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ESTIMATE OF SEDIMENT DISCHARGES SANTA ANA RIVER AT SANTA ANA AND SANTA MARIA RIVER AT GUADALUPE CALIFORNIA

U.S. GEOLOGICAL SURVEY

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During the water years 1968-71 the mean daily suspended-sediment discharge of the Santa Ana River at Santa Ana, Calif., was 7,400 tons, and the mean daily coarse-sediment discharge was 3,400 tons. Extrapolated over the 31 water years 1941-71 of streamflow record, the mean daily values are 1,200 and 620 tons. In the Santa Maria River at Guadalupe, Calif., during the water years 1969-71, the mean daily suspended-sediment discharge was 8,700 tons and the mean daily coarse-sediment discharge was 5,500 tons. Extrapolated over the 31 water years 1941-71 of adjusted streamflow record, the mean daily values are 1,400 and 830 tons. The estimated long-term coarse-sediment discharge of the Santa Ana River is 620 tons per day or 190,000 cubic yards per year, and that of the Santa Maria River is 830 tons per day or 250,000 cubic yards per year. Only during floodflow is any significant quantity of sediment transported. In the Santa Maria River an estimated 99 percent of all coarse sediment was transported in 1 percent (113 days) of the 31-year period.

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ESTIMATE OF SEDIMENT DISCHARGES

SANTA ANA RIVER AT SANTA ANA AND

SANTA MARIA RIVER AT GUADALUPE

CALIFORNIA

By Carl G. Kroll

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations 40-74

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UNITED STATES DEPARTMENT OF THE INTERIOR

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GEOLOGICAL SURVEY

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CONVERSION FACTORS

Factors for converting English units to metric units are shown to four significant figures. However, in the text the metric equivalents are shown only to the number of significant figures consistent with the values for the English units.

English	*Multiply by*	*Metric*
ft (feet)	0.3048	m (metres)
ft/s (feet per second)	.3048	m/s (metres per second)
ft^3/s (cubic feet per second)	.02832	m^3/s (cubic metres per second)
lb/ft^3 (pounds per cubic foot)	16.02	kg/m^3 (kilograms per cubic metre)
mi (miles)	1.609	km (kilometres)
tons (short)	.9072	t (tonnes)
yd^3 (cubic yards)	.7646	m^3 (cubic metres)

ESTIMATE OF SEDIMENT DISCHARGES, SANTA ANA RIVER AT SANTA ANA AND SANTA MARIA RIVER AT GUADALUPE, CALIFORNIA

By Carl G. Kroll

ABSTRACT

The computed sediment discharge of Santa Ana River at Santa Ana for the water years 1968-71 was 11,700,000 tons (10,600,000 tonnes) of suspended sediment and 5,000,000 tons (4,500,000 tonnes) of coarse sediment. The computed discharge of Santa Maria River at Guadalupe for the water years 1969-71 was 9,500,000 tons (8,600,000 tonnes) of suspended sediment and 6,000,000 tons (5,400,000 tonnes) of coarse sediment. Estimated mean annual coarse-sediment discharge for the 31 water years, 1941-71, is 230,000 tons (209,000 tonnes) in the Santa Ana River and 300,000 tons (272,000 tonnes) in the Santa Maria River. Streamflow in the Santa Maria River was adjusted to represent 1971 conditions. The 31-year mean annual volumes of coarse-sediment discharges are 190,000 cubic yards (140,000 cubic metres) in the Santa Ana River and 250,000 cubic yards (190,000 cubic metres) in the Santa Maria River.

Only during floodflow is any significant quantity of sediment transported. In the Santa Maria River an estimated 99 percent of all coarse sediment was transported in 1 percent (113 days) of the 31-year period.

INTRODUCTION

Historically, the principal contributors of sand that maintains the southern California beaches have been the coastal streams. These streams transport sediment from coastal watersheds and form deltas of coarse sediment. The coarse sediment from the deltas is transported along the coast by wave action (littoral drift) providing sand for the beaches.

A long dry period and the extensive urban development of inland areas have affected erosion of the watershed, which has reduced the supply of sediment available for transport. In addition, the construction of dams and the consequent reduction of streamflow have decreased the quantity of sediment carried to the coastal zone for deposition on the beaches.

Although the supply of sand has been reduced, the transportation of sand along the shore by littoral drift has not diminished but has created a loss of sand from the beaches. To mitigate beach erosion, it is essential to know (1) the sediment contribution from each coastal stream in a particular reach of shoreline, (2) the littoral transport within the reach, (3) the loss of sediment to submarine canyons, and (4) how the net littoral transport compares with sediment yields from streams so that long-term critical erosion areas can be predicted.

This report defines the sediment yield from two coastal streams that historically have supplied major quantities of sediment to the littoral regime. Sediment-discharge measurements were made at Santa Ana River at Santa Ana, Orange County, during the water years 1968-71[1] and at Santa Maria River at Guadalupe, Santa Barbara County, during the water years 1969-71 (fig. 1). The study was made by the U.S. Geological Survey in cooperation with the California Department of Navigation and Ocean Development.

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[1]A water year is the 12-month period ending September 30 and is designated by the year in which it ends.

