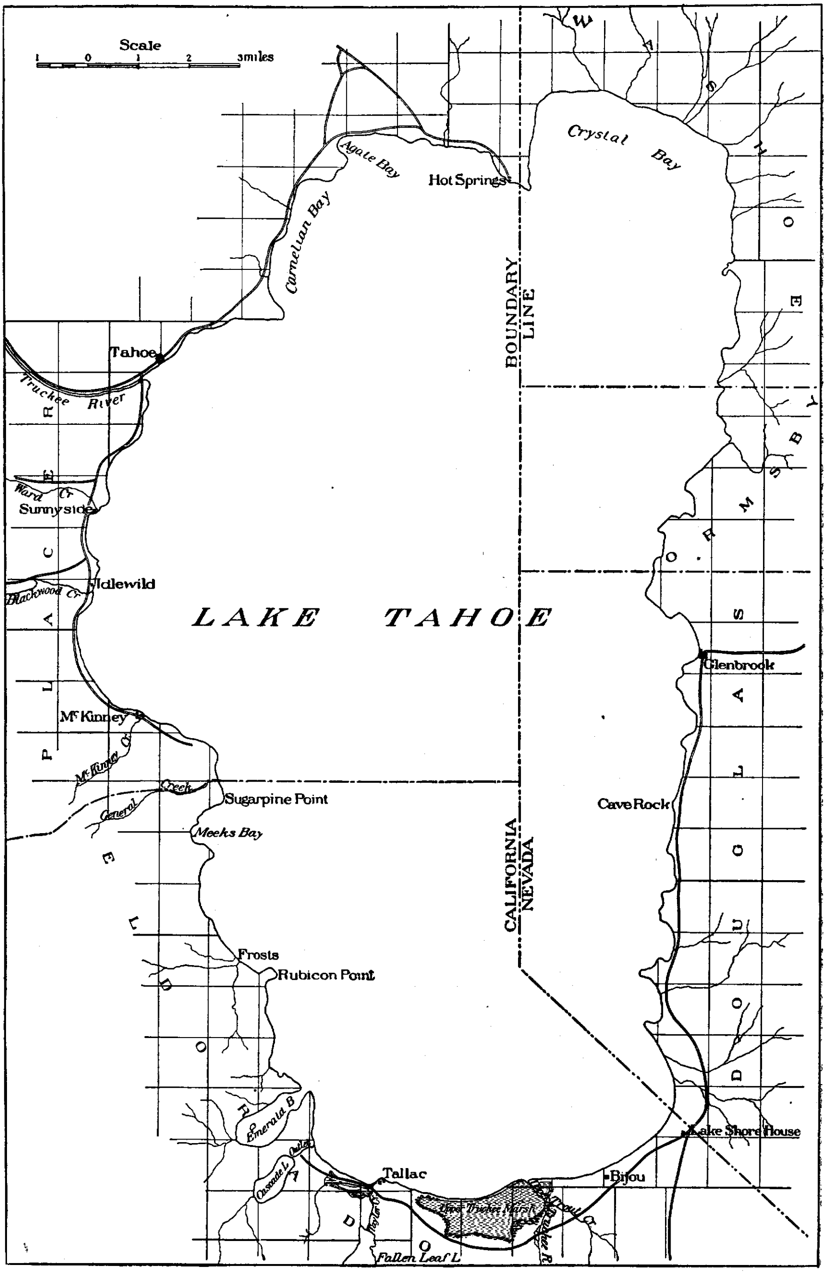


FIG. 5.—Map of Lake Tahoe.

widths of the openings given. The dam has a waste way of 72 feet clear length and 6 feet above the floor of the gates.

The following data regarding the fluctuations in the lake's surface are taken from the Eleventh Annual Report of the United States Geological Survey, Part II. On July 19, 1889, the elevation of the lake surface was taken at 6,225 feet. As subsequently found, the water afterwards fell during that summer about 1.2 feet, reaching extreme low water in the autumn. At the time of the survey, July 19, the wasteway crest was 5.05 feet above the water surface of the lake. As afterwards ascertained by Mr. William Ham. Hall, supervising engineer of the United States Irrigation Survey, the lowest known water plane of the lake was in October, 1889, when, as already stated, the surface was about 1.2 feet lower than at the time of the survey. The highest observed elevation of the lake's waters at Tahoe occurred in the spring of 1886, and was from 5.3 to 5.5 feet above the extreme low water of 1889. The high water of 1888 was observed on September 8, 1.85 feet, and that of 1889 in the early spring of that year, 1.55 feet above the same datum. The high water of the spring of 1890 was very nearly as great as that of 1886, notwithstanding the fact that the outlet gates of the dam remained open during the rising period.

From 1890 to 1895 no data of the fluctuations of the lake level are obtainable, but on July 3 of the latter year the writer began a series of observations of the outflow from the lake. At that time the water surface in the lake was 5.95 feet higher than the above datum. The outlet gates then and for a considerable time previously were open and more than 1,100 cubic feet per second were flowing out. The maximum stage was reached on July 7, when the water stood at 5.97 feet, but on July 11 it began to recede, reaching the lowest point on December 17, when it was 4.5 feet. On February 29, 1896, when observations were discontinued, the water stood 4.98 feet higher than the datum mentioned. From that time until April 28, 1900, no reliable record of the variations in the lake level was kept. On the latter date the writer began the investigations described herein, and found that the water level was then 3.30 feet above the extreme low-water level of 1899, or 3.05 feet above the floor of the outlet gates in the dam at the lake outlet. The water continued to rise gradually until June 17, when the outlet gates were first opened, having then reached a height of 3.95 feet. After that date it remained stationary until July 1, when it began to fall gradually, until on October 17 it was 2.82 feet. After that time, until November 30, it fluctuated between 2.82 and 2.98 feet, standing at 2.95 feet on the latter date. From November 30, 1900, to July 27, 1901, only occasional observations were made. On the latter date the water in the lake reached the highest stage during the year—5.38 feet above extreme low water of 1889, or 5.13 feet above the floor of the outlet gates. From July 27 until August 4 the water level remained stationary, but on the latter date it began to decline, reaching the lowest stage on November 30, when it was 3.86 feet above the floor of the outlet gates. During December it rose as high as 4.06 feet, but on the last day of that month it stood at 3.98 feet.

The following table shows the height of the lake surface above the floor of the outlet gates in the dam as observed daily from April 28 to November 30, 1900, and at intervals from that date until December 31, 1901.

Observed heights of water surface in Lake Tahoe above floor of outlet gates.

1900.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1		3.09	3.54	3.70	3.39	2.89	2.63	2.61
2		3.10	3.55	3.69	3.38	2.88	2.62	2.61
3		3.11	3.56	3.67	3.36	2.87	2.62	2.61
4		3.15	3.57	3.67	3.34	2.90	2.63	2.60
5		3.16	3.58	3.66	3.33	2.90	2.64	2.60
6		3.17	3.59	3.65	3.32	2.89	2.65	2.60
7		3.18	3.60	3.64	3.30	2.88	2.64	2.59
8		3.19	3.61	3.63	3.28	2.87	2.64	2.64
9		3.20	3.62	3.61	3.27	2.86	2.63	2.64
10		3.22	3.63	3.60	3.25	2.84	2.62	2.65
11		3.24	3.64	3.59	3.24	2.83	2.61	2.65
12		3.26	3.65	3.58	3.22	2.82	2.60	2.65
13		3.28	3.66	3.59	3.20	2.81	2.60	2.65
14		3.30	3.68	3.58	3.19	2.80	2.59	2.64
15		3.32	3.69	3.57	3.17	2.78	2.58	2.64
16		3.34	3.69	3.56	3.15	2.77	2.58	2.64
17		3.36	3.70	3.55	3.13	2.76	2.57	2.69
18		3.37	3.70	3.54	3.11	2.75	2.57	2.70
19		3.39	3.70	3.53	3.10	2.74	2.63	2.69
20		3.40	3.70	3.52	3.08	2.73	2.63	2.70
21		3.41	3.70	3.51	3.07	2.72	2.63	2.72
22		3.43	3.70	3.50	3.05	2.71	2.62	2.73
23		3.44	3.70	3.49	3.03	2.69	2.61	2.73
24		3.45	3.70	3.48	3.02	2.68	2.61	2.72
25		3.46	3.70	3.47	3.00	2.67	2.60	2.71
26		3.47	3.70	3.46	2.98	2.67	2.59	2.72
27		3.48	3.70	3.45	2.96	2.66	2.59	2.72
28	3.05	3.49	3.70	3.44	2.94	2.65	2.62	2.71
29	3.06	3.51	3.70	3.43	2.93	2.64	2.62	2.71
30	3.07	3.52	3.70	3.42	2.91	2.63	2.61	2.70
31		3.53		3.41	2.90		2.61	

1901.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		2.88						5.13	4.81			
2								5.13	4.79			
3		2.88						5.13	4.76			
4							5.05	5.13	4.74			
5			3.70					5.12	4.71			
6				3.90				5.12	4.68			4.06
7				3.90				5.12	4.66			4.05
8								5.12	4.63			
9		3.07						5.12	4.61			4.03
10								5.12	4.59			4.02
11								5.12	4.56			
12								5.12	4.55		4.04	
13				3.90				5.11	4.53			4.00
14								5.11	4.51		4.03	
15								5.11	4.51			3.98
16								5.11	4.51			
17			3.80					5.11	4.51			
18								5.10	4.50		3.98	
19		3.47						5.10	4.49			
20	2.88							5.09	4.47			
21								5.07	4.46			
22								5.05	4.45			
23			3.80					5.02	4.44			
24								4.99	4.49			
25								4.96	4.48			
26						5.01		4.93	4.47			
27	2.88						5.13	4.91	4.46			
28		3.65					5.13	4.89	4.45			
29							5.13	4.87	4.44			
30			3.80	4.10			5.13	4.85	4.43		3.86	
31					4.62		5.13	4.83		4.20		3.98

Observations of rainfall, evaporation, elevation of lake surface, and discharge should be continued at Lake Tahoe, in order that the records may be perfected and the estimates herein given be verified and checked. In considering these conditions doubtful features have been decided on the side of safety, so as to decrease the estimated supply. The estimates are therefore believed to be conservative, and it is expected that further physical studies, although deemed necessary, will demonstrate a greater and cheaper water supply.

No rainfall observations have ever been made within the Tahoe Basin, excepting those at Marlette Lake during 1894 and 1895 and at Glenbrook during the early part of 1901, and these extend over too short a time to be of much value. It is believed, however, that if the precipitation due to the elevation at the lake surface, computed from the table of increase of precipitation with each 100 feet rise, with Wadsworth as a base, or 31.97 inches, be taken as the normal for the entire Tahoe drainage area, it will be well on the side of safety. This amount of rainfall upon the lake surface will ordinarily compensate for all losses from evaporation, and the run-off from the remainder of the catchment area (326 square miles in extent), computed from the Newell curve, would be equal to a depth of 19½ inches, or 339,000 acre-feet in an average year, which can be impounded and drawn off as required.

During the seasonal year ending August 31, 1901, the mean precipitation at five stations in the upper part of the Truckee Basin was about 17 per cent in excess of the normal, though at Summit it was only 10 per cent above and at Truckee it was slightly below.

The run-off measured at Vista for the same period was only 645,112 acre-feet, being about 11 per cent less than the normal, as deduced from measurements made up to the present time, and in the writer's judgment, still below the normal run-off for the entire basin, after making allowance for the water impounded in Lake Tahoe, which would otherwise have been added to the measured run-off.[1]

During the seasonal year under consideration the volume of water discharged from Lake Tahoe through Truckee River was as follows:

Volume of water, in acre-feet, discharged from Lake Tahoe through Truckee River from September, 1900, to September, 1901.

Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
11,667	9,781	8,047	4,981	6,262	4,502	1,845	565	000	1,765	13,801	25,760	88,976

On August 31, 1900, the water surface in the lake stood 2.90 feet above the floor of the outlet gates in the dam in Truckee River. On August 31, 1901, it stood 4.83 feet above, the difference being 1.93 feet, representing 241,250 acre-feet of water which had been impounded during the year. This, added to the 88,976 acre-feet discharged

[1] This conclusion is based upon the discussion of evaporation and run-off on pages 47-48.

through Truckee River, gives 330,226 acre-feet as the total run-off of the Tahoe Basin in excess of evaporation for a year when the run-off from other parts of the Truckee Basin appears from data at hand to have been somewhat below the normal. Hence it is believed that the mean annual run-off will closely approximate that estimated on page 47, or 339,000 acre-feet.

Of course the watershed will not yield this volume of water every year, but it will be seen from the figures given that frequently the run-off is greater; and by building in the lake outlet a dam of sufficient height to hold back two or three times that amount of water, which is entirely feasible, it is certain that sufficient water can be

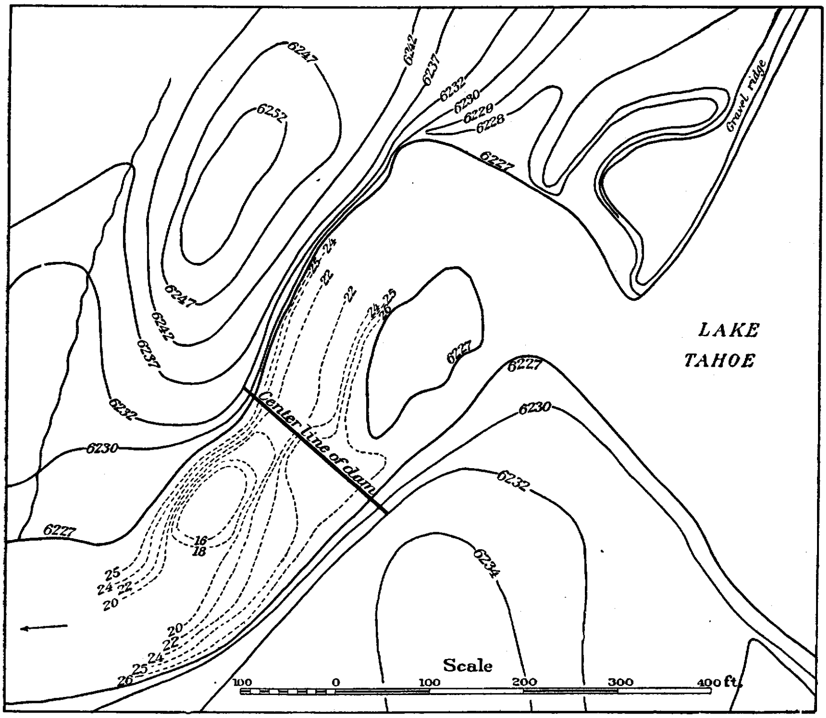


FIG. 6.—Contour map of Lake Tahoe dam site.

drawn off each season to materially augment the flow of Truckee River during low-water periods. It is estimated that fully 200,000 acre-feet can thus be drawn annually.

On making a survey of the outlet of Lake Tahoe, where the existing dam is located, it was found that the bed of the channel above this dam is in its deepest part from 1½ to 2 feet below the floor of the outlet gates, and that the general level of the ground a few feet back from the south or left bank is about 10 feet above the same datum, while the right bank rises quite abruptly to a height of 12 or 13 feet, and then more gradually for a considerable distance. This is shown in the contour map of the Tahoe dam site, fig. 6. On this map the elevation of the floor of the outlet gates is assumed at 6,223.8 feet, and in the further discussion of this storage project that elevation is used. By reference to the map it will be seen that a dam could readily be built to a height of 8.15 feet above the floor of the outlet gates, which would raise the water to the 6,232-foot contour and yet not be excessively long nor flood a large area of land around the outlet. Investigation, however, developed the fact that if the water should be raised much above the 6,230-foot contour it would necessitate raising the many landing piers on the lake, besides doing considerable damage at several of the summer resorts upon its shores. Inasmuch, therefore, as the storage capacity at the 6,230-foot contour would be nearly 750,000 acre-feet, or almost four times the amount contemplated to be drawn off annually, which would appear to afford a sufficient reserve to tide over any dry period likely to occur, this contour has been fixed upon as the highest flow line of the proposed reservoir; and in order that the water may not be lowered to such an extent as to interfere with navigation, the 6,224-foot contour is the ultimate low-water line provided for in this report. The capacities and areas of the reservoir within these limits are estimated as follows:

Area and capacity of proposed Lake Tahoe reservoir at different elevations.

