UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
Water Resources Division

SEDIMENTATION OF WILLIAMS RESERVOIR, SANTA CLARA COUNTY CALIFORNIA

By

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Prepared in cooperation with the
U.S. Department of Justice

OPEN-FILE REPORT

72-315

Menlo Park, California
April 6, 1972

3013-14

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ABSTRACT

Fifty-two acre-feet of sediment was deposited in Williams Reservoir between 1913 and 1971. From calculations of the sediment yields in other nearby drainage basins in Santa Clara County, it was determined that 24 to 38 acre-feet of sediment would have been transported to Williams Reservoir between 1961 and 1971 under natural conditions. The difference (14 to 28 acre-ft) is probably a consequence of increased sediment yield due to a fire that destroyed much of the vegetation in the drainage basin in 1961.

INTRODUCTION

Williams Reservoir, about 13 miles south of San Jose in Santa Clara County, Calif., is the farthest upstream reservoir of four on Los Gatos Creek. The drainage basin above the reservoir (fig. 1), is characterized by steep slopes and bedrock of conglomerate, shale, and sandstone. The basin, 5.25 square miles in area, has a width of about 1.5 miles and a length of about 3.5 miles. The mean annual precipitation in the basin is about 45 inches.

In July 1961 an uncontrolled fire destroyed much of the vegetation that protected the drainage basin above Williams Reservoir. Because sediment yields and erosion rates often increase significantly after a fire (Krammes, 1965), small check dams were built to catch debris and sediment that otherwise would be deposited in the reservoir. Despite these check dams, Williams Reservoir has filled considerably with sediment since the fire and consequently has lost part of its capacity to store water.

Because of the loss of storage capacity, the reservoir has not been used to the extent that it was used before the fire. R. M. Ritchey, (oral commun., 1971) chief engineer of the San Jose Water Works, which owns and operates Williams Reservoir, reports that prior to the fire the reservoir usually was drained each summer. Since 1963, however, the reservoir outlets have been inoperable because of the sediment load and the reservoir cannot be drained or operated for cyclic storage. Consequently, water from the perennial stream that feeds the reservoir flows over the crest of the dam, which serves as the spillway.

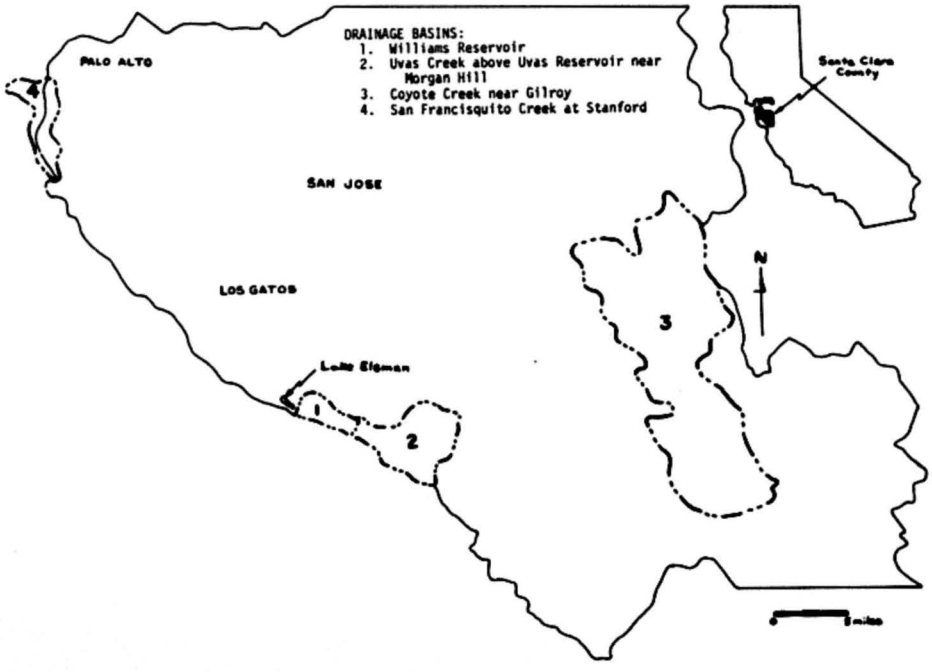

FIGURE 1.--Santa Clara County and drainage basins used for calculating sediment yield of the drainage basin above Williams Reservoir.

The purpose of this report is to determine the volume of sediment that has deposited in Williams Reservoir since 1913 and to learn how the 1961 fire affected the deposition of sediment. To determine the rate of sediment deposition, the reservoir was surveyed in 1971, and the 1971 storage capacity was compared with the storage capacity in 1913 (when the only other comprehensive survey of the reservoir was made). Sediment yields of nearby drainage basins were used to calculate what the sediment yield of the drainage basin above Williams Reservoir might have been from 1961 to 1971 if that basin had not been affected by the fire.

This investigation was made in cooperation with the U.S. Department of Justice, and the work was done in 1971 under the general supervision of R. Stanley Lord, district chief in charge of water-resources investigations in California and under the immediate supervision of Loren E. Young, chief of the Menlo Park subdistrict office.

THE EFFECT OF STORM EVENTS ON SEDIMENT-TRANSPORT RATES

It is evident that considerable quantities of sediment have been deposited in Williams Reservoir since 1961. Aerial photographs taken in 1953 show that the outline of the reservoir was practically the same as the outline determined by the reservoir survey that was made in 1913 (fig. 2).[1] Aerial photographs taken in 1968 and 1970 show that the outline of the reservoir has changed considerably. Areas of the reservoir that had been under water when the reservoir was full are now above water (fig. 2). The eastern arm of the reservoir into which Los Gatos Creek flows is now filled with sediment to the extent shown in figure 2, and the northern arm of the reservoir is almost completely filled. In both areas, the surface sediment is coarse material (mostly pebbles) that probably was deposited in 1963. The depositional surfaces probably have been above water since 1963 as indicated by tree-ring counts of cores from the larger trees growing on the deposits. The date of the uppermost deposition in the two arms of the reservoir coincides with a water year during which two large storms occurred.

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[1]Aerial photographs used during this study were obtained from the photo files maintained by the Topographic Division, U.S. Geological Survey. Photographs of the Williams Reservoir drainage basin were included in the following flight series: (1) GS-HR, 1948, (2) GS-XY, 1953, (3) GS-VBZK, 1968, and (4) GS-VCMI, 1970.

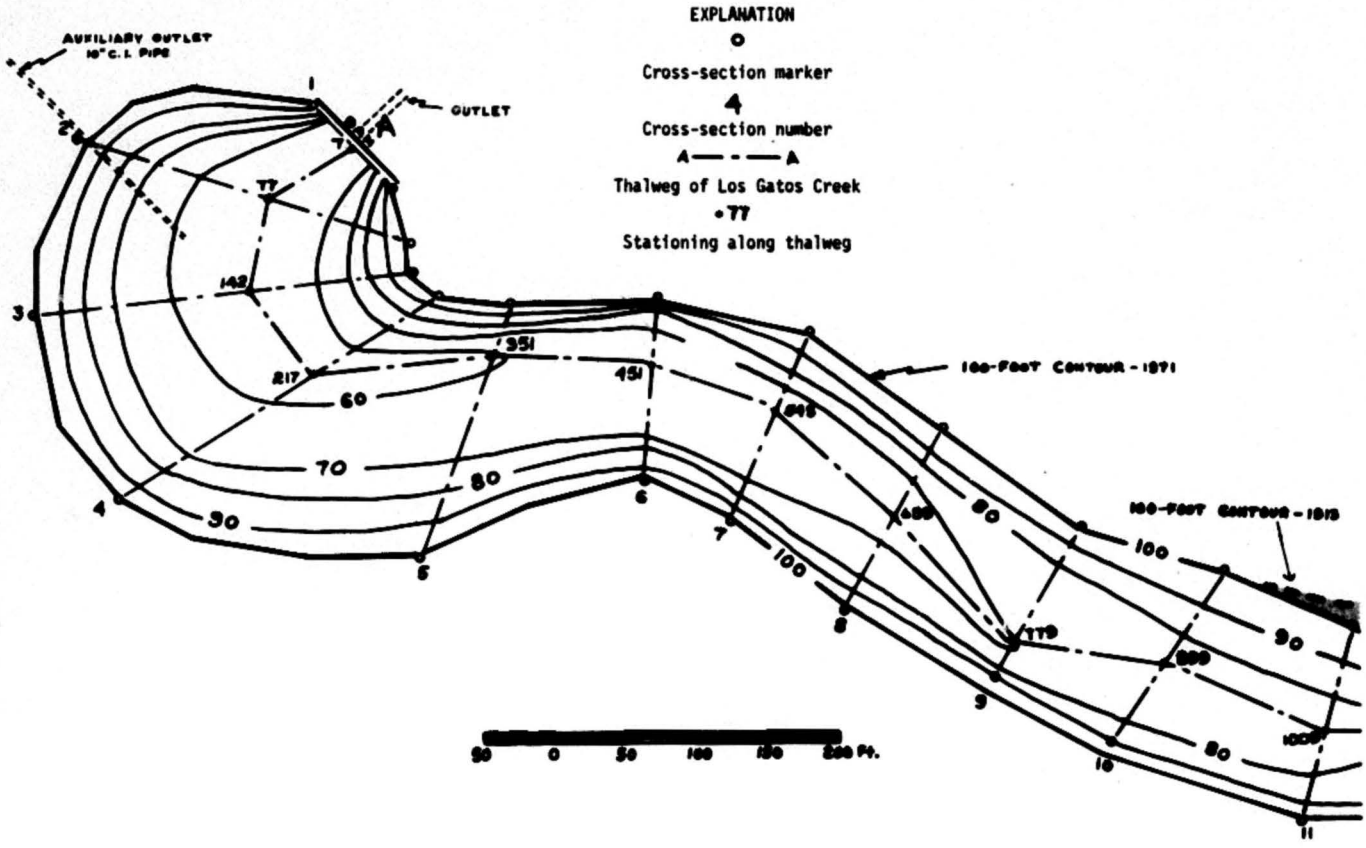

FIGURE 2.--Maximum area of water surface in 1913 and in 1971 for Williams Reservoir.