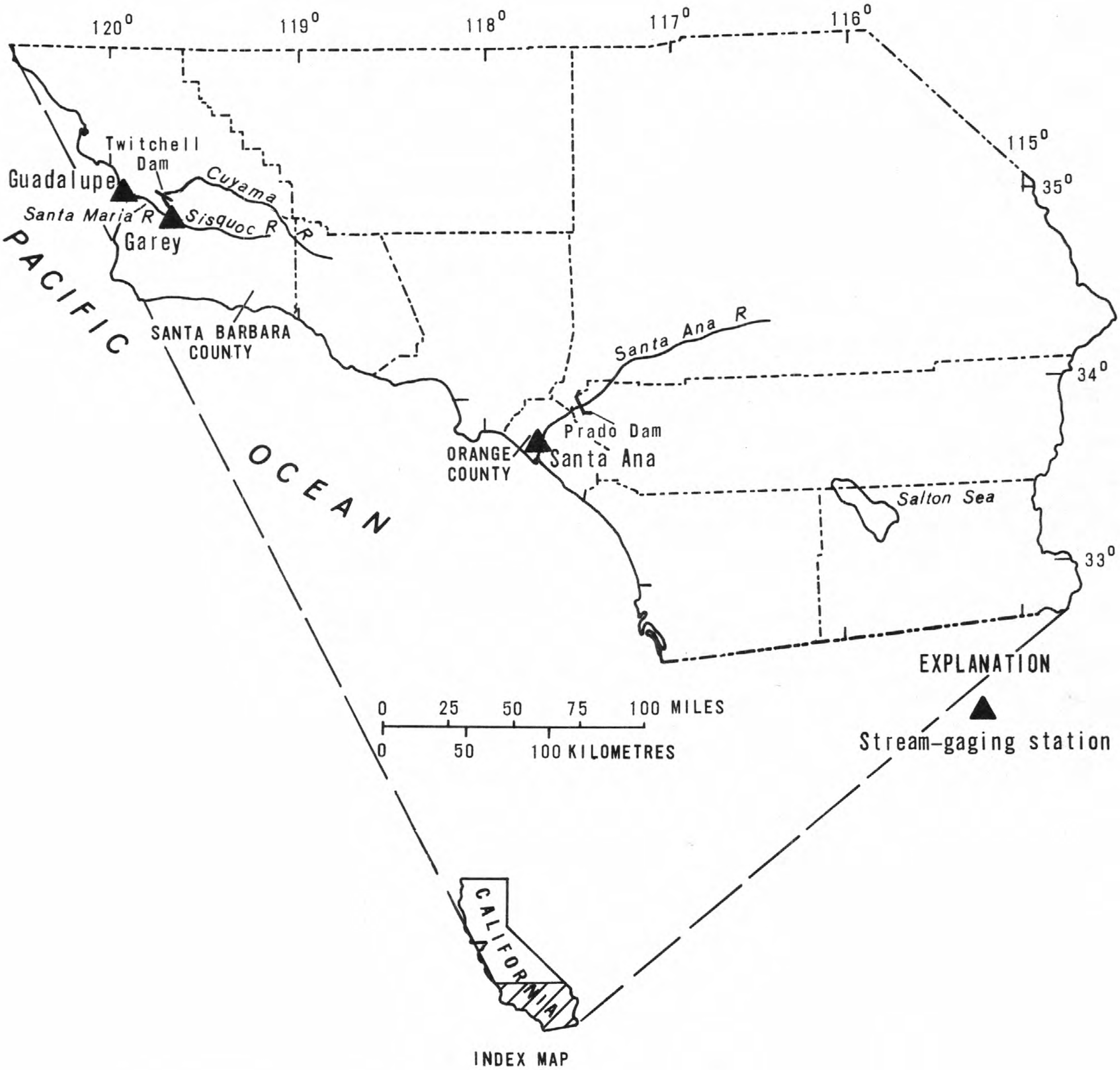

FIGURE 1.--U.S. Geological Survey stream-gaging stations and dams discussed in this report.

DATA COLLECTION AND ANALYSIS

Data were collected at the Geological Survey stream-gaging stations: Santa Ana River at Santa Ana and Santa Maria River at Guadalupe (fig. 1). The program consisted of (1) collecting one or more suspended-sediment samples daily during periods of medium and high flow and less frequently during low flow, and (2) obtaining data needed to compute total-sediment discharge.

Total-sediment discharges were computed by the modified Einstein procedure (Colby and Hembree, 1955). Data required for these computations are:

1. Stream width, average depth, and mean velocity from a streamflow measurement or other suitable source.
2. Average depth at the verticals where the suspended-sediment samples were collected.
3. Average concentration of suspended sediment.
4. Particle-size analysis of the suspended sediment.
5. Particle-size analysis of the bed material.
6. Water temperature.

Particle-size analyses of bed material were made on seven samples from the Santa Ana River and on four samples from the Santa Maria River. The analyses show that both streambeds are sand channels and that most of the material is finer than 4 mm (millimetres). Because the size distributions of the bed-material samples collected after various storms did not vary significantly, the average of all samples from each stream was used to compute total-sediment discharge. The average particle-size distribution of bed material for each stream is shown in table 1.

TABLE 1.--*Average particle-size distribution of surface bed material*

[Method of analysis: sieve]

Stream	Number of samples	Particle size: Percentage finer than the size (millimetres) indicated									
		0.062	0.125	0.250	0.500	1.00	2.00	4.00	8.00	16.0	32.0
		Sand						Gravel			
Santa Ana River at Santa Ana	7	--	3	21	60	88	95	97	99	99	100
Santa Maria River at Guadalupe	4	4	16	52	83	93	96	98	99	100	--

Particle-size analyses were made on selected suspended-sediment samples. These analyses are listed in table 2.

Daily values of suspended-sediment discharge, as well as particle-size analyses of suspended sediment and bed material, are published annually by the Geological Survey in "Water Resources Data for California, Part 2, Water Quality Records."

COMPUTATION OF TOTAL-SEDIMENT DISCHARGE

The total-sediment discharge of a stream can be divided into two parts on the basis of flow (Colby, 1963, p. A12, A22): (1) the fine-sediment discharge, which usually comes from land-surface erosion and consists of particles so fine that they are not found in appreciable quantity in the streambed; and (2) the coarse-sediment discharge, which consists of particle sizes found in appreciable quantity at the surface of the streambed. The dividing size between fine and coarse sediment is considered herein to be 0.062 mm, which is also the dividing size between sand and silt.

