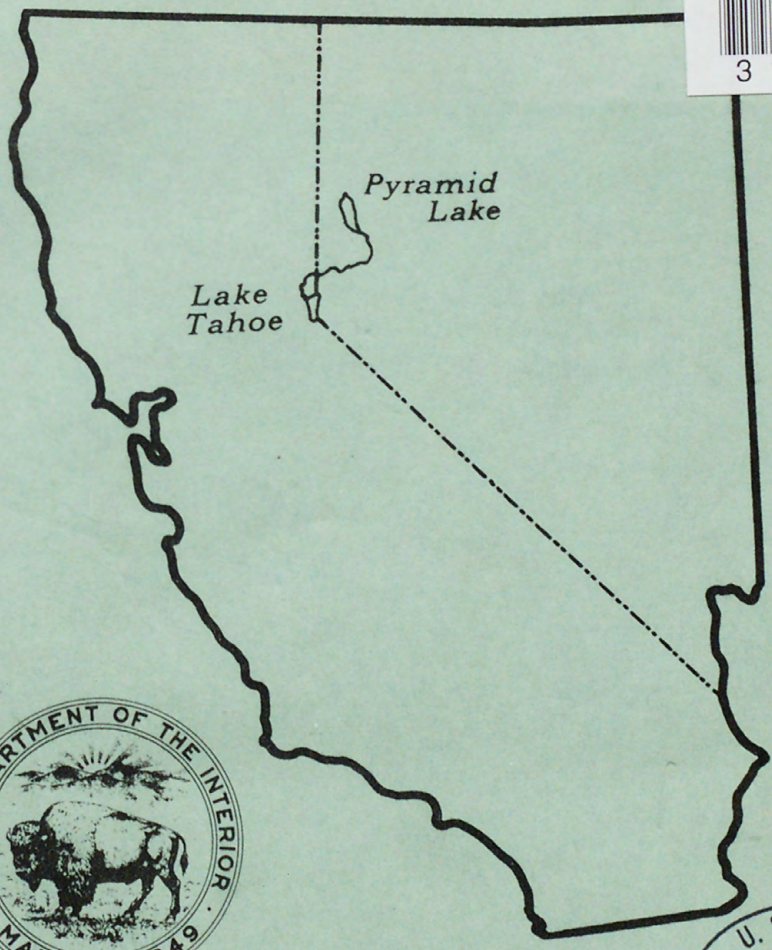
# LONG-TERM FLOW OF THE TRUCKEE RIVER IN CALIFORNIA AND NEVADA








OPEN-FILE REPORT



U.S. (DEPARTMENT OF THE INTERIOR)
GEOLOGICAL SURVEY, [Reports - Open file series]

Menlo Park, California
September 1974

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY [Reports - Open file series]

# LONG-TERM FLOW OF THE TRUCKEE RIVER IN CALIFORNIA AND NEVADA

By

Howard F. Matthai

OPEN-FILE REPORT

74-213

Menlo Park, California

September 1974

## CONTENTS



## ILLUSTRATIONS



## TABLES

# LONG-TERM FLOW OF THE TRUCKEE RIVER IN CALIFORNIA AND NEAVADA

By

Howard F. Matthai

## Introduction

The Office of the Solicitor, Department of the Interior, requested the Geological Survey to evaluate the reliability of streamflow records in the Truckee River basin and to determine the long-term average annual runoff.

The reliability of streamflow records was evaluated by comparisons between pairs of records at six locations along the Truckee River between Lake Tahoe and Pyramid Lake.

The observed or estimated annual runoff near Nixon, Nevada was adjusted for changes in storage, evaporation losses, diversions, and depletions to approximate the inflow into Pyramid Lake under natural conditions.

The long-term average annual runoff near Nixon was computed on the basis of streamflow records since 1899. The long-term (124-year) record of precipitation at Sacramento and tree ring information were used to substantiate the conclusion that the average runoff during the 74 years of streamflow record is a reliable measure of the average runoff for a longer period.

## Data Available

The earliest streamflow records in the Truckee River basin were obtained in 1889. However, continuous records were not started until 1899, 1900, and 1901. The latter were the river discharge at Farad, CA, the stage of Lake Tahoe, and the river discharge at Tahoe City, CA. Other main stem flow records were intermittent for various periods until 1958. The streamflow and reservoir records examined and used in this report are listed in table 1.

Precipitation records for Tahoe City, Truckee Ranger Station, Reno, and Sacramento were converted to a water-year basis. The Sacramento record was included because it is the longest record near the Truckee River basin. The precipitation records used are tabulated below.

| | |
|---|---|
| Tahoe City | 1909-73 |
| Truckee Ranger Station | 1870-1919; 1933-73 |
| Reno | 1871-1973 |
| Sacramento | 1849-1973 |

The elevations of the Great Salt Lake, Utah, since 1847 were also obtained as an index of wet and dry periods.

Two reports of tree ring studies, one in the Truckee River basin and one including three nearby basins in California, were used to generalize wet and dry periods over several hundreds of years.

Table 1. Selected stream and reservoir records in Truckee River basin

| Station number | Station name | Periods of record |
|---|---|---|
| 10337000 | Lake Tahoe at Tahoe City, CA | 1900- |
| 10337500 | Truckee River at Tahoe City, CA | 1895-96; 1900- |
| 10339380 | Martis Creek Lake near Truckee, CA | 1971- |
| 10340300 | Prosser Creek Reservoir near Boca, CA | 1963- |
| 10344300 | Stampede Reservoir near Boca, CA | 1969- |
| 10344490 | Boca Reservoir at Boca, CA | 1938- |
| 10346000 | Truckee River at Farad, CA | 1890; 1899- |
| 10348000 | Truckee River at Reno, NV | 1906-21; 1925-26; 1930-35; 1943; 1946- |
| 10348700 | Washoe Lake near Carson City, NV | 1963- |
| 10350000 | Truckee River at Vista, NV | 1899-1907; 1932-54; 1958- |
| 10350500 | Truckee River at Clarks, NV | 1907-15 |
| 10351300 | Truckee Canal near Wadsworth, NV | 1918- |
| 10351600 | Truckee River below Derby Dam, near, Wadsworth, NV | 1909-10;1916; 1918- |
| 10351700 | Truckee River near Nixon, NV | 1928- |
| 10336500 | Pyramid Lake near Nixon, NV | 1867-* |

*Occasional elevations prior to 1926

Depletions along the Truckee River were obtained from Harding (1965). His depletion figures are based on irrigated acreage, diversions, and comsumptive use; therefore, the writer assumed that diversions into several ditches such as the Orr ditch are included in the depletion adjustment.

## Evaluation of Streamflow Records

The double-mass curve technique was used to compare flows at several pairs of main stem stations. This technique should show up any significant inconsistencies in the records. The relation between two streamflow records may be altered if the method of data collection, or the site location, or another physical condition is changed.

No significant changes could be determined between the following pairs of Truckee River records.