Rainfall records from a National Weather Service station, about 2 miles downstream from Williams Reservoir, show that 18.07 inches of rain fell during October 9-13, 1962; 13.79 inches fell on October 12, and 19.61 inches fell during the 4-day period January 29-February 1, 1963, with a daily high of 8.63 inches on January 31. The maximum discharge, 6,580 cfs (cubic feet per second) for the period of record 1962-69 water years[2] at the stream-gaging station on Uvas Creek above Uvas Reservoir near Morgan Hill, occurred on October 13, 1962 (table 1); another high discharge (6,400 cfs) occurred January 31, 1963. The Uvas Creek drainage area is adjacent to and just east of the area that drains into Williams Reservoir (fig. 1). At some of the other gaging stations in nearby watersheds (fig. 3) the maximum discharge of record occurred January 31, 1963. However, at stations where the period of record began before 1955 the maximum discharge occurred in December 1955, a peak discharge which was much higher than the peak discharge in 1963 (table 1).

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[2]In U.S. Geological Survey reports the water year is a 12-month period, October 1 through September 30. The year is designated by the calendar year in which it ends and which includes 9 of the 12 months. All years referred to hereafter in this report are water years unless otherwise noted.

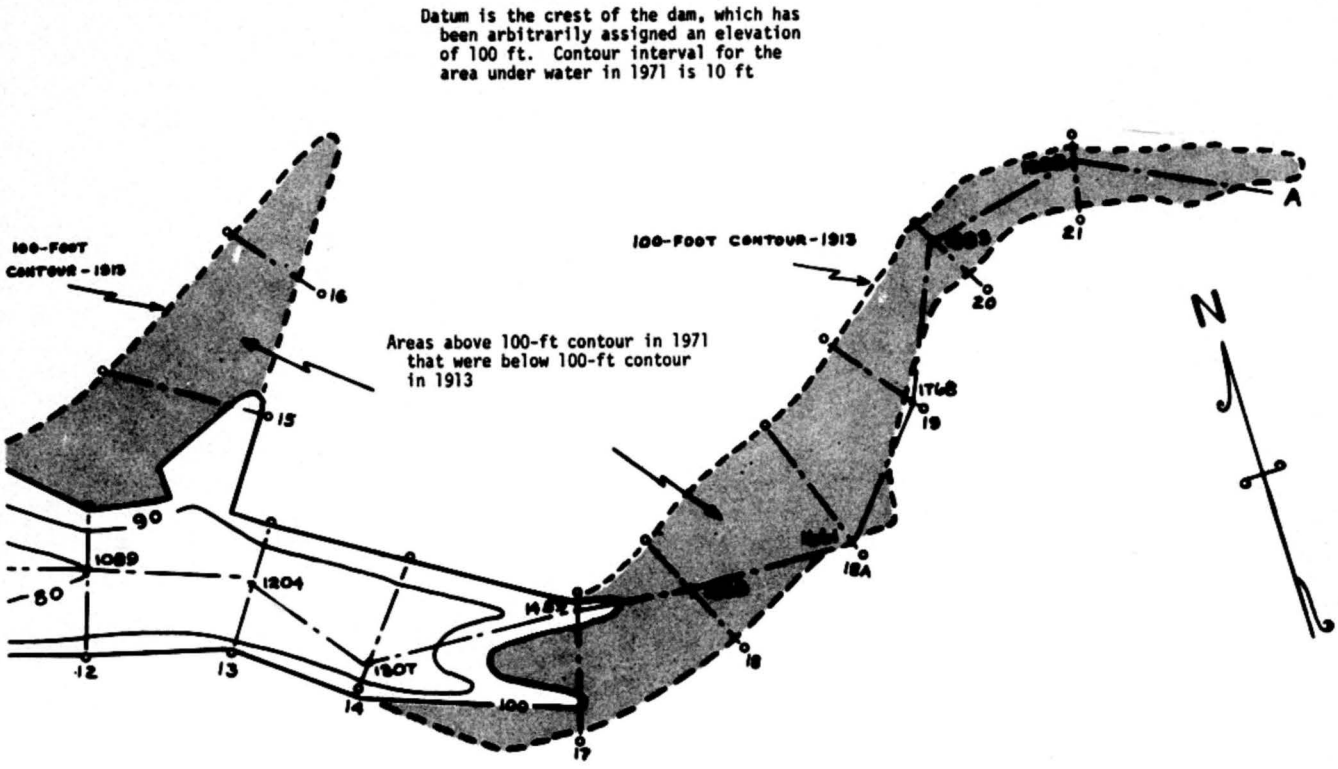


FIGURE 2.--Continued.

From the above discussion it is apparent that since 1961 the highest flows in the streams that drain the area of this report probably occurred in October 1962 and January 1963. During this period, streams that enter Williams Reservoir probably deposited sufficient material to raise the depositional surface above the water surface (fig. 2). Most of the sediment transported by streams annually in coastal California is transported during brief periods of highest flows. In some instances the quantity of sediment transported during a major storm may be greater than the quantity carried during several years. For example, the Eel River carried more sediment during a 30-day period in December 1964 and January 1965 than it did during the remaining 9 years and 11 months (Brown and Ritter, 1970, p. 15). Thus, it is probable that much of the sediment debouched into the reservoir from 1961 to 1971 was transported during the two storms of the 1963 water year.

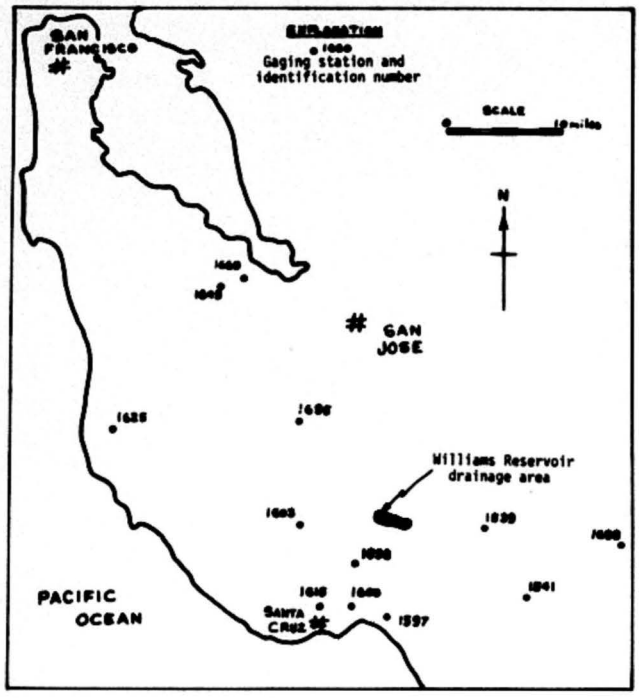


FIGURE 3.--Location of stream-gaging stations referred to in this report.

TABLE 1.--*Peak discharges at stream-gaging stations referred to in this report*

Station number	Station	Drainage area (sq mi)	Period of record	Maximum flood		Maximum discharge 1963 water year
				Date	Discharge (cfs)	
1539	Uvas Creek above Uvas Reservoir near Morgan Hill	21.0	1962-69	Oct. 13, 1962	6,580	6,580
1541	Bodfish Creek near Gilroy	7.40	1960-69	Jan. 31, 1963	1,240	1,240
1597	Aptos Creek at Aptos	12.2	1959-69	Jan. 31, 1963	2,110	2,110
1598	West Branch Soquel Creek near Soquel	12.2	1959-69	Jan. 24, 1967	4,530	4,120
1600	Soquel Creek at Soquel	40.2	1952-69	Dec. 23, 1955	15,800	7,950
1603	Zayante Creek at Zayante	11.1	1958-69	Apr. 2, 1958	3,700	2,830
1615	Branciforte Creek at Santa Cruz	17.3	1940-43 1953-68	Dec. 22, 1955	8,100	2,820
1625	Pescadero Creek near Pescadero	45.9	1952-69	Dec. 23, 1955	9,420	6,700
1645	San Francisquito Creek at Stanford University		1931-41 1951-69	Dec. 22, 1955	5,560	3,270
1660	Matadero Creek at Palo Alto	7.24	1953-69	Dec. 22, 1955	854	641
1695	Saratoga Creek at Saratoga	9.22	1934-69	Dec. 22, 1955	2,730	1,160
1698	Coyote Creek near Gilroy	109	1961-69	Jan. 31, 1963	10,100	10,100

SURVEY OF WILLIAMS RESERVOIR, 1971

To compute the amount of deposition in Williams Reservoir, a survey was made in February and March 1971. The only other survey of the reservoir was done in 1913, about 18 years after the reservoir was completed. In 1913 the capacity of the reservoir was 157 acre-feet at the crest of the dam which was given an arbitrary elevation of 100 feet.

In the 1971 survey, the crest of the dam was given an arbitrary elevation of 100 feet to correspond to the 1913 survey and cross sections were measured to determine the volume of the reservoir. Because water was flowing over the crest of the dam, the elevation of the water surface in the reservoir was assumed to be 100 feet. The 1971 reservoir capacity, calculated by several methods, was determined to be 108 acre-feet. The procedures followed for computing the reservoir capacity and sediment volumes were described by Heinemann and Dvorak (1963) and included the following:

1. A stage-area curve method wherein the curve is integrated between selected elevations to determine the reservoir capacity between those elevations;

2. An average contour-area method wherein areas enclosed by successive contours were averaged, multiplied by the contour interval, and summed to determine the reservoir capacity; and
3. A curve-integration method wherein the area of each cross section is plotted against the distance between its midpoint and the upstream face of the dam. The reservoir capacity is then represented by the area between the curve and the "distance-from-dam" axis.

The variation in capacities obtained by these methods was within 1 acre-foot and certainly within the accuracy of the plotted curves. Heinemann and Dvorak (1963, p. 855) indicated that these methods are sufficiently accurate and particularly desirable for use in studies of small reservoirs, and that more detailed or more complicated procedures probably will not give more accurate results.

The sediment volume was determined by computing the difference in reservoir capacities for 1913 and 1971. The volume of sediment deposited above the arbitrary datum (100 ft) was computed independently by an average end-area method and found to be about 3 acre-feet. Thus, the total quantity of sediment deposited in the reservoir since 1913 was 157-108+3 or 52 acre-feet. The change in storage capacity and the change in the surface area of the reservoir is indicated in figure 4.

As shown in figure 5, the thickness of sediment deposited is easily discerned in each cross section. The sediment ranged from about 10 to 30 feet in thickness, and in general, the amount of sediment increased with distance upstream from the dam (figs. 5 and 6). The profile of the thalweg of the reservoir (fig. 6) shows the delta at the mouth of Los Gatos Creek, which causes an abrupt decrease in depth at 1,300 to 1,500 feet upstream from the dam.