All the fine sediment and generally the major part of the coarse sediment are transported in suspension and are easily sampled through the depth of flow to within 0.3 ft (0.09 m) of the bed. This sampled part of the total-sediment discharge is referred to as the suspended-sediment discharge and is published in the annual data reports for California.

The remaining coarse sediment is transported as bedload (sliding, skipping, and rolling along or very close to the bed) or in suspension within 0.3 ft (0.09 m) of the bed. This part of the total-sediment discharge is referred to as the unsampled-sediment discharge. Hence, the total-sediment discharge is the sum of the suspended-sediment discharge plus the unsampled discharge.

Sediment-transport curves that define the relations between water discharge and suspended, unsampled, and total-sediment discharges for the Santa Ana River are illustrated in figure 2; those for the Santa Maria River are illustrated in figure 3.

The coarse-sediment discharges for each stream were computed by the modified Einstein procedure (Colby and Hembree, 1955) and are listed in table 3. The relation between coarse-sediment discharge and water discharge is shown in figures 4 and 5.

TABLE 2.--*Particle-size distribution of suspended sediment,*

[Method of analysis: C, chemically dispersed; P, pipet; S, sieve;

Date	Time	Water temper-ature (°C)	Discharge (ft^3/s)	Sediment concen-tration (mg/l)	Sediment discharge (tons per day)	Percentage 0.002 Clay	0.004
			Santa Ana River at Santa Ana				
Nov. 19, 1967	1050	18	478	4,130	5,330	21	24
Nov. 19, 1967	1610	18	50	2,030	274	35	42
Dec. 18, 1967	1330	12	576	13,800	21,500	9	11
Dec. 18, 1967	1530	12	225	4,610	2,800	34	34
Dec. 21, 1967	0800	--	165	2,340	1,040	35	42
Mar. 8, 1968	0145	13	1,000	9,780	26,400	15	17
Mar. 8, 1968	1915	--	306	20,900	17,300	32	47
Mar. 10, 1968	1550	18	457	4,370	5,390	30	35
Mar. 12, 1968	1555	14	195	2,190	1,150	18	24
Jan. 14, 1969	0850	13	140	9,980	3,770	33	44
Jan. 19, 1969	1000	13	37	748	75	50	56
Jan. 20, 1969	1605	13	372	6,120	6,150	35	38
Jan. 23, 1969	1320	13	931	5,830	14,700	23	25
Jan. 27, 1969	1415	13	5,700	23,100	356,000	14	19
Jan. 31, 1969	1500	13	2,470	11,300	75,400	19	21
Feb. 11, 1969	1130	15	2,710	6,690	49,000	11	12
Feb. 24, 1969	0600	12	5,420	31,400	460,000	33	37
Feb. 25, 1969	1240	13	17,000	28,700	1,320,000	26	31
Feb. 27, 1969	1215	14	6,720	28,100	510,000	29	32
May 6, 1969	1545	18	494	24,400	32,500	20	22
			Santa Maria River at Guadalupe				
Jan. 20, 1969	0910	11	1,750	24,200	114,000	38	44
Jan. 21, 1969	1600	11	4,140	43,900	491,000	26	29
Jan. 22, 1969	1700	12	716	19,100	36,900	30	38
Jan. 29, 1969	1300	11	284	13,900	10,700	30	35
Feb. 7, 1969	1500	13	1,270	19,000	65,200	21	26
Feb. 13, 1969	0930	6	30	7,400	599	43	56
Feb. 25, 1969	1715	11	7,920	63,100	1,350,000	14	15
Feb. 27, 1969	1745	12	2,400	29,800	193,000	17	21
Mar. 4, 1969	0845	12	4,330	16,700	195,000	11	13

Santa Ana and Santa Maria Rivers, water years 1968-69

V, visual accumulation tube; W, in distilled water]

Particle size of particles finer than the size (millimetres) indicated									Method of analysis
Silt			Sand						
0.008	0.016	0.031	0.062	0.125	0.250	0.500	1.000	2.000	
Santa Ana River at Santa Ana									
30	37	42	52	69	93	100	--	--	VPWC
46	55	59	65	73	85	93	100	--	VPWC
13	17	22	28	37	49	67	94	99	SPWC
43	52	61	71	83	97	100	--	--	VPWC
48	53	60	70	83	97	100	--	--	VPWC
22	28	33	38	46	74	91	100	--	VPWC
60	71	76	79	84	94	99	100	--	VPWC
43	49	55	60	76	96	100	--	--	VPWC
27	30	33	36	41	54	72	99	100	VPWC
57	71	79	86	90	96	99	100	--	SPWC
66	80	84	90	96	100	--	--	--	VPWC
50	60	72	81	91	100	--	--	--	VPWC
30	35	39	44	53	68	86	96	97	SPWC
25	34	44	54	70	86	98	100	--	VPWC
27	39	51	63	80	94	100	--	--	VPWC
16	22	28	37	46	71	93	100	--	VPWC
44	59	74	82	89	96	100	--	--	VPWC
39	52	65	74	86	96	100	--	--	VPWC
47	64	74	80	86	93	99	100	--	VPWC
26	45	74	89	94	99	100	--	--	VPWC
Santa Maria River at Guadalupe									
55	71	78	82	90	98	100	--	--	VPWC
35	47	57	64	75	91	97	100	--	SPWC
57	73	87	95	99	100	--	--	--	VPWC
45	58	70	82	95	99	100	--	--	VPWC
32	44	59	75	91	98	100	--	--	VPWC
73	85	90	96	100	--	--	--	--	VPWC
19	26	38	50	75	94	99	100	--	SPWC
27	37	51	66	88	97	100	--	--	SPWC
17	22	32	44	68	93	100	--	--	SPWC