Contour.	Area.	Capacity.	Contour.	Area.	Capacity.
Feet.	*Acres.*	*Acre-feet.*	*Feet.*	*Acres.*	*Acre-feet.*
a 6,224	123,500	....	6,228	124,700	495,600
6,226	123,700	247,200	6,230	125,100	745,400

a Level of outlet.

From the discussion of the water supply on the preceding pages it appears that two or three times in a decade there occurs a season when the drainage area yields nearly, if not quite, sufficient water to fill the reservoir, besides making up evaporation losses; while, so far as is known, there never has been a year when some water did not flow out of the lake in addition to that lost by evaporation. The precipitation tables given in the first part of this report show that at Truckee and Summit, the two stations which from their situation and surroundings should give results most nearly applicable to the Tahoe Basin, with thirty and twenty-five year records, respectively, there never have been more than two years of extremely light rainfall in succession, and never more than three in which the mean at these two stations was below the normal. This being true, it would appear reasonably safe to assume the same conditions to exist in the Tahoe watershed. It is upon this assumption and those previously stated, together with the known facts that during some years the water supply is equal to and possibly in excess of the proposed reservoir capacity and that the run-off from the drainage area is always in excess of the losses from evaporation, that the estimate of 200,000 acre-feet available annually from a reservoir holding nearly four years' supply is based.

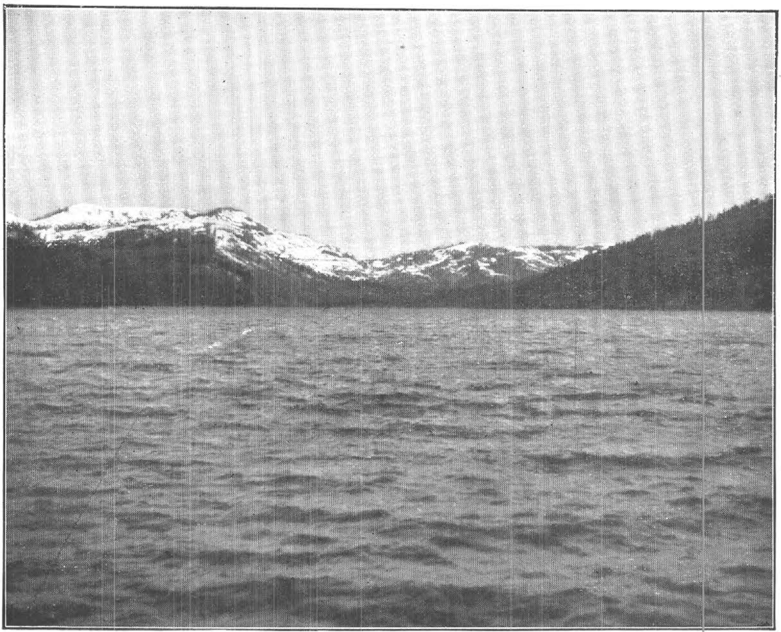
It may be that by impounding the water to a greater height the reservoir could be made to supply a larger amount than is here estimated, but in the absence of definite data it is not safe to rely upon it. If, however, a dam be built of sufficient height to raise the water to the 6,220-foot contour, a few years would suffice to determine the fact, and provision could then be made for the increased capacity before there would be pressing demand for the additional water.

The site selected as the most favorable one for the location of a permanent dam is a few feet above (toward the lake front) the existing dam. Here, at about the level of the lowest part of the river bed and extending across the channel, is a firm conglomerate which would afford a very good foundation. On this it is planned to erect a concrete dam having a maximum height of 13 feet and a top length of 220 feet. In this structure will be 20 gates or sluiceways, each having a clear width of 5 feet and a height of 3 feet. These will be closed by cast-iron or steel gates working on bronze bearings, which will be opened and closed by means of screw stems working in capstan head female screws at the top. No wasteway will be required in this dam, as the surplus water can at all times be drawn off through the outlet gates or can safely pass over its crest. The following estimate of cost has been prepared:

Estimate of cost of Lake Tahoe reservoir.

Dam:		
2,100 cubic yards of concrete, at $10		$21,000
Cofferdam for foundation		500
Excavation for foundation, 700 cubic yards, at $1		700
Outlet works, 20 gates complete		2,500
Deepening channel from lake to dam, distance 500 feet, excavation 5,000 cubic yards, at $0.60		3,000
Deepening channel below dam for 2,000 feet, bed width 100 feet, excavation 10,000 cubic yards, at $0.20		2,000
Damages for lands flooded:		
Upper Truckee marsh, 1,240 acres, at $4	$4,960	
Taylor Creek marsh, 110 acres, at $5	550	
Grounds at Tallac	1,250	
At Tahoe, 7½ acres, at $100	750	
		7,510
Engineering		5,000
Legal expenses		3,000
Contingencies, 10 per cent		4,521
Total		49,731

It will be seen that in this estimate provision is made for damages to lands flooded. At the southern end of the lake, at the mouth of Upper Truckee River, is a considerable area of low, marshy ground, much of which is under water at even ordinary stages of the lake,



A. DONNER LAKE.

B. FALLS OF LITTLE TRUCKEE RIVER, ONE-HALF MILE BELOW WEBBER LAKE.

but is dry at extremely low stages. A survey was made of this area, and it was found that approximately 1,240 acres lay between the 6,225-foot and the 6,230-foot contours and outside of a narrow sand bar which marks the boundary of the lake proper. The higher portions of this marsh are used for pasturage purposes in the summer and autumn. The sum of $4 an acre, or $4,960, is considered a liberal price for this land.

At the mouth of Taylor Creek, to the west of Tallac, is a similar tract of land, part marsh and part meadow, a little higher than that of the Upper Truckee, also used for pasturage. Of this area, 110 acres are below the 6,230-foot contour. A valuation of $5 an acre, which is believed to be fair, has been placed upon this land.

At Tallac about 1 acre of the improved grounds immediately adjacent to the hotel buildings is slightly below the 6,230-foot contour. The damage to this property is estimated at the cost of filling in this low ground to a height of 1 foot above the high-water line in the reservoir, which would be cheaper than moving the buildings to higher land and would really constitute an improvement of the grounds.

At Tahoe a small area of land would be flooded on each side of the lake outlet, amounting to about 7½ acres in the aggregate. That to the south is unimproved and not very valuable; part of that to the north is used by the Lake Tahoe Railway and Transportation Company. An average price of $100 an acre, or $750, which is thought reasonable, has been placed on this. In addition, $3,000 has been added to cover probable legal expenses.

DONNER LAKE.

Donner Lake, a view of which is shown in Pl. V, *A*, occupies a glacial basin lying close under the crest of the main Sierra Nevada and lengthwise between two spurs which jut eastward therefrom. Its ordinary water surface is almost 3 miles long, with a nearly uniform width of approximately a half mile, and is about 6,095 feet above sea level. It is about 3 miles west of the town of Truckee and immediately north of and below the line of the Central Pacific Railroad, where it ascends the Sierra from the east. (See fig. 7.)

The old glacial basin of Donner Lake extends eastward as a valley about 1¾ miles beyond the limits of the lake, thence its outlet is to the south, through a gap in a granite ridge, into Truckee River Valley. Cold Creek, flowing in from the south, joins Donner Creek, the lake's overflow channel, about three-fourths of a mile east of the lower end of the lake, and after flowing eastward through the valley turns to the south, through the gap mentioned, and joins Truckee River. The project for the utilization of the Donner Lake basin for a reservoir contemplates the construction of a long, low dam following an ancient terminal moraine nearly a half mile from the lower end of the lake, and impounding not only the surplus waters of the Donner

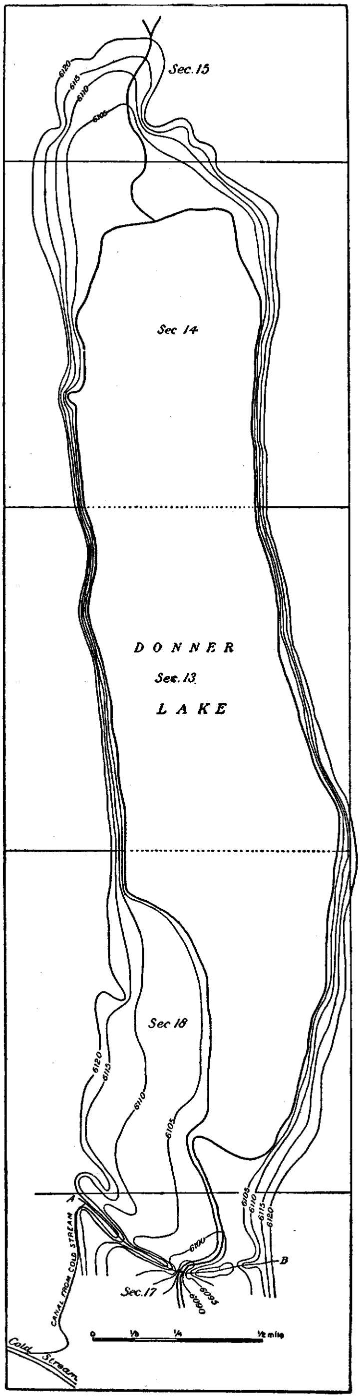


FIG. 7.—Contour map of Donner Lake reservoir site. The site occupies portions of secs. 13, 14, and 15 in T. 17 N., R. 15 E., and secs. 17 and 18, T. 17 N., R. 16 E., M. D. M.

Lake watershed, but those of the Cold Creek drainage basin also, by leading them into the reservoir by means of a canal about 3,000 feet in length. The drainage area of Donner Lake above the dam site is 14 square miles, while that of Cold Creek above where the water will be diverted to the reservoir is 13½ square miles. Several years ago Hon. Francis G. Newlands had constructed across Donner Creek, a few hundred yards below the lake, a timber dam of sufficient height to raise the water 10 or 11 feet above the low-water plane. This structure was not kept in repair, however, and it is now in condition only to retain the water to a height of 6½ or 7 feet. No continuous record of the run-off from this watershed has ever been kept, but numerous measurements of the flow of both Donner and Cold creeks were made during the years 1889 and 1900, the results of which have been given on pages 17 and 32. The measurements during the year 1889 were made after the season of high water, which occurred very early that year; hence they are not of special value, except to demonstrate the fact that the run-off from the combined Donner and Cold Creek basins during the months of July and August of the driest years is sufficient to make up all loss from evaporation, if that loss be not very much greater than was found to occur at Lake Tahoe during those months in 1900. It will be remembered that since these measurements were made below the lake, which has an area of about 840 acres, and from which evaporation was then going on, the water there found would only be required to compensate for the loss from the increased area of the completed reservoir over that of the natural lake.

About the middle of April, 1900, the gates in the dam across the lake outlet were closed, and the water was held back until May 12, when it had risen to a height of 5½ feet above the floor of the outlet gates. On that date the gates were partly opened, and on May 16 the water surface had fallen 0.5 foot. There was then passing the gates 128 cubic feet per second. The gates were afterwards closed down somewhat, so as to maintain the water level at about the same height as on the 16th, but were not entirely closed until May 30, when the lake surface was 5.2 feet higher than the datum mentioned. The issuing stream was measured on May 29 and was found to amount to 73 second-feet. After that date the water continued to rise slowly, until on June 25 it had reached the height of 6½ feet. During that period, however, and until the gates were again opened, about August 15, there was a leakage through them of from 1 to 10 second-feet. On May 21 a measurement of the discharge of Donner Creek was made just above where it enters Truckee River, and showed 324 second-feet, of which nearly 200 second-feet were supplied by Cold Creek. On June 3 another measurement at the same point gave a result of 127 cubic feet per second, all but about 2 second-feet of which was supplied by the latter tributary; and again on June 12 the flow was 99 second-feet, practically all of which was supplied by Cold Creek. On July 13 the combined discharge of Donner and Cold creeks a short distance above the confluence with Truckee River was 15 second-feet. No additional measurements were made until August 20, after the gates in the lake outlet were opened, when the discharge, measured immediately below the dam, was 69 second-feet. On September 13 there was flowing out of Donner Lake a stream of 19 second-feet, while Cold Creek was discharging 1.35 cubic feet per second. The lake surface on that date was 3.7 feet above the floor of the outlet gates. Since Donner Lake was filled to a height of 5.5 feet, or to a capacity of more than 4,200 acre-feet, between the middle of April and the 12th of May, it is apparent that during that time the mean run-off from the watershed was at least 70 cubic feet per second, and from the known character of the Cold Creek basin it must have yielded very nearly the same amount. After May 12 and until May 30, a period of eighteen days, the combined flow of Donner and Cold creeks is estimated at an average of 280 second-feet, or a total run-off of about 10,000 acre-feet. During the month of June the average discharge of Cold Creek was about 60 second-feet, equal to 3,500 acre-feet, and about 1,300 acre-feet were impounded in Donner Lake, 250 acre-feet more escaping through the outlet dam by leakage. Thus the total amount of water yielded by the Donner and Cold Creek basins between April 15 and June 30, 1900, was approximately 23,000 acre-feet.

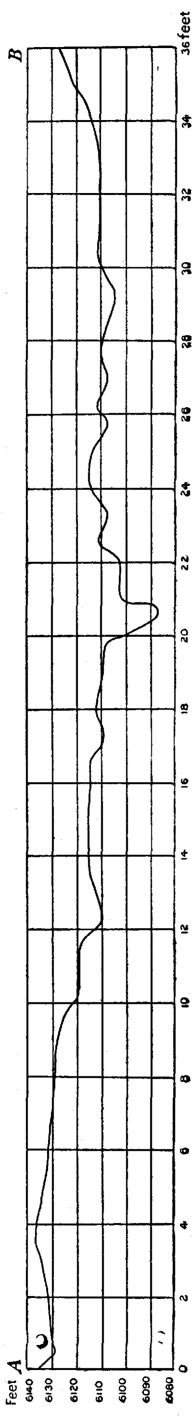


FIG. 8.—Profile of Donner Lake dam site.

While no data of the run-off in the earlier part of the year are at hand, it is certain that it was great enough to bring the total up to 28,000 or 30,000 acre-feet; and it is equally certain, as already stated, that the run-off after June 30 was ample to compensate for all loss from evaporation. Hence it has been deemed safe to plan for the storage in this basin of 26,900 acre-feet of water.

To accomplish this it will be necessary to build an earth dam or embankment along the crest of the ancient glacial moraine previously referred to, having a total length of 2,630 feet and a maximum height of 38 feet in the narrow gap through which Donner Creek flows. (See fig. 8.) The dam estimated upon would have a slope on the inner or water face of 3 horizontal to 1 vertical, and on the outer face a slope of 2 to 1, the inner slope to be paved with broken stone to protect it from the eroding action of the water, the width of the dam at its crest to be 30 feet. As previously stated, it will also be necessary to construct a canal 3,000 feet long from a point in Cold Creek nearly east of the south end of the dam, to lead the water of that stream into the reservoir.

A survey was made for this canal, and with the exception of about 200 feet of its length, where it passes around the point of the mountain and where a little rock will be encountered, it will be in earth, with nearly level cutting. The line was run on a grade of 1 to 1,000, and the canal planned to have a sectional area of 50 square feet, making the capacity 200 second-feet. For headworks all that is required is a dam or fill across the channel of Cold Creek and a waste and regulating gate near the head of the canal.