Reno and Farad
Reno and Vista
Farad and Vista
Vista and Derby Dam
Below Derby Dam and Nixon

There is a slight indication of a change in slope in the Farad-Vista double-mass curve between the first period of concurrent record prior to 1908 and the second period starting in 1933. There are no other streamflow data during the early years to substantiate this change in slope, or to tell at which station a change might have occurred.

The double-mass curve for Tahoe City and Farad is not a straight line, which would indicate a change in the relation. There is a change in slope about 1908 and offsets to another parallel line during the periods 1930-35 and 1962-64. There are no other concurrent records spanning the period 1900 to 1925 that might be used to explain the cause for the change in slope or to determine its significance.

The offset in the 1930's can be explained by the fact that during parts of the very dry years in this period, the Lake Tahoe basin was contributing very little flow to the Truckee River at Tahoe City. The offset in the 1960's cannot be fully rationalized. A possible reason is that a relatively large increase, 318,000 acre-feet, in storage in Lake Tahoe occurred in 1963 after fairly low stages in 1961 and 1962. By storing most of the inflow, outflow was held to 24,020 acre-feet, about half of that in 1962; whereas, 1963 flows in nearby streams were 10 to 90 percent greater than in 1962.

Another double-mass curve was constructed for the total flow at Derby Dam and the unimpaired runoff for the Truckee River basin computed by Harding (1965, p. 121). The period plotted was 1922 to 1960 since these were the only concurrent years when Harding had yearly values. The points have slightly more scatter than those for actual records, but a straight line fits the data very well.

The writer concludes that there is no reason to question any of the flow records along the main stem of the Truckee River or that for the Truckee Canal. Also, that Harding's figures are consistent with the flow at Derby Dam.

## Estimates of Missing Records

The only complete streamflow record for the water years 1900-73 is the one at Farad. Records were obtained during most of this period at Vista and near Derby Dam and at Tahoe City for the water years 1901-73.

Using graphical techniques, correlations were made between the annual runoff at Vista and those at Farad, Reno, and Derby Dam and between the annual runoff near Nixon and that below Derby Dam. Except when the runoff near Nixon was less than 45,000 acre-feet, the standard errors of the correlations were 5 percent or less. That is, two out of three estimates made from the relations are expected to be within 5 percent and 19 out of 20, within 10 percent.

The 1929-73 record near Nixon was extended to 74 years (table 2) by estimating the 1900-28 period from one or more of the graphical relations. The average annual runoff for the 45 years of record near Nixon is 264,000 acre-feet and for the 74-year period 1900-73 it is computed to be 360,000 acre-feet.

## Adjusted Flow near Nixon, NV

The annual runoff near Nixon, estimated for 1900-28 and observed for 1929-73, has been adjusted to approximate "natural flow" (table 2). Some of the adjustments made are computed and some are estimated. Also, the adjustments were selected after several assumptions were considered.

The known adjustments are:

| | | |
|---|---|---|
| Change in storage in | | |
| 1. | Lake Tahoe | 1900-1973 |
| 2. | Boca Reservoir | 1938-1973 |
| 3. | Prosser Creek Reservoir | 1963-1973 |
| 4. | Washoe Lake | 1963-1973 |
| 5. | Stampede Reservoir | 1969-1973 |
| 6. | Martis Creek Reservoir | 1971-1973 |
| Diversions by Truckee Canal | | 1905-1973 |

Prior to 1963 the annual change in contents of Washoe Lake may have been greater than in any year since. There are no records prior to 1963, but much larger changes in contents would not significantly alter the long-term average annual flow near Nixon.

Adjustments estimated are:

Evaporation losses in reservoirs

Depletions along Truckee River

# Table 2.-- Computation of adjusted flows, Truckee River near Nixon, NV.

| Water Year | Total flow Derby Dam | Truckee Canal (a) | Flow below Derby Dam | Nixon (b) | Adjustments: Storage Evapor | Adjustments: Truckee Canal | Adjustments: Depletion (a) | Adjusted Flow near Nixon | Rank |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| | Flows are in 1,000's of acre-feet | | | | | | | | |
| | | | | | | | | | |
| 1900 | [c] 370 | | 370 | 400 | (+100) | | 90 | 590 | 34 |
| 1 | [c] 630 | | 630 | 650 | +220 | | 90 | 960 | 55 |
| 2 | [c] 510 | | 510 | 530 | + 10 | | 100 | 640 | 40 |
| 3 | [c] 550 | | 550 | 570 | - 10 | | 100 | 660 | 41 |
| 4 | [c] 1350 | | 1350 | 1300 | +120 | | 100 | 1520 | 72 |
| 5 | [c] 570 | 100 | 470 | 500 | - 180 | 100 | 100 | 520 | 31 |
| 6 | [c] 1060 | 150 | 910 | 910 | + 170 | 150 | 100 | 1330 | 67 |
| 7 | [c] 1600 | 150 | 1450 | 1420 | + 110 | 150 | 100 | 1760 | 74 |
| 8 | [d] 582 | 150 | 430 | 460 | -330 | 150 | 100 | 380 | 21 |
| 9 | [d] 1010 | 180 | 830 | 840 | + 80 | 180 | 100 | 1200 | 63 |
| 1910 | [d] 778 | 180 | 600 | 620 | - 120 | 180 | 100 | 780 | 49 |
| 11 | [d] 1150 | 180 | 970 | 970 | + 160 | 180 | 100 | 1410 | 70 |
| 12 | [d] 382 | 190 | 190 | 210 | -140 | 190 | 100 | 360 | 20 |
| 13 | [d] 383 | 190 | 190 | 210 | -120 | 190 | 100 | 380 | 22 |
| 14 | [d] 1060 | 190 | 870 | 870 | +320 | 190 | 100 | 1480 | 71 |
| 15 | [d] 654 | 190 | 460 | 490 | - 60 | 190 | 100 | 720 | 44 |
| 16 | [e] 800 | 190 | 610 | 630 | +120 | 190 | 100 | 1040 | 57 |
| 17 | [e] 680 | 190 | 500 | 530 | - 50 | 190 | 100 | 770 | 48 |
| 18 | [e] 430 | 220 | 210 | 230 | -150 | 220 | 90 | 390 | 23 |
| 19 | | | 284 | 310 | -140 | 234 | 90 | 490 | 29 |
| 1920 | | | 85 | 100 | -170 | 245 | 90 | 260 | 16 |
| 21 | | | 203 | 230 | + 80 | 230 | 90 | 630 | 39 |
| 22 | | | 403 | 430 | + 80 | 224 | 100 | 830 | 51 |
| 23 | | | 298 | 330 | + 60 | 259 | 90 | 730 | 45 |
| 24 | | | 55 | 70 | -370 | 161 | 90 | [f] 5 | 1 |
| 25 | | | 95 | 110 | +150 | 247 | 90 | 600 | 36 |