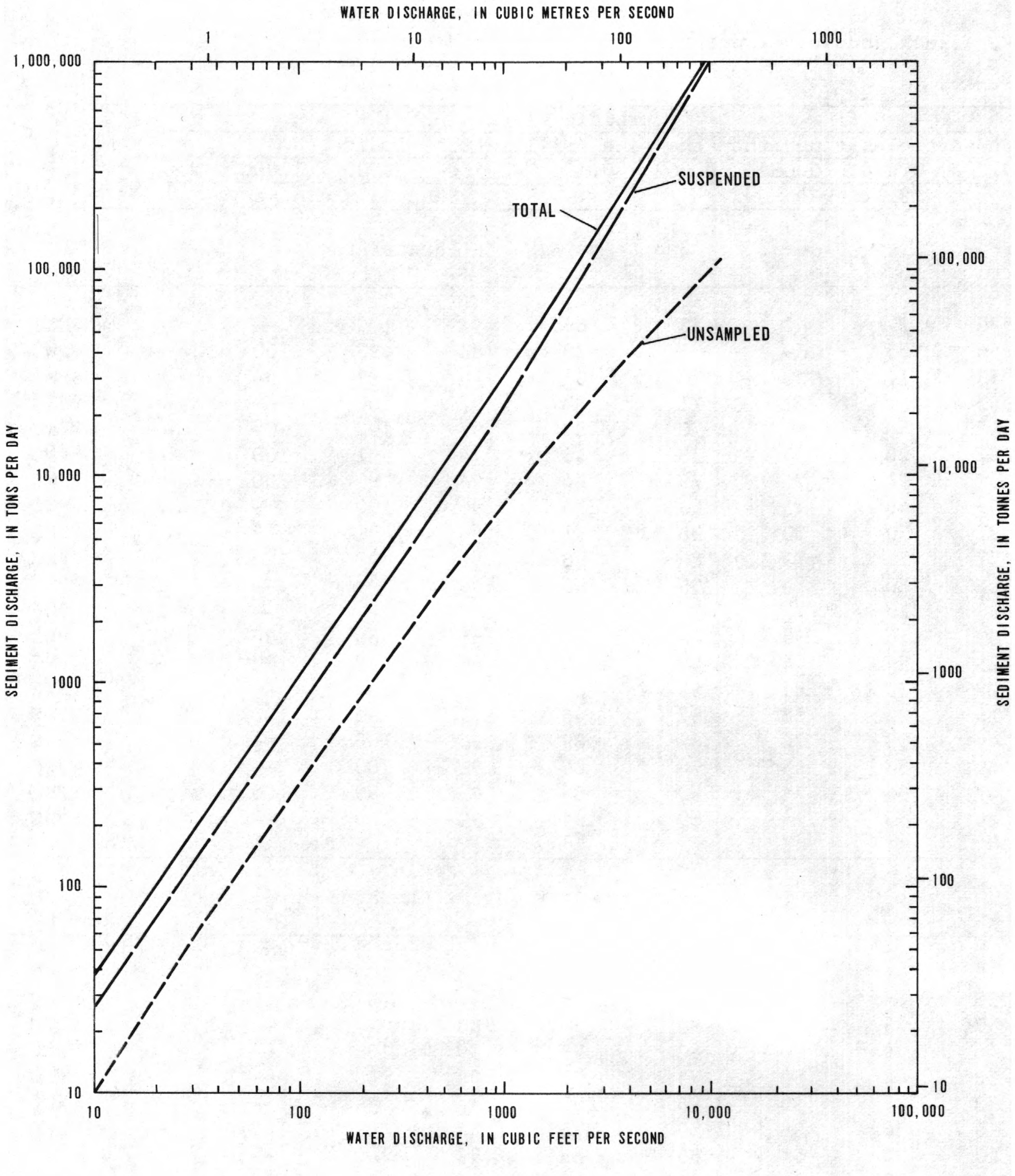

FIGURE 2.--Relation between water discharge and suspended, unsampled, and total sediment discharges, Santa Ana River at Santa Ana, 1968-71.

