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SEDIMENT TRANSPORT AND DEPOSITION, WALNUT AND PACHECO CREEKS

CONTRA COSTA COUNTY, CALIFORNIA

AUGUST 1965-APRIL 1970

By

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ABSTRACT

Average annual sediment discharge in Pacheco Creek basin, Contra Costa County, Calif., was larger during August 1965-April 1970 than the historical annual sediment discharge (1909-62) by a factor of about 1.3. This increase in sediment discharge is attributed primarily to an increased frequency of peak streamflows and to a larger average annual streamflow during the 1965-70 period.

INTRODUCTION

Pacheco Creek and tributaries, which include Walnut Creek, are located in Contra Costa County, Calif., and flow north into Suisun Bay (fig. 1). Land uses in Pacheco Creek basin include urban, industry, and agriculture. Because of the proximity to San Francisco, urbanization and industrialization are increasing rapidly.

The U.S. Army Engineer District, Sacramento, Corps of Engineers, leveed and stabilized the lower reaches of Walnut and Pacheco Creeks as part of a flood-control project. However, sediment deposited in the lower reach of Pacheco Creek reduces the capacity of the channel to convey floodflows. Therefore, maintenance of the flood-control project will require, among other responsibilities, the periodic dredging for sediment.

Sediment surveys made by the Corps of Engineers show that 1,060,000 cubic yards of sediment was deposited in the lower reach of Pacheco Creek during the period August 1965-April 1970. This quantity of sediment was in excess of the original estimate of average annual quantity of sediment transported by Pacheco Creek and available for deposition. Some of the questions caused by the excess of deposited sediment relative to the estimated quantity of sediment available for deposition are:

1. Was the quantity of sediment available for deposition underestimated?
2. Was streamflow and sediment transport during August 1965-April 1970 larger than the historic average during 1909-62?

This report is the result of assistance provided to the Corps of Engineers to estimate, on the basis of historical records, the quantity of sediment that would be transported by Walnut Creek at Walnut Creek during the period August 1965-April 1970, and to determine if streamflow and sediment transport during this period were larger than the historical average.

This report was prepared by the U.S. Geological Survey, Water Resources Division, under the general supervision of R. Stanley Lord, district chief in charge of water-resources investigations in California.

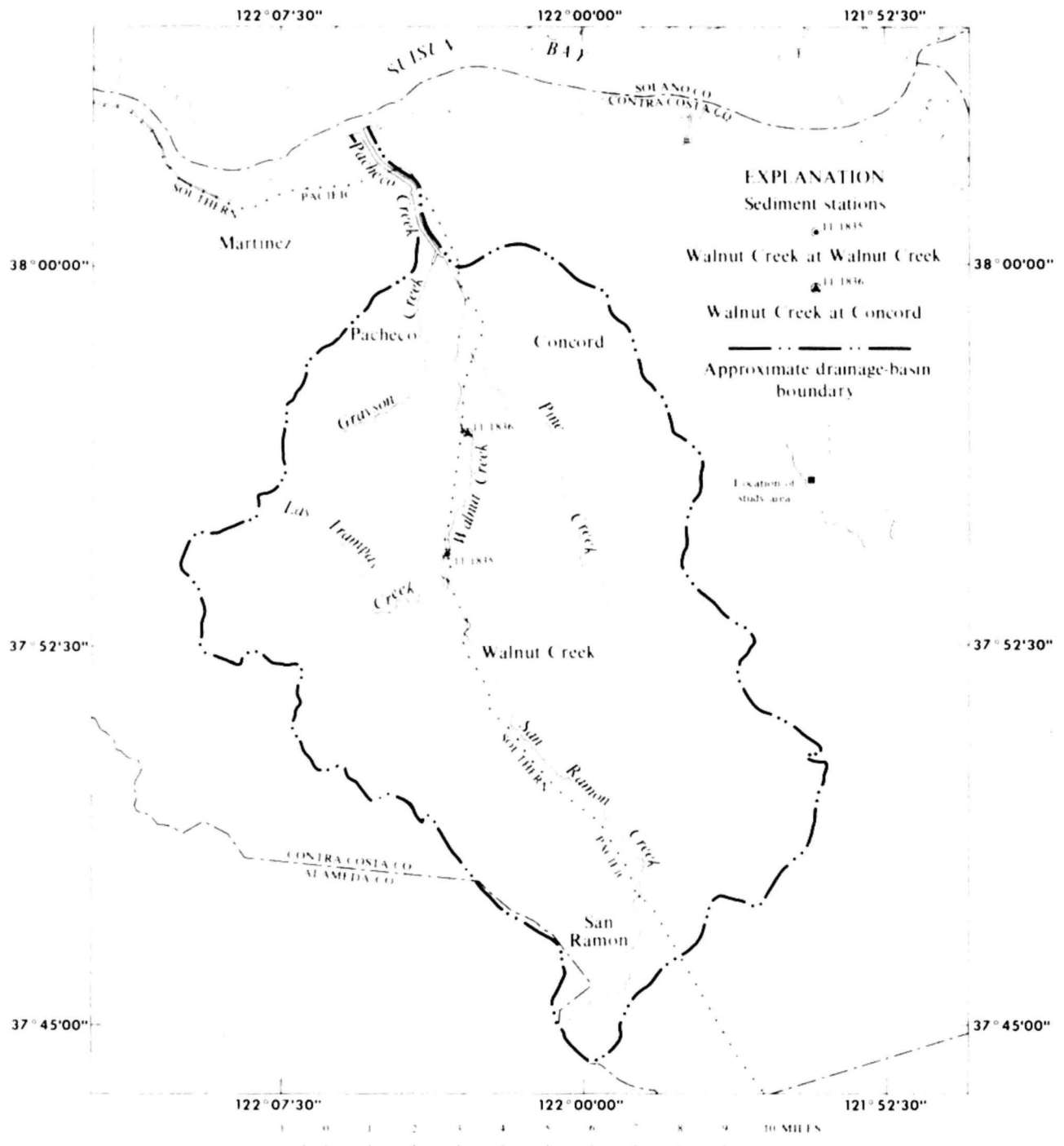


FIGURE 1--Pacheco Creek basin

STREAMFLOW AND SEDIMENT DATA

Streamflow data used to compute sediment discharge of Pacheco Creek basin for selected periods during 1957-70 are based on streamflow records obtained at gaging stations on Walnut Creek at Walnut Creek and at Concord (fig. 1). The location, drainage area, elevation, and records available for these stations are listed in table 1.