At the south end of the dam there is a favorable location for a wasteway, the width of which should be about 50 feet and the crest 6 feet below that of the dam. The outlet works estimated upon consist of two 36-inch cast-iron pipes laid side by side, incased in Portland-cement concrete and slightly curved upward at the intake end, where they will be fitted with hinged gates or valves, which will be operated from the top of the dam by means of rods working in collars set in its face.

Each pipe will also be fitted with a low-pressure screw valve at its discharge end.

The area of the Donner Lake reservoir site at different elevations above the low-water plane in the lake, given in the following table, was found by plotting the contours from the data of the surveys of 1899[1] and subsequent surveys by Mr. T. K. Stewart, a civil engineer, of Reno, Nev., and determining the area inclosed by planimeter. The lowest part of the bed of Donner Creek at the dam site is assumed to be at an elevation of 6,088 feet, and the low-water plane in the lake at 6,095 feet.

Area and capacity of proposed Donner Lake reservoir at different elevations.

Contour.	Area.	Contents.	Contour.	Area.	Contents.
Feet.	*Acres.*	*Acre-feet.*	*Feet.*	*Acres.*	*Acre-feet.*
6,095	840	0	6,115	1,260	20,400
6,105	980	9,100	6,120	1,340	26,900
6,110	1,140	14,400			

The lands which would be flooded by the construction of this dam are all private property. They are almost entirely unimproved, though at the head of the lake there is a dairy farm which is occupied during the summer, and on the north shore there is a small summer resort. The buildings of the latter, however, are small and cheap, probably costing not more than $2,500, and could readily be moved to higher ground—the shore being quite abrupt where they are situated—and the value of the resort be very slightly impaired. The existing dam at the lake outlet is also private property, but it has never been put to any beneficial private use, and has become greatly impaired since its construction. To provide for the damage to these lands and improvements the sum of $20,000 has been included in the estimate, and this provision is believed to be very liberal. The following is the estimated cost of the Donner Lake reservoir·

Estimate of cost of Donner Lake reservoir.

Dam:		
Earth embankment, 134,000 cubic yards, at $0.25		$33,500
Foundation		2,000
Riprap revetment, 14,400 square yards, at $0.65		9,360
Outlet works:		
400 feet of 36-inch cast-iron pipe, at $8.75 laid	$3,500	
200 cubic yards of concrete incasing pipe, at $8	1,600	
Valves, gates, and hoist	1,400	
		6,500
Wasteway		2,000
Supply canal from Cold Creek, complete		1,500
Damage to land and improvements		20,000
Engineering		4,000
Contingencies, 10 per cent		7,886
Total		86,746

The cost per acre-foot stored is $3.225.

[1] Thirteenth Ann. Rept. U. S. Geol. Survey, Pt. III.

INDEPENDENCE LAKE.

Independence Lake (see contour map, fig. 9) is almost an exact counterpart of Donner Lake, of glacial origin, immediately under the Sierra's crest, and held lengthwise between high, precipitous spurs projecting at right angles to it. The natural dam between these spurs, which forms the lake, is an old terminal moraine, but is not so plainly defined as that proposed to be utilized in forming the Donner Lake reservoir. It lies 9 miles, in a direct line, a little west of north from the latter lake. Its ordinary water surface is about 2½ miles in length, somewhat less than a half mile in width, and

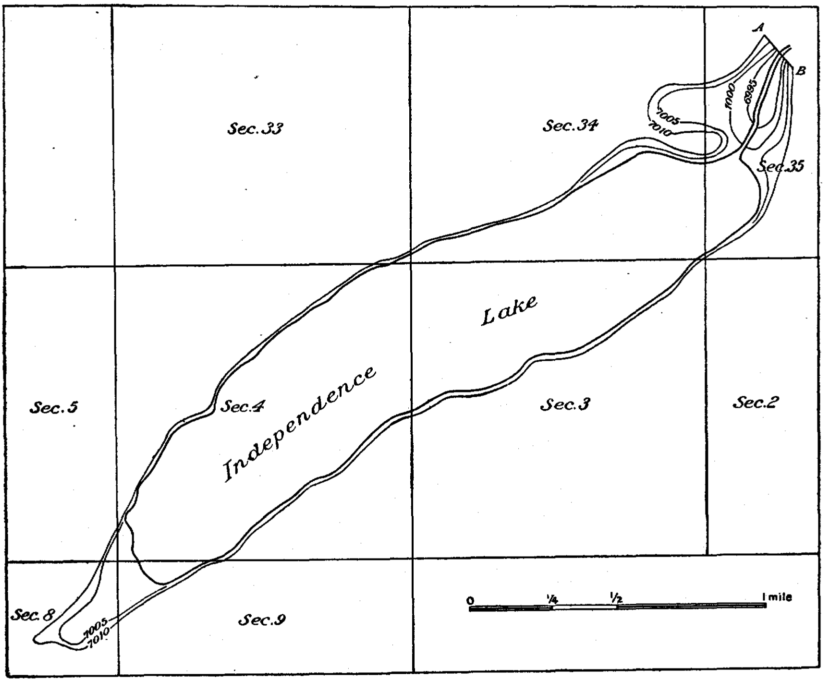


FIG. 9.—Contour map of Independence Lake reservoir site. The site occupies portions of secs. 33, 34, and 35 in T. 19 N., R. 15 E., and secs. 3, 4, 5, 8, and 9 in T. 18 N., R. 15 E., M. D. M.

covers an area of 709 acres. It is about 7,000 feet above sea level. Its waters escape through Independence Creek, flow northward, and become tributary to the Little Truckee, a main branch of Truckee River.

A survey for a storage reservoir was made at this site in 1889.[1] The dam section was chosen at a narrow part of the valley, 1,800 feet beyond the end of the lake, where the bed of the outlet creek is 12 feet below the reference water plane. (See fig. 10.) The margin of the lake and a contour 25 feet above were meandered, and a number of cross sections of the valley were measured, supplying the data

[1] Eleventh Ann. Rept. U. S. Geol. Survey, Pt. II.

from which the area and capacity of the reservoir were computed. The area embraced within the highest contour was 984 acres, and the capacity, not allowing for lowering the lake, was 23,707 acre-feet. In the autumn of 1900 this site and the drainage basin tributary to it were examined; and while the construction of a reservoir of the capacity mentioned appears feasible, and the probable cost not excessive, the water supply, except in seasons of abnormal precipitation, would not be sufficient to fill it, the catchment area, including the lake surface, being only 8½ square miles.

While no rainfall records have ever been kept in this neighborhood, the precipitation is known to be much greater than at Truckee, and probably the mean over the entire basin is greater than at Summit, on the Central Pacific Railroad. The normal at the lake-level elevation (7,000 feet), computed from the table on page 15, would be 41.89 inches. With this precipitation the annual run-off, computed from the Newell curve, would amount to 32 inches in depth, or a total of 14,500 acre-feet in volume, from 8½ square miles of watershed.

It is the common belief that the ordinary run-off from this basin is much greater, but in the absence of definite knowledge it has not been

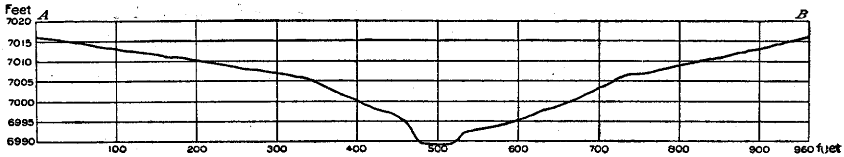


FIG. 10.—Profile of Independence Lake dam site.

deemed safe to rely upon so great a supply. Therefore a reservoir of 11,725 acre-feet capacity, contemplating raising the lake surface to a maximum height of 10 feet above the ordinary low-water plane and ultimately drawing it down to a depth of 5 feet below the same plane, has been estimated upon. To accomplish this will require the construction of a dam of 27 feet maximum height and a top length of 960 feet at the site surveyed in 1889, which appears to be the most favorable location. (See fig. 10.)

The bed of Independence Creek at this point is 12 feet below the plane of reference mentioned. To draw the water down 5 feet lower it will be necessary to excavate the channel to a depth varying from zero to 5 feet for a distance of 1,200 feet below the lake, removing about 5,000 cubic yards of earth, sand, and gravel.

The dam estimated upon is of the same type as that described for the Donner Lake reservoir, having the same slopes, a top width of 20 feet, and provided with the same type of outlet works. The material available for its construction, a loam containing a slight mixture of fine gravel and clayey matter, is plentiful near the site and can be cheaply put in place by scrapers. No investigations were made to ascertain the character of the substrata at the dam site, but the indications are that they are not such as to either endanger the stability of a dam of this type or permit the passage and loss of a volume of water that would be of consequence with the comparatively low head which will be behind the dam.

The elevation of the creek bed at the dam site has been assumed at 6,988 feet and that of the ordinary low-water level in the lake at 7,000 feet above the sea. The area of the reservoir 5 feet below the latter level is estimated. The areas embraced within the 7,005-foot and the 7,010-foot contours were determined by plotting those contours as closely as possible from the surveys of 1889 and measuring them with a planimeter. The following table gives the areas and capacities of the reservoir:

Area and capacity of proposed Independence Lake reservoir at different elevations.

Contour.	Area.	Capacity.	Contour.	Area.	Capacity.
Feet.	*Acres.*	*Acre-feet.*	*Feet.*	*Acres.*	*Acre-feet.*
6,995	700	0	7,005	820	7,500
7,000	740	3,600	7,010	870	11,725

Only about 160 acres of land, all in private ownership, outside of that occupied by the present lake would be flooded by the construction of this reservoir, and none of this is in itself of special value. Part of it is occupied by the Independence Lake summer resort, which would have to be moved to a higher and somewhat less attractive location. To defray the cost of this removal and the compensating damages, as well as the damages to lands flooded, the sum of $12,000, which is considered ample, has been included in the estimate.

Estimate of cost of Independence Lake reservoir.

Dam:		
Earth embankment, 25,600 cubic yards, at $0.25		$6,400
Foundation		1,000
Riprap revetment, 3,600 square yards, at $0.75		2,700
Outlet works:		
Excavating channel to drain lake to depth of 5 feet, 5,000 cubic yards, at $0.20	$1,000	
300 feet of 30-inch cast-iron pipe, at $8 laid	2,400	
140 cubic yards of concrete incasing pipe, at $8.50	1,190	
Valves, gates, and hoist	1,200	
		5,790
Wasteway, complete		1,000
Damage to land and summer resort		12,000
Engineering		2,000
Contingencies, 10 per cent		3,089
Total		33,979

The cost per acre-foot stored is $2.898.

TWIN VALLEY.

This reservoir site (see fig. 11) is on the North Fork of Prosser Creek, one of the main branches of Truckee River, about 4 miles, in a direct line, a little east of south of Independence Lake, and at an approximate altitude of 6,300 feet above sea level. The drainage area above the site is 12 square miles in extent, in character similar to and having about the same precipitation as the Independence Lake Basin. No measurements of discharge of the North Fork of Prosser Creek have ever been made, though during a portion of the years 1889 and 1890 the main stream was gaged immediately above its junction with

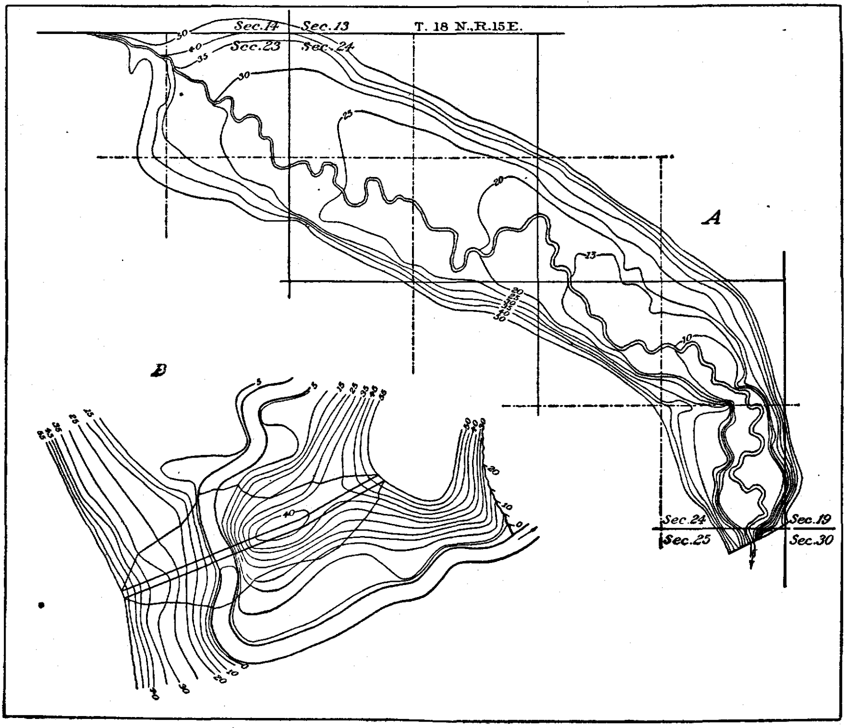


FIG. 11.—Contour maps of Twin Valley reservoir site and dam site. The site occupies portions of secs. 23 and 24 in T. 18 N., R. 15 E., M. D. M.

Truckee River, the results of the gagings being given in the tables of monthly discharge on page 21, and again in 1900 three measurements of discharge were made near the same point. However, since the reservoir planned for this location will have a capacity of but 7,818 acre-feet, there can be no question about the water supply being ample to fill it.

A survey of the reservoir site was made during the fiscal year 1889-90,[1] a cross section at the dam site being measured, a contour 30 feet above the lowest point at the dam site meandered, and several cross sections of the reservoir site surveyed to supply data for calcu-

[1] Twelfth Ann. Rept. U. S. Geol. Survey, Pt. II.

lating the capacity. It was found that the area inclosed by the 30-foot contour was 310 acres, and the contents between that contour and the base of the dam approximately 3,480 acre-feet. During the month of August, 1901, a more detailed survey of this site was made by the writer, and it was developed that water could with economy be impounded to a height of 50 feet above the lowest point in the stream bed at the dam site, or 15 feet higher than was contemplated by the original survey, the so-called 30-foot contour of that survey being really 35 feet higher than the above datum. (See fig. 11.)

The dam site is at a narrow place in the valley, which has been partially closed by an ancient glacial moraine, between which and the high granite ridge to the southwest the creek flows. It is proposed to raise this moraine somewhat and to dam the gorge now occupied by the stream by means of an earth embankment to be put in place by scrapers. The maximum height of the embankment will be 55 feet and the top length over all 760 feet. A contour map of the dam site is shown in fig. 11.

The assumed elevation of the lowest point at the dam site is 6,300 feet. The outlet gate will be at an elevation of 6,305 feet, and the high-water flow line in the reservoir at 6,350 feet. The various contours between these elevations were plotted and the areas determined by means of a planimeter. The areas and capacities are as follows:

Area and capacity of Twin Valley reservoir site at different elevations.

Contour.	Area.	Capacity.	Contour.	Area.	Capacity.
Feet.	*Acres.*	*Acre-feet.*	*Feet.*	*Acres.*	*Acre-feet.*
6,305	3	0	6,330	221	2,105
6,310	23	65	6,335	266	3,323
6,315	50	248	6,340	292	4,718
6,320	85	585	6,350	328	7,818
6,325	151	1,175			

The dam estimated upon is of the same type as that described for the Donner Lake and the Independence Lake reservoirs, with the same slopes and a top width of 20 feet. Material for its construction, of fair quality, is to be found in the valley above, the average haul being about 1,000 feet. As designed, the outlet works will consist of a tunnel through the glacial moraine referred to, about 225 feet east of the creek bed, in which will be laid a single 30-inch cast-iron pipe encased in Portland-cement concrete and surrounded by proper cut-off rings of the same material. To this pipe will be fitted valves and gates similar to those described for the Donner Lake reservoir outlet. The wasteway will be located at the north end of the dam. It will consist of a concrete weir with a wooden discharge flume lined with sheet iron, to convey the water to the creek channel below the dam.