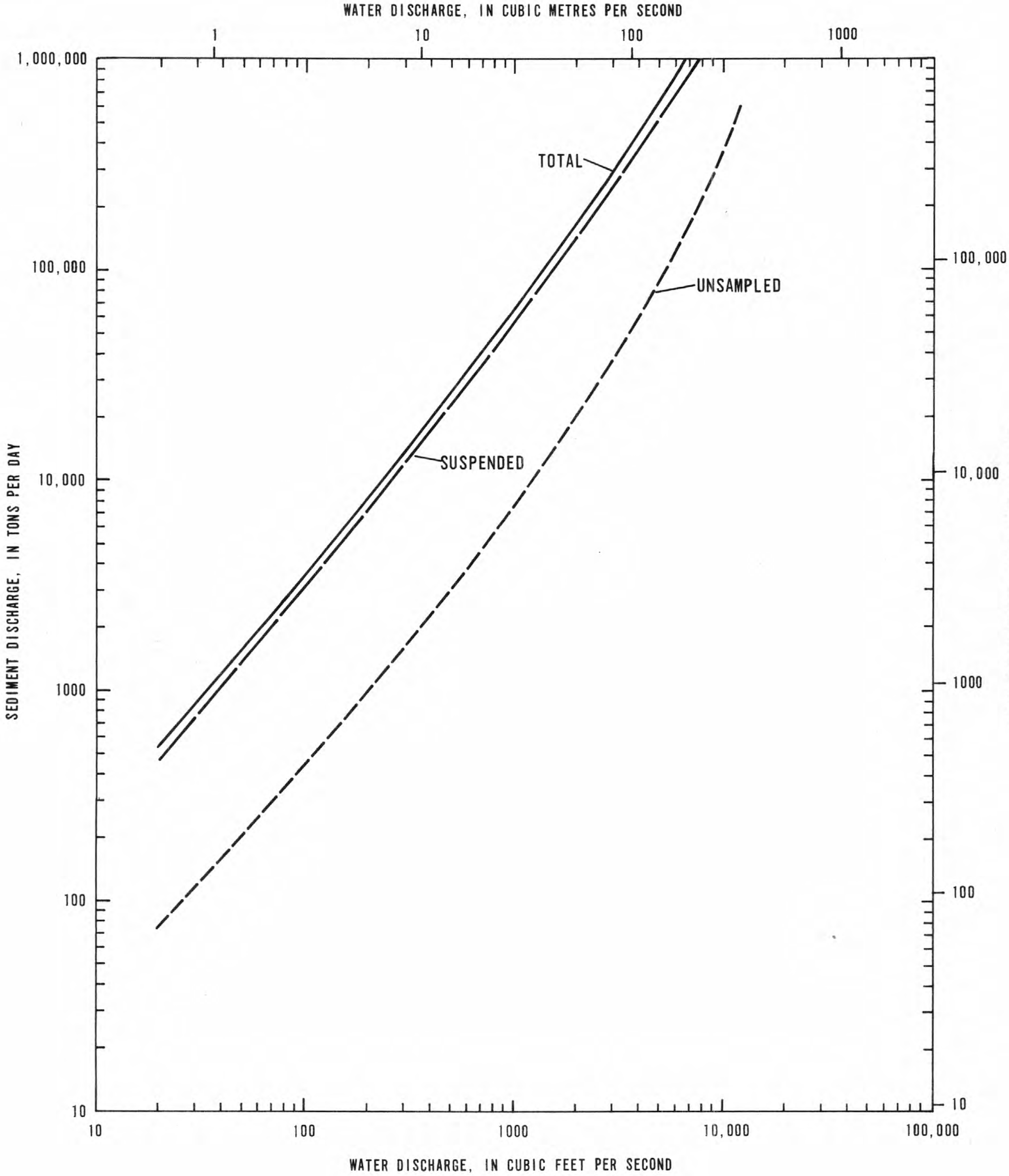

FIGURE 3.--Relation between water discharge and suspended, unsampled, and total sediment discharges, Santa Maria River at Guadalupe, 1969-71.

TABLE 3.--*Coarse-sediment discharge, Santa Ana and Santa Maria Rivers, water years 1968-69*

Date	Water discharge (ft^3/s)	Water velocity (ft/s)	Stream width (feet)	Coarse-sediment discharge (tons per day) Suspended	Unsampled	Total
			Santa Ana River at Santa Ana			
Nov. 19, 1967	50	1.6	69	96	114	210
Jan. 14, 1969	140	2.2	80	528	280	808
Mar. 12, 1968	195	2.4	100	736	952	1,690
Dec. 18, 1967	225	3.1	81	812	978	1,790
Jan. 20, 1969	372	4.0	89	1,170	1,750	2,920
Mar. 10, 1968	457	3.0	193	2,160	2,400	4,560
May 6, 1969	494	3.9	162	3,520	4,380	7,900
Jan. 23, 1969	931	4.4	140	8,230	8,270	16,500
Mar. 8, 1968	1,210	5.1	178	8,960	8,440	17,400
Jan. 31, 1969	2,470	6.1	236	27,900	18,700	46,600
Feb. 11, 1969	2,710	6.2	248	30,900	33,000	63,900
Jan. 27, 1969	5,700	7.7	251	160,000	36,000	196,000
Feb. 27, 1969	6,720	7.9	250	99,800	41,200	141,000
Feb. 25, 1969	17,000	11.5	268	335,000	361,000	696,000
			Santa Maria River at Guadalupe			
Feb. 13, 1969	30	1.9	43	30	177	207
Jan. 29, 1969	284	3.2	198	1,880	4,920	6,800
Jan. 22, 1969	716	4.2	139	1,810	3,510	5,320
Feb. 7, 1969	1,270	4.9	297	15,900	22,100	38,000
Jan. 20, 1969	1,750	5.6	85	19,000	9,000	28,000
Feb. 27, 1969	2,400	5.5	244	64,300	27,500	91,800
Jan. 21, 1969	4,140	2.5	871	173,000	27,000	200,000
Mar. 4, 1969	4,330	4.4	688	108,000	60,000	168,000
Feb. 25, 1969	7,920	5.2	847	650,000	139,000	789,000