| Water Year | Flow below Derby Dam | Nixon | Adjustments: Storage Evapor | Adjustments: Truckee Canal | Adjustments: Depletion | Adjusted Flow near Nixon | Rank |
|---|---|---|---|---|---|---|---|
| 1926 | 52 | 70 | -120 | 195 | 90 | 240 | 10 |
| 27 | 338 | 370 | +250 | 279 | 90 | 990 | 57 |
| 28 | 291 | 320 | - 70 | 205 | 100 | 560 | 33 |
| 29 | | 33 | -190 | 190 | 90 | 120 | 3 |
| 1930 | | 48 | + 10 | 256 | 90 | 400 | 25 |
| 31 | | 13 | -140 | 99 | 90 | 60 | 2 |
| 32 | | 123 | +160 | 231 | 100 | 610 | 37 |
| 33 | | 40 | - 90 | 128 | 90 | 170 | 7 |
| 34 | | 28 | - 80 | 124 | 90 | 160 | 6 |
| 35 | | 134 | + 80 | 197 | 90 | 500 | 30 |
| 36 | | 190 | +220 | 249 | 100 | 760 | 47 |
| 37 | | 200 | - 30 | 184 | 100 | 450 | 27 |
| 38 | | 747 | +420 | 143 | 100 | 1410 | 69 |
| 39 | | 159 | -270 | 161 | 100 | 150 | 5 |
| 1940 | | 290 | +180 | 278 | 100 | 850 | 52 |
| 41 | | 206 | + 60 | 254 | 100 | 620 | 38 |
| 42 | | 562 | + 80 | 175 | 100 | 920 | 54 |
| 43 | | 712 | + 10 | 193 | 100 | 1020 | 58 |
| 44 | | 96 | -190 | 258 | 100 | 260 | 15 |
| 45 | | 153 | + 60 | 283 | 100 | 600 | 35 |
| 46 | | 222 | + 80 | 254 | 100 | 670 | 42 |
| 47 | | 90 | -170 | 243 | 100 | 260 | 14 |
| 48 | | 38 | -100 | 298 | 100 | 340 | 19 |
| 49 | | 22 | -160 | 281 | 100 | 240 | 12 |
| 1950 | | 105 | +220 | 354 | 100 | 780 | 50 |
| 51 | | 554 | +210 | 283 | 100 | 1150 | 62 |
| 52 | | 1040 | + 90 | 369 | 100 | 1600 | 73 |
| 53 | | 288 | + 10 | 361 | 100 | 760 | 46 |
| 54 | | 56 | -160 | 328 | 100 | 320 | 18 |
| 55 | | 24 | -170 | 293 | 100 | 250 | 13 |

| Water Year | Nixon | Adjustments: Storage Evapor | Adjustments: Truckee Canal | Adjustments: Depletion | Adjusted Flow near Nixon | Rank |
|---|---|---|---|---|---|---|
| 1956 | 590 | +340 | 313 | 100 | 1340 | 68 |
| 57 | 101 | - 60 | 376 | 100 | 520 | 32 |
| 58 | 521 | + 60 | 370 | 100 | 1050 | 60 |
| 59 | 24 | -220 | 290 | 100 | 190 | 8 |
| 1960 | 25 | -210 | 298 | 100 | 210 | 9 |
| 61 | 18 | -180 | 204 | 100 | 140 | 4 |
| 62 | 47 | + 60 | 258 | 100 | 460 | 28 |
| 63 | 320 | +330 | 305 | 100 | 1060 | 61 |
| 64 | 42 | -110 | 281 | 100 | 310 | 17 |
| 65 | 437 | +410 | 271 | 100 | 1220 | 65 |
| 66 | 153 | -280 | 269 | 100 | 240 | 11 |
| 67 | 640 | +260 | 216 | 100 | 1220 | 64 |
| 68 | 241 | -120 | 181 | 100 | 400 | 24 |
| 69 | 974 | + 80 | 171 | 100 | 1320 | 66 |
| 1970 | 472 | + 60 | 252 | 100 | 870 | 53 |
| 71 | 510 | +140 | 221 | 100 | 970 | 56 |
| 72 | 230 | -140 | 242 | 100 | 430 | 26 |
| 73 | 351 | + 80 | 154 | 100 | 680 | 43 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 1900-73 | | | | | | |
| Total | 26829 | | | | 50280 | |
| Average | 360 | | | | 680 | |
| 1905-73 | | | | | | |
| Total | | | 15868 | | | |
| Average | | | 230 | | | |
| 1964-73 | | | | | | |
| Aver. | | | | | 770 | |
| | | | | | | |
| 1900-60 | | | | | | |
| Aver. | | | | | 670 | |
| Aver. (Harding) | | | | | 650 | |

Note.--Except for the actual records of annual flows, values shown to three significant figures should not be interpreted to imply that degree of accuracy. In general, values have been rounded to the nearest 10,000 acre-feet.

a From S.T. Harding, 1965
b Estimated 1900-1928 from correlation with flow below Derby Dam.
c From correlation with Vista, NV.
d Record at Clarks, NV.
e From correlation with Farad and Reno
f Estimated on basis of recent seepage measurements.

On the basis of seasonal evaporation data at Tahoe City, evaporation from the four reservoirs, Boca, Prosser Creek, Stampede, and Martis Creek, was estimated as 3.5 feet annually. This rate is equivalent to a loss of about 15,000 acre-feet per year.

Harding (1965, p. 119) has estimated annual stream depletions from diversions for irrigation along the Truckee River, and estimates of return flow and consumptive use. He estimated stream depletion as 10,000 acre-feet in 1861, increasing to 100,000 acre-feet in 1903, and remaining quite steady since then.

One of the assumptions made is that the evaporation losses in Lake Tahoe and in Washoe Lake would occur whether the lakes are regulated or not because the surface areas are virtually the same throughout the small ranges in stage. Therefore, man's activity has not changed the evaporation losses from these two lakes to any significant degree.

Another assumption implicit in the adjustments is that changes in storage, evaporation, and stream depletions have not altered the stream system enough to cause significant changes in such factors as channel losses or the travel time of flows on an annual basis.

The 74-year record near Nixon was adjusted on a yearly basis for changes in storage, evaporation, Truckee Canal diversions, and stream depletion to obtain an approximation of the "natural flow" at that point (table 2). The average annual runoff, adjusted, is computed as 680,000 acre-feet.

## Variability of Annual Flows

The following paragraphs contain only a few of the many comparisons that could be made to illustrate the annual variability of flows with respect to the long-term mean.

For the 61 year period, 1900-60, Harding obtained an average annual runoff of 650,000 acre-feet. This period is concurrent with data used in this report, which give a mean annual runoff of 670,000 acre-feet, a difference of only 3.0 percent. The two values are an excellent check considering the different methods used.