The lands which will be flooded by this reservoir are all in private ownership, and nearly all are excellent pasture lands, though they can be used for this purpose only in summer time. The only improvements upon them consist of a small frame dwelling and a dairy house of very cheap construction. The sum of $3,200 has been allowed in the estimate for right of way over flooded lands and damages to improvements. Following is the estimate of cost:

Estimate of cost of Twin Valley reservoir.

Dam:		
Preparing foundation		$1,000
Earth embankment, 72,000 cubic yards, at $0.25		18,000
Riprap revetment, 7,800 square yards, at $0.50		3,900
Outlet works:		
250-foot tunnel with approaches	$1,250	
260 feet of 30-inch cast-iron pipe, at $8, laid	2,080	
Concrete encasing pipe, cut-off walls, and tunnel portals, 160 cubic yards, at $0.10	1,600	
Valve, gate, and hoist	820	
		5,750
Wasteway, complete		2,600
Right of way over flooded lands and damages		3,200
Engineering		3,000
Contingencies, 10 per cent		3,745
Total		41,195

Cost per acre-foot, stored, is $5.27.

LITTLE TRUCKEE.

This reservoir site, surveyed during the season 1889-90 and designated reservoir No. 34[1], is on Little Truckee River, between Webber

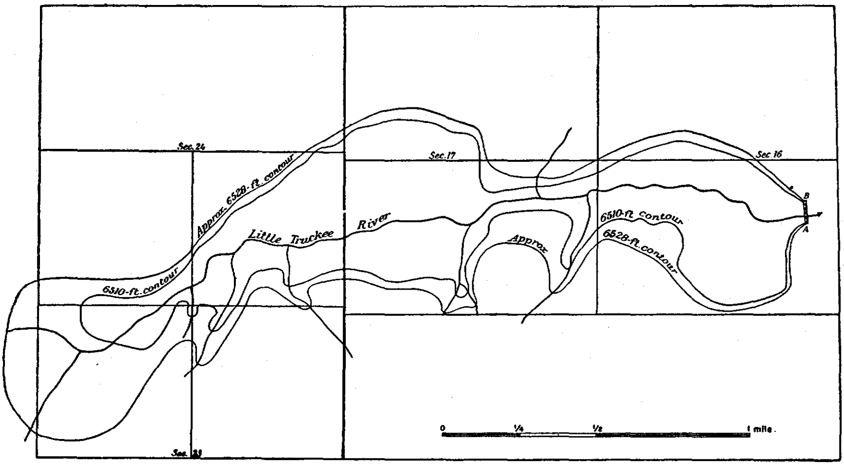


FIG. 12.—Contour map of Little Truckee reservoir site No. 1, in secs. 24 and 25, T. 19 N., R. 14 E., and secs. 16 and 17, T. 19 N., R. 15 E., M. D. M.

Lake and its junction with Independence Creek, and is shown in fig. 12. It occupies a valley of irregular width, extending about 3 miles up from a narrow canyon through which the stream flows, and where

[1] Twelfth Ann. Rept. U. S. Geol. Survey, Pt. II.

it is proposed to construct the impounding dam. The altitude of the stream bed at this point is about 6,460 feet above sea level. The tributary drainage area, including the watershed above Webber Lake, is 33 square miles in extent, lying to the north and west of Mount Lola, the highest peak in this part of the Sierras. The major part of the area has an altitude of more than 7,000 feet. A view of the river a half mile below Webber Lake is shown in Pl. V, *B*.

The survey which was made during 1889–90 consisted of the measurement of a cross section of the canyon at the dam site, the meandering of a contour 60 feet above the base of the proposed dam, and the measurement of several cross sections of the valley below this contour. The height of the dam proposed was 60 feet, the area inclosed

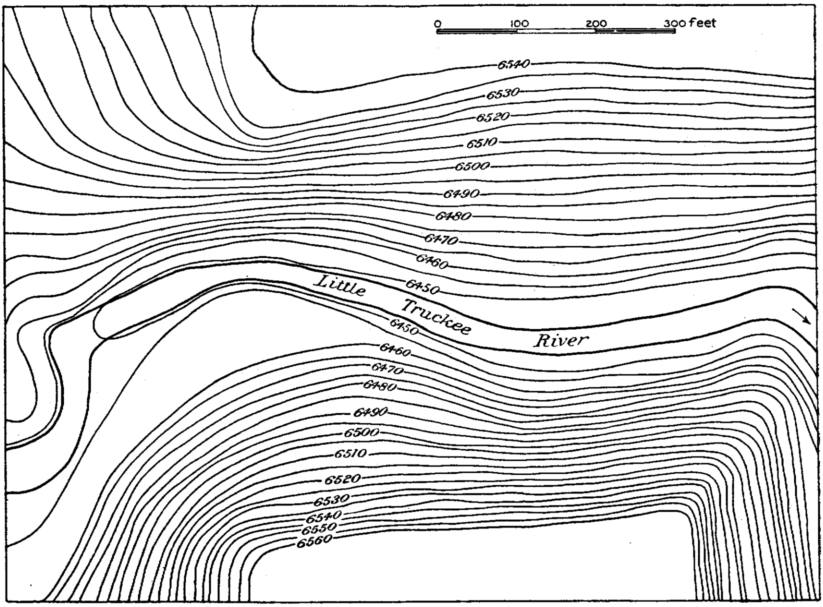


FIG. 13.—Contour map of dam site of Little Truckee reservoir No. 1.

by the 60-foot contour 450 acres, and the approximate contents 10,100 acre-feet. An examination of this site made in 1900 demonstrated the feasibility and economy of raising the water 18 feet higher than was contemplated by the earlier survey, by constructing the dam a little farther down the canyon and raising it to a height of 87 feet, the crest being 7 feet above the highest flow line in the reservoir, and the base 2 feet lower than at the site previously selected. A contour map of the dam site now proposed is shown in fig. 13. A rough preliminary survey was made for the purpose of determining approximately the area and capacity of the reservoir which would be formed by the higher dam. The area was found to be about 710 acres, and the capacity about 20,540 acre-feet.

No definite data of the amount of the water supply are in existence. The precipitation is known to be greater than at Independence Lake, but no measurements of the run-off from the basin of Little Truckee River have ever been made, except at a point near its mouth, where the drainage from its entire watershed, 179 square miles in extent, is concentrated. During the year 1890 a continuous record of discharge was kept at this point from April to October, inclusive, the total run-off for the period being 338,753 acre-feet, equivalent to a depth of 35½ inches over the entire watershed. The run-off from the portion of the drainage basin above the reservoir site under consideration, where the precipitation is far greater than on the lower part, which is also less precipitous, was of course much more than the average. During the same period the discharge of Truckee River below Boca, where the Little Truckee joins the main stream, was 968,334 acre-feet, from a total drainage area of 902 square miles, or 1,071 acre-feet per square mile. The year 1890 was one of abnormally large water supply, but, no record of the discharge of Little Truckee River having been kept during drier years, it is impossible to make a direct comparison between the run-off from its watershed and that from other portions of the Truckee Basin for such years. Yet if, as seems reasonable, somewhere near the same relative proportion of the total run-off from the upper portion of the drainage basin (above Stateline Mills) is supplied by the Little Truckee during the same months of each year, it is possible to roughly approximate the total discharge of that stream during that period in 1900, and this has been done.

The run-off above Boca from April to October, inclusive, 1890, being 1,071 acre-feet per square mile, the total run-off above Stateline Mills during the same period—the area being 955 square miles and the additional drainage area being high and precipitous—would be about 1,022,800 acre-feet. Of this total Little Truckee River supplied 33⅓ per cent. During the same months of the year 1900 the total flow of the Truckee at Stateline Mills was 305,578 acre-feet. The probabilities are that even a larger proportion than in 1890 was furnished by Little Truckee River, inasmuch as during a considerable portion of the time no water was flowing from Lake Tahoe, while during 1890 the gates in the outlet to that lake were not at any time closed. However, if not more than 33⅓ per cent came from that basin, the run-off must have amounted to 100,840 acre-feet. Owing to the diminished precipitation over the drainage area, it is certain that a much greater proportion of the run-off was from the upper portion of the watershed, where the rainfall and snowfall are heaviest, than was the case in 1890. In the former years the 33 square miles of watershed above the proposed Little Truckee reservoir No. 1 probably yielded one-fourth of the total supply, while during 1900 it is likely that fully one-third, or more than 33,000 acre-feet, came from the same area, and during the remaining five months of the year it is safe to estimate that not less than 6,000 acre-feet of water flowed past this point.

Thus if the foregoing reasoning be correct, and it is certainly within the realm of probability and is the only foundation upon which to base even an approximate estimate, it appears to be, and the writer believes it is, perfectly safe to rely on this reservoir being filled annually, even during dry years, and to count on there being, besides, a surplus of from 18,000 to 19,000 acre-feet available for storage at other points, while during years of average rainfall there will certainly be a much larger supply than that estimated.

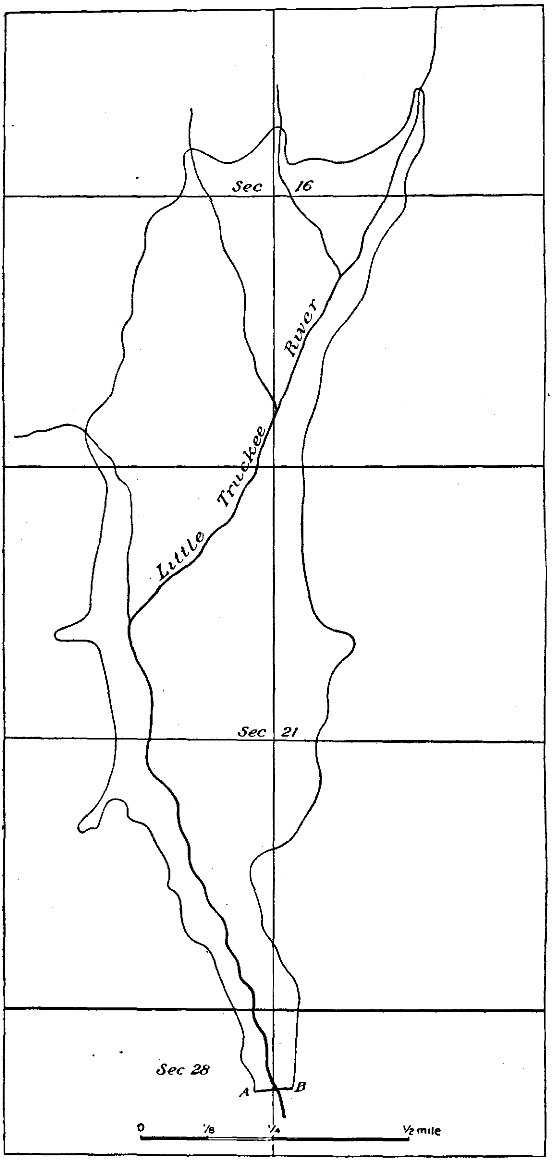


FIG. 14.—Map of Boca reservoir site, in secs. 16, 21, and 28 of T. 18 N., R. 17 E., M. D. M.

The dam estimated upon is of earth, of the hydraulic-fill type, the conditions being favorable for that method of construction. On either side of the canyon is earth of a sandy loam character, with a sufficient percentage of clayey matter to render the embankment watertight when deposited in that manner; and the grades from the base of the mountains, a considerable distance back from the edge of the canyon, are ample for sluicing. By constructing from a creek on the south side of the valley a ditch having a length of about $2\frac{1}{2}$ miles and traversing ground through which construction would be comparatively easy, it will be possible to deliver at the dam, and at a considerable elevation above its crest, whatever volume of water may be required for handling the material. While extremely flat slopes are not essential in an earth dam constructed by this method, to be on the side of safety the slopes allowed in the structure estimated upon are 3 to 1 and 2 to 1 on the inner and outer faces, respectively. The former slope is designed to be paved with broken stone and cobbles to protect it from wave action. The crest of the dam will be 24 feet wide and 490 feet in length.

The arrangement of the outlet works, which are designed to be located 7 feet above the base of the dam, is identical with that described for the Donner Lake reservoir. The wasteway will be around the north end of the dam, discharging back into the stream several hundred feet beyond its lower toe. It is designed to have a discharging capacity of 2,500 second-feet with the water in the reservoir 2 feet below the top of the dam, its crest, arranged as a weir, being 10 feet below that of the dam.

The estimate contemplates the construction of a concrete waste weir and a wooden discharge flume. The character of the substrata at the dam site is unknown, but it is believed that the provision in the estimate for preparing foundations is sufficient to cover the cost of properly connecting the artificial fill with approximately impervious material beneath the surface of the ground.

The assumed elevation of the lowest part of the stream bed at the dam site is 6,458 feet above sea level. The outlet gates are designed to be placed at an elevation of 6,465 feet, and the ordinary high-water flow line in the reservoir will be at 6,528 feet. The 60-foot contour of the earlier survey referred to corresponds to the elevation of 6,520 feet, and the area embraced within and the capacity up to that contour are accepted at the figures given by that survey.[1] The 6,528-foot contour was plotted approximately (see fig. 12, p. 61) and the area determined by planimeter. The areas and capacities are as follows:

Area and capacity of proposed Little Truckee reservoir at different elevations.

Contour.	Area.	Capacity.	Contour.	Area.	Capacity.
Feet.	*Acres.*	*Acre-feet.*	*Feet.*	*Acres.*	*Acre-feet.*
6,465	[a] 10	([b])	6,528	710	20,540
6,520	450	10,100			

[a] Estimated. [b] Level of outlet.

Nearly all of the land which would be flooded by this reservoir is in private ownership, and part of it is under fence, though it is used only for pasture during the summer. There are also upon the land a

[1] Twelfth Ann. Rept. U. S. Geol. Survey, Pt. II.

small frame house and barn. These, however, are cheap structures, and while they are within the basin and would have to be paid for with the right of way over the land, they would not very greatly increase the cost. In the following estimate the sum of $10,000 is allowed for right of way and damages to property, and this sum is deemed ample. The following is the estimate which has been prepared:

Estimate of cost of proposed Little Truckee reservoir.

Dam:		
Hydraulic filling, 150,000 cubic yards, at $0.10		$15,000
2½ miles of ditch to supply water for fill		1,500
Preparing foundation		1,000
Riprap revetment, 8,000 square yards, at $0.75		6,000
Outlet works:		
900 feet of 30-inch cast-iron pipe, at $8 laid	$7,200	
330 cubic yards of concrete incasing pipe, at $8.50	2,805	
160 cubic yards of concrete for gate tower, at $10	1,600	
Valves, gate, and hoist complete	1,250	
Cable-suspension footbridge and gatehouse	845	
		13,700
Wasteway		4,000
Damages to land and improvements		10,000
Engineering		5,000
Contingencies, 10 per cent		5,620
Total		61,820

The cost per acre-foot of storage capacity is $3.01.

A map of Boca reservoir site is shown in fig. 14 (p. 64).

HENNESS PASS VALLEY.

This reservoir site, which is shown in outline in fig. 15, occupies a small basin immediately to the north of the valley of Little Truckee River, opposite the junction of that stream and Independence Creek, from which it is separated by a narrow, rocky ridge. About 200 acres of the floor of this basin are perfectly level, somewhat marshy in character, and on the west and south are bounded by the narrow ridge mentioned, which rises from it abruptly, while to the north and east the ground rises very gradually. The elevation is about 6,367 feet above sea level. The immediate drainage area consists of 4½ square miles of undulating ridges almost bare of timber. The main water supply for the reservoir will be drawn from Little Truckee River, by means of a canal about 4 miles in length, having a capacity of 100 cubic feet per second, heading a short distance below the dam for Little Truckee reservoir, last described. The total drainage area, including that of the reservoir mentioned and the territory whose drainage would be intercepted by the supply canal, is 41 square miles. The discussion of the water supply for the Little Truckee reservoir, showing, so far as is practicable in the absence of complete data, the volume available at that point, indicates a surplus sufficient to fill the reservoir contemplated, even in dry seasons, so that there can be no question about its sufficiency in years of normal precipitation, while the run-off from 8 square miles of additional catchment area will still further tend to insure this, though the precipitation on the latter area is lighter.