Streamflow data used to compute historical sediment discharge prior to the 1953 water year were estimated. (A water year begins October 1 and ends September 30, and is designated by the year in which it ends.) Estimated streamflow data for a 1909-59 base period were obtained by correlating the 1953-59 data for Walnut Creek at Walnut Creek with data for a comparable period from stations where long-term records were available, and then extrapolating on the basis of the long-term records. The historical streamflow data for the period prior to the 1953 water year used in this report are those used to compute historical sediment discharge for Walnut Creek in the study by Porterfield and others (1961).

Suspended-sediment samples were collected during the 1957-62 water years at Walnut Creek at Walnut Creek (fig. 1). Samples were collected infrequently during periods of low flow and frequently during periods of medium and high flow. Particle-size distribution was determined for selected samples to determine the quantity of sand, silt, and clay transported by Walnut Creek.

TABLE 1.--Records available, elevation, and drainage area of selected locations in Pacheco Creek basin

Station		Location	Drainage area (sq mi)	Elevation, in feet above mean sea level	Streamflow records available
Number	Name				
11-1835	Walnut Creek at Walnut Creek	At Southern Pacific railroad bridge, 0.7 mile down- stream of confluence of San Ramon and Las Trampas Creek	79.2	102.71	Oct. 1952-Sept. 1968
11-1836	Walnut Creek at Concord	3.6 miles downstream from confluence of San Ramon and Las Trampas Creeks	85.1	35.44	Oct. 1968-Sept. 1970
--	Pacheco Creek near mouth	50 feet downstream from Southern Pacific railroad bridge near Martinez, about 5,000 feet above mouth and about 7.8 miles down- stream from station 1836	138.44	Near sea level	None

¹October 1952 to June 1957 at a site 0.6 mile upstream.

Because a continuous temporal relation between streamflow and suspended-sediment concentration cannot be defined by samples collected on an infrequent basis, daily values of sediment discharge generally cannot be determined readily or accurately from infrequent samples. Suspended-sediment discharges for monthly or annual periods, however, may be approximated from streamflow records and a sediment-transport curve--a curve that defines the average relation between streamflow and sediment discharge. The sediment-transport curve for Walnut Creek at Walnut Creek for the period 1957-62 (fig. 2) is based on data obtained over a range in streamflow from 1.0 to 2,180 cfs (cubic feet per second) and represents a sediment-discharge range from 0.02 to 48,000 tons per day. This sediment-transport curve is not considered well defined because insufficient samples were obtained, on an infrequent basis, to establish the relation between sediment concentration and streamflow for the entire range of streamflow. Sediment discharge is assumed, however, to be a reasonable estimate.

Sediment transported by Walnut Creek at Walnut Creek is mostly fine material, in the silt-clay size range, that probably comes from overland flow and from bank erosion during periods of high flow. Bank stabilization, flood-control measures, and land-use changes in the basin since sediment sampling was discontinued may have affected the relation between streamflow and sediment discharge for periods subsequent to 1962.

Most of the streamflow and the sediment transport in Walnut Creek at Walnut Creek occur during the large infrequent storms. For example, 47 percent of the streamflow during 1957-62 occurred in only 1 percent of the time and these flows, which include peak discharges, transported about 89 percent of the suspended sediment and 96 percent of the suspended sand. A summary of discharges occurring during selected time intervals is given in table 2.

TABLE 2.--Percentage streamflow and sediment discharge that occurs during indicated time, Walnut Creek at Walnut Creek, 1957-62

	Time (percent)		
	1	5	15
Streamflow	47	76	89
Suspended sediment	89	99	99.9
Suspended sand	96	100	100

Daily streamflow during the period of record (1953-68 water years) for Walnut Creek at Walnut Creek ranged from no flow to 5,510 cfs; daily sediment discharge ranged from 0 to about 220,000 tons. Annual streamflow ranged from a low of 3,330 acre-feet during the 1955 water year to a high of 70,390 acre-feet during the 1958 water year.

During 1909-62 an estimated 85 percent of the sediment was transported during days when the daily discharge equaled or exceeded 560 cfs. During 1966-70 an estimated 82 percent of the sediment was transported during days when the daily discharge equaled or exceeded 560 cfs, a discharge which occurred only 24 days or in 1.4 percent of the time; an estimated 56 percent of the sediment was transported during days when the daily discharge equaled or exceeded 1,100 cfs, a discharge which occurred only 6 days or in 0.44 percent of the time.