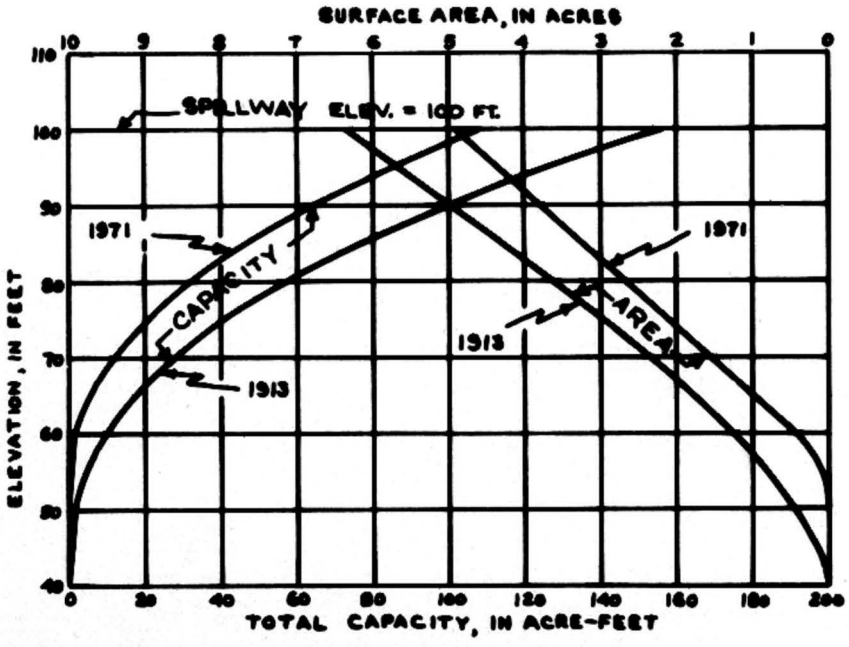


FIGURE 4.--Area-capacity curves, Williams Reservoir.

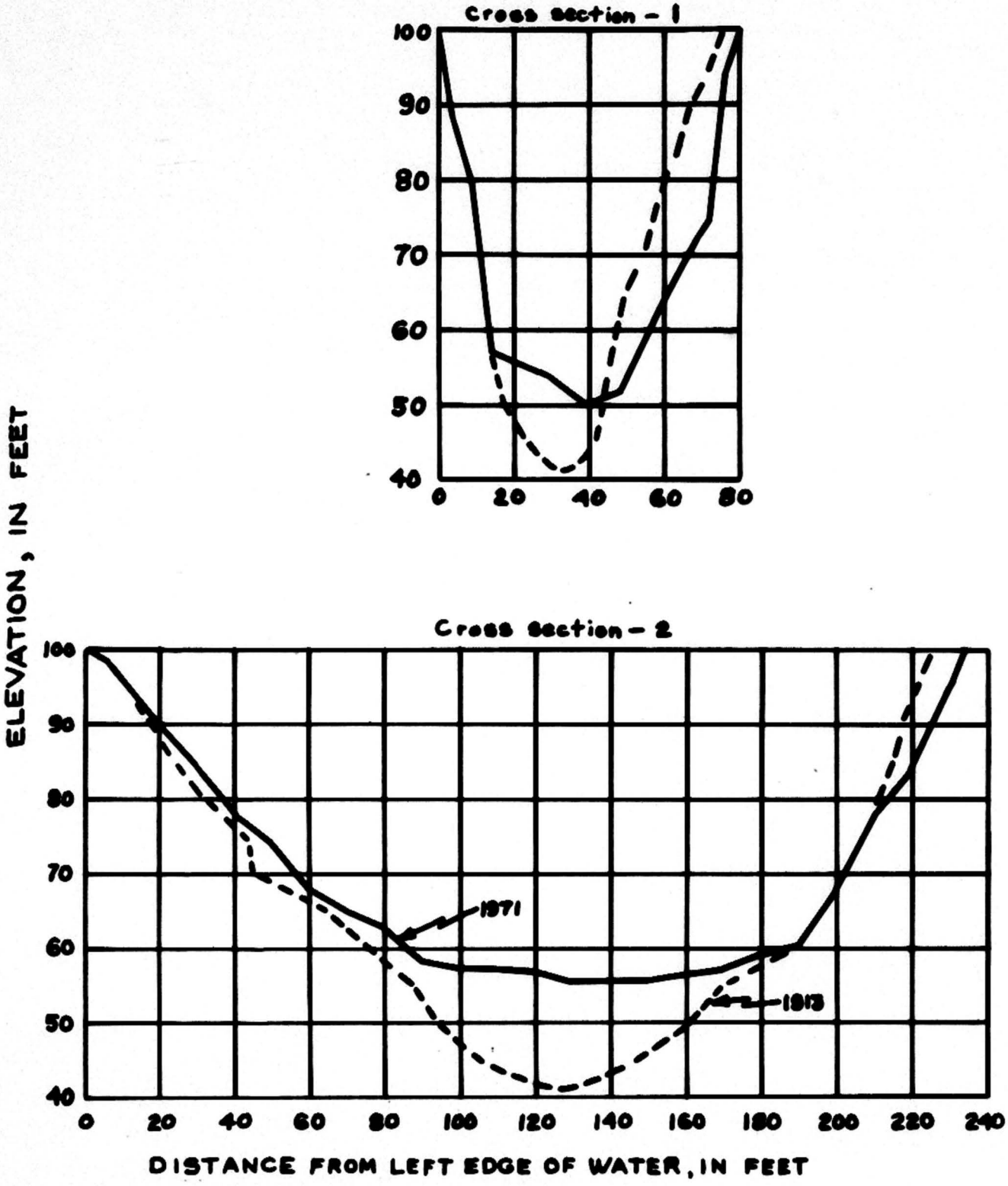
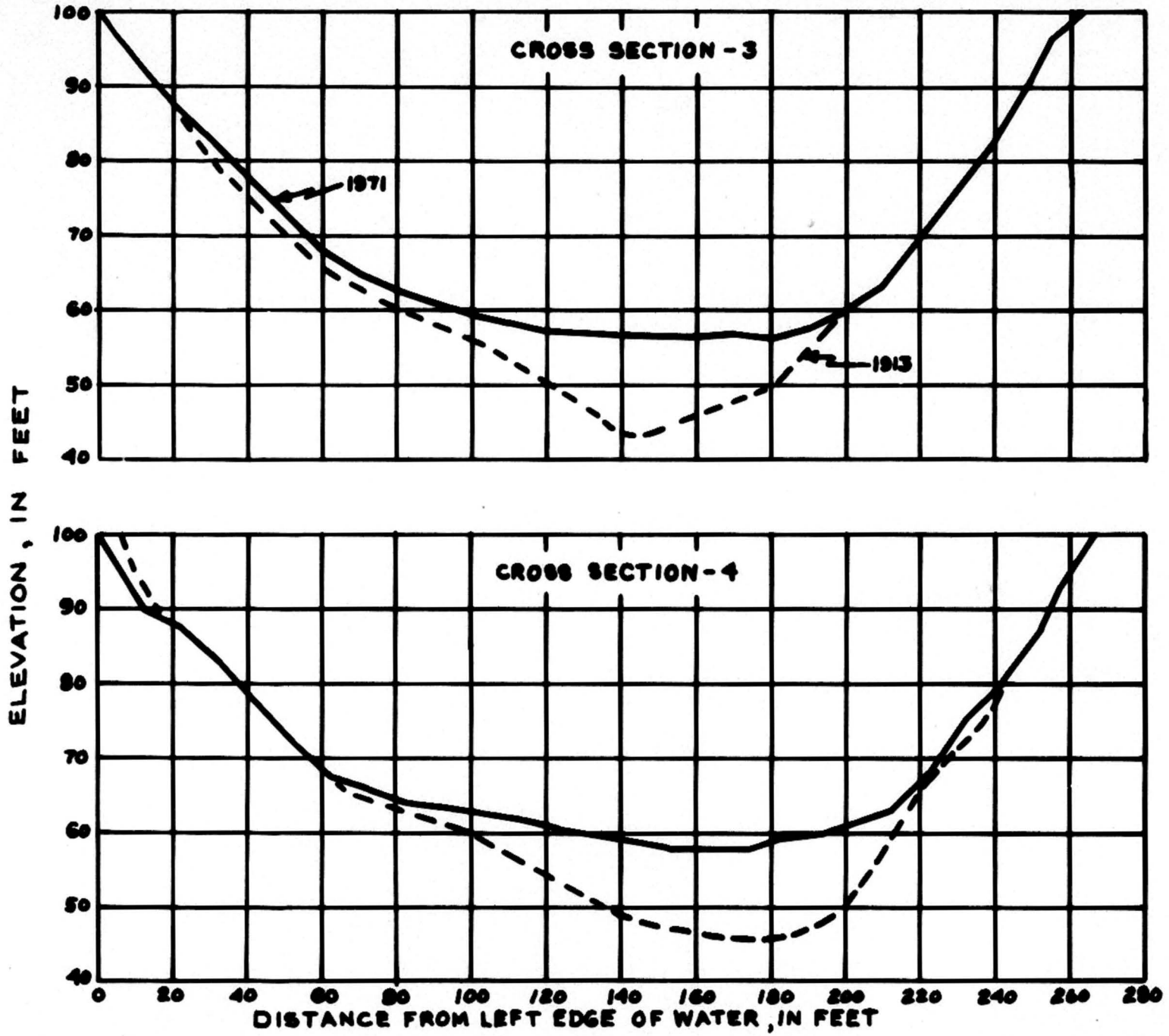


FIGURE 5.--Bottom profiles in Williams Reservoir, 1913 and 1971. (See fig. 2 for location of cross sections.) The bottom profiles for 1913 were obtained from a topographic map of the reservoir that was made in 1913. Bottom profiles for 1971 were made by measuring, at spaced intervals along each cross section, the vertical distance between the water surface and the reservoir bottom.