The dam site, shown in fig. 16, is in the canyon leading out of the valley to Little Truckee River. The maximum height of the dam will be 56 feet, its length on top 720 feet, and its top width 24 feet. It will be of earth, of the hydraulic-fill type, with the same section as the dam last described. The water for making this fill will be furnished by the reservoir-supply canal from the Little Truckee, which can be brought in about 25 or 30 feet higher than the proposed crest of the dam. The material for the structure is a clayey earth containing some gravel, cobbles, and bowlders. The outlet works estimated upon are of the same type as those described for the Donner Lake and the Twin Valley reservoirs, and will be located 5 feet above the base of the dam. A very small wasteway, located at a depression in the rocky ridge at the south side of the reservoir, will

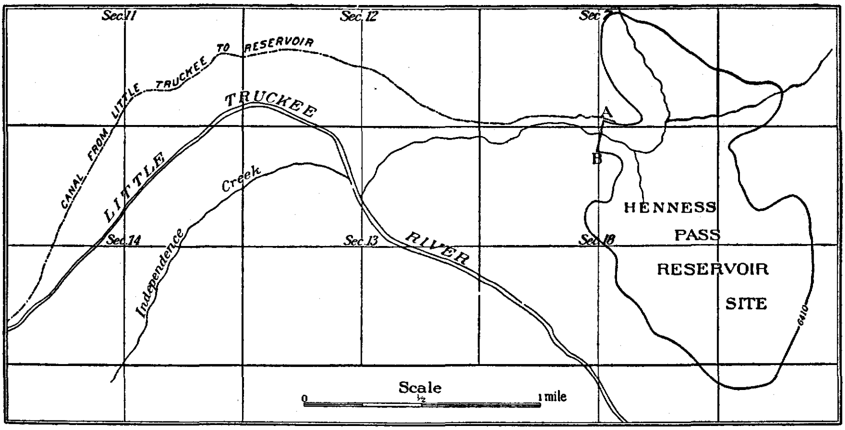


FIG. 15.—Map of Henness Pass Valley reservoir site and supply canal. The site occupies portions of secs. 7, 8, 18, and 19 in T. 19 N., R. 16 E., M. D. M.

be required, as almost the entire water supply comes from Little Truckee River and can be shut off at will.

This reservoir site was surveyed by Mr. T. K. Stewart, for Hon. Francis G. Newlands, in 1890, a contour 50 feet above the floor being meandered and a few cross sections of the basin measured, from which data the area and capacity were computed. The former was given as 590 acres, which is accepted as correct for the purpose of this report; but the latter, as demonstrated by measurements made in October, 1900, was overestimated. The later survey, while furnishing sufficient information to determine the approximate capacity of the reservoir up to the 50-foot contour mentioned, was not close enough to permit accurate plotting of contours intermediate between that and the base of the dam. The elevation of the floor of the canyon at the dam site is taken at 6,360 feet above sea level. The outlet works are planned to be at 6,365 feet and the highest flow line in the reservoir at 6,410 feet. The estimated capacity is 17,000 acre-feet. The lands which would be flooded by this reservoir are all in private ownership, but are entirely unimproved. They furnish some grazing in the summer, but are valuable for no other purpose. In the following estimate the sum of $3,000, or a little more than $5 an acre, is allowed

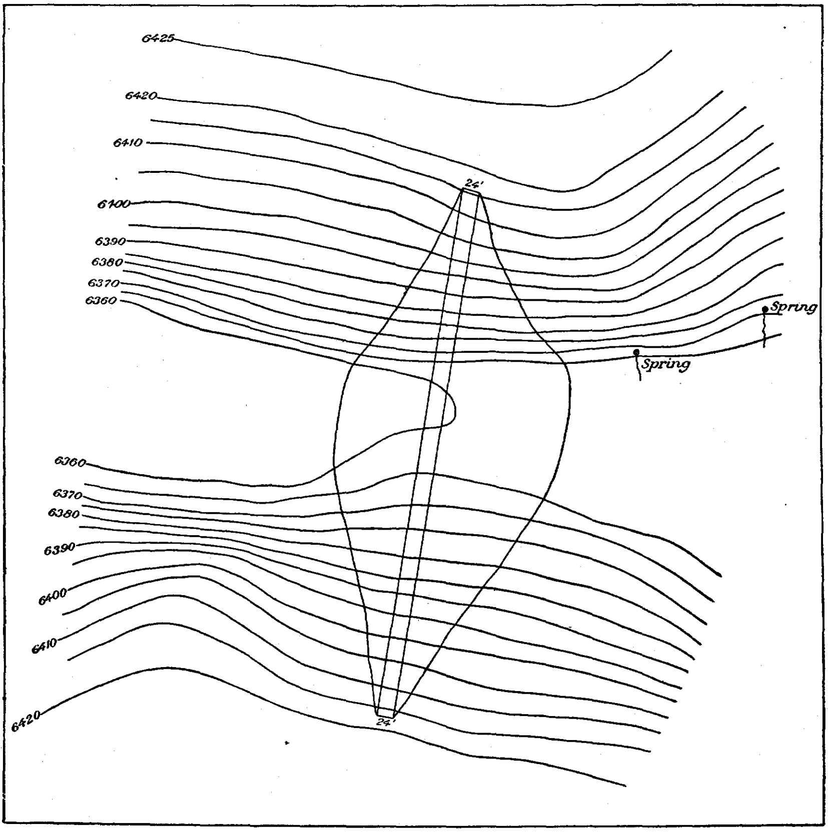


FIG. 16.—Contour map of Henness Pass Valley dam site.

for the cost of right of way over them, and this amount is considered liberal. The following is the estimate which has been prepared:

Estimate of cost of proposed Henness Pass Valley reservoir.

Dam:		
Hydraulic filling, 108,800 cubic yards, at $0.10		$10,880
Preparing foundation		1,000
Riprap revetment, 8,400 square yards, at $0.50		4,200
Supply canal, complete, 4 miles, at $3,000		12,000
Outlet works:		
620 feet 30-inch cast-iron pipe laid, at $8	$4,960	
260 cubic yards concrete, encasing pipe, at $8.50	2,210	
Gates and hoist, complete	1,000	
		8,170
Right of way, complete		3,000
Engineering		4,000
Contingencies, 10 per cent		4,325
Total		47,575

The cost per acre-foot of storage capacity is $2.80.

DOG VALLEY.

This reservoir site, shown in fig. 17, occupies a small valley situated between outlying spurs of the Sierra Nevada just west of the boundary line between California and Nevada, and about 4 miles northwest of the town of Verdi, Nev. The elevation is about 5,700 feet above sea level. The catchment basin comprises 16 square miles, ranging in altitude from that of the reservoir to 8,500 feet, most of which is covered with pine and fir timber, and is quite precipitous. This site

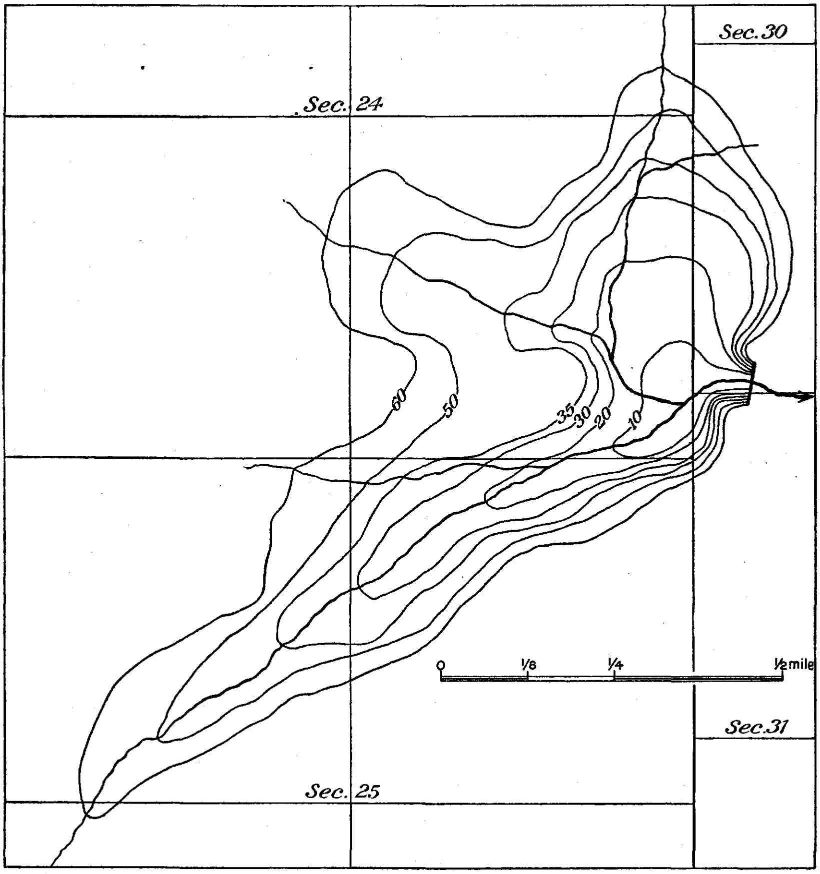


FIG. 17.—Contour map of Dog Valley reservoir site, in secs. 24 and 25 of T. 20 N., R. 17 E., and secs. 30 and 31 of T. 20 N., R. 18 E., M. D. M.

was surveyed by the writer in 1895, the topography of the lower portion of the valley being taken by means of transit and stadia, and the contours plotted as shown in fig. 17. A cross section of the outlet canyon immediately below the valley, at what appeared to be the most favorable site for a dam was also measured (see fig. 18), and it was found that by the construction of a dam to a maximum height of 65 feet with a top length of 235 feet, a reservoir having a surface area of 274 acres and a capacity of approximately 5,785 acre-feet would be created. No exact data of the water supply for this reservoir have been collected, only three measurements of the discharge of Dog Valley Creek, the outlet of the basin, having been made. The first of these was on May 22, 1889,[1] at the point where the creek joins Truckee River, opposite the town of Verdi, when the discharge was 7 cubic feet per second. The last two were on July 26 and September 10, 1900, when 0.40 and 0.80 second-foot, respectively, were found a short distance above where the earlier measurements were made. The discharge at the reservoir site, except at flood stage, is always greater than at the points described, which are about 3 miles below. A considerable loss occurs by absorption in the bed of the canyon, which is filled with gravel and bowlders to an unknown depth, and there are no affluent streams to compensate for this loss. The measurements were all made after the flood season had passed, the snow falling on this watershed melting much earlier than on other parts of the Upper Truckee Basin. Usually the greatest run-off from the Dog Valley drainage area occurs during the latter part of March and through the month of April.

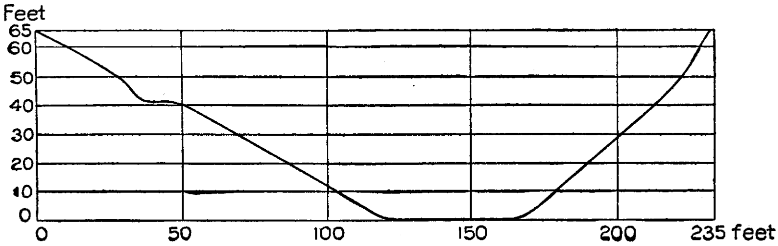


FIG. 18.—Profile of Dog Valley dam site.

In the absence of definite data on which to base an estimate of the water supply available for storage in the proposed Dog Valley reservoir, a rough approximation can be reached by computing the precipitation which should occur at this altitude, from the table of "Increase in precipitation with each 100-foot rise in elevation, with Wadsworth, Nev., as a base," page 15, and the probable run-off from a watershed composed almost entirely of precipitous mountains. The mean precipitation at an elevation of 5,700 feet, the altitude of the lowest point in the basin, which is taken in order to be on the side of conservatism, would be 25.25 inches, and the run-off, computed from the Newell curve, a trifle more than 11 inches, or a total of 9,420 acre-feet from the 16 square miles of drainage area, which is more than 60 per cent greater than the reservoir capacity. Therefore, the writer, who has been acquainted with the Dog Valley Basin for the last ten years and has observed the creek quite frequently during that period, believes that the water supply will be ample even in dry seasons—and it certainly will be ample during seasons of normal rainfall—to fill the proposed reservoir, and that the flow of the creek at the lowest stage in the summer will nearly offset the loss from evaporation, which at this point will be greater than from the reservoirs previously described.

[1] Eleventh Ann. Rept. U. S. Geol. Survey, Part II.

To form this reservoir, as already stated, will require a dam having a maximum height of 65 feet and a top length of 235 feet. It should be of the rock-fill type, with an earthen face on the upstream side. The slope of the rock fill on the lower side will be 1½ horizontal to 1 vertical, and on the line of contact with the earth it will be vertical. The earth will be obtained from the bed of the reservoir and be placed with scrapers. It will have a slope of 2½ to 1 on the upper face, which will be pitched with stone to protect it from wave action. The top width of the dam will be 10 feet. The outlet will be by means of a cast-iron pipe embedded in concrete in a tunnel run through the bed rock in the projecting abutment. The assumed elevation of the stream bed at the dam site is 5,700 feet above sea level. The outlet works will be at 5,710 feet elevation, the highest flow line in the reservoir at 5,760 feet, and the crest of the dam at 5,765 feet. The wasteway will be arranged as a weir discharging over a porphyry ledge at the south end of the dam, the crest of which will be 5 feet below the crest of the dam.

The reservoir contours were plotted to scale, as shown in fig. 17, and the areas inclosed were determined by planimeter. The areas and capacities thus determined are as follows:

Area and capacity of Dog Valley reservoir site at different elevations.

Contour.	Area.	Capacity.	Contour.	Area.	Capacity.
Feet.	*Acres.*	*Acre-feet.*	*Feet.*	*Acres.*	*Acre-feet.*
5,700	(a)	0	5,735	110	1,240
5,710	b 10	0	5,750	188	3,475
5,720	36	230	5,760	274	5,785
5,730	74	780			

a Base of dam. b Level of outlet gates.

The land which would be flooded by the construction of this dam is all in private ownership and most of it under fence, but it is used only for pasturage. In 1895 $1,800 was the price placed upon it, and as its value has not been enhanced since that time this sum has been included in the estimate to provide for its purchase for reservoir purposes. The following is the estimate of cost:

Estimate of cost of Dog Valley reservoir.

Dam:		
Rock filling, 13,380 cubic yards, at $0.75		$10,035
Earth embankment, 25,500 cubic yards, at $0.25		6,375
Riprap revetment, 2,800 square yards, at $0.50		1,400
Preparing foundation		500
Outlet works:		
300-foot tunnel, 3½ by 5 feet, at $6	$1,800	
300 feet of 24-inch cast-iron pipe, at $5	1,500	
110 cubic yards of concrete incasing pipe, etc., at $10	1,100	
Gates and hoist, complete	500	
		4,900
Wasteway, complete		1,250
Rights of way		1,800
Engineering		3,000
Contingencies, 10 per cent		2,926
Total		32,186

The cost per acre-foot of storage capacity is $5.564.

PRESENT USES OF WATER AND EXISTING WATER RIGHTS.