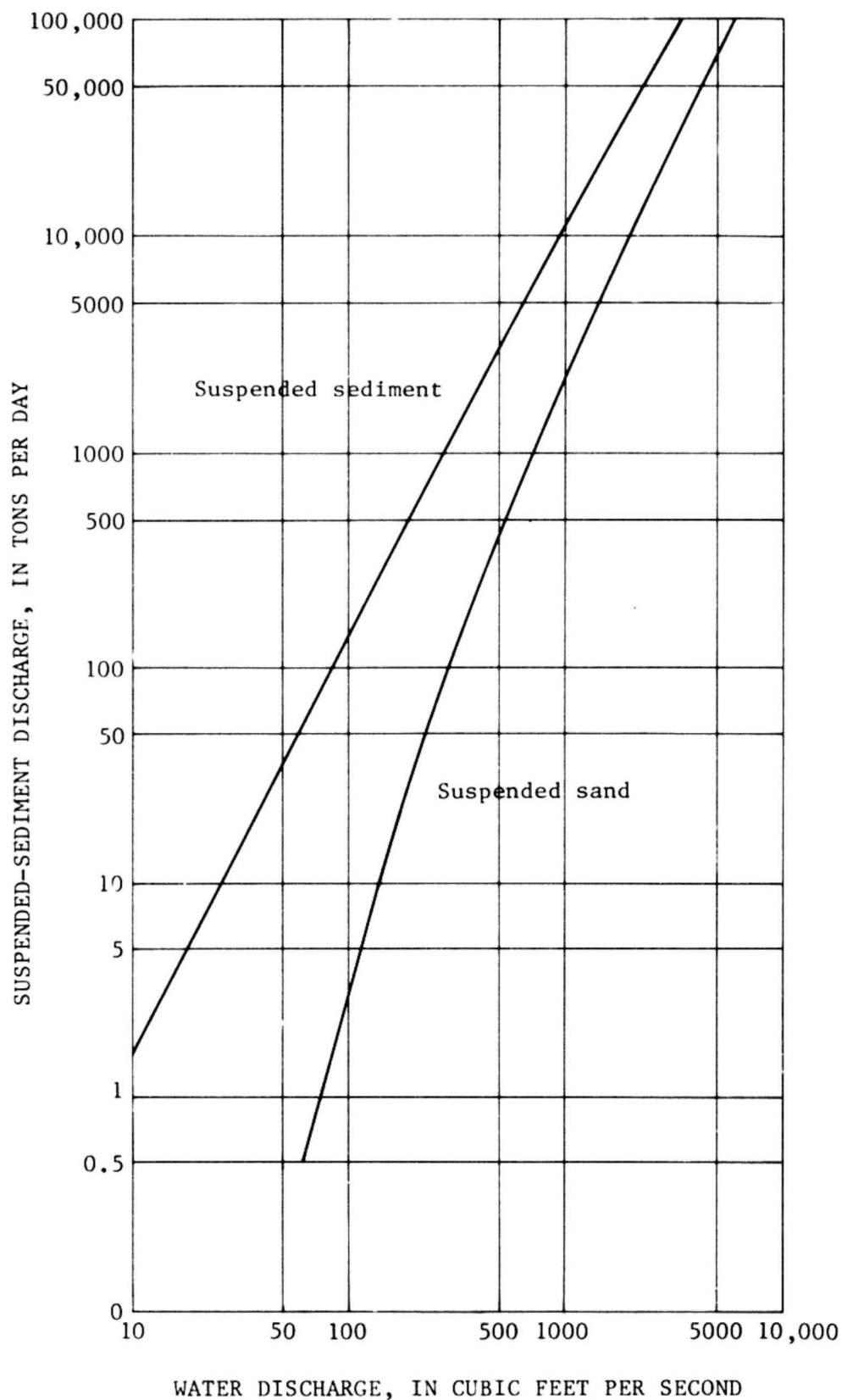


FIGURE 2.--Relation between streamflow and suspended-sediment discharge, Walnut Creek at Walnut Creek, 1957-62.

SUSPENDED-SEDIMENT DISCHARGE

Walnut Creek at Walnut Creek, 1966-70

Suspended-sediment discharge during the water years 1966-70 was computed from the sediment-transport curve (fig. 2) defined by samples collected at Walnut Creek during 1957-62 and from daily streamflow records. This is the sediment discharge that would occur if no significant change in sediment yield occurred in the basin since 1962. Streamflow at Walnut Creek at Walnut Creek, October 1968-September 1970, was estimated from data obtained at the gaging station at Concord and adjusted for the difference in drainage area. Streamflow and suspended-sediment discharge are listed in table 3.

The large variation in annual streamflow and suspended-sediment discharge is apparent from an inspection of annual values in table 3. Daily mean streamflow, for example, ranges from 16 to 63 cfs during 1966-70 and the average of 41 cfs for the period is 1.3 times the average for 1909-62; the average sediment discharge during 1966-70 is 1.3 times the long-term average. On this basis, therefore, the use of the long-term average to predict annual sediment discharge during 1966-70 would yield a low sediment discharge.

TABLE 3.--*Streamflow and suspended-sediment discharge for selected periods, Walnut Creek at Walnut Creek*

Period (water years)	Streamflow		Suspended-sediment discharge						
	Average (cfs)	Average annual (acre-ft)	Clay		Silt		Sand		Total
			Tons per year	Percent	Tons per year	Percent	Tons per year	Percent	Tons per year
1957-62	24.5	17,750	37,300	45	22,800	27	23,100	28	83,200
1909-62	31.9	23,090	40,300	46	26,000	30	21,000	24	87,300
1966	16.2	11,750	--	--	--	--	653	8	8,540
1967	63.3	45,830	--	--	--	--	73,700	32	232,700
1968	16.4	11,920	--	--	--	--	2,250	16	13,800
1969	58	¹ 42,220	--	--	--	--	21,400	18	120,900
1970	53	¹ 38,060	--	--	--	--	44,900	25	177,000
1966-70	41	29,960	49,900	45	32,100	29	28,600	26	110,600

¹Estimated from streamflow records Walnut Creek at Concord.

Walnut Creek at Concord, August 1965-April 1970

Streamflow and suspended-sediment discharge for Walnut Creek at Concord was computed for periods corresponding to the periods included in the surveys of sediment deposited near the mouth of Pacheco Creek.

Streamflow prior to October 1968 is based on records obtained at Walnut Creek at Walnut Creek, 3.1 miles upstream, and adjusted for the drainage area between Walnut Creek and Concord. The relation between sediment discharge and streamflow is based on the samples collected at Walnut Creek during 1957-62 and adjusted for the difference in drainage areas. Sediment yield of the basin upstream from Walnut Creek is assumed to be representative of the yield of the basin upstream from Concord because of the small drainage area between Walnut Creek and Concord, and because there is no significant change in land use or inflow between stations.

The estimated sediment discharge for Walnut Creek at Concord during August 1965-April 1970 is 594,000 tons. Because only a small quantity of sediment was transported during August and September 1965 (6 tons) and during May to September 1970 (260 tons), the quantity of sediment transported and deposited during the surveyed period August 1965-April 1970 can, for all practical purposes, be considered as the quantities transported and deposited during the water years 1966-70.

Pacheco Creek near Mouth, August 1965-April 1970

The annual suspended-sediment discharge at a point near the mouth of Pacheco Creek was determined by estimating the quantity of sediment transported by streams tributary to Pacheco Creek downstream from the streamflow station at Concord. The yield from the drainage area in the foothills and higher elevations is assumed equal to that at Concord and adjusted on the basis of drainage area. The drainage area of the basin at lower elevations near the mouth is assumed to be noncontributing. Drainage areas are from a basic-data compilation by the U.S. Geological Survey (1962).