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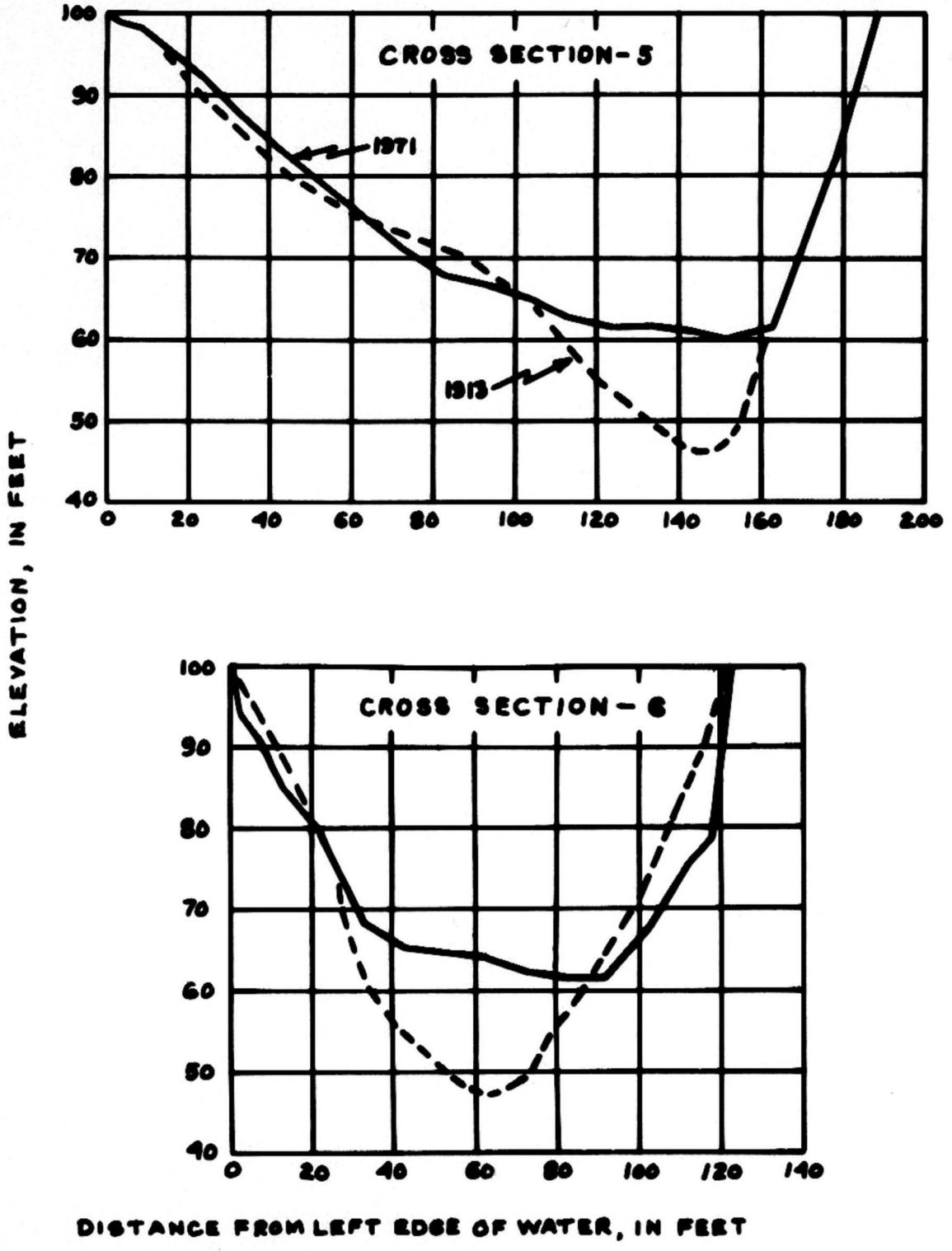

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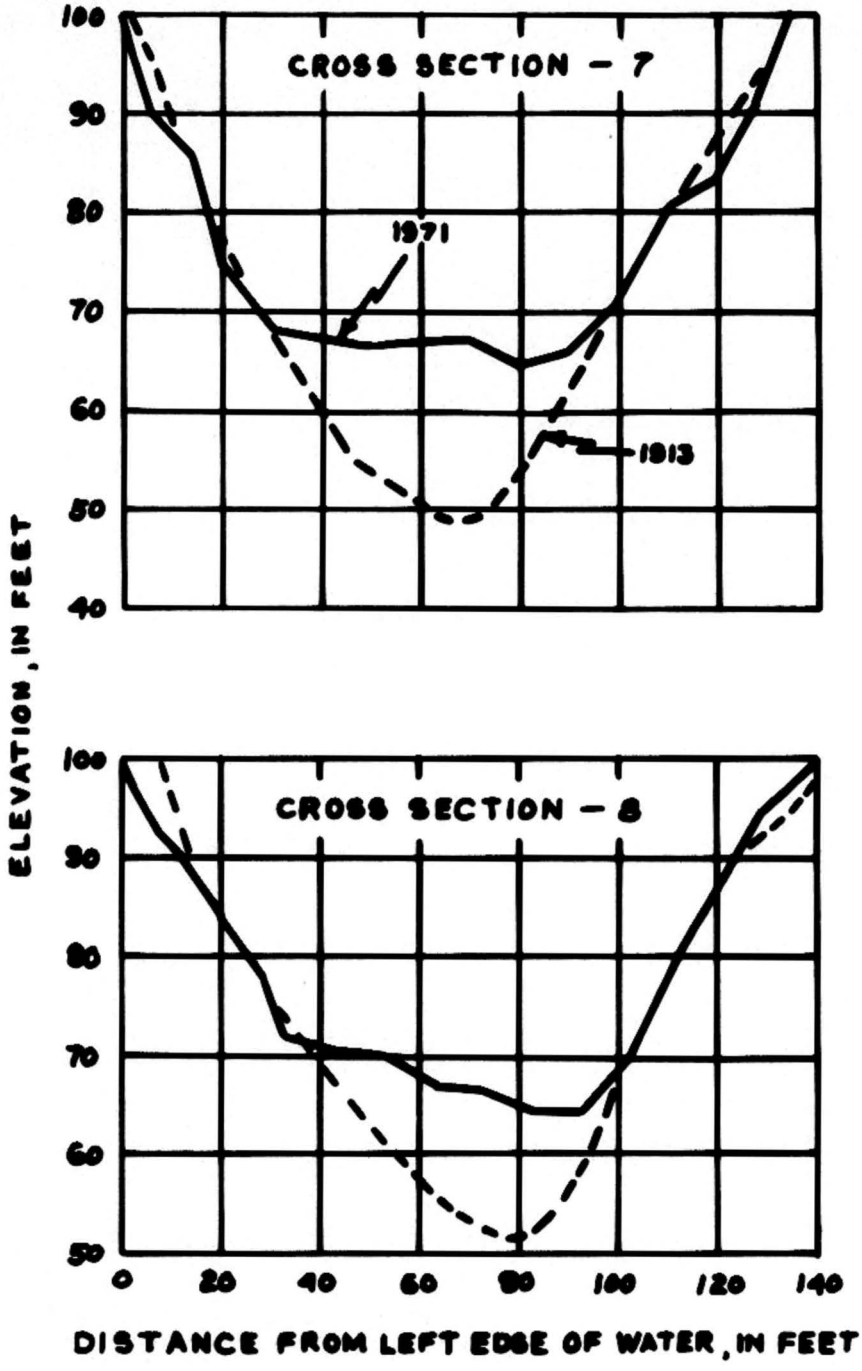

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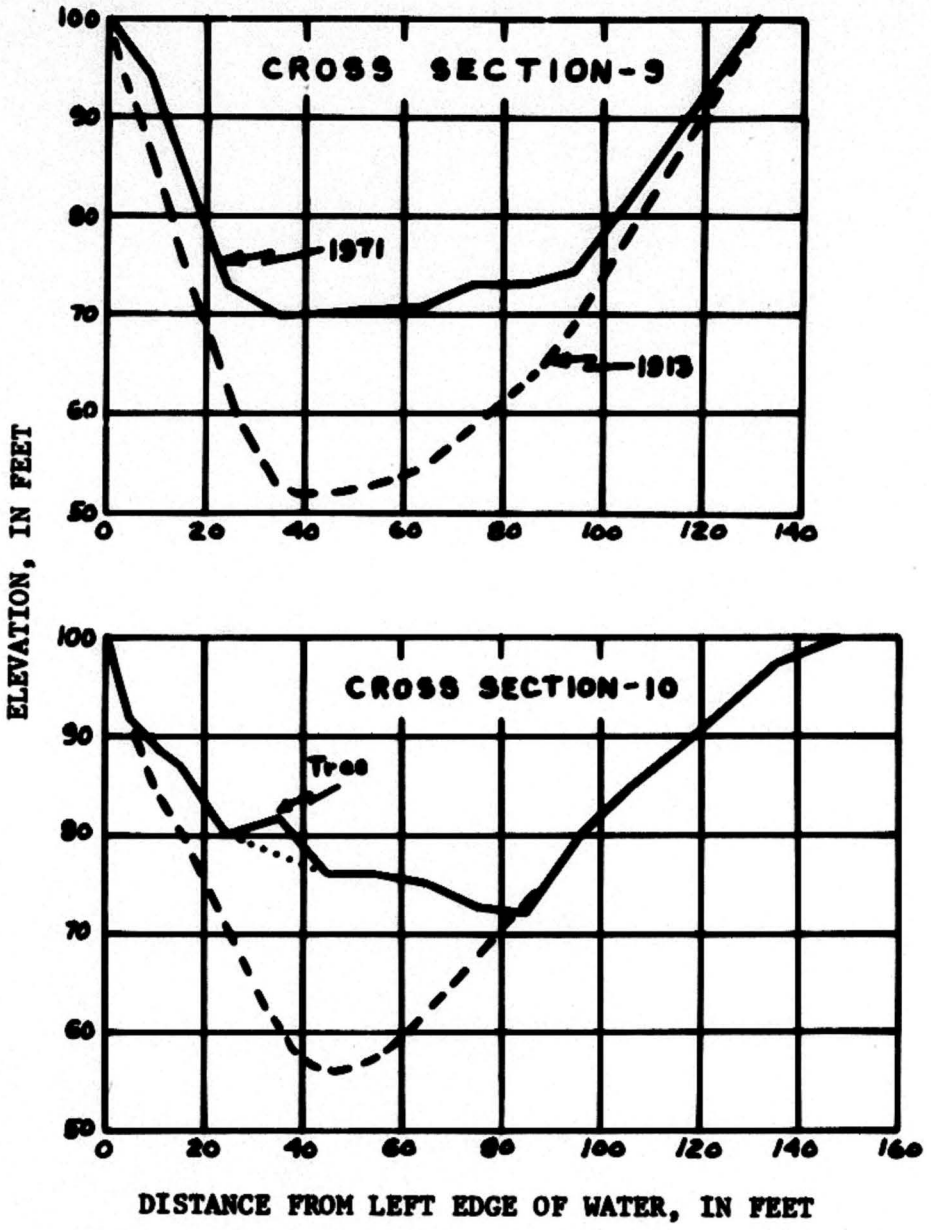