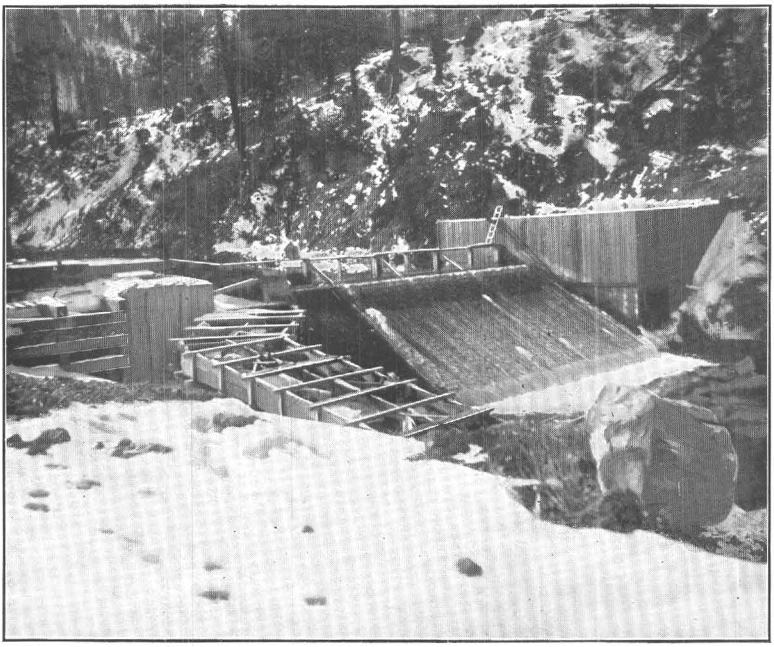
In the foregoing pages an effort has been made to show the extent of the water supply of the Truckee Basin and the means by which it can be conserved to the best advantage. Before proceeding to the consideration of the possibilities of and the means for its use for irrigation and other purposes, it is necessary to inquire into the existing rights to the waters of the stream which have become vested and can not be disturbed.

POWER.

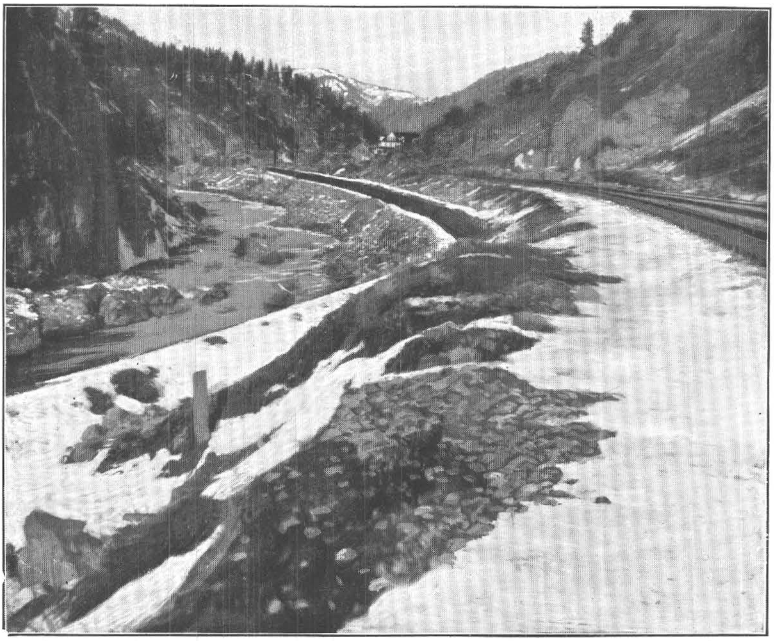
At the present time the waters of Truckee River are employed by eight companies, at as many localities on the stream, for the generation of power, as follows: Truckee Lumber Company, at Truckee, Cal.; Floriston Pulp and Paper Company, at Floriston, Cal.; Truckee River General Electric Company, at Mystic, Cal.; Verdi Mill Company, at Verdi, Nev.; Reno Electric Light and Power Company, a short distance above Reno, Nev.; Riverside Flour Mill Company, at Reno, Nev.; Reno Reduction Works, a short distance below Reno, Nev.; and Wadsworth Light and Power Company, at Wadsworth, Nev.

At Truckee the Truckee Lumber Company operates a sawmill and a door, sash, and box factory. To supply power for these the water is diverted directly from the main river a short distance below the mouth of Donner Creek by means of a timber dam and a short canal. The sawmill is run by a turbine working under an effective head of 21 feet, and requires about 160 second-feet of water to generate the 300 horsepower necessary to run it to its full capacity. The factory is located below the sawmill, is operated by a turbine working under a head of 26 feet, and requires about 110 second-feet of water, which is taken from the sawmill tailrace to run it to its full capacity. It is operated the year round, but the mill is always closed down from December 1 to about May 1.

The Floriston Pulp and Paper Company, the next user of water for power purposes below Truckee, is engaged in the manufacture of paper from wood pulp. For the operation of the plant the water is diverted from the river by means of a timber dam (see Pl. VI, *A*) and is conveyed to the mill through a wooden stave pipe 9 feet in internal diameter and 2,000 feet long (see Pl. VI, *B*). Six turbines, varying in capacity from 100 to 1,000 horsepower and aggregating 2,700 horsepower, are employed to run the machinery, the water being delivered to each wheel under a head of 51 feet. It is estimated by the owners of this plant that 1,500 horsepower is required to run it to its full capacity, to generate which about 320 cubic feet per second of water is needed. The flow of the river during the fall and winter, however, is frequently less than that amount, and as a consequence the company is now preparing to install steam power for supplemental use.



A. DAM OF FLORISTON PULP AND PAPER COMPANY IN TRUCKEE RIVER.



B. TRUCKEE RIVER CANYON, LOOKING DOWNSTREAM FROM FLORISTON PULP AND PAPER COMPANY'S DAM.

Less than 2 miles below Floriston is the power plant of the Truckee River General Electric Company, which is engaged in the development of power for transmission, electrically, to Virginia, Nev., for use in mining operations. (See Pls. VII and VIII.) The water employed for this purpose is taken from the river immediately below the Floriston paper mills, and is conveyed by means of a wooden flume (Pl. VII) 8,500 feet in length to the power house, where it is delivered to the wheels under a head of 85.6 feet. The inside dimensions of the flume are, width 10 feet and depth 7 feet. Its carrying capacity when filled to a depth of 6 feet is estimated at 300 second-feet.

Several years ago water from Truckee River was employed at Marmol, about 3 miles above the town of Verdi, to supply power for cutting and dressing marble, but this plant has not been in operation for more than three years past, and it was not possible to ascertain either the amount of water claimed or the power required for its operation.

The Verdi Mill Company requires and uses a short distance above the town of Verdi about 90 second-feet of the river water, under a head of 24 feet, to supply power for its door, sash, and box factory.

About 1½ miles above Reno the Reno Electric Light and Power Company diverts water from the river to supply power for lighting the town. For this purpose it is estimated by the electrician in charge that 200 horsepower is now employed, and as the net head on the water wheel is about 38 feet, approximately 60 cubic feet per second are necessary. The capacity of the canal and flume from the river is probably double this, however.

In the town of Reno is the Riverside flour mill, requiring 56 horsepower to run to its full capacity, to supply which about 40 second-feet of water are diverted from the river and delivered to the wheel under a head of 16 feet.

A short distance below the Riverside flour mill the Reno reduction works diverts water for the development of power to operate the ore-crushing machinery in the plant, to run which requires about 75 horsepower. The turbine for developing this power is run under a net head of about 13 feet, and approximately 56 cubic feet of water per second are required.

The last power plant on Truckee River, that of the Wadsworth Light and Power Company, is operated to light the town of Wadsworth with electricity. For this purpose about 17 second-feet of water are diverted from the river above the town and led, by a canal 6 miles in length, to the power station, where it is delivered to the wheels under a working head of 44 feet.

From the foregoing it will be seen that the existing rights to the waters of Truckee River for power purposes amount to 160 cubic feet per second during part of the year, and to 110 cubic feet per second during the remainder of the year, which comprises the most of the period of low water at Truckee, and a maximum of 320 second-feet at Floriston, which is more than sufficient to supply all of the requirements of existing power plants below that point. It would therefore appear that if 160 and 320 second-feet of water be supplied at Truckee and Floriston, respectively, from May 1 to December 1, and the minimum discharge from December 1 to May 1 be maintained at 110 and 300 second-feet, not only will the existing rights be supplied but the companies owning them will be greatly benefited.

IRRIGATION.

Within the basin of Truckee River there are under irrigation at the present time about 42,384 acres of land, of which 28,288 acres are supplied with water diverted directly from the main river by means of canals; 2,130 acres are supplied from seepage water collected, by

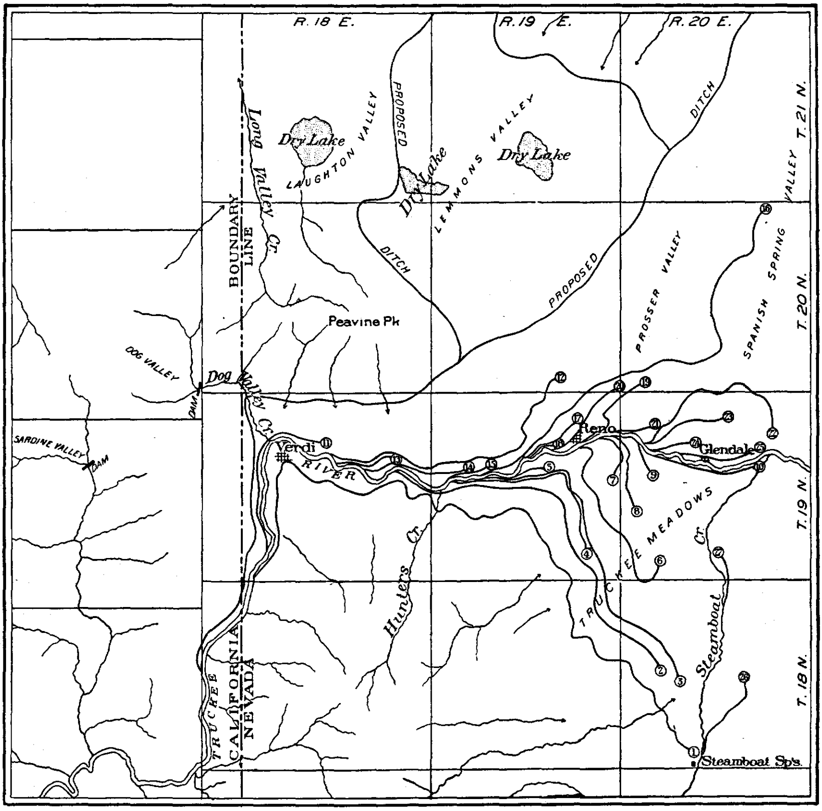
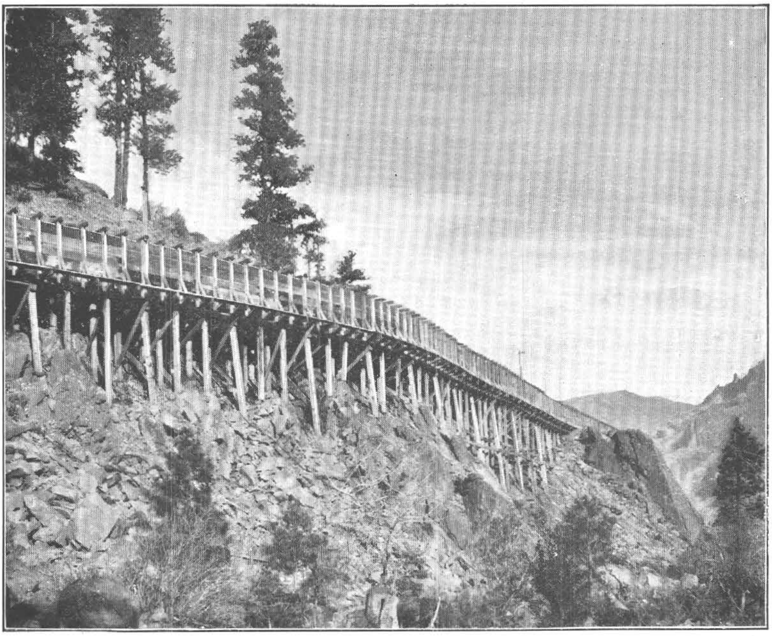
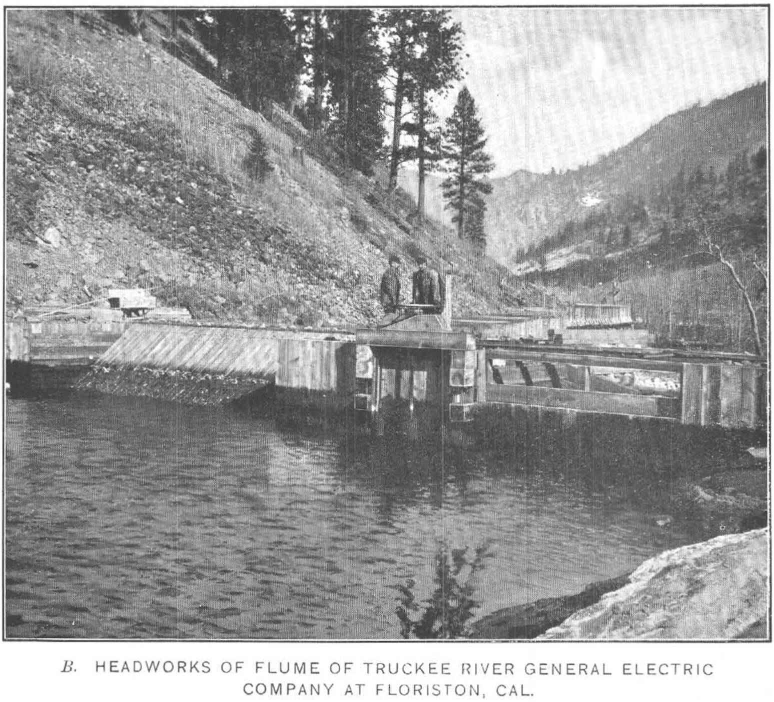


FIG. 19.—Map showing location of irrigation canals in western portion of the Truckee Basin.

1. Steamboat canal.
2. Mayberry ditch.
3. Truckee Meadows ditch.
4. South Side irrigating canal.
5. Indian Flat ditch.
6. Cochran ditch.
7. Scott's ranch ditch.
8. Abbey ditch.
9. Wilson ditch.
10. Pioneer ditch.
11. Merrill ditch.
12. Highland ditch.
13. Hogan ditch.
14. Mayberry & Carr ditch.
15. Mayberry Northside ditch.
16. Orr ditch.
17. Countryman ditch.
18. Chisholm ditch.
19. Sullivan ditch.
20. Auburn ditch.
21. (?)
22. North Truckee irrigating ditch.
23. Sessions ditch.
24. Mitchell & Carmac ditch.
25. Glendale ditch.
26. Crane & Bullock ditch.
27. Alexander ditch.



A. FLUME OF TRUCKEE RIVER GENERAL ELECTRIC COMPANY ON SIDE HILL ABOVE MYSTIC, CAL.



B. HEADWORKS OF FLUME OF TRUCKEE RIVER GENERAL ELECTRIC COMPANY AT FLORISTON, CAL.

means of drain ditches, before it reenters the river, and 11,966 acres are supplied from various tributary streams. (See figs. 19 and 20.) Of the latter area, 10,621 acres are irrigated from Steamboat Creek and its tributaries, though the supply is sometimes short. All of these lands are in the State of Nevada, about 959 acres being

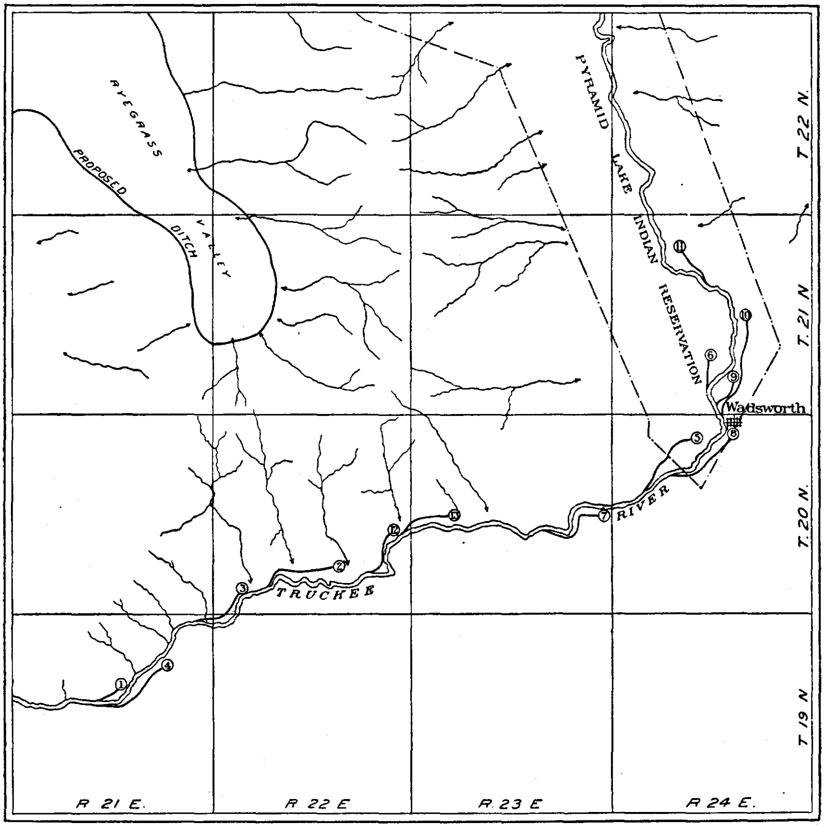


FIG. 20.—Map showing location of irrigation canals in eastern portion of the Truckee Basin.