The 74-year period was divided into three almost equal periods as shown in the following tabulation.

| | | Average annual runoff | | Percentage of 74-year average | |
|---|---|---|---|---|---|
| | | Computed or Observed | Adjusted | | |
| Period | Years | Acre-feet | Acre-feet | Observed | Adjusted |
| 1900-1923 | 24 | 570,000 | 830,000 | 158 | 122 |
| 1924-1948 | 25 | 200,000 | 510,000 | 56 | 75 |
| 1949-1973 | 25 | 311,000 | 710,000 | 86 | 104 |
| 1900-1973 | 74 | 360,000 | 680,000 | 100 | 100 |
| 1918-1970 | 53 | 250,000 | 600,000 | 69 | 88 |

The average adjusted runoff for three periods ranged from 122 percent down to 75 percent of the 74-year mean. Also, the 50-year average for 1924-73 is only 90 percent of the 74-year mean. These arbitrary divisions show the wide range in runoff over relatively long periods and that the 1900-23 period had an average flow 36 percent higher than that for the next 50 years.

The period 1918-70 is also included in the table above because it is the 53-year base period used by the Pyramid Lake Task Force (1971). The average annual adjusted runoff for this period is 88 percent of the average for the 1900-73 period.

During the last 10 years, 1964-73, the average annual adjusted runoff was about 770,000 acre-feet, 113 percent of the 74-year mean; however, the 74-year mean was exceeded only in 6 of the 10 years. Also, runoff in 2 of the 10 years was less than half of the 74-year mean, and the runoff in 1966 was only 19 percent, roughly one fifth, that in 1969.

## Long Term Trends

### Precipitation records

The use of the precipitation record at Sacramento as an index of Truckee River flows can only be justified in part. It is the longest record near Lake Tahoe, and most of the time, when a wet year occurs at Sacramento, the year is also wet at Tahoe City and the Truckee Ranger Station. See figures 1 and 2. However, the relative amounts of precipitation can be

significantly different in both wet years and dry years. For example: Compare the precipitation amounts (fig. 1) for the wet years of 1952, 1956, and 1958 or the dry years of 1960, 1964, 1966, 1968, and 1972. However the comparisons in the following paragraphs offer some indication of the relationship of the streamflow records to long-term precipitation.

The precipitation record at Sacramento, CA is continuous from 1849. The period prior to 1900, when streamflow records on the Truckee River began, had a cumulative excess of precipitation of 76.48 inches more than the average precipitation for the period 1849-1973 (fig. 3). The excess increased to 93.30 inches in 1907 and then decreased to 43.12 inches by 1923, to zero in 1932, and to a deficit of 20.01 inches in 1934. Since then, the excess or deficit has been within 21 inches of the average precipitation.

To express the trends in another way, the average annual precipitation for the period prior to 1900, the three periods of streamflow record selected previously, the 74-year period of streamflow records, and the entire period of rainfall records at Sacramento are:

| | | |
|---|---|---|
| 1850-1899 | 50 years | 19.57 inches |
| 1900-1923 | 24 years | 16.65 inches |
| 1924-1948 | 25 years | 16.35 inches |
| 1949-1973 | 25 years | 18.01 inches |
| 1900-1973 | 74 years | 17.01 inches |
| 1850-1973 | 124 years | 18.04 inches |