The estimated sediment discharge, drainage area, and location of streams tributary to Pacheco Creek are listed below:

<i>Station</i>	<i>Drainage area (sq mi)</i>	<i>Sediment discharge (tons)</i>
Walnut Creek at Concord (Lat 37°56'43", long 122°02'55")	85.1	594,300
Pine Creek at Concord (Lat 37°58'10", long 122°02'45")	26.64	233,300
Grayson Creek near Pacheco (Lat 37°57'25", long 122°04'20")	4.36	
Unnamed stream near Vine Hill (fig. 3) (Lat 38°00'25", long 122°04'50")	2.41	
Noncontributing	19.93	--
Total	138.44	827,600

Walnut Creek at Walnut Creek, November-December 1970

Four samples of suspended sediment were obtained at Walnut Creek at Concord, November 28-29 and December 2, 1970, subsequent to compilation of the data listed in this paper. These data were adjusted for drainage area and plotted on the sediment-transport curve defined by 1957-62 Walnut Creek at Walnut Creek data to determine the relation of current sediment yield to the yield used to predict sediment discharge during August 1965-April 1970.

The 1970 samples were collected at streamflows ranging from 200 to 500 cfs and indicate, at least for this range in flow, that the sediment concentrations are only 30 to 40 percent of the average concentrations during 1957-62. An extrapolation of the data from these samples indicate the concentration at 1,100 cfs may be about 80 percent of the 1957-62 concentrations and that above 1,500 cfs the concentrations may be unchanged.

During 1909-62 an estimated 85 percent of the sediment was transported at flows larger than 560 cfs and during 1966-70 an estimated 82 percent of the sediment was transported during days when the discharge equaled or exceeded 560 cfs. Therefore, decreases in concentration during flows ranging from 200 to 500 cfs may not decrease significantly the total quantity of sediment transported by Walnut Creek.

Lining the bed and banks of sections of the channel has reduced sediment yield attributed to channel erosion. Sediment yield attributed to urbanization, industry, or agriculture, and associated with larger streamflows may yet be equal to or even greater than the yield during 1957-62.

The 1970 sediment data do not prove that a significant change in sediment yield occurred because (1) four samples are insufficient to be conclusive and (2) the data fall within the limits of random variation of concentration sampled during 1957-62. However, because of the excellent agreement among data from the 1970 samples the possibility should be considered that a change in sediment yield has occurred, and additional data should be obtained to determine the effect of land-use changes and channel stabilization on the sediment yield.

TOTAL SEDIMENT DISCHARGE

Sediment sampling at Walnut Creek at Walnut Creek, 1957-62, included the collection and analysis of suspended sediment only, and although the suspended-sediment discharge is the major part of the total sediment discharge the unsampled part of the sediment discharge was estimated and added to the sampled discharge to obtain total discharge (U.S. Inter-Agency Committee on Water Resources, Subcommittee on Sedimentation, 1963, p. 107).

The estimate of total sediment discharge was based on procedures described by Colby and Hembree (1955) and by Colby (1957). Data required include water discharge, the stream width, depth, and velocity, the concentration and particle-size distribution of suspended sand, water temperature, and the particle-size distribution of the bed material.

DEPOSITED SEDIMENT

Sediment Surveys, August 1965-April 1970

The quantity of sediment deposited in the lower reach of Pacheco Creek was determined from five surveys made by the Corps of Engineers, Sacramento District, August 1965-April 1970. During this period a total of 1,060,000 cubic yards of sediment was deposited. During the same period, which for all practical purposes is equal to the water years 1966-70, the suspended sediment transported by Walnut Creek at Concord was an estimated 594,000 tons and the suspended sediment transported by Pacheco Creek to mouth was 828,000 tons.

Bed-Material Samples, September 30, 1970

Samples of bed material were collected September 30, 1970, by the Geological Survey at the six sites shown in figure 3. The unit weight and the percentages of sand, silt, and clay for deposits at each site are shown in table 4. Specific weight of material ranged from 36 to 72 lb per cu ft (pounds per cubic foot) and the weighted mean was 52.4 lb per cu ft. A plot of the size distribution of material at each sampling site is shown in figure 4.

TABLE 4.--*Distribution and characteristics of deposited sediment, Pacheco Creek near mouth, September 30, 1970*

Site number (fig. 3)	Deposited sediment								
	Volume (cu yds)	Unit weight (lb per cu ft)	Particle size (percent by weight)			Tons			
			Clay	Silt	Sand	Total	Clay	Silt	Sand
1	135,000	36	46	45	9	65,600	30,180	29,520	5,900
2	219,000	45	29	56	15	133,000	38,570	74,480	19,950
3	165,000	43	35	48	17	95,800	33,530	45,980	16,290
4	341,000	58	14	26	60	267,000	37,380	69,420	160,200
5	140,000	72	14	15	71	136,000	19,040	20,400	96,560
6	60,000	65	24	11	65	52,700	12,650	5,800	34,250
Total	1,060,000	52.4	--	--	--	750,100	171,350	245,600	333,150
Percentage of total	100	--	--	--	--	100	23	33	44