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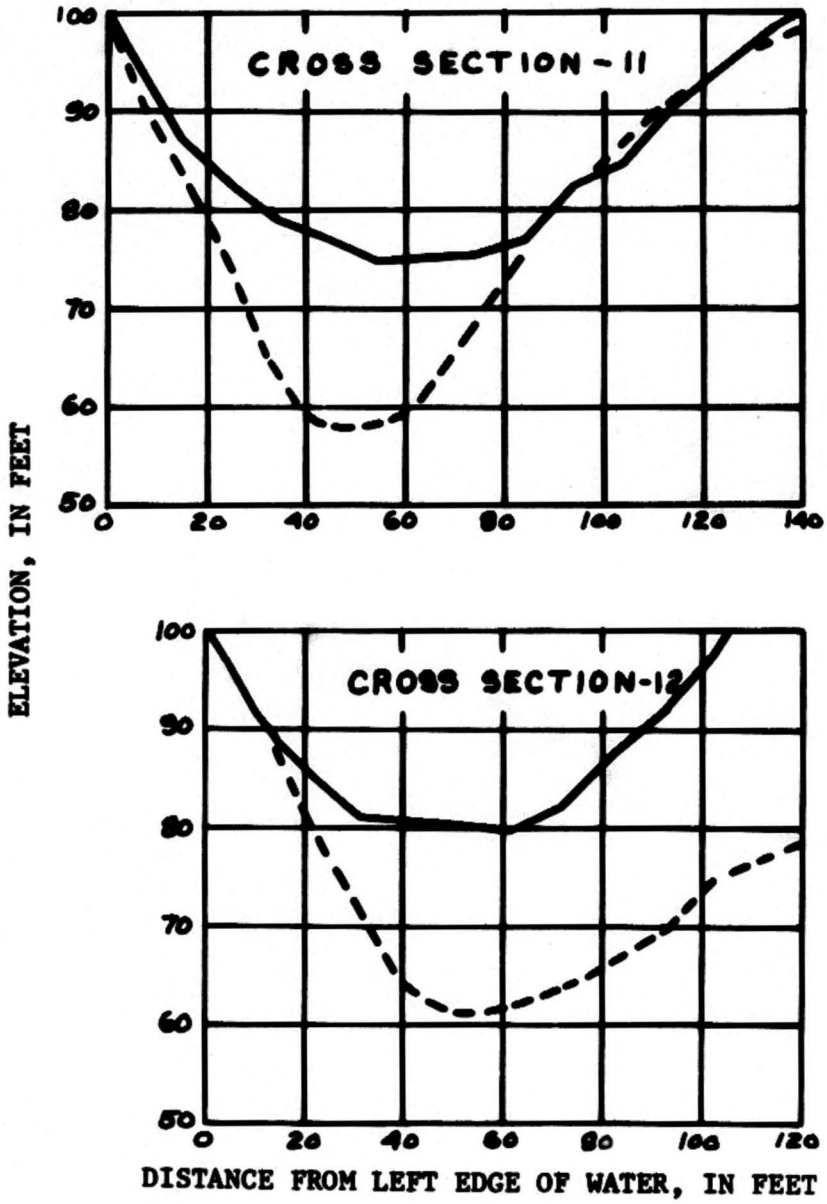

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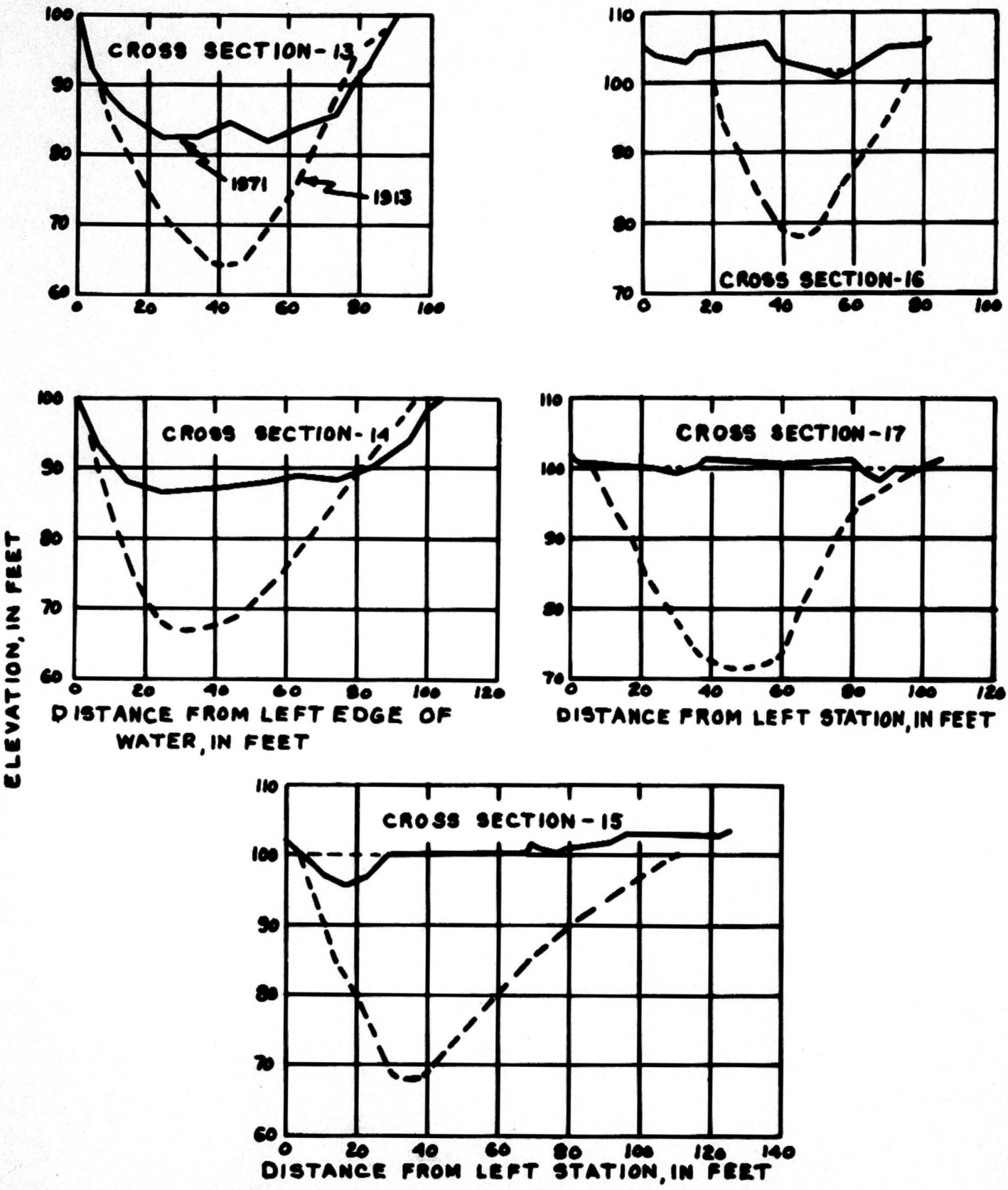

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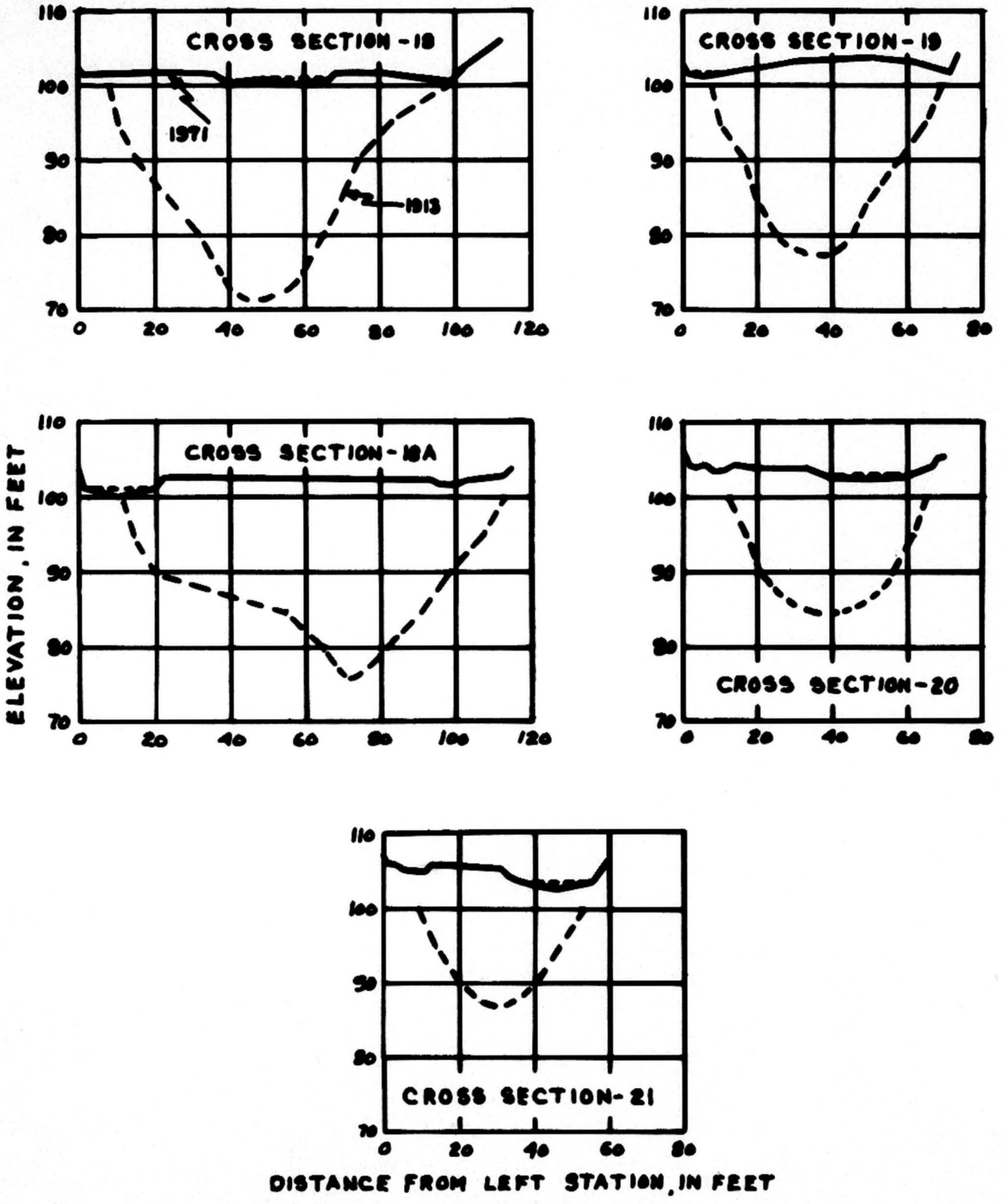