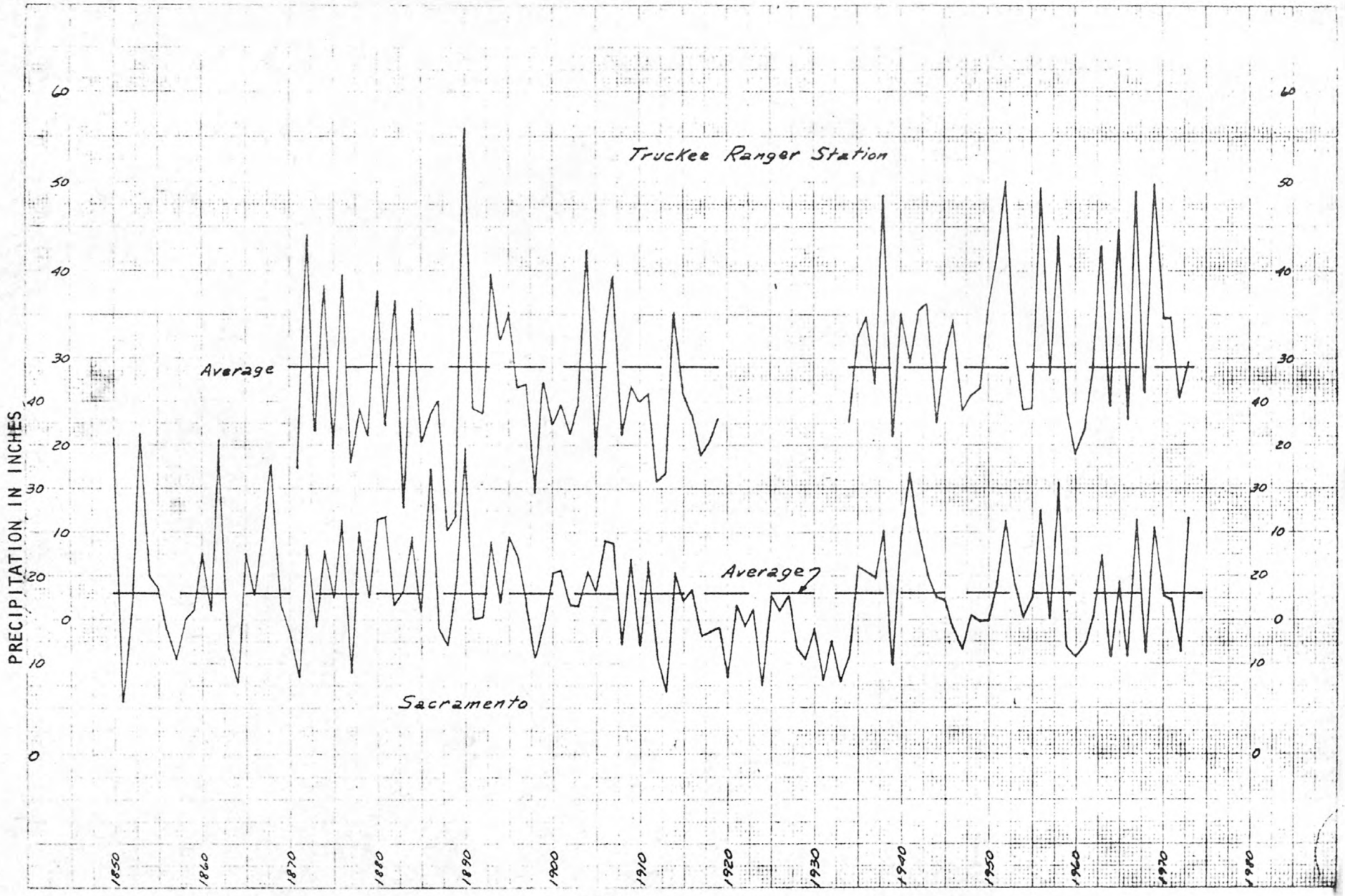



Figure 1. Annual precipitation at Sacramento and Truckee Ranger Station, CA

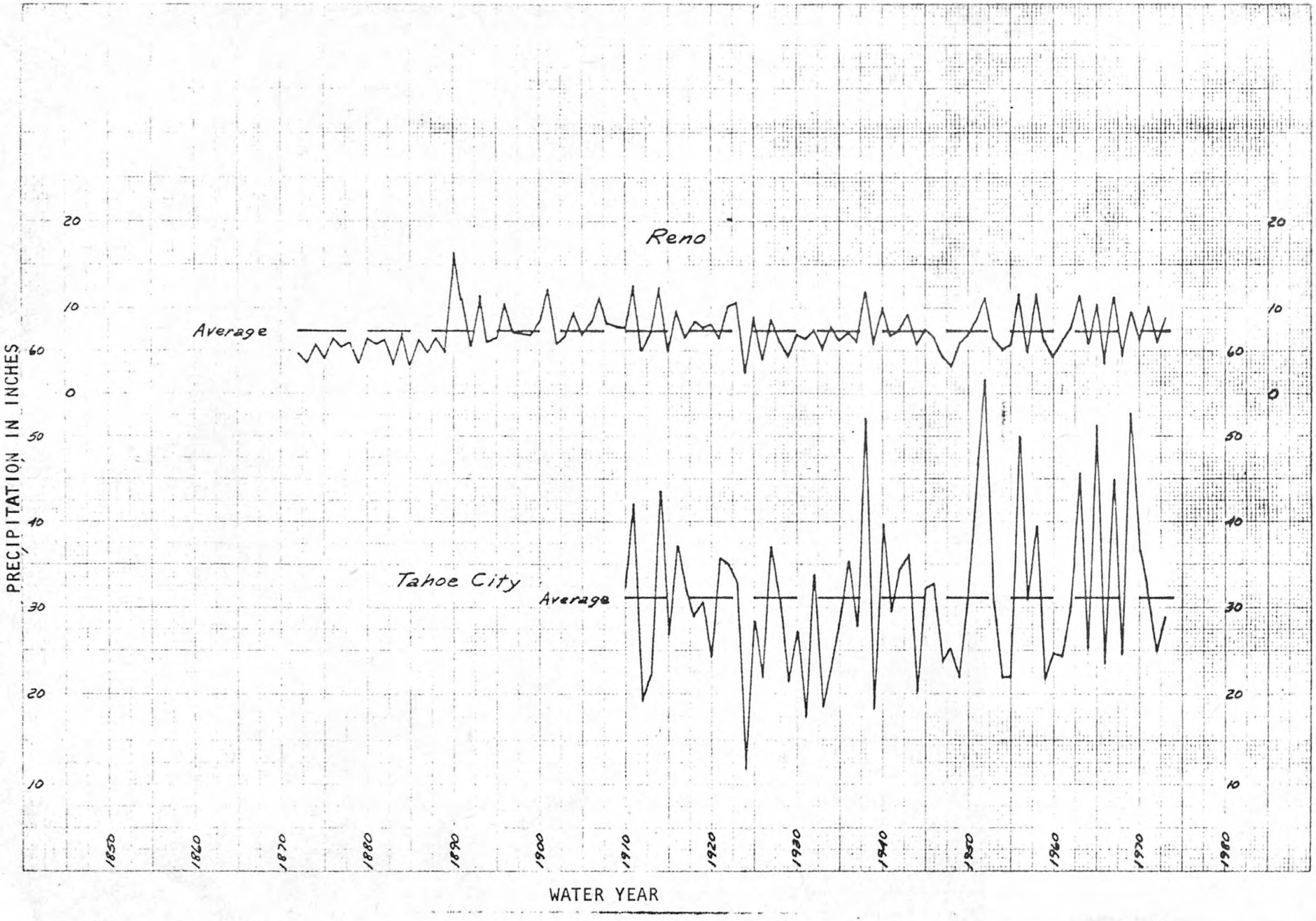



Figure 2. Annual precipitation at Reno, NV and Tahoe City, CA

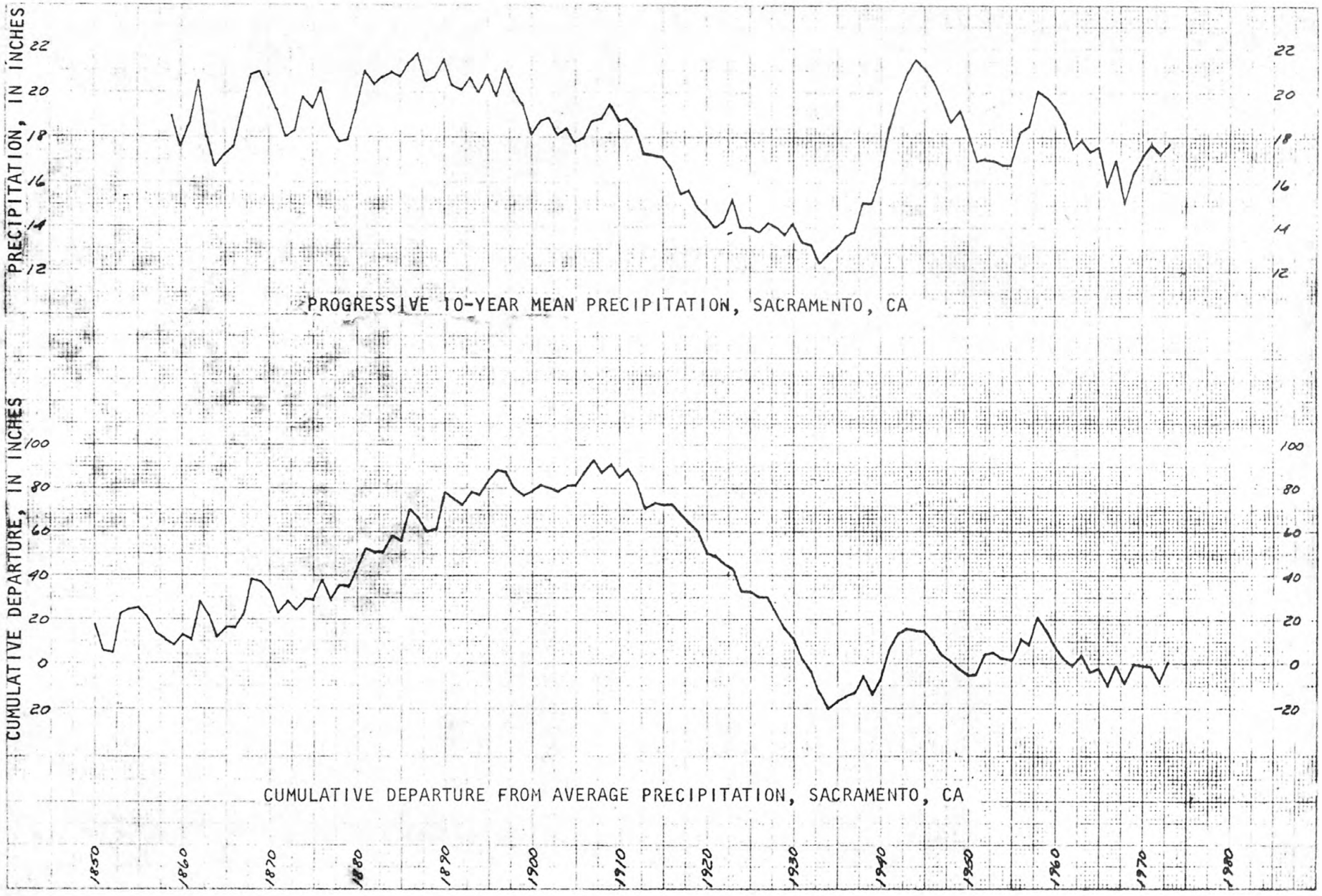



Figure 3. Graphs of progressive 10-year mean precipitation and cumulative average precipitation, Sacramento, CA

From the above tabulation, it is evident that the average precipitation at Sacramento from 1850 to 1899 was 115 percent of that from 1900 to 1973. Also, that the average precipitation for 1900 to 1973 was 94 percent of the 124 year average.