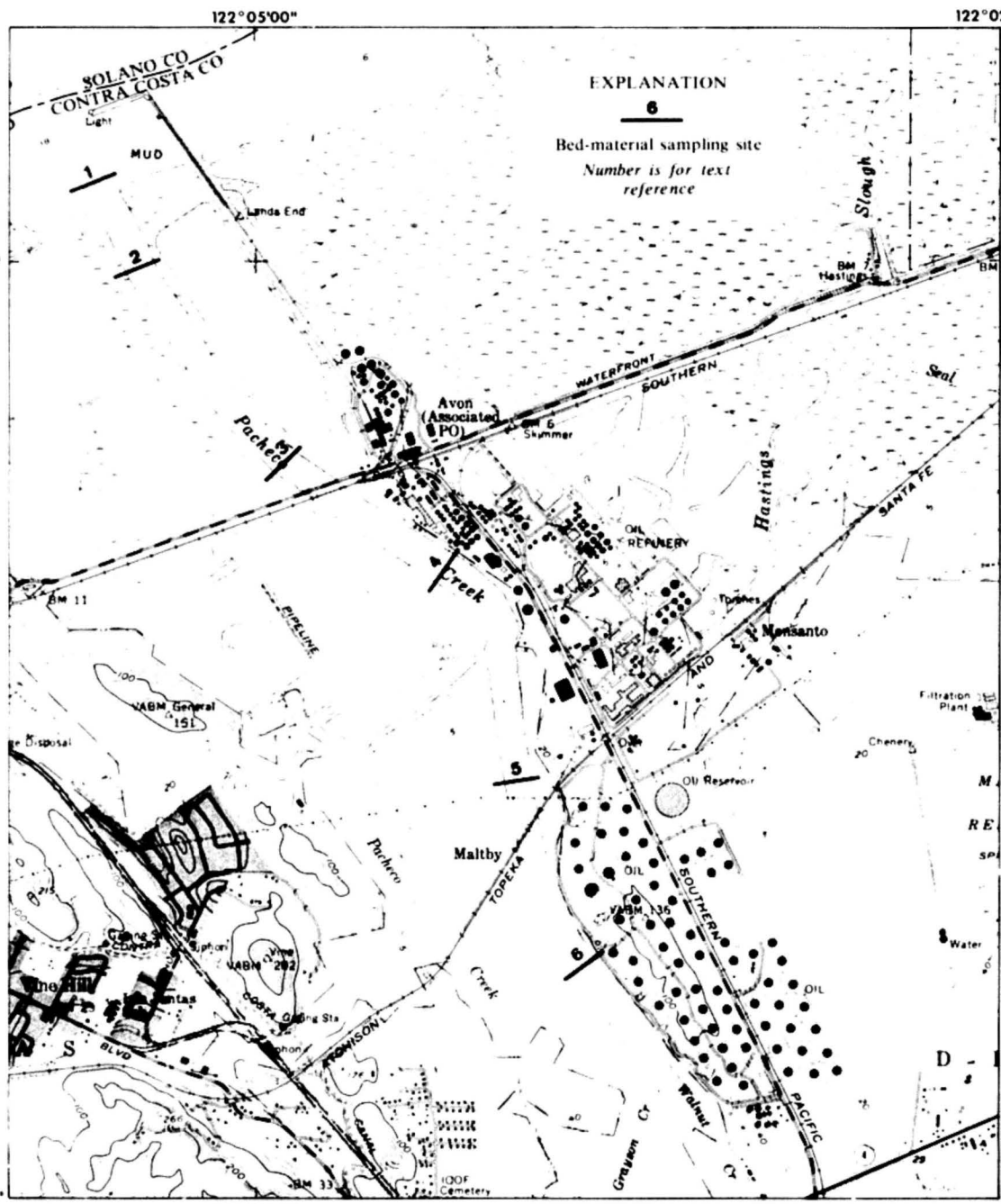


FIGURE 3.--Bed-material sampling sites, September 30, 1970, Pacheco Creek near mouth.

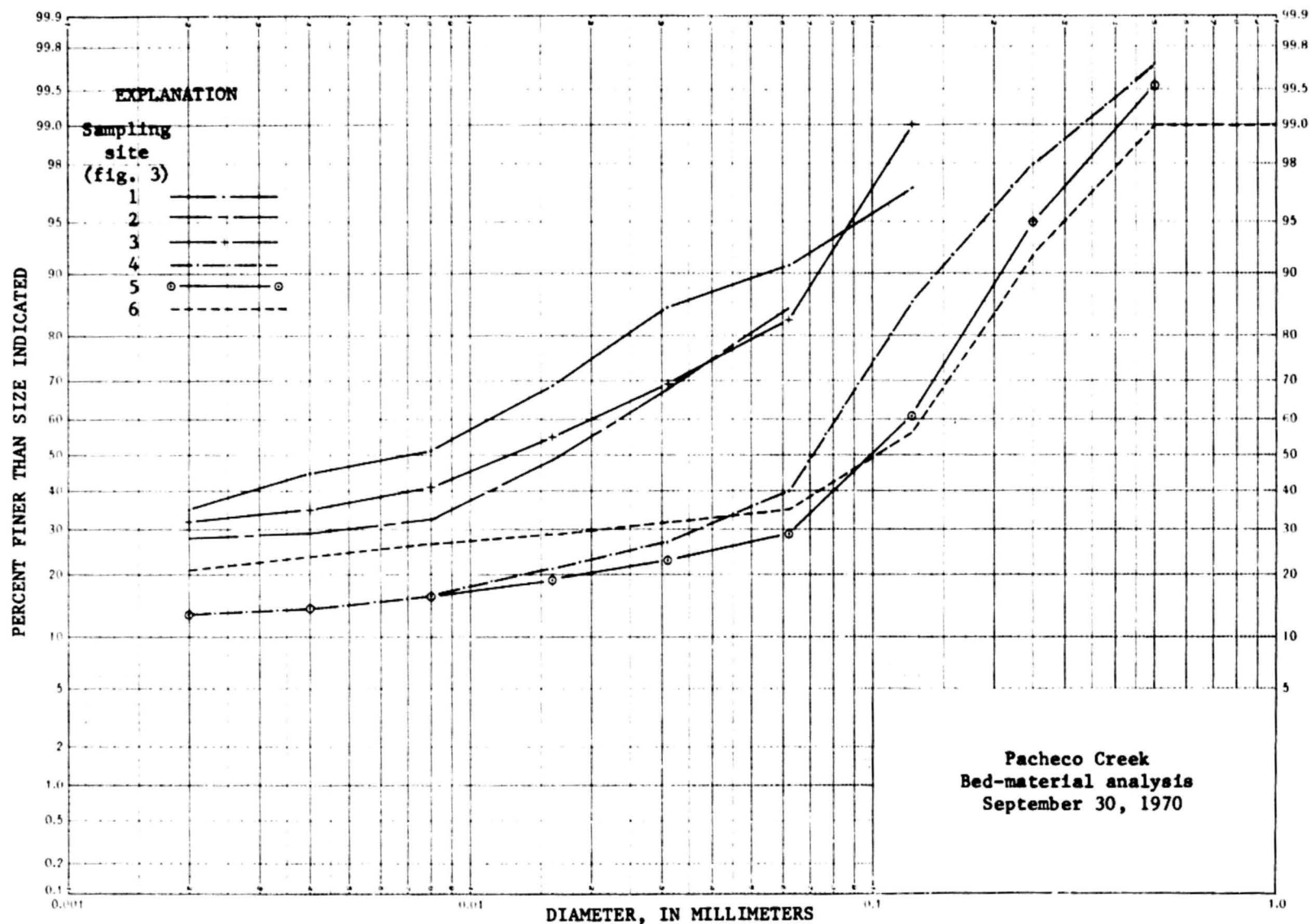


FIGURE 4.--Particle-size distribution of deposited material.