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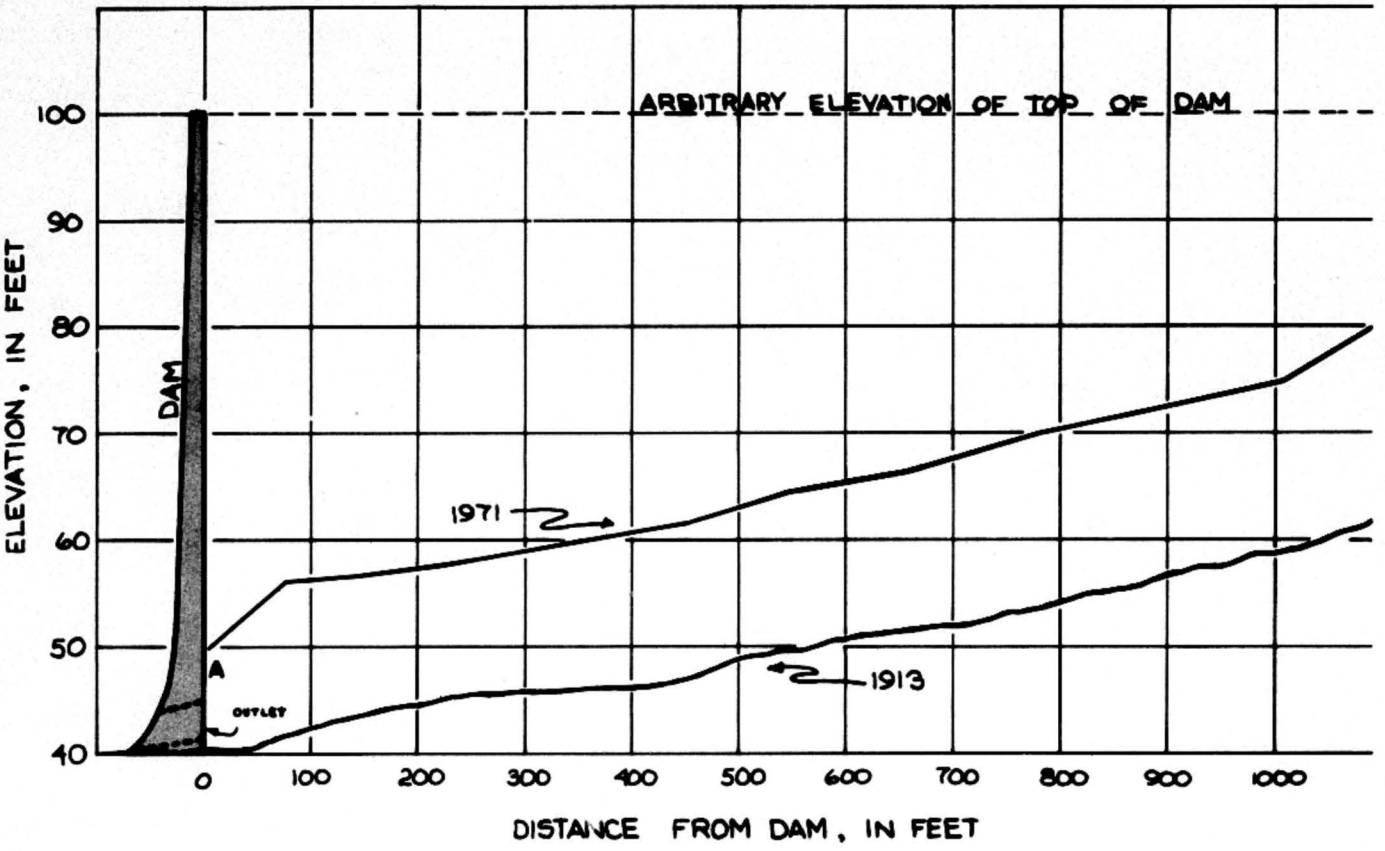

FIGURE 6.--Profiles of the thalweg of Williams Reservoir in 1913 and in 1971.

Samples of the bottom sediment in the reservoir and samples of the surface sediment that is exposed above cross sections 15 and 17 were collected so that the specific weight of the sediment could be calculated. Most of the samples were collected near the middle of the cross sections (table 2). Three types of sediment samplers were used to collect samples from the reservoir: (1) BMH-60, a grab sampler, (2) Echman sampler, another type of grab sampler, and (3) a short gravity corer (table 2). Samples of sediments exposed above the water line were collected with a shovel (table 3).

Calculations of specific weight were made from the particle sizes of the sediment using methods described by Lara and Pemberton (1965), the California Division of Water Resources (1934), and Koelzer and Lara (1958). The specific weight of the samples was needed to convert sediment volumes to weight in tons. The various sampling devices obtained samples from near the top of the sediment columns and the materials collected were assumed to represent the underlying sediment column. In other words, compaction and the possibility that the underlying sediment may have a different particle size than the surface sediment was not considered in the conversion from volume to weight.

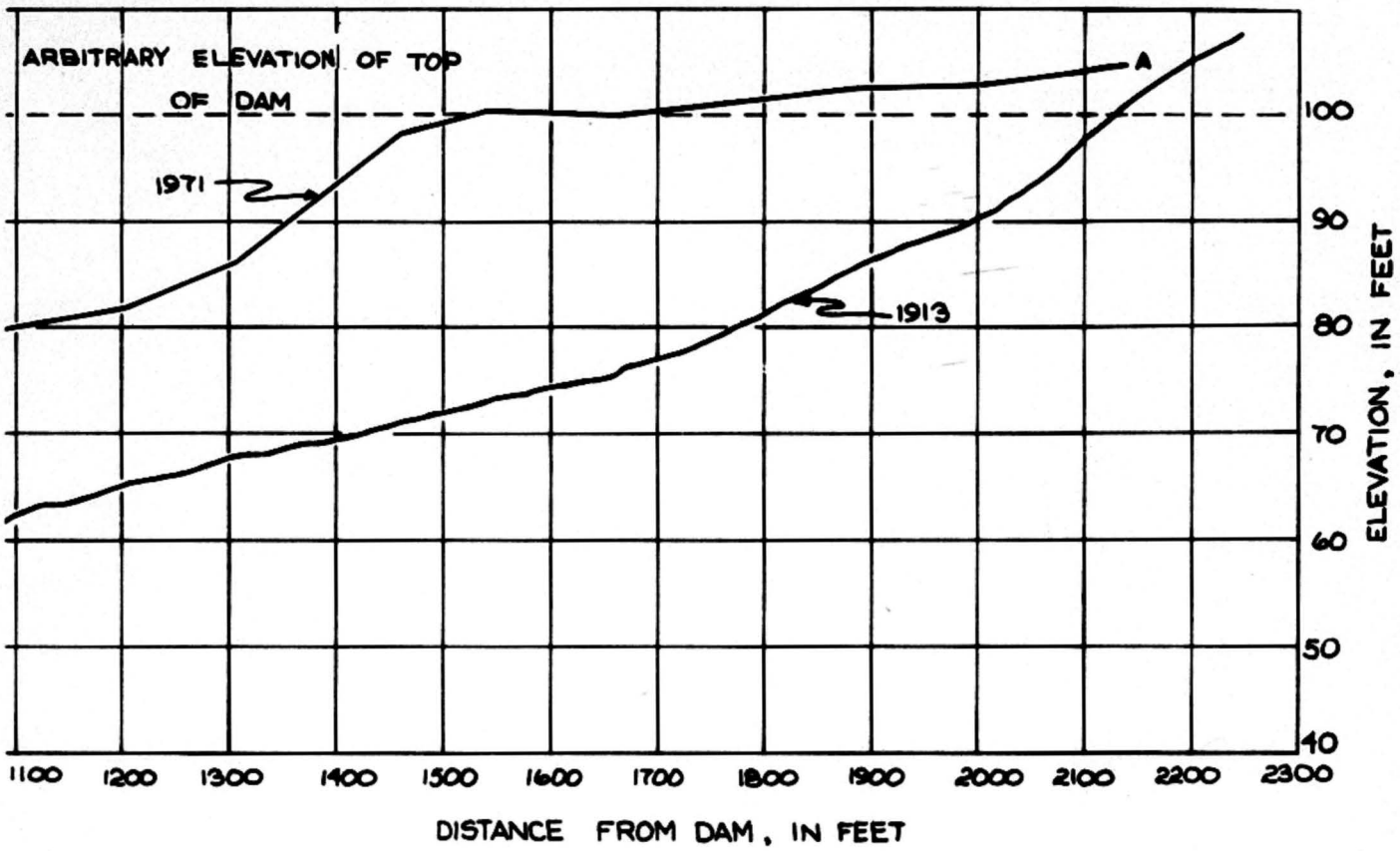

FIGURE 6.--Continued.

In order to determine the total weight of sediment deposited in the reservoir, the sediment deposited in areas that are above the arbitrary datum established for the dam's crest and sediment deposited below the arbitrary datum were computed separately. The median particle size of the sediment in the reservoir ranged from 0.011 to 0.15 mm. The samples collected at sampling points shown on the various cross sections were mostly silt (fig. 7 and table 2) although the percentage of sand increased with distance from the dam. The specific weight of the sediment in the reservoir ranged from 57 to 78 pounds per cubic foot and averaged 65 pounds per cubic foot (table 2). The sediment deposited in the bottom of the reservoir was computed to be 30 acre-feet, or 42,000 tons.

The sediment on the areas filled above the crest of the dam (arbitrary datum, 100 ft) was composed mostly of pebbles (table 3). The specific weight of that sediment ranged from 121 to 136 pounds per cubic foot and averaged 129 pounds per cubic foot. The volume of sediment deposited in those areas was calculated to be 22 acre-feet or 62,000 tons. The total weight of the sediment deposited in the reservoir (above and below the arbitrary datum) was computed to be 104,000 tons.