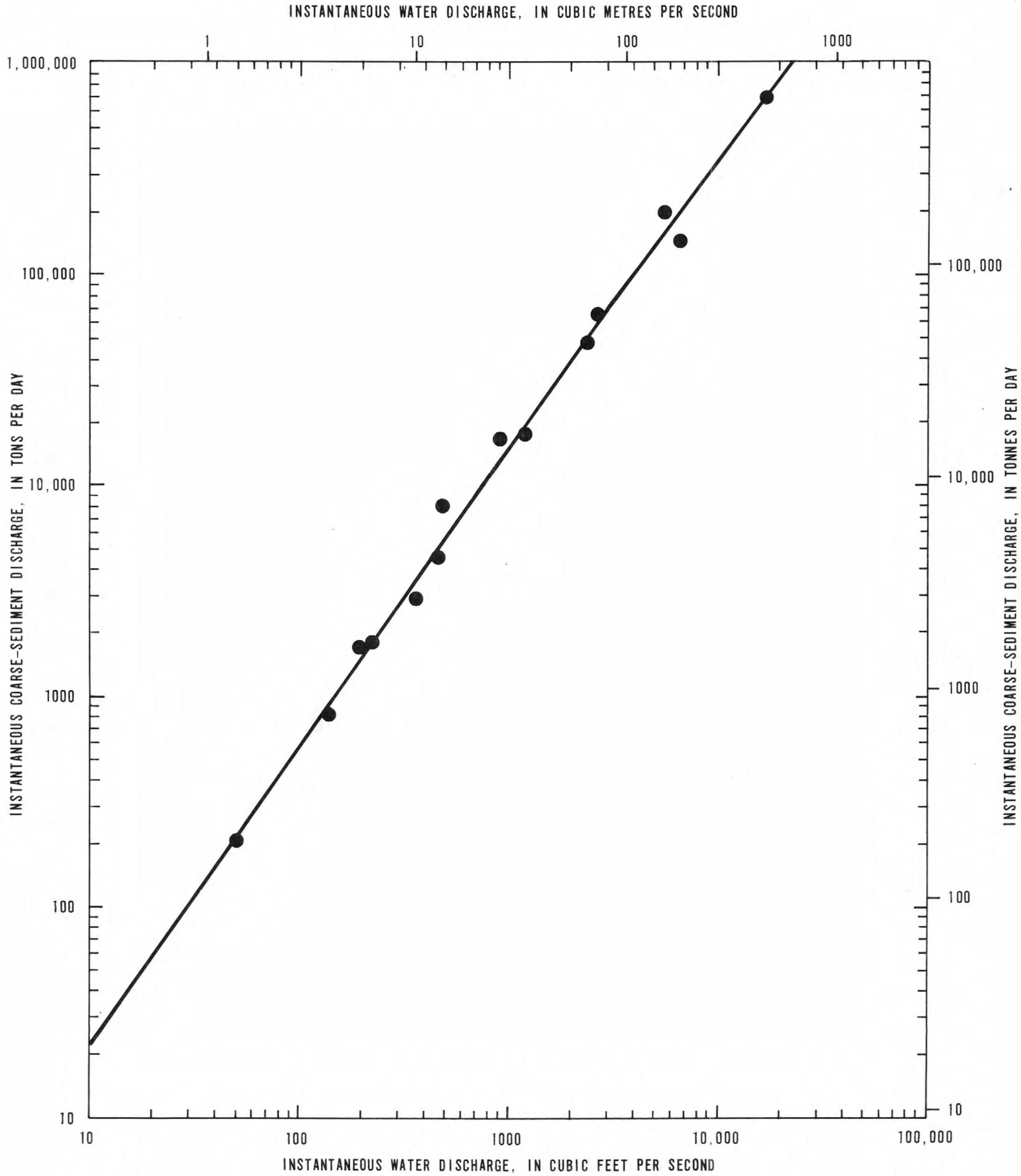

FIGURE 4.--Relation between water discharge and coarse-sediment discharge, Santa Ana River at Santa Ana, 1968-71.