For purposes of computation in this report, the volume of deposited sediment assumed to be represented by each sample was determined by the midsection interval; that is, each sampling site was assumed to represent a section of the channel extending from one-half the distance to the adjacent upstream site to one-half the distance to the adjacent downstream site. The volume of deposited sediment determined for each section is given in table 4. The average unit weight determined for each sampling site was used to compute the tons of sediment in each section. Total tons in each section were then divided into tons of sand, silt, and clay on the basis of the particle-size distribution.

Distribution of Deposited Sediment

Computations based on values in table 4 indicate that 750,000 tons of sediment, of which 44 percent was sand; was deposited in the lower reach of Walnut and Pacheco Creeks during the period August 1965-April 1970.

Of the deposited material, 61 percent by weight or 51 percent by volume of the total material and 87 percent of the sand are in the reach which includes sampling sites 6, 5, and 4 and ends about 1,000 feet upstream of the Southern Pacific Railroad bridge (fig. 3). The remaining material is predominantly in the silt-clay range, and is deposited in the lower reach, which includes sites 3, 2, and 1.

Particle-size distributions of deposited sediment are shown in figure 4. Material at sites 1 to 3 ranged from 83 to 91 percent (by weight) silt and clay (finer than 0.062 mm); and material at sites 4 to 6 ranged from 60 to 71 percent sand.

Particle-size distributions of suspended samples collected at Walnut Creek, at streamflows larger than 249 cfs, are shown in figures 5 and 6. Size distributions of suspended sediment, except for the sample collected at 450 cfs, are similar to the distribution of deposited sediment at sites 1 to 3, although in general the size analyses indicate more sand and less silt and clay was in transport than was deposited in sites 1 to 3.

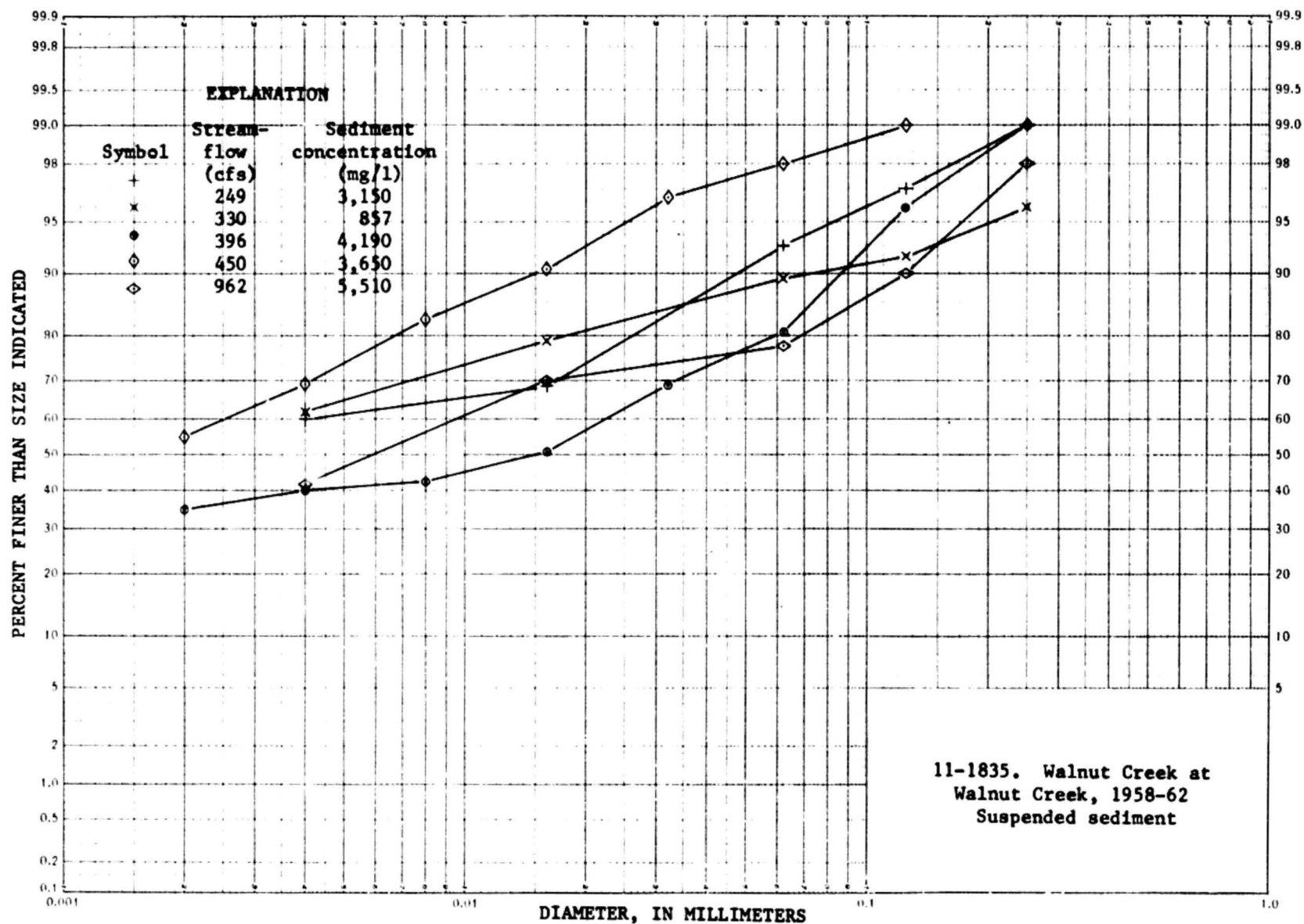


FIGURE 5.--Particle-size distribution of suspended sediment for streamflows ranging from 250 to 960 cfs.