1. (?)
2. (?)
3. (?)
4. (?)
5. Herman ditch.
6. Fellnagle ditch.
7. O'Brien ditch.
8. Wadsworth irrigating ditch.
9. Olinghouse ditch.
10. Proctor ditch.
11. Hill ditch.
12. (?)
13. (?)

between the California-Nevada boundary line and the junction of Hunter Creek with Truckee River; 30,000 acres are in the Reno Valley; 8,500 acres are in the Washoe, Pleasant, and Steamboat valleys, to the south of the Reno Valley, and 2,925 acres are along the river below Vista, 500 acres of which are on the Pyramid Lake Indian Reservation and are cultivated by the Piute Indians.

A number of discharge measurements were made of the principal canals diverting water from Truckee River for the irrigation of these lands, but no attempt was made to ascertain the amount of water taken from the river by the numerous small ditches, nor were any of the ditches below the Reno Valley measured. During the time that the measurements were being made and for some time afterwards the entire flow of the river was diverted. The following are the results of the measurements:

Measurements of flow of irrigating ditches taking water from Truckee River in Nevada.

SOUTH SIDE.

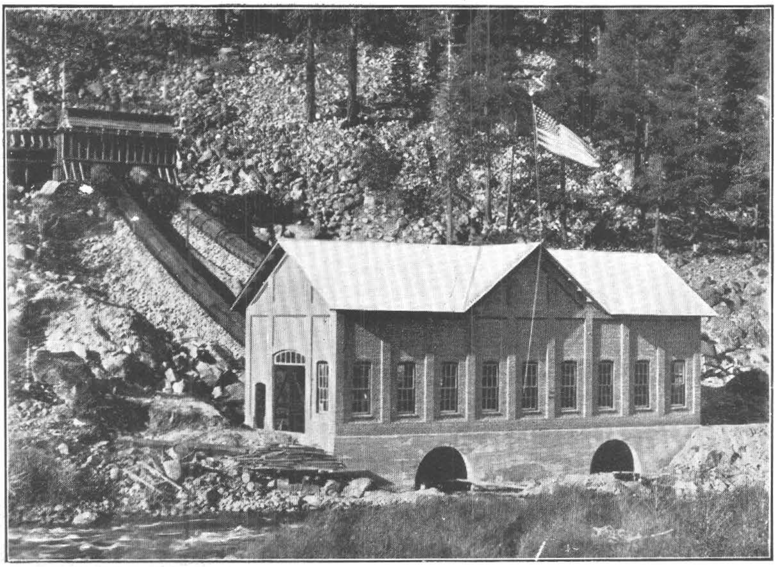
Date.	Name of ditch.	Length.	Discharge.
1900.		*Miles.*	*Sec-ft.*
July 3	Steamboat	31	51.2
July 30	do		8.4
1899.			
September 4	Mayberry		46.9
1900.			
July 3	Mayberry		41.7
July 30	do		39.7
July 10	Lake or Truckee Meadows	14	58.4
July 30	do		36.4
July 7	Cochran	8	14.5
July 31	do		26.7
July 7	Scott's ranch	2	29.6
July 31	do		13.5
July 8	Abbey	3	3.6
July 31	do		4.4
July 8	Wilson	1	4.2
August 1	do		3.7
July 8	Pioneer	3¾	12.7
August 1	do		21.1

NORTH SIDE.

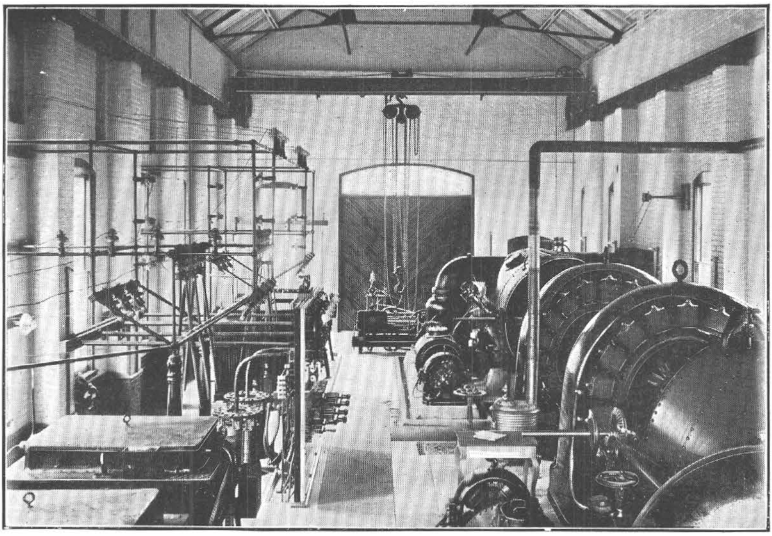
Date.	Name of ditch.	Length.	Discharge.
1900.			
September 4	Highland	14¼	16.7
July 9	do		11.8
July 30	do		17.5
1889.			
September 4	Orr		42.0
1900.			
July 6	Orr		83.8
July 30	do		60.6
July 9	Auburn		15.8
July 7	Sullivan	3½	24.7
July 31	do		25.0
July 10	North Truckee	7	31.4
August 1	do		18.8
July 8	Sessions	1	5.4
August 1	do		8.0
July 8	Mitchell & Carmac	¾	14.0
August 1	do		6.8
Do	Glendale	3¼	2.7

At the time of making the foregoing measurements an attempt was made to segregate the lands supplied from each ditch, with a view to approximating the duty of water under each, but owing to the fact that many of the farms were supplied from more than one ditch this was found to be impossible.

In the lower part of the Reno Valley, called the Truckee Meadows, several drain ditches have been constructed to carry off the seepage from the higher irrigation. These discharge into Truckee River a short distance above the United States Geological Survey gaging



A. POWER HOUSE OF TRUCKEE RIVER GENERAL ELECTRIC COMPANY AT MYSTIC, CAL.



B. INTERIOR OF POWER HOUSE OF TRUCKEE RIVER GENERAL ELECTRIC COMPANY.

station at Vista, but a portion of the water collected by them is employed for irrigation, which explains the fluctuations in the discharge of the stream at that station during July and August, the entire flow during the greater part of those months coming from that source.

No attempt was made to ascertain the amount of water employed for irrigation on the lands along Steamboat Creek and in the Washoe Valley, but it is certain that the average quantity per acre is materially less than in other parts of the Truckee Basin.

SUMMARY.

From the foregoing it will be seen that the vested rights to the waters of Truckee River are as follows: For power purposes, 300 cubic feet per second at Floriston and Mystic during the period when the river, unaided by storage, discharges that volume; and for irrigation purposes below those points sufficient water to irrigate 27,493 acres of land in the Reno Valley. With reasonable care and economy in its use the latter quantity should not exceed 275 second-feet, or 1 second-foot for each 100 acres. Thus the water employed for generating power at Floriston and Mystic, which can be applied to the lands below, is more than ample to supply existing water rights for irrigation. This volume, with the surplus from the power plants mentioned, will supply the requirements of the power plants at Verdi and Reno, as many of the irrigating canals are taken out below them, and the water which will necessarily return to the river from seepage is ample for the irrigation of the lands below Vista and for the purpose of the Wadsworth Light and Power Company. Thus it appears that the waters of Truckee River in excess of 300 cubic feet per second are available for use in the extension of the irrigated area or for other purposes. But since that volume of water (300 cubic feet per second) is at all times required for power purposes, the river should never be permitted to fall below that stage.

IRRIGABLE LANDS.

While almost the entire water supply of Truckee River comes from the upper portion of the basin, where all of the projected storage reservoirs would be located, it is in the lower part of the basin that the best agricultural lands are found, and where practically all of the water will be used in irrigation. There is a considerable area in Martis Valley and along Prosser Creek, also along Little Truckee River in California, which is favorably situated for irrigation, but the climate is not adapted to any but the lowest class of farm products, hence it is not deemed advisable to devote to their irrigation water which is needed and can be so much more profitably employed in the valleys farther east and at lower altitudes.

Within the Reno Valley and to the east of the Nevada-California boundary line, including the areas already under cultivation, are 42,000 acres of land suitable for farming purposes, which are already commanded by canals from Truckee River. Lying along the foothills to the north and northeast of the town of Reno, and in the Lemmons, Prosser, Spanish Springs, and Warm Springs valleys, are fine tracts of sagebrush land, aggregating about 75,000 acres, which are within reach of the Truckee's waters. On the lower stretches of the river, in the canyon below the Reno Valley and in the vicinity of Wadsworth and Pyramid lakes, are, approximately, 30,000 acres of good land, about 20,000 acres of which are embraced in the Pyramid Lake Indian Reservation, while to the east and southeast of Wadsworth, but over a low, flat divide from which the drainage is toward Carson River, and including a part of the Lower Carson or Carson Sink Valley, are more than 100,000 acres which can be reached by canals from Truckee River.

Besides these there are not less than 3,000 acres of land along the foothills bordering the Reno Valley, to the south of the river, 1,345 acres of which are already irrigated, which can be supplied with water from the numerous small streams which flow down from the northern part of the Tahoe Range; while still farther south, in the Steamboat, Pleasant, and Washoe valleys, are more than 12,000 acres of good land which could be reached by ditches from Steamboat Creek and the streams flowing into the Washoe Valley from the west. The latter, however, being beyond the reach of the stored water under consideration, and no study of the supply for their irrigation having been made, are left out of the estimates of irrigation possibilities. It is believed that, reenforced and regulated by storage reservoirs, the water supply will be sufficient, not only to maintain the flow of Truckee River at a minimum of 300 second-feet, but with economical methods of distribution and application, to properly irrigate 219,000 acres of the foregoing lands, as follows:

	Acres.
From small tributaries south of river	3,000
In the Reno Valley, from Truckee River	42,000
On foothills north of Truckee River, and in the Lemmons, Prosser, Warm Springs, and Spanish Springs valleys	75,000
Below the Reno Valley and north of Wadsworth	24,000
East and southeast of Wadsworth	75,000
Total	219,000

OWNERSHIP OF LANDS.

No attempt was made to ascertain in detail the ownership of all of the lands included in the foregoing table, but from the maps in the United States land office and in the offices of the assessors of Washoe, Lyon, Churchill, and Storey counties, in Nevada, in which the lands are situated, the following general information was obtained:

All of the lands, except about 9,000 acres in the northern end of the Warm Springs Valley and perhaps a part of those in the Carson Sink Valley, are within the limits of the grant to the Central Pacific Railroad Company, and consequently half of them—the odd-numbered sections—are, or originally were, the property of that company. The 42,000 acres in the Reno Valley are all in private ownership, as are also the 3,000 acres of foothill lands south of Truckee River. Of the 75,000 acres of irrigable lands north of Truckee River, not more than 20,000 acres still remain the property of the Government, the rest being in private ownership or the property of the railroad company. The title to the land in the vicinity of Wadsworth is approximately as follows:

	Acres.
Public domain	37,000
Pyramid Lake Indian Reservation	20,000
Central Pacific Railroad grant	37,000
Private individuals	5,000
Total	99,000

Thus it appears that, of the total area which it is estimated can be irrigated, about 25 per cent, or less than 60,000 acres, still belongs to the public domain.

DUTY OF WATER.

Under present methods of irrigation in the basin of the Truckee, especially in the Reno Valley, where a large portion of the lower lands have been converted into marshes, the duty of water is extremely low, averaging, probably, not more than 50 acres to the cubic foot per second. It is certain, however, that this can at least be doubled, so in making an estimate of irrigation possibilities with the available water supply, 1 second-foot of water measured in the river is allowed for each 100 acres in the Reno Valley, or 420 cubic feet per second for 42,000 acres. These lands in the main comprise soils of a clayey and loamy nature, varying in depth from a little more than a foot to 4 or 5 feet, underlain by gravel and bowlders; and as the grades are generally heavy the water sinking through the surface stratum drains off very rapidly.

In the valleys to the north of Truckee River and in the neighborhood of Wadsworth the soils are of a different character, and the duty of water will be higher. For the Lemmons, Warm Springs, Spanish Springs, and Prosser valleys an average duty of 150 acres to the second-foot is estimated, after making allowance for losses in transit through the main canals. On the mesa north of Wadsworth, which is partially drained by deep ravines and borders Truckee River, whose channel is from 50 to 200 feet below the irrigable lands, the duty is estimated at 120 acres to the second-foot. To the east of Wadsworth and in the Carson Sink Valley an average of 150 acres to the second-foot is believed to be a fair duty, assuming reasonable economy in the application of the water. In each of the last two cases it is assumed that the water will be measured where taken out from the main canals.

QUANTITY OF WATER REQUIRED AND AVAILABLE.

To supply 75,000 acres of land to the north of Truckee River it will be necessary to construct a canal of sufficient capacity to divert 550 cubic feet per second, it being assumed that 50 second-feet will be lost in transit.

The main canal to supply 99,000 acres in the vicinity of Wadsworth must have a capacity of 750 cubic feet per second, or 50 second-feet in excess of the requirements of the land to be served, in order to provide for losses in the main canals. It must not be understood that the 50 second-feet allowed in each case will represent the entire loss from the main canals referred to, but when it is remembered that probably not more than 70 or 80 per cent of the total area assumed to be supplied with water will be actually under irrigation during any season, this allowance in fixing the canal capacities appears to be sufficient.

For the supply of 42,000 acres of land in the Reno Valley, with the duty assumed, 420 cubic feet per second will be diverted from the river.

The water supply of these lands will be derived from the main Truckee River, supplemented by that which will be stored in the seven reservoirs situated above the town of Verdi, in the State of California, which will discharge directly into it. The irrigation season in this region is generally considered to begin about April 1 and to end about September 1, but in the lower portion of the basin some water can be used with profit during the month of March and some will be required for garden irrigation later than September 1.

From the foregoing, from a study of the records of stream discharge given on previous pages of this report, and from the storage possibilities, the following table, showing, by months, the probable mean available flow of Truckee River at Floriston during the driest year (after deducting the proportion which will be held back by reservoirs), the total mean quantity which will be required for irrigation and for power purposes, the mean quantity expected to return to the river by seepage above Vista, the mean flow required at Floriston, which, added to the seepage water during the irrigating season, will supply all requirements, and the volume which must be drawn from the reservoirs to maintain the required flow at Floriston, has been compiled.

Table showing quantity of water required and available.