However, there is not a 1 to 1 relation between average precipitation for a period and average streamflow. The variations in the relations expressed as percentages of the means for the 74-year period, 1900-73, are indicated in the following table:

| Period | Precipitation at Sacramento | Adjusted runoff near Nixon |
|---|---|---|
| 1900-1923 | 98 | 122 |
| 1924-1948 | 96 | 75 |
| 1949-1973 | 106 | 105 |

Because the record near Nixon was estimated prior to 1929, the observed record at Farad was also adjusted to approximate natural flow. The percentages of the 74-year mean, 590,000 acre-feet, were 122, 75, and 107 percent, respectively, for the three periods tabulated above - an excellent agreement with the percentages near Nixon.

## Tree ring records

The proponents of the use of tree ring studies indicate that they are valuable tools to extend man's knowledge of earlier climatic conditions. Unfortunately, tree ring studies in the Truckee River basin are not plentiful. Hardman and Reil (1936) obtained cores from 200 trees in

the Truckee River basin, and the University of Nevada, in cooperation with the University of Arizona, is currently analyzing tree ring data from the basin.

Fritts (1965) used cores from small groups of pine trees in northeastern and east-central California, probably in the upper Feather River basin and upper San Joaquin River basins, respectively, and in the White Mountains of California. Helley and LaMarche (1973) dated redwood trees in northern California.

Only general interpretations of the tree-ring information are pertinent to this analysis. Hardman and Reil (1936) and Fritts (1965) are in general agreement that since about the year 1200, or possibly earlier, the period starting about 1875 and ending about 1915 was one of the longest and wettest. widespread and severe droughts have occurred frequently since 1500. One such drought period was from roughly 1917 to 1934. Hardman and Reil mention that stumps under water in Lake Tahoe indicate that the water surface may have been below the rim at the outlet for most of the 100 years prior to 1850.

This type of general information is not sufficient to extend or adjust measured flows in the Truckee River.

After considering the precipitation records, general tree-ring information, the observed and estimated streamflow values, the writer concludes that the average flow for the 74-year period, 1900-73, is a reliable index

of the long term average. The 74-year average flow at Farad, adjusted for storage, evaporation, and depletions, is 590,000 acre-feet per year; and that near Nixon is 680,000 acre-feet per year.

Under average depletions and diversions through the Truckee Canal now in effect, the estimated unadjusted average flow near Nixon is 350,000 acre-feet per year.

Note that the average adjusted flow near Nixon is computed on basis of yearly values that ranged from 5,000 acre-feet in 1924 to 1,760,000 acre-feet in 1907 (table 2). During the 74 years, 32 years had above average flow and 42 had below average flow. The average is 680,000, but the median is only 620,000.

## Great Salt Lake

Stages of the Great Salt Lake are plotted (fig. 4) along with those of Pyramid Lake to illustrate some general trends and wet and dry periods. In broad terms, both lakes are lower than they were about 100 years ago. rising and falling stages have occurred on both lakes at nearly the same times, and both have been affected by increased water uses in tributary basins.

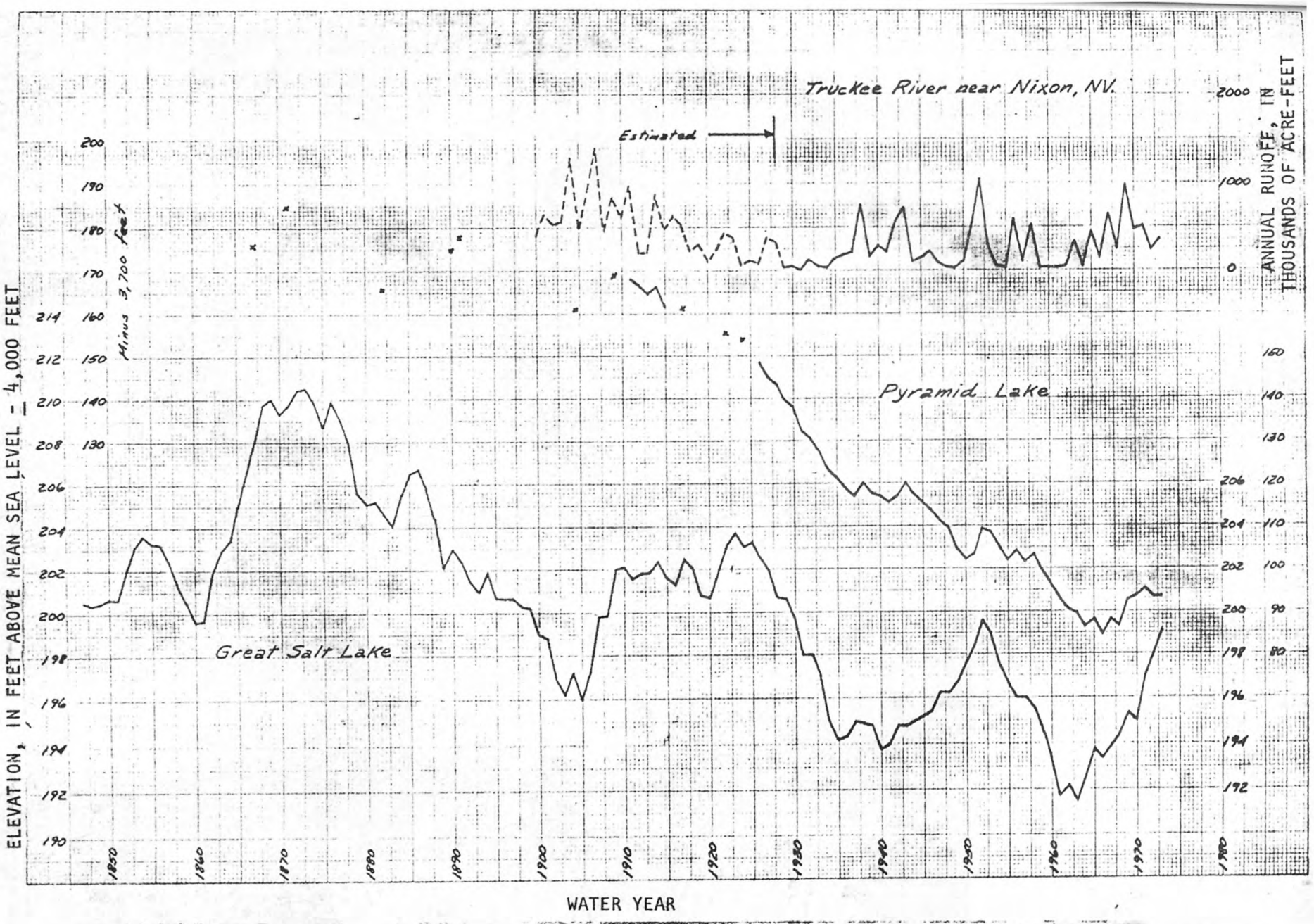



Figure 4. Graphs of water-surface elevations of Pyramid Lake and Great Salt Lake and annual runoff of Truckee River near Nixon, NV