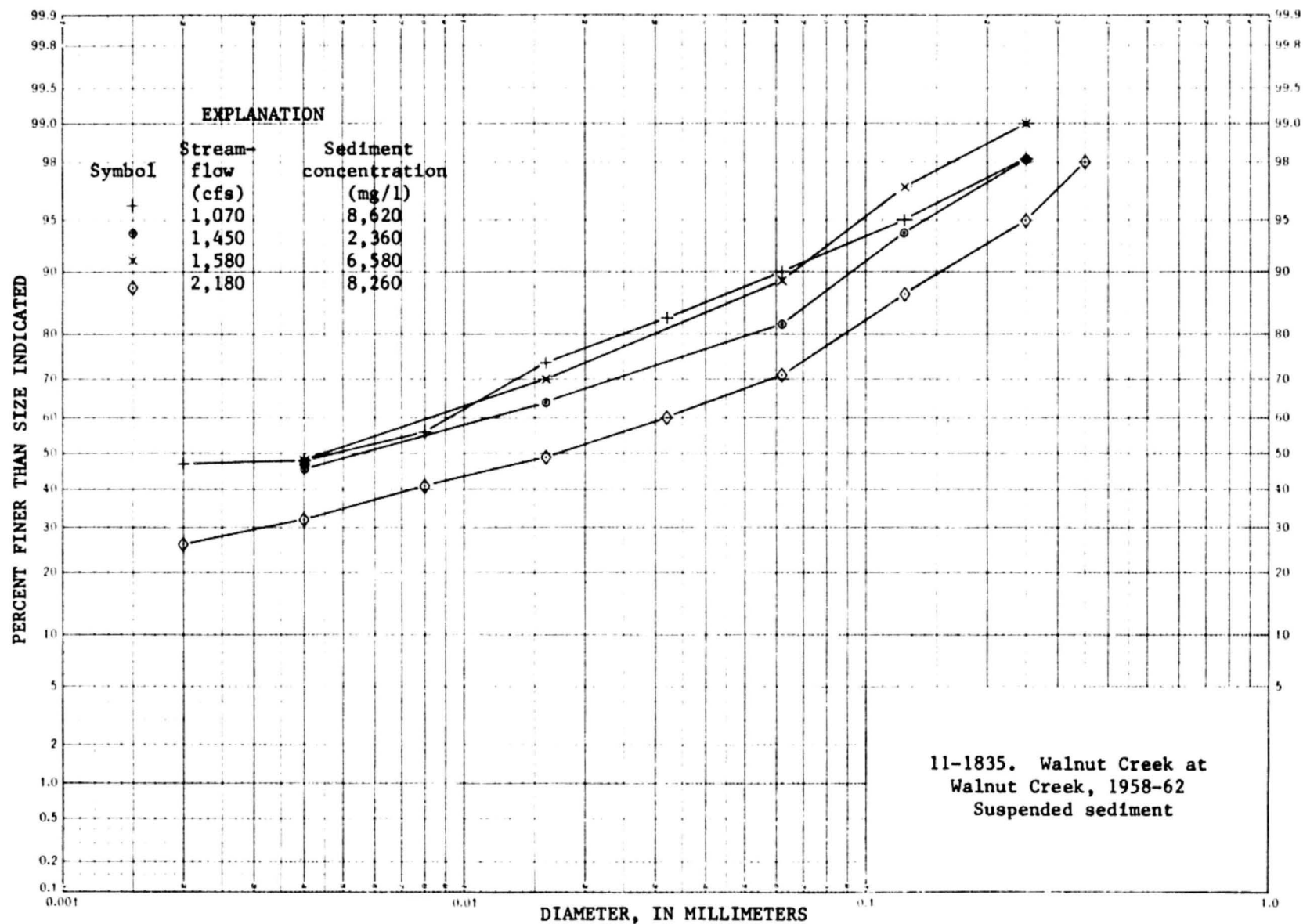


FIGURE 6.--Particle-size distribution of suspended sediment for streamflows ranging from 1,100 to 2,200 cfs.

UNIT WEIGHT OF SUSPENDED SEDIMENT TRANSPORTED BY WALNUT AND PACHECO CREEKS, 1966-70

The quantity of deposited sediment is usually determined by volume and the quantity of suspended sediment in transport is usually determined by weight. Therefore, to provide an estimate of the relative quantity of sediment transported and theoretically available for deposition to that deposited, the tons of sediment transported by Walnut and Pacheco Creeks during each survey period were converted to volume. The conversion was made by assuming that the unit weight of sediment found in the deposit was representative also of the weight of sediment transported by the stream.

Unit weights then were assumed for sand and silt; 90 lb per cu ft was assumed for sand and 70 lb per cu ft was assumed for silt. These are average values and were selected from U.S. Inter-Agency Committee on Water Resources, Subcommittee on Sedimentation (1943), and Lara and Pemberton (1963). Unit weights in the U.S. Inter-Agency report are based on experiments by Straub and Trask and on measurements made during many reservoir surveys. Lara and Pemberton data are based on average values determined during 1,316 reservoir surveys.

A weight of 90 lb per cu ft was chosen for sand because most of the sand transported by Walnut Creek is less than 0.25 mm (millimeters) in diameter. Sand composed 26 percent of the sediment discharge of Walnut Creek during 1966-70 and is the minor fraction of material in suspension. The unit weight chosen for sand is not critical because small changes in the assumed value have little effect on the mean unit weight of the entire sample. A weight of 90 lb per cu ft was also assumed for bed material. The 70 lb per cu ft chosen for silt is an average of values (rounded) determined by the several investigators.

Assuming 90 and 70 lb per cu ft for sand and silt and a mean sampled unit weight of 52 lb per cu ft (table 4), the unit weight of clay would be 24 lb per cu ft. Although this computed weight of clay is less than that normally expected for the weight of clay deposited in a fresh-water reservoir (Lara and Pemberton, 1963, lists a range in values from 26 to 60 lb per cu ft) it is a weight that is both possible and probable for a deposit of clay in a brackish, estuarine environment. For example, the unit weight of shoal material in San Francisco Bay determined by the U.S. Army Corps of Engineers (1967, p. 16 19) from 314 measurements of density of in-place shoal material found in navigation channels, harbors, and slips ranged from 26 to 35 lb per cu ft and the average was 33 lb per cu ft. This shoal material contained both sand and silt, and grain-size analyses indicated that about 11 percent of the material was in the sand-size range.