TABLE 2.--*Particle sizes and specific weights of sediment samples collected from below the water surface in Williams Reservoir*

Cross section[1]	Location of sample[2]	Sampler	Particle size: Percent sand (0.062-3 mm)	Percent silt (0.004-0.62 mm)	Percent clay (<0.004 mm)	Median diameter in millimeters	Specific weight in pounds per cubic foot
1	1/2	BMH-60	7	78	15	0.016	65
2	1/3	Corer	1	73	26	.012	59
2	2/3	Corer	5	79	16	.014	65
3	1/2	Echman	0	75	25	.011	59
3	1/2	BMH-60	0	75	25	.011	59
4	1/2	Echman	1	68	31	.011	57
5	1/2	Corer	8	70	22	.016	62
6	1/2	Echman	4	71	25	.014	60
7	1/3	Corer	22	61	17	.023	68
7	2/3	Corer	25	61	14	.030	71
8	1/2	BMH-60	7	74	19	.017	64
9	1/2	BMH-60	8	67	25	.016	61
10	1/2	BMH-60	12	68	20	.016	64
11	1/2	BMH-60	21	57	22	.022	66
12	1/2	BMH-60	30	52	18	.026	70
13	1/2	BMH-60	40	52	9	.15	78
14	1/2	MBH-60	38	45	17	.026	73
Average			13	66	20	.025	65

[1]See figure 2 for location of cross section.
[2]In fraction of distance from left bank to right bank.

TABLE 3.--*Particle sizes and specific weights of sediment samples from areas above the water surface in Williams Reservoir*

Cross section[1]	Particle size: Percent cobble (64-256mm)	Percent pebble (4-64mm)	Percent granule (2-4mm)	Percent sand (0.062-2mm)	Median diameter in millimeters	Specific weight in pounds per cubic foot
15	0	60	8	33	6.5	123
16	30	56	3	10	37	136
17	0	70	9	21	8.5	121
18	0	96	1	4	38	135
Average	8	70	5	17	22	129

[1]See figure 2 for location of cross sections.

TABLE 4.--*Suspended-sediment discharge at Uvas Creek above Uvas Reservoir, near Morgan Hill, 1962-69*

Water year	Suspended-sediment discharge (tons)
1962	[1]7,300
1963	[1]82,200
1964	[1]600
1965	[1]5,200
1966	600
1967	48,100
1968	4,400
1969	23,900

[1]Estimated from sediment-transport curve and daily streamflow.

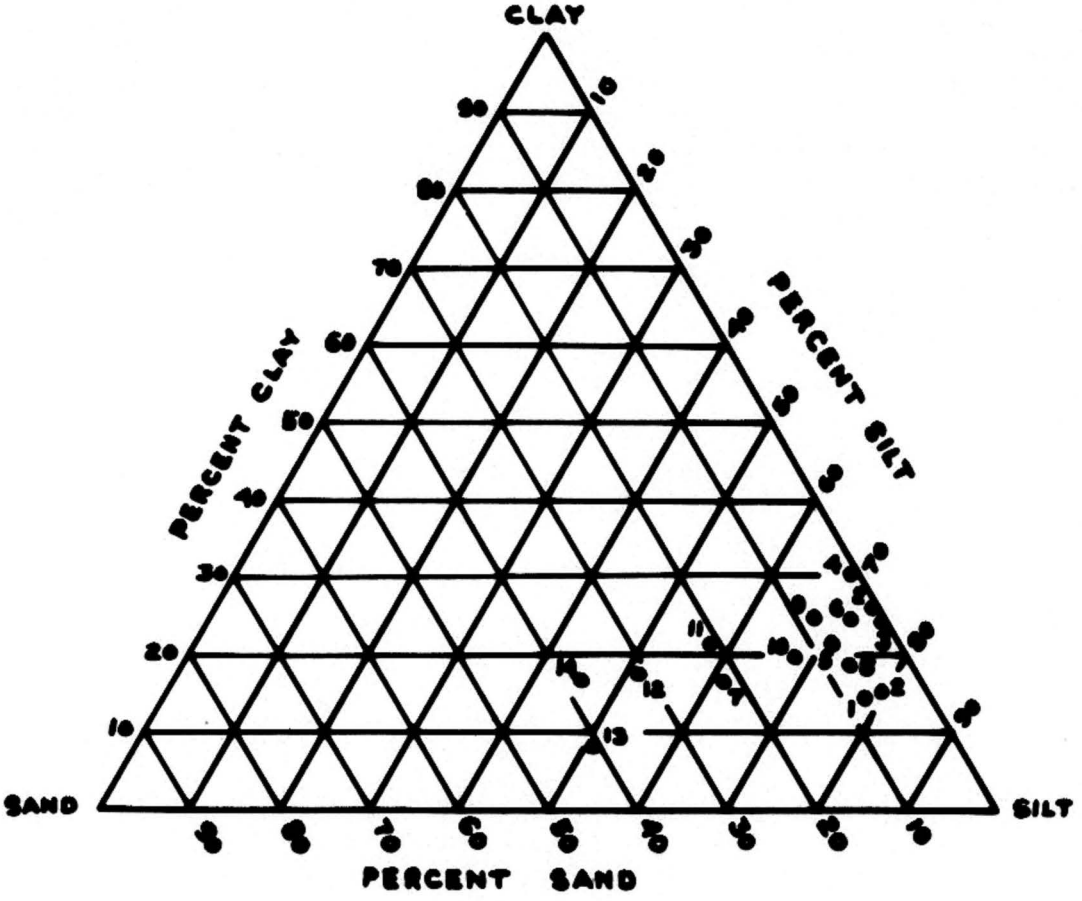

FIGURE 7.--Particle-size distribution of bottom sediment in Williams Reservoir. Numbers indicate cross section where sample was taken.

RATE OF SEDIMENT YIELD IN THE WILLIAMS RESERVOIR WATERSHED SINCE 1961

The sediment yields from three stream basins in Santa Clara County (fig. 1) were used to estimate the volume of sediment that would be transported to Williams Reservoir if the fire had not occurred. That estimate then could be compared to the volume of sediment that was calculated from information obtained during this study. The water discharge and the suspended-sediment discharge of each of the three basins (Uvas Creek above Uvas Reservoir near Morgan Hill, San Francisquito Creek at Stanford, and Coyote Creek near Gilroy) was monitored by recording equipment maintained by the U.S. Geological Survey. Of the three basins, the sediment yield of the drainage area above Williams Reservoir probably would compare most favorably with the sediment yield of the Uvas Creek basin. Because of their close proximity, the Uvas Creek and Williams Reservoir basins are more alike in average annual precipitation, geology, and environment than the two more distant basins. However, calculations of sediment yields in the other basins provides a check on the sediment yield calculated for Uvas Creek.

Annual suspended-sediment discharge for Uvas Creek above Uvas Reservoir near Morgan Hill (drainage area, 21.0 sq mi) is shown in table 4. Suspended-sediment discharge for the 1966-69 water years was obtained from annual water-resources data reports of the U.S. Geological Survey. Suspended-sediment discharge for the 1962-65 water years was estimated from the daily mean water discharge (U.S. Geol. Survey, 1957-69) for that period and relations between water and sediment discharge which existed during the 1966-69 water years (fig. 8).

As expected, the quantity of sediment that was transported during the 1963 water year was far greater than the quantities transported in other years. In fact, the 1963 sediment load was almost as great as the total quantity transported during the other 7 years. This supports observations made earlier (p. 3) that a substantial part of the sedimentation in Williams Reservoir probably occurred in 1963. The average annual suspended-sediment discharge for the 8-year period (1962-69) on Uvas Creek was 21,500 tons per year and the average annual suspended-sediment yield was 1,000 tons per square mile per year.

Annual suspended-sediment at Coyote Creek near Gilroy (drainage area, 109 sq mi, fig. 1) for the 1962-69 water years was determined by the same method used for Uvas Creek. These data are given in table 5. Suspended-sediment discharge for the 1964-69 water years was obtained from annual reports of the Geological Survey. The average sediment discharge for the 8-year period was 52,600 tons or an average annual sediment yield of 483 tons per square mile per year.