## Other Considerations

The request for this evaluation of Truckee River records emphasized the need to determine the long-term average annual runoff. In the section, Variability of Annual Flows, some of the wide ranges in annual runoff were mentioned primarily to show that long-term average flows are not in themselves a very good measure of water available on a year to year basis. The capacity of storage reservoirs upstream from Farad totals 1.1 million acre-feet; however, carry-over storage from wet years is seldom adequate to provide average flows during a series of dry years.

The extremes of flow and the probabilities of their occurrence are major considerations in evaluating the supply of water available. To present some information in this vein, a duration curve and a frequency curve of the 74 adjusted annual runoff figures were prepared. Though annual runoff is not an extreme in itself, annual runoff amounts can be studied as annual events using duration and frequency curves.

The duration curve (fig 5) shows that the adjusted average annual runoff near Nixon, 680,000 acre-feet, is exceeded almost 50 percent of the time. Or conversely, the annual runoff is less than 680,000 acre-feet about half the time.

The frequency curve (fig. 6) shows that, on the average, an adjusted annual runoff of 680,000 acre-feet has a recurrence interval of about

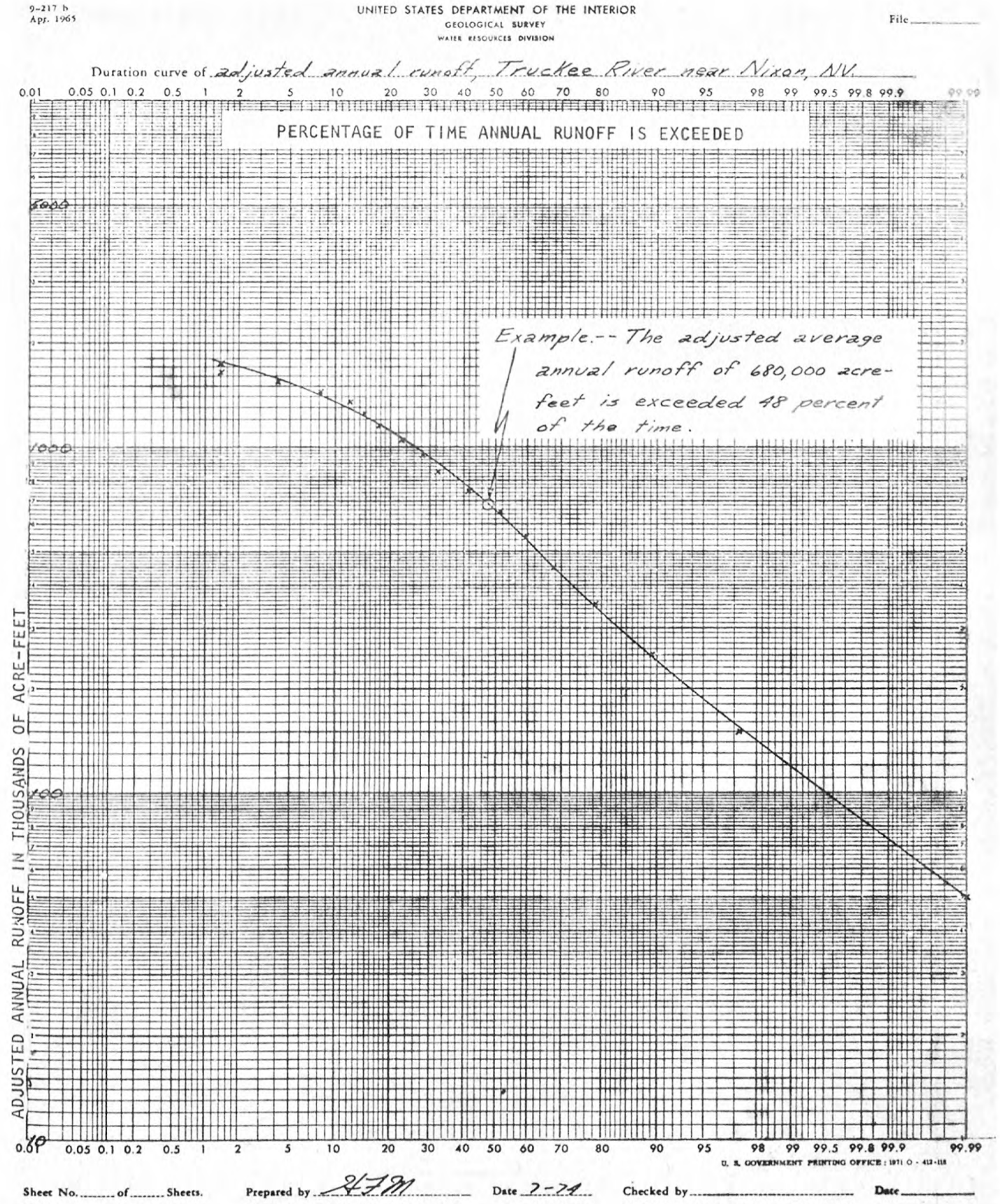



Figure 5. Duration curve of adjusted annual runoff, Truckee River near Nixon, NV

9-179a
Flood data plot
(March 1949)