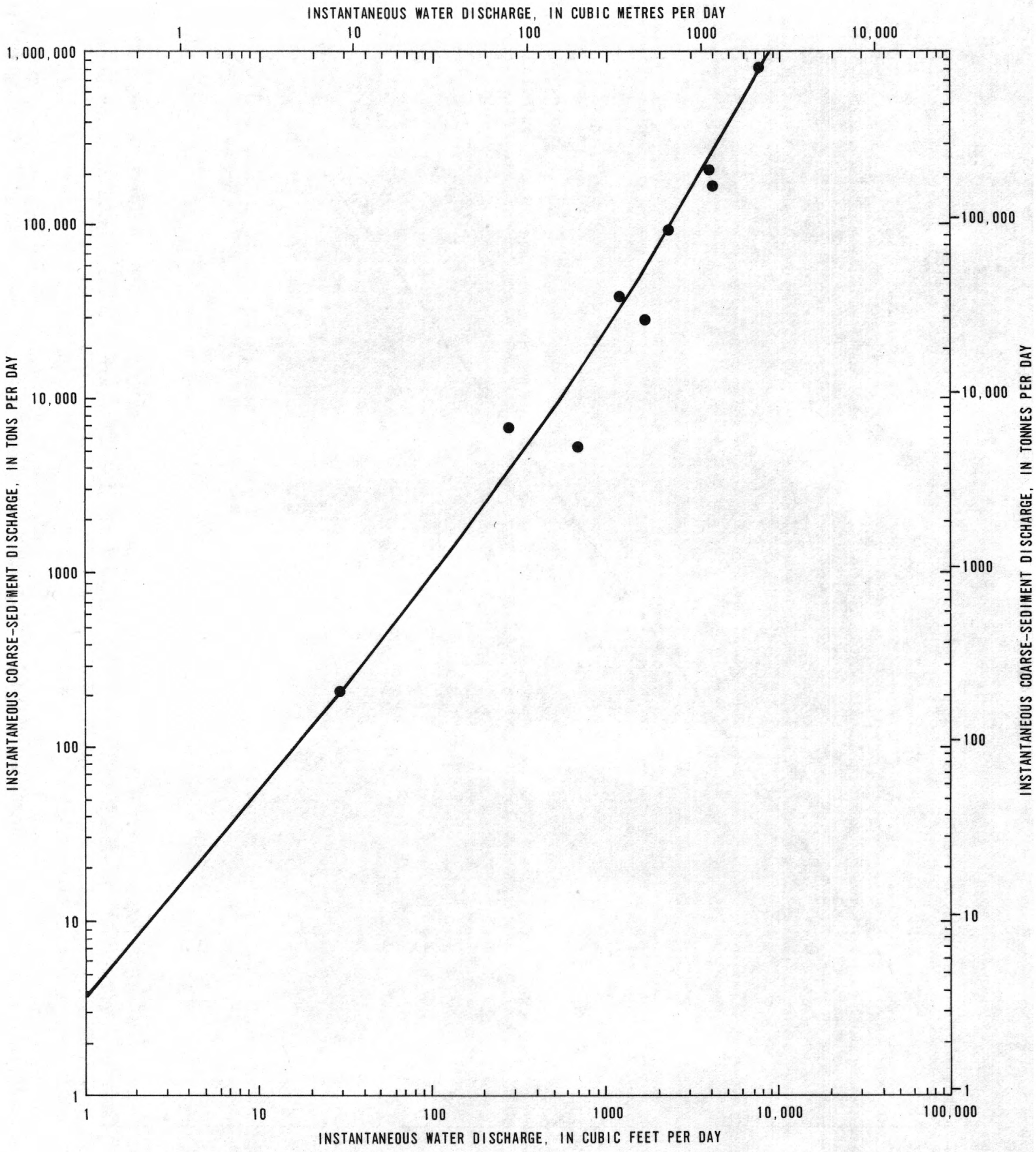

FIGURE 5.--Relation between water discharge and coarse-sediment discharge, Santa Maria River at Guadalupe, 1969-71.

COMPUTATION OF SEDIMENT DISCHARGE, 1968-71

Intense tropical-type storms in January and February 1969 caused runoffs from 3 to 10 times the 1930-60 median in the central and southern coastal areas. Sediment discharge during these storms accounted for almost the entire discharge during the study periods; therefore, the mean discharge is not representative of a long-term period.

During the study periods--1968-71 for the Santa Ana River and 1969-71 for the Santa Maria River--daily values of suspended-sediment discharge were computed using the daily water-discharge record and the concentration of suspended sediment. Table 4 shows the annual suspended-sediment discharges from each stream during the respective study periods. The suspended-sediment discharge during the water years 1968-71 in the Santa Ana River was 11,700,000 tons (10,600,000 t); that during the water years 1969-71 in the Santa Maria River was 9,500,000 tons (8,600,000 t).

TABLE 4.--*Annual suspended-sediment discharges, Santa Ana and Santa Maria Rivers*

Water year	Suspended-sediment discharge, in tons	
	Santa Ana River	Santa Maria River
1968	53,200	--
1969	11,600,000	9,540,000
1970	22,500	1,430
1971	17,100	0
Total (rounded)	11,700,000	9,500,000

The coarse-sediment and total-sediment discharges were computed by the flow-duration-curve technique, shown in tables 5 and 6. Using table 5 as an example, the coarse-sediment discharge is read from figure 4 for each water discharge in column 3, entered in column 5, and then multiplied by the corresponding time interval of each discharge in column 2. The products (not shown) are added and the sum divided by 100 to obtain the mean daily discharge of coarse sediment. Corresponding transport curves were used to obtain the values in columns 4 and 6 (from fig. 2). The difference between the mean daily suspended-sediment discharge in column 4 and the total suspended-sediment discharge in table 4 divided by 1,461 (number of days measured), reflects errors in fitting the curve to the data and in rounding. The difference is 7.5 percent for the Santa Ana River and zero for the Santa Maria River.

The coarse-sediment discharge during each study period was 5,000,000 tons (4,500,000 t) in the Santa Ana River and 6,000,000 tons (5,400,000 t) in the Santa Maria River.

TABLE 5.--*Duration-table summary of daily water and sediment discharges, Santa Ana River at Santa Ana, 1968-71*

Time (percent)	Time interval (percent)	Discharge equaled or exceeded during percentage of time indicated (Col. 1)			
		Water (ft^3/s)	Suspended sediment (tons per day)	Coarse sediment (tons per day)	Total sediment (tons per day)
(1)	(2)	(3)	(4)	(5)	(6)
100.0	87.0	--	--	--	--
13.0	3.0	40	200	150	280
10.0	2.0	100	740	560	1,050
8.0	2.0	280	3,300	2,500	4,700
6.0	2.0	640	11,000	7,600	15,000
4.0	1.0	920	19,000	13,000	26,000
3.0	1.0	1,300	33,000	22,000	43,000
2.0	.50	2,200	78,000	46,000	98,000
1.5	.50	3,400	160,000	84,000	190,000
1.0	.40	5,200	330,000	140,000	370,000
.60	.40	7,400	580,000	230,000	650,000
.20	.13	8,400	720,000	280,000	800,000
.07	.07	11,400	1,200,000	420,000	1,300,000
Mean daily discharges:		140	7,400	3,400	8,600

TABLE 6.--*Duration-table summary of daily water and sediment discharges, Santa Maria River at Guadalupe, 1969-71*

Time (percent)	Time interval (percent)	Discharge equaled or exceeded during percentage of time indicated (Col. 1)			
		Water (ft^3/s)	Suspended sediment (tons per day)	Coarse sediment (tons per day)	Total sediment (tons per day)
(1)	(2)	(3)	(4)	(5)	(6)
100.0	95.0	--	--	--	--
5.0	1.0	64	1,800	530	2,100
4.0	1.0	180	6,300	2,000	7,200
3.0	.50	340	14,000	5,000	15,000
2.5	.50	620	30,000	11,000	34,000
2.0	.50	1,200	70,000	30,000	81,000
1.5	.50	2,400	180,000	98,000	210,000
1.0	.50	4,000	380,000	230,000	450,000
.50	.23	5,400	600,000	370,000	700,000
.27	.09	7,900	1,050,000	750,000	1,300,000
.18	.09	8,500	1,200,000	850,000	1,500,000
.09	.09	11,700	2,000,000	1,500,000	2,500,000
Mean daily discharges:		83	8,700	5,500	10,000

ESTIMATE OF LONG-TERM SEDIMENT DISCHARGE

Long-term mean daily sediment discharges at both stream-gaging sites were estimated by applying the short-term relation between water and sediment discharges to flow-duration data for long-term streamflow at each site. The long-term frequencies and the corresponding sediment-discharge values from the sediment-transport curves used to obtain the mean daily sediment discharges are listed in tables 7 and 8. The estimated values assume that long-term relations between streamflow and sediment discharge were similar to those existing during the sampled period. Therefore, the estimate of historic sediment discharge should provide a reasonable estimate of future discharge under 1971 conditions.