Month.	Mean available discharge of Truckee River at Floriston (dry years).	Total mean quantity of water required for irrigation and power.	Mean volume of seepage or return water at Vista.	Mean flow required at Floriston.	Amount necessary to draw from reservoirs.	
	Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Acre-ft.*
January	225	300	50	300	75	4,612
February	200	300	50	300	100	5,554
March	450	400	75	400	00	000
April	700	1,100	100	1,000	300	17,851
May	1,200	1,720	120	1,600	400	24,595
June	600	1,750	150	1,600	1,000	59,505
July	200	1,400	200	1,200	1,000	61,489
August	150	1,100	200	900	750	46,117
September	150	500	150	400	250	14,876
October	300	300	100	300	00	000
November	280	300	60	300	20	1,190
December	225	300	50	300	75	4,612
Total necessary to draw from reservoirs						240,401
Total net capacity of reservoirs						288,767
Reserve capacity of reservoirs providing a margin of safety						48,366

PROPOSED DISTRIBUTION CANALS.

During the year 1889–90 a line was run from Truckee River,[1] beginning near Clarks station, on the Central Pacific Railroad, which demonstrates the feasibility and furnishes the basis for approximate estimates of cost of delivering water to the lands in the vicinity of Wadsworth. This survey, with later ones made by Mr. T. K. Stewart, C. E., supply the data for the estimates herein contained. In 1892 the author and Mr. Morris Hacker, C. E., now of Chevy Chase, Md., made surveys for and estimates of cost of a canal from a point in Truckee River, where the Floriston Pulp and Paper Company now diverts the water for the operation of its mills, to the divide between the Reno and the Lemmons valleys, with branches thence to distribute water to the other valleys lying to the north of the river. This was then known as, and will here be designated, the Truckee River Highline canal. To supply water to the lands in the Reno Valley and the Truckee Meadows several of the existing canals can be employed, notably the Highland canal on the north and the Steamboat canal on the south side of the river.

No data are at hand concerning canals or ditches required for the delivery of water from the small creeks to the foothill lands south of Truckee River, nor for distributing purposes in the Washoe Valley and on Steamboat Creek. In neither case, however, will these be of great magnitude, nor will their construction be expensive.

TRUCKEE RIVER HIGHLINE CANAL.

As previously stated, the survey of this canal line was made in 1892. It was designed to head in the left bank of Truckee River at the

[1] Thirteenth Ann. Rept. U. S. Geol. Survey, Pt. III, pp. 393–394.

place where the diversion dam of the Floriston Pulp and Paper Company has since been constructed. From that point the line as surveyed runs in a general northerly direction—nearly all the way along precipitous and rocky mountain sides—for a distance of about 12 miles, to a point west of the town of Verdi, where it turns, crosses Dog Valley Creek, and runs in a general direction a little north of east, over less precipitous and rocky ground, to the divide between the Reno and the Lemmons valleys, a total distance of 163,950 feet, or a little more than 31 miles. In its course the line traverses a great deal of ground—about 10 miles in the aggregate, more than 8 miles of which are above Dog Valley Creek—through which the construction of a water-tight canal would be so expensive that it was decided to usé lumber flumes, to be built on benches cut in the mountain side, it being estimated that the interest on the additional cost of a canal through this ground would at least maintain the flumes. Besides this, the line traversing the mountain sides crosses numerous lateral drainage lines which would be passed by means of flumes supported on timber trestles. Dog Valley Creek, a little more than 14 miles from the head of the canal, flows in a deep canyon, which it is proposed to cross by means of a double line of pressure pipes 66 inches in diameter and about 1,700 feet in length. There are nine tunnels on the line, varying in length from 150 to 2,200 feet and aggregating 8,312 feet. The grades on which the canal is designed to be constructed, also its dimensions, vary with the character of the ground, as follows: Canal in earth on comparatively flat slopes, grade 0.4 in 1,000, bed width 16 feet, top width 30 feet, depth of water 7 feet; canal in rocky or clayey soil, generally on steeper hillsides, grade 0.6 in 1,000, bed width 16 feet, top width 23 feet, depth of water 7 feet; tunnels, grade 1.25 in 1,000, width 15 feet to a height of 7 feet, with arched roof, crown of arch 10 feet high; flumes, grade 0.6 in 1,000, inside dimensions 12 feet wide by 7.5 feet deep, depth of water 7 feet. The estimated capacity is 550 cubic feet per second.

BRANCH CANALS.

From the lower terminus of the main canal just described surveys were made of two main branch lines, one to the west, known as Branch canal No. 1, around the south and west sides of the Lemmons Valley, to supply about 17,000 acres of land in that valley, having a total length of 24 miles and a capacity at its head of 130 second-feet; the other, Branch canal No. 2, designed to supply about 53,000 acres in the Lemmons, Prosser, Spanish Springs, and Warm Springs valleys, was located around the east side, a distance of 21 miles, to the head of a canyon leading to the valley last mentioned, its capacity, where it leaves the main canal to be 400 cubic feet per second. Both of these lines were run on a grade of 0.6 in 1,000.

The foothill lands between the Nevada-California boundary and the terminus of the main line, comprising about 5,000 acres, can be supplied directly from the main canal. No attempt was made to locate the minor ditches for the distribution of water from the main canals, but with a few exceptions these would be entirely in earth and quite easy and cheap of construction.

The surveys of this canal system, especially of the main diversion line from Truckee River to the divide north of the Reno Valley, were made with all the care and attention to details deemed requisite for the final location of so important a work, and the estimates, of which only a summary is here given, embraced as close a classification of the material to be excavated as could be made in advance of actual construction. The prices ranged from a minimum of 12 cents per cubic yard for earth to a maximum of 90 cents for solid rock in open cuts. The estimates for tunneling ranged from $10 to $25 per foot. So far as could be judged, the material to be encountered in the tunnels is nearly all comparatively soft rock, but, as evidenced by tunnels already in existence through similar material, is of such character that it would rarely require timbering or other support. In making up the estimates an allowance of 15 per cent was made in all cases for engineering and contingencies. Following is the estimate of cost of this canal system, being a slight modification of that made in 1892, to fit somewhat altered conditions:

Estimate of cost of proposed Truckee River Highline canal, branch canals, and distributing ditches.

Main canal:		
Dam and regulating gates	$10,000	
Canal excavation	216,000	
Nine tunnels, 8,312 feet	117,000	
Flumes, 5,000 M feet B. M., at $28	140,000	
Dog Valley Creek inverted siphon, 1,700 feet	27,000	
		$510,000
Branch canal No. 1		46,000
Branch canal No. 2		104,000
Minor distributing ditches		90,000
Total		750,000

The cost per acre for delivering water to 75,000 acres of land is $10.

LOWER TRUCKEE CANAL.

The Lower Truckee canal line, surveyed by the engineers of the United States Irrigation Survey in 1889–90, and already referred to, was designed to take water from near the crest of a dam across the river and about 50 feet above its bed. The location of this proposed dam is about 3 miles below Clarks station, on the Central Pacific Railroad. In order to obviate the necessity for this high dam, which would be very expensive, and yet gain the required elevation to command all of the irrigable lands, the writer proposes a canal to head in the right bank of the river a short distance above Clarks station, about 4 miles, by the canal route, westerly from the site of the dam first mentioned; from that point the line to follow along the mountain side, close to the river, for a distance of about 10 miles, to a point approximately 5 miles above the town of Wadsworth, where it would divide into two main branches, designated A and B. Up to that point the main canal would have a uniform grade of 0.4 in 1,000, a sectional area of 205 square feet, and a carrying capacity of 750 second-feet.

Branch canal A, designed to supply the lands southeast of Wadsworth, to continue along the mountain side to the south of the river for about 7 miles, to a point east of south from Wadsworth, where it would enter the plain; thence to run in an easterly direction about 13 miles, to the edge of Carson Sink Valley. This line was run on a grade of 0.4 in 1,000, the canal to have a sectional area of 160 square feet and a capacity of 525 second-feet for the first 10 miles, after which its sectional area and carrying capacity would diminish as lateral ditches branch off from it.

Branch canal B would run northward from the terminus of the main canal, crossing Truckee River by an inverted siphon 66 inches in diameter, and extending to Pyramid Lake. It would have a total length of about 24 miles, and would furnish water to about 24,000 acres of land lying west and north of Wadsworth. Except in the pipe line across the river, where the hydraulic grade is 3 in 1,000, this line is designed to be run on a uniform grade of 0.3 in 1,000. The sectional area and capacity at the head are 90 square feet and 225 second-feet, respectively, but these would be gradually diminished to the north.

The main distributing canals would be entirely in earth and cheap of construction. While no surveys have been made to furnish data for an estimate of their cost, it is believed that it will not exceed 80 cents to the acre of irrigable land.

The following preliminary estimate of the cost of the canal system has been prepared:

Estimate of cost of proposed Lower Truckee canal system.

10 miles of main canal, with headworks	$144,000
Branch canal A, 20 miles	120,000
Branch canal B, 24 miles	52,000
Inverted siphon of branch canal B	20,000
Minor distributing canals	80,000
Total	416,000

Engineering and contingencies are provided for in this estimate, as in that of the Highline canal.

POSSIBLE USES OF WATER FOR POWER DEVELOPMENT.

It has been shown that the minimum discharge of Truckee River at Truckee can be maintained at 110 second-feet and at Floriston at 300 second-feet, the tributary streams entering between the two points (the principal of which is the Little Truckee, at Boco) helping to make up the greater volume. Below Floriston there are a number of small streams entering the river, which will still further increase its flow, so that the discharge will probably never fall below 300 second-feet between Floriston and the head of the Highland ditch, about 1½ miles below Verdi. From that point to Reno an average minimum flow of not less than 250 cubic feet per second can be relied upon, for not more than 50 second-feet will be required by the intervening irrigation canals during the low-water periods. Below Reno, as far as Vista, the grade being comparatively light, no estimate of power possibilities will be made. From Vista to Clarks station the minimum discharge of the river will probably be in excess of 300 second-feet, but that volume is taken in order to be on the side of safety. On this basis the following table, which fairly exhibits the possibilities for power development on Truckee River, has been prepared:

Possible power development on Truckee River.

Between—	Distance.	Minimum water supply.	Total fall.	Available fall.	Actual power, 80 per cent of theoretic.
	Miles.	*Sec.-ft.*	*Feet.*	*Feet.*	*H. P.*
Truckee and Boca	9.0	110	300	250	2,500
Boca and Floriston	4.5	250	200	150	3,400
Floriston and Mystic	2.0	300	143	136	*a* 3,700
Mystic and Highland ditch	19.5	300	410	300	*b* 8,200
Highland ditch and Reno	10.0	250	280	220	*b* 5,000
Vista and Clarks station	12.0	300	250	180	4,900
Total					27,700
Power now utilized between above points					4,100
Total possible and undeveloped					23,600

a Utilized. *b* Two hundred horsepower utilized.

NECESSITY FOR NATIONAL CONTROL OF WATER.

Since almost the entire water supply of Truckee River comes from the upper portion of the basin, the major part of which is in California, and the irrigable lands are all in the lower portion, within the State of Nevada, it follows that the users of the water for irrigation purposes can never have entire control of the source of their supply, though such control is vital to the ultimate prosperity, and it may be said to the very existence, of communities dependent upon irrigation. If the irrigation of these lands be undertaken by private enterprise or by the State of Nevada, it is certain that sooner or later interstate complications will arise which may result in at least the partial destruction of all that may be accomplished. It is a problem, therefore, with which the National Government only is competent to cope. So it is recommended that the entire upper portion of the Truckee Basin be segregated into a national forest and water reserve and the waters be dedicated to industrial and irrigation purposes within the basin and upon such lands immediately adjacent thereto as can be supplied.

GENERAL CONCLUSIONS AND RECOMMENDATIONS.

(1) It is feasible to construct in the upper portion of the Truckee Basin seven storage reservoirs with gross and net capacities as follows:

Cost and capacities of proposed reservoirs in the Truckee Basin.

Name of reservoir.	Gross capacity.	Net capacity (can be drawn annually).	Cost, complete.
	Acre-feet.	*Acre-feet.*	
Lake Tahoe	745,400	200,000	$49,731
Donner Lake	26,900	26,900	86,746
Independence Lake	11,725	11,725	33,979
Twin Valley	7,818	7,818	41,195
Little Truckee	20,540	20,540	61,820
Henness Pass	17,000	16,000	47,575
Dog Valley	5,785	5,785	32,186
Total	835,168	288,768	353,232

(2) The watersheds tributary to the reservoirs mentioned yield sufficient water, even in seasons of minimum precipitation, as that of 1899 and 1909, to fill each of them.

(3) The water stored in the reservoirs mentioned, if employed to supplement the ordinary flow of Truckee River and used with moderate economy, is sufficient, even in dry years, to irrigate 185,116 acres of land in excess of that now watered, or a total of 219,000 acres, and maintain the minimum discharge of Truckee River at 300 cubic feet per second above Reno and Clarks station.

(4) It is feasible, by utilizing the foregoing minimum discharge of Truckee River, to develop between Truckee and the head of the Lower Truckee canal at Clarks station over 20,000 horsepower in excess of that now developed.

(5) It is feasible to construct an irrigating canal having a capacity of 550 second-feet, leading from Truckee River near Floriston, Cal., to supply 75,000 acres of arable lands above and to the north and east of Reno, at a cost, including headworks and the main branches and distributaries, of $750,000.

(6) It is feasible to construct a canal having a capacity of 750 cubic feet per second on the south side of Truckee River from above Clarks station to a short distance above Wadsworth, where a branch with 225 second-feet capacity can be taken across the river by pressure pipes and be led northward toward Pyramid Lake, while the main branch, with a capacity of 525 second-feet, can be continued to the southeast and east of Wadsworth, the two branches supplying water to 99,000 acres of land, about 30,000 acres of which are in the Truckee River Basin (more than 20,000 acres of this being in the Pyramid Lake Indian Reservation) and 69,000 acres in the basin of Carson River (approximately 50,000 acres of this being in the Carson Sink Valley); and the cost of this canal system, including the principal distributing branches, will probably be about $4.20 for each acre commanded, or a total of $416,000.

(7) The entire upper portion of the Truckee River Basin, embracing all of the drainage area above the town of Verdi, and the north and east slopes of the Tahoe Range, should be set aside as a forest and water reserve or a national park.

(8) The Lake Tahoe dam should be built as the first step in the storage of water on the Truckee, and all private rights in the other reservoir sites described should be acquired by the Government, so that when the time for their utilization arrives there will be no obstacles in the way of their construction.

(9) The portion of the public domain which can be irrigated from the stored waters of Truckee River should be withdrawn from entry, and after being provided with a system of canals for the delivery of water should be offered for sale at a price commensurate with the cost of their reclamation as irrigable lands with water rights.

(10) Measurements of stream discharge and evaporation in the basin of the Truckee should be continued at important points, to supply more complete and reliable data on the water supply.

FINANCIAL SUMMARY.

Summarizing, the estimated cost of the projected storage works is as follows:

Summary of cost of storage works.

Seven reservoirs	$353,232
Truckee River Highline canal system	750,000
Lower Truckee canal system	416,000
Total	1,519,232

There are 185,116 acres of land, public and private, which would be irrigated by these works in addition to the area already watered. Assuming that 7,116 acres, or 7,616 acres including the 500 acres already under irrigation, be irrigated for the Piute Indians—an area believed to be ample for the sustenance of that tribe without cost to the Government—there remain 178,000 acres to sustain the cost of these irrigation works, making the necessary charge per acre for water rights $8.50. It is believed that these water rights and the remaining public lands could be sold at that rate within a very few years. The actual value of 178,000 acres of land with water rights would be not less than $30 an acre, or a total of $5,340,000. The increase in the value of town property which would necessarily follow, and the value of the water power made available, all of which would be without expense to the public, can not here be estimated.

While the construction of the Lake Tahoe dam is recommended as the first step in the storage of water on the Truckee, it must not be forgotten that in order to utilize the stored waters a system of main canals, costing not less than $416,000 for one or $750,000 for the other, must first be provided, and that without such canals to deliver the water to irrigable lands the construction of the Tahoe or any other reservoir is useless.

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