UNITED STATES DEPARTMENT OF THE INTERIOR – GEOLOGICAL SURVEY – WATER RESOURCES DIVISION

File Number

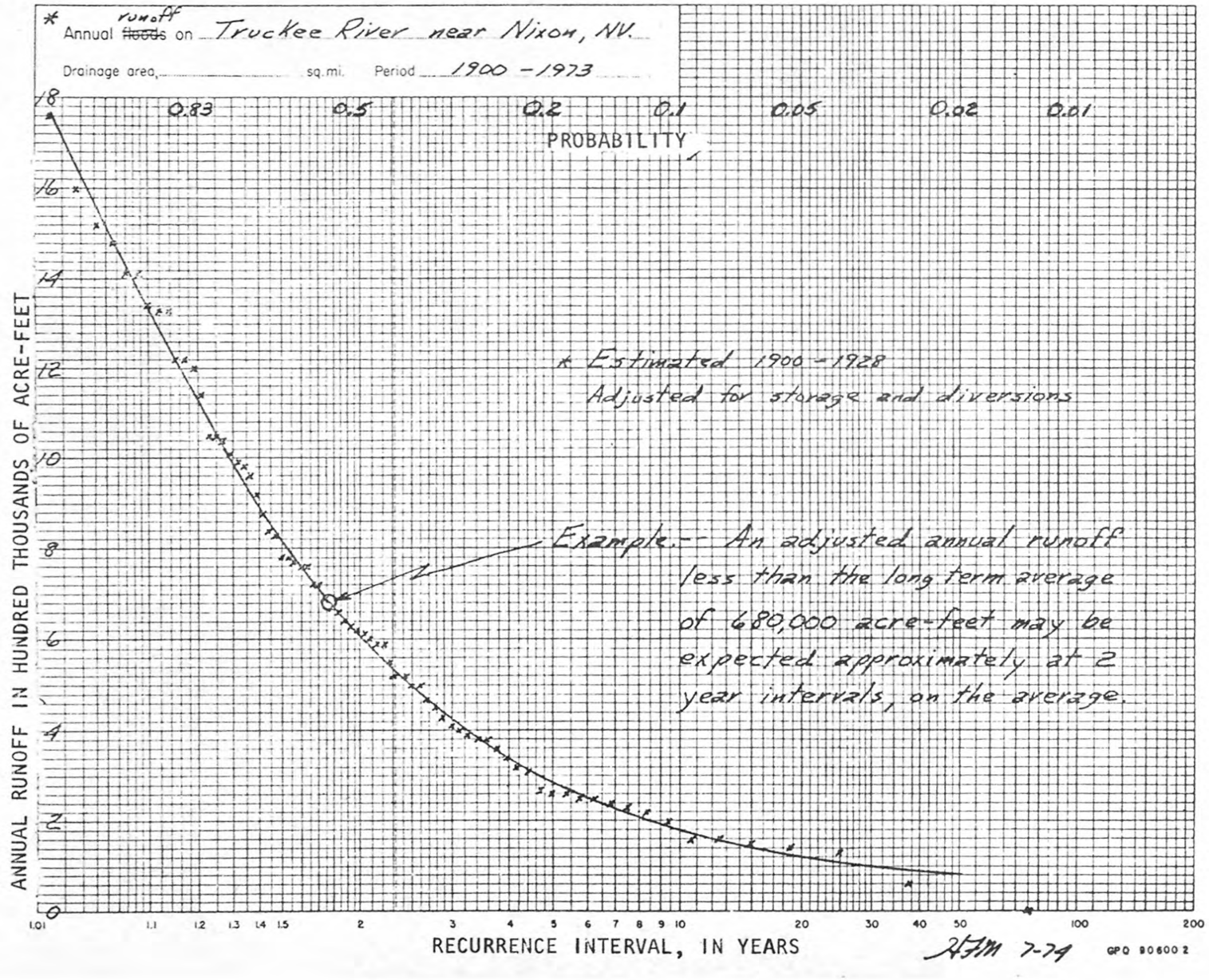



Figure 6. Frequency curve of adjusted annual runoff, Truckee River near Nixon, NV

2 years. A 2-year recurrence interval is equivalent to a 0.5 probability, the same result as shown by the duration curve. The adjusted annual runoff will be as low as 180,000 acre-feet at a recurrence interval of about 10 years. Such a low flow has a 10-percent chance of occurring in any given year.

Of the 10 driest years in the 74-year period, 6 of them occurred in the 11 year period 1924-34.

## Summary

The evaluation of the reliability of streamflow records showed that there is no reason to question any of the records along the main stem of the Truckee River or that for the Truckee Canal.

The long-term average flow was based upon the 74-years of record that were either observed or estimated. The 1900-73 period provides a reliable index of the long-term average flow because it includes wet periods and a drought and includes virtually all the streamflow data available. A supporting factor is that the average annual precipitation at Sacramento for 1900-73 was 94 percent of the mean annual precipitation for the 124 years of record.

The adjusted average annual runoff for the period 1900-73 at Farad is 590,000 acre-feet and near Nixon it is 680,000 acre-feet. The actual average annual runoff at Farad is 576,000 acre-feet and that near Nixon is estimated as 360,000 acre-feet.

The longer record of precipitation at Sacramento and the general information from tree-ring studies are not sufficient bases to extend or adjust the 74-year records on the Truckee River.

The flows for individual years vary widely from the average. The average annual flow will be exceeded one year out of two, and the annual flow will be only 25 percent of the 74-year average about once in 10 years, over a long period.

## References


Fritts, H.C., 1965, Tree-ring evidence for climatic changes in western North America: U.S. Weather Bureau, Monthly Weather Review, Vol 93, No. 7, pp. 421 to 443.

Harding, S.T., 1965, Recent variations in the water supply of the western Great Basin: Univ. Calif., Arch. Ser. Rept. No. 16, 225 p.

Hardman, George, and Reil, O.E., 1936, The relationship between tree growth and stream runoff in the Truckee River basin, California-Nevada: Univ. Nev. Agric. Exp. Stat., Bull. No. 141, 38 p.

Helley, E. J., and LaMarche, Jr., V.C., 1973, Historic flood information for northern California streams from geological and botanical evidence: U.S. Geol. Survey Prof. Pap. 485-E, 16 p.

Pyramid Lake Task Force, 1971, Pyramid Lake Task Force, final report: Pyramid Lake Task Force, 63 p.

Searcy, J.K., and Hardison, C.H., 1960, Double-mass curves: U.S. Geol. Survey Water-Supply Paper 1541-B, 66 p.

U.S. Geol. Survey, 1960 and 1963, Compilation of surface water records, the Great Basin, through 1950 and 1950-60: U.S. Geol. Survey Water-Supply Papers 1314 and 1734.

_____ 1970, Surface water supply of the United States 1961-65, Part 10, The Great Basin: U.S. Geol. Survey Water-Supply Paper 1927.

_____ 1967 through 1974, Water resources data for Nevada: U.S. Geol. Survey annual basic data release, water years 1966 through 1973.

U.S. Weather Bur., 1934, 1964, Climatic summary of the United States - to 1930, 1931 through 1952, 1951 through 1960 - California: Climatography of the U.S., Sec. 16, No. 11-4, and No. 86-4.

_____ 1932, 1960, 1965, Climatic summary of the United States - to 1930, 1931 through 1952, 1951 through 1960 - Nevada: Climatography of the U.S., Sec. 19, No. 11-22, and No. 86-22.

U.S. Weather Bur., Environmental Data Serv., 1962 through 1974, Climatological data, California and Nevada, Annual summaries, 1961 through 1973.

VanDenburgh, A.S., Lamke, R.D., and Hughes, J.L., 1973, A brief water-resources appraisal of the Truckee River basin, western Nevada; Nevada Dept. Conserv. and Nat. Res., Div. Water Res., Rept. 57, Water Res. Reconn. Ser.


WERT
BOOKBINDING
MIDDLETOWN, PA.
JANUARY 75
We're Quality Bound