Calculations were made also of the hypothetical unit weight of the clay fraction at each of the six sampling sites. Assuming 90 and 70 lb per cu ft for sand and silt, the weight of clay ranged from 20 to 24 lb per cu ft at sampling sites 1-4 and 36 lb per cu ft at sites 5 and 6.

The unit weight chosen to convert tons of sediment transported by Walnut and Pacheco Creeks to volume of sediment transported are 90 lb per cu ft for sand, 70 lb per cu ft for silt, and 24 lb per cu ft for clay.

SUMMARY OF SEDIMENT SURVEYS AND SEDIMENT DISCHARGE, AUGUST 1965-APRIL 1970

1. A summary of the sediment transported by Walnut Creek at Concord and Pacheco Creek near mouth, and the sediment deposited near the mouth during several periods, August 1965-April 1970, is given in table 5. A summary of sediment discharge and deposition by size classes--sand, silt, and clay--is given in table 6.
2. Peak discharges, which transport most sediment, occurred frequently during the 1966-70 water years. A mean daily discharge equal to or more than 1,100 cfs occurred 2 days in 1967, 1 day in 1969, and 3 days in 1970. The 1970 water year is the second water year since 1958 that a discharge equal to or more than 1,100 cfs occurred on 3 days.
3. Streamflow during 1966-70 water years was 1.3 times the estimated long-term mean during 1909-62 (table 3). Suspended-sediment discharge during 1966-70 was 1.3 and suspended sand 1.4 that of the long-term mean.
4. Streamflow and sediment discharge are extremely variable from year to year. Average streamflow at Walnut Creek at Walnut Creek ranged from 12,000 to 46,000 acre-feet per year; suspended-sediment discharge ranged from 8,500 to 233,000 tons per year; suspended-sand discharge ranged from 650 to 74,000 tons per year.
5. Long-term average streamflow and sediment discharges are sufficiently accurate for long-term planning; however, because of the large range in daily and annual discharge at this station, predictions of sediment transport and deposition during a short period must include the probability of the unusual event.
6. The ratio of deposited sediment to total sediment discharge, which is the sediment theoretically available for deposition, ranged from 0.24 to 0.93 (table 5). The ratio of deposited sediment to suspended-sediment discharge decreased during each survey period. Although estimates of deposited sediment for each survey period may not be as accurate as total deposition based on all surveys, the decreasing trend based on individual surveys is considered valid. This trend indicates (1) that coarse sediment available for deposition decreased and (or) (2) that changes in channel geometry caused by sediment deposition increased significantly the competence of Pacheco Creek near mouth to transport sediment.

TABLE 5.--Summary of sediment discharge and deposited sediment by periods, August 1965-April 1970

Period of survey	Deposited sediment near mouth Pacheco Creek ¹ (cu yds)	Walnut Creek at Concord			Pacheco Creek near mouth ³								Ratio deposited sediment to total sediment discharge
		Streamflow ² (cfs-days)	Suspended-sediment discharge ³		Suspended-sediment discharge				Unsampled sediment discharge		Total sediment discharge		
			Sand (tons)	Total (tons)	Sand		Total		Sand		Tons	Cu yds	
					Tons	Cu yds	Tons	Cu yds	Tons	Cu yds			
August 1965–November 1967	660,000	31,890	79,900	259,300	111,300	91,600	361,100	691,100	22,000	18,000	383,100	709,100	0.93
December 1967–April 1969	275,000	27,250	25,410	144,280	35,360	29,100	200,900	384,500	12,200	10,100	213,100	394,600	.70
May 1969–April 1970	125,000	20,790	48,200	190,700	67,100	55,200	265,600	508,300	16,000	13,000	281,600	521,300	.24
Total	1,060,000	79,930	153,510	594,280	213,760	175,900	827,600	1,583,900	50,200	41,100	877,800	1,625,000	.65

¹From U.S. Army Corps of Engineers sediment survey. Initial survey August 1965.²Streamflow August 1965 to September 1968 based on records of Walnut Creek at Walnut Creek.³Based on sediment samples collected at Walnut Creek at Walnut Creek.

TABLE 6.--Summary of sediment discharge and deposited sediment by size classes--sand, silt, and clay--Pacheco Creek near mouth, August 1965-April 1970

* Material	Grain size (mm)	Sediment discharge							Deposited sediment				Ratio deposited sediment to sediment discharge
		Suspended sediment (tons)	Unsampled (tons)	Total	Estimated unit weight (lb per cu ft)	Volume (cu yds)	Percent in suspension, by weight	Percent of total, by weight	Tons	Estimated unit weight (lb per cu ft)	Volume (cu yds)	Percent in deposit	
Sand	0.062-2.00	213,800	50,200	264,000	90	217,300	26	30	333,150	90	274,200	44	1.26
Silt	.004-.062	240,000	--	240,000	70	254,000	29	27	245,600	70	259,900	33	1.02
Clay	<.004	373,800	--	373,800	24	1,154,000	45	43	171,350	24	528,800	23	.46
Total		827,600	50,200	877,800	--	1,625,300	100	100	750,100	52	1,060,000	100	.65

The ratios of deposited sediment to sediment discharge by size classes (table 6) indicate more sand was deposited than was transported, and more clay was transported than was deposited. The excess of sand may be (1) because sand was made available by urbanization, other changes in land use, and construction activities, and (or) (2) because of lack of definition of the suspended-sediment transport curve and (or) lack of sufficient size analyses to define particle-size distribution of deposited material. The trap efficiency of sand in Pacheco Creek probably approaches 100 percent. Additional clay material also may have been made available by construction but a quantitative prediction is not practicable because of the unknown trap efficiency of the clay. As indicated by the size distribution of suspended and deposited material much of the fine material entered Suisun Bay. Material transported in suspension was 26, 29, and 45 percent by weight of sand, silt, and clay whereas material in the deposit was 44, 33, and 23 percent by weight of sand, silt, and clay.

7. Sixty-one percent of the suspended sediment and 87 percent of the sand was deposited above the Southern Pacific Railroad bridge (sites 4 to 6, fig. 3).
8. Collection of suspended-sediment discharge data should be resumed at Walnut Creek to verify or to revise the relation between streamflow and sediment transport shown in figure 2. If the sediment yield is now larger than indicated by the 1957-62 data, additional studies are recommended to locate sources of sediment and to plan remedial action.

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