TABLE 7.--*Duration-table summary of daily water and sediment discharges, Santa Ana River at Santa Ana, 1941-71*

Time (percent)	Time interval (percent)	Discharge equaled or exceeded during percentage of time indicated (Col. 1)			
		Water (ft^3/s)	Suspended sediment (tons per day)	Coarse sediment (tons per day)	Total sediment (tons per day)
(1)	(2)	(3)	(4)	(5)	(6)
100.0	95.0	--	--	--	--
5.0	2.0	77	500	400	750
3.0	1.0	220	2,300	1,700	3,300
2.0	.50	430	6,200	4,400	8,800
1.5	.50	670	12,000	8,500	16,000
1.0	.30	900	18,000	13,000	25,000
.70	.20	1,100	25,000	17,000	33,000
.50	.20	1,600	44,000	29,000	58,000
.30	.10	2,200	78,000	46,000	98,000
.20	.050	3,000	130,000	70,000	160,000
.15	.050	4,800	270,000	135,000	340,000
.10	.040	6,700	480,000	200,000	570,000
.060	.034	7,800	600,000	250,000	720,000
.026	.017	8,400	720,000	280,000	800,000
.009	.009	11,400	1,200,000	420,000	1,300,000
Mean daily discharges:		31	1,200	620	1,500

TABLE 8.--*Duration-table summary of adjusted daily water and sediment discharges, Santa Maria River at Guadalupe, 1941-71*

Time (percent)	Time interval (percent)	Discharge equaled or exceeded during percentage of time indicated (Col. 1)				
		Water Sisquoc (ft^3/s)	Water[1] Santa Maria (ft^3/s)	Suspended sediment (tons per day)	Coarse sediment (tons per day)	Total sediment (tons per day)
(1)	(2)	(3a)	(3b)	(4)	(5)	(6)
100.0	92.0	--	--	--	--	--
8.0	4.0	140	--	--	--	--
4.0	2.0	340	--	--	--	--
2.0	.60	510	40	1,050	290	1,200
1.4	.50	800	180	6,300	2,000	7,200
.90	.30	1,100	480	22,000	8,000	24,000
.60	.20	1,500	900	48,000	20,000	56,000
.40	.15	2,000	1,400	88,000	38,000	100,000
.25	.090	2,800	2,200	170,000	80,000	190,000
.16	.060	4,000	3,200	280,000	150,000	320,000
.10	.040	5,600	4,600	470,000	300,000	550,000
.060	.025	7,800	6,200	750,000	480,000	880,000
.035	.018	9,800	7,500	950,000	680,000	1,200,000
.017	.017	13,000	9,500	1,400,000	1,000,000	1,800,000
Mean daily discharges:		42	17	1,400	830	1,700

[1]Based on flow frequencies of the Sisquoc River near Garey and relation of flow of the Sisquoc River to flow of the Santa Maria River.

For both streams the long-term period used was 1941-71, which represents the entire period of record since construction of Prado Dam on the Santa Ana River. Construction of Twitchell Dam in 1958 prevents the use of streamflow data during the same period at the Santa Maria River gage site. The 1941-71 streamflow that would have occurred at Santa Maria River at Guadalupe, assuming 1971 conditions, was estimated by extending the 1959-71 record using a procedure discussed by Searcy (1959, p. 12). The streamflow record used as a base was the 1941-71 record at Sisquoc River near Garey. Daily discharges of Sisquoc River near Garey from October 1940 to January 1941 and from October 1970 to September 1971 were estimated.

The estimated mean daily total-sediment discharge during the period 1941-71 at Santa Ana River at Santa Ana is 1,500 tons (1,400 t); the coarse-sediment discharge is 620 tons (560 t). The estimated mean daily total-sediment and coarse-sediment discharges, 1941-71, at Santa Maria River at Guadalupe under adjusted streamflow conditions are 1,700 and 830 tons (1,500 and 750 t).

The estimated mean annual volume of coarse sediment discharged and available to the beaches under 1971 conditions is 190,000 yd^3 (140,000 m^3) from the Santa Ana River basin and 250,000 yd^3 (190,000 m^3) from the Santa Maria River basin (table 9). Volumes are based on an assumed unit weight of 90 lb/ft^3 (1,400 kg/m^3) for bed material (Gottschalk, 1964, p. 17-18).

The sediment discharges listed in table 9 are averages for a 31-year period. It is emphasized that during many years there was very little or no water and sediment discharge, and only during major floodflow is any significant quantity of sediment transported. For example, in the Santa Maria River an estimated 99 percent of all coarse sediment was transported in 1 percent (113 days) of the 31-year period.

TABLE 9.--*Estimated long-term coarse-sediment discharge of the Santa Ana and Santa Maria drainage basins, 1941-71*

Stream	Estimated coarse-sediment discharge[1] under present conditions		
	Tons per day	Tons per year	Cubic yards per year
Santa Ana River	620	230,000	190,000
Santa Maria River[2]	830	300,000	250,000

[1]Estimates are based on suspended-sediment concentrations, bed-material size distributions, and water-discharge measurements obtained at the gaging stations during water years 1968-71.

[2]Figures are adjusted to include the storage effects of Twitchell Dam.

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