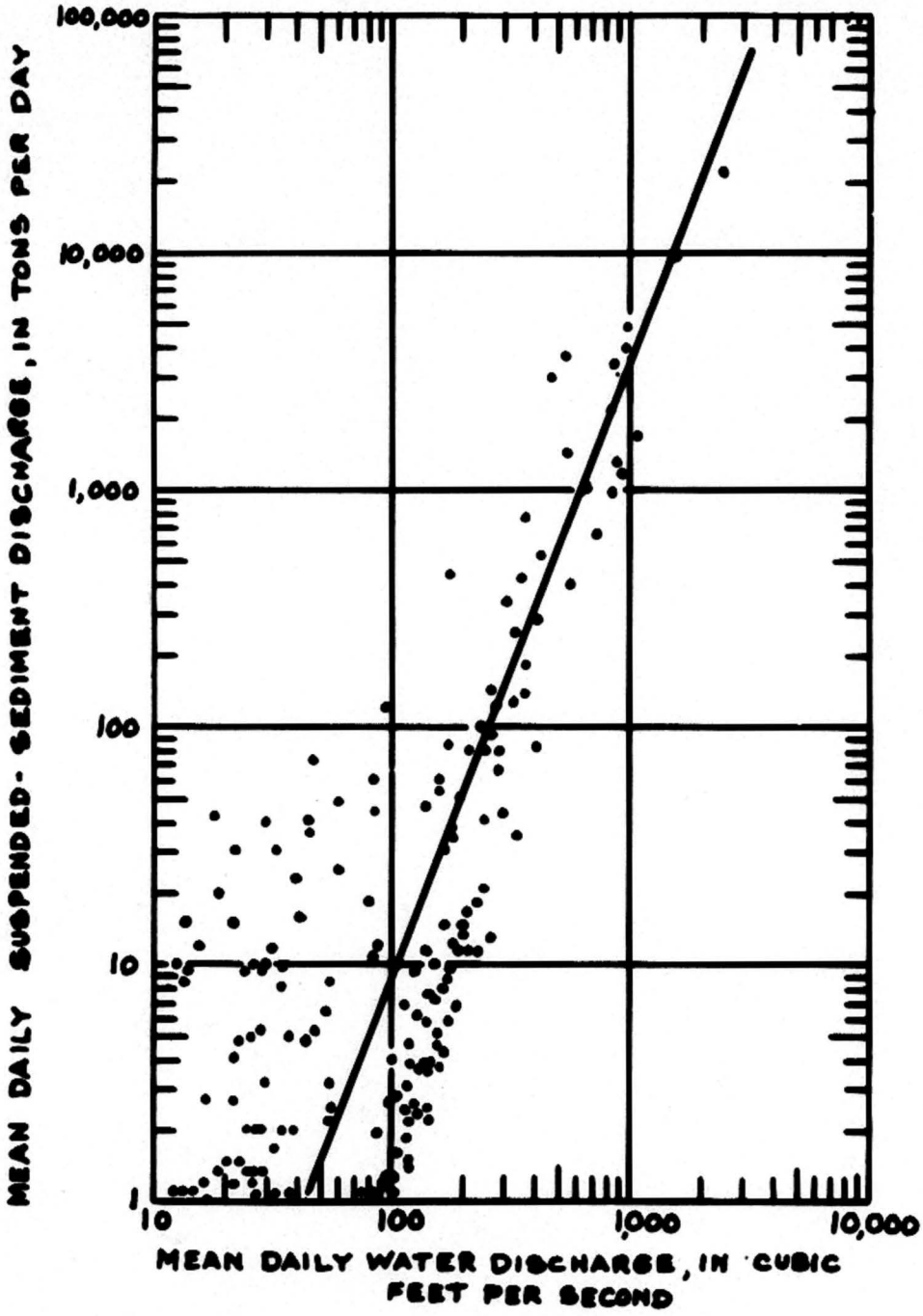

FIGURE 8.--Sediment-transport curve for Uvas Creek above Uvas Reservoir, near Morgan Hill (1966-69).

TABLE 5.--*Suspended-sediment discharge at Coyote Creek near Gilroy*

Water year	Suspended-sediment discharge (tons)
1962	[1]28,000
1963	[1]100,000
1964	[1]4,000
1965	41,000
1966	2,800
1967	78,600
1968	100
1969	168,300

[1]Estimated from sediment-transport curve and daily streamflow.

TABLE 6.--*Suspended-sediment discharge at San Francisquito Creek at Standord*

Water year	Suspended-sediment discharge (tons)[1]
1962	1,880
1963	18,700
1964	1,100
1965	10,500
1966	1,100
1967	50,600
1968	2,700
1969	34,200

[1]Estimated from the sediment-transport curve and daily streamflow.

Annual suspended-sediment discharge for San Francisquito Creek at Stanford during the water years 1962-69 is shown in table 6. These data were estimated from a sediment-transport curve that was based on instantaneous measurements of water and suspended-sediment discharge for the 1957-62 water years and streamflow records for the 1957-69 water years. The drainage area upstream from the Stanford station is 37.5 square miles but only the 23.0-square-mile area between the station and Searsville Lake, a reservoir upstream from the station, was used to compute the yield of the drainage basin. It was assumed that most of the sediment yield from the upper part of the basin was intercepted by Searsville Lake. It was also assumed that the diversion of about 800 acre-feet of water each year for irrigation on the Stanford University campus carried such small quantities of sediment that it can be ignored in calculating the sediment yield of the drainage area (23.0 sq mi). The average annual suspended-sediment discharge during 1962-69 was 15,100 tons per year, and the average annual sediment yield was 660 tons per square mile per year.

From the above discussion, it is seen that during the 1962-69 period the average annual yield of suspended sediment of the three drainage basins ranged from 483 to 1,000 tons per square mile per year. To provide a more representative value for the total sediment yield for the drainage basin above Williams Reservoir, the sediment yields for the other basins must be adjusted for basin size and for the quantity of sediment moved as bedload.[3]

Brune (1948, p. 15) stated that:

> "As the size of the drainage area increases, the rate of sediment production per square mile usually decreases. This is the result of several factors. Gradients become progressively flatter downstream, carrying power is consequently reduced, and large amounts of sediment are dropped on flood plains and in channels. The average slopes and topography generally become less steep as the watershed area increases, this being particularly true for those streams rising in mountainous areas. The chances that an intense storm will occur over the entire watershed become less and less as the watershed becomes larger."

Langbein and Schumm (1958) using Brune's (1948) data showed that rates of sediment yield are inversely proportional to the 0.15 power of the drainage area. Even though Brune's study pertained to midwestern drainage basins, a not too dissimilar relation was found for basins in southern California (Scott and others, 1968). Thus, the sediment yield for the drainage basin above Williams Reservoir is

$$\left(\frac{x}{5.25}\right)^{0.15}$$

multiplied by the sediment yield of the basin for which x is the drainage area. The sediment yield thus calculated pertains only to the suspended-sediment yield. If the bedload is assumed to be 15 percent of the total sediment load then by dividing the adjusted drainage area values by 0.85, the total sediment yield for the drainage basin above Williams Reservoir is computed. For example, the total sediment yield for Williams Reservoir basin as calculated from the sediment yield of the Uvas Creek basin is

$$\frac{1{,}000\left(\frac{21.0}{5.25}\right)^{0.15}}{0.85}$$

or 1,450 tons per square mile per year for the 1962-69 water years.

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[3]Bedload includes both the sediment that moves along in continuous contact with the streambed and the material that bounces along the bed in short skips or leaps. The total sediment yield is the sum of the suspended load and the bedload, usually expressed in tons per square mile per year.

Similarly, the yield for the Williams Reservoir basin as calculated from the sediment yields of Coyote Creek and San Francisquito Creek is 900 and 970 tons per square mile per year, respectively. If these average annual sediment yields are assumed to be representative of 1970 and 1971, then the total quantity of sediment that was transported to the reservoir since the 1961 fire would be the sediment yield multiplied by the drainage area and 10 years (the number of years since the fire) or 47,000 to 76,000 tons, an average of 4,700 to 7,600 tons of sediment per year. It must be emphasized that because the higher figure was computed from data for Uvas Creek that this figure (76,000 tons) probably is more realistic than the other two. Thus, the quantity of sediment that would have been transported into the reservoir during 1961-71 under conditions unaffected by fire would be at least 47,000 tons and most probably about 76,000 tons.

CONCLUSIONS

It is assumed in the discussion below, that (1) the quantity of sediment caught in small check dams above the reservoir since 1961 is minor, (2) the quantity of sediment moved into the reservoir by slides and erosion along the periphery of the reservoir is minor, and (3) the quantity of sediment transported out of the reservoir since 1961 is minor.

By making those assumptions, it can be postulated that of the 104,000 tons (52 acre-ft) of sediment that was deposited in Williams Reservoir since 1913, 47,000 to 76,000 tons (24 to 38 acre-ft) can be considered as sediment that would probably have been transported to the reservoir during 1961-71 if the 1961 fire had not occurred. Thus, 28,000 to 57,000 tons (14 to 28 acre-ft) of sediment that was deposited in the reservoir can be considered as the maximum quantity of sediment that could be attributed to an increase in sediment yield caused by the 1961 fire, if it is assumed that no sediment was deposited from 1913 to 1961. However, sediment was transported into the reservoir from 1913 to 1961. Even though some of this sediment passed through the reservoir and much of it was perhaps sluiced out when the reservoir was drained during the summer, some sediment would remain. For example, a large quantity of sediment must have been transported into the reservoir during the storm of December 1955 and some of that sediment should have remained in the reservoir. However, there was no way to determine the rate of sediment deposition before 1961.

Two factors suggest that little of the sediment transported to the reservoir from 1913 to 1961 was deposited.

1. Aerial photographs suggest that the shape of reservoir remained about the same from 1913 to 1953 (no aerial photographs were found for the period of 1953-61). Therefore, no deposition was observed from aerial photographs.

2. A sediment yield for the drainage basin above Williams Reservoir of 4,700 to 7,600 tons per year (p. 24) suggests a rate of deposition of 2.4 to 3.8 acre-feet of sediment per year. Thus, for a period of 58 years (1913-71) the reservoir should have contained 139 to 220 acre-feet of sediment, a quantity that would have filled, or almost filled, the reservoir. The fact that only 52 acre-feet of sediment has been deposited in the reservoir suggests that the rate of sediment deposition from 1913 to 1961 was not great and that much of the sediment transported to the reservoir during that period was flushed out of the reservoir.

REFERENCES

Brown, W. M., 3d, and Ritter, J. R., 1970, Sediment transport and turbidity in the Eel River basin, California: U.S. Geol. Survey open-file rept., 139 p.

Brune, G. M., 1948, Rates of sediment production in midwestern United States: U.S. Dept. Agriculture Soil Conser. Service SCB-TP-65, 40 p.

California Division of Water Resources, 1934, Geology and ground water storage capacity of valley fill: Bull. 45, 273 p.

Heinemann, H. G., and Dvorak, V. I., 1963, Improved volumetric survey and computation procedures for small reservoirs *in* Proceedings of the Federal Inter-Agency Sedimentation Conference: U.S. Dept. of Agriculture Mis., Pub. No. 970, p. 845-856.

Koelzer, V. O., and Lara, J. M., 1958, Densities and compaction rates of deposited sediment: Jour. Hydraulics Div. Am. Soc. Civil Engineers, v. 84, No. HY2, Paper 1603, 15 p.

Krammes, J. S., 1965, Seasonal debris movement from steep slopes in southern California: Federal Inter-Agency Sedimentation Conference Proc., 1963, Paper 12, p. 85-88.

Langbein, W. F., and Schumm, S. A., 1958, Yield of sediment in relation to mean annual precipitation: Am. Geophys. Union Trans., v. 39, p. 1076-1084.

Lara, J. M., and Pemberton, E. L., 1965, Initial unit weight of deposited sediments: Federal Inter-Agency Sedimentation Conference Proc., 1963, p. 818-845.

Scott, K. M., Ritter, J. R., and Knott, J. M., 1968, Sedimentation in the Piru Creek watershed, southern California: U.S. Geol. Survey Water-Supply Paper 1798-E, 48 p.

U.S. Geological Survey, 1957-69, Water resources data for California, pt. 1, vol. 1, surface-water records, Colorado River basin, southern Great Basin, and Pacific slope basins excluding Central Valley: U.S. Geol. Survey annual repts.

_____1964-69, Water resources data for California, pt. 2, Water quality records: U.S. Geol. Survey annual repts.