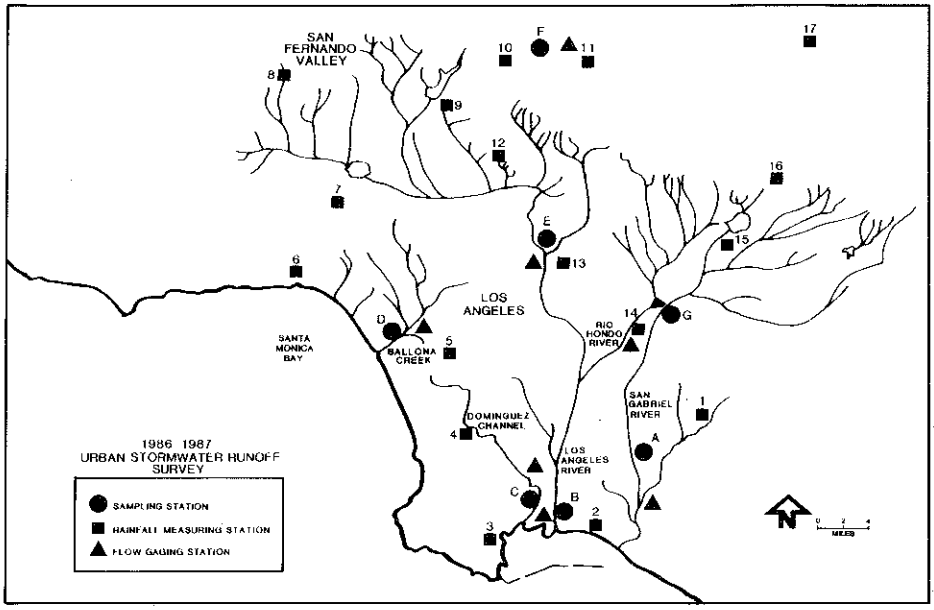

Figure 1. Los Angeles River Basin.

Storm Runoff in Los Angeles and Ventura Counties

One of SCCWRP's long-term projects is to update and improve past estimates of contaminant inputs to the Southern California Bight. By the summer of 1988, SCCWRP staff will have sampled storm runoff from the largest storm channels in four of the coastal counties of southern California.

On September 23-25, 1986, SCCWRP investigators collected 49 samples of storm runoff from eight sites in Los Angeles and Ventura Counties (Santa Clara River, Calleguas Creek, Ballona Creek, Dominguez Channel, Los Angeles River [Big Tujunga Wash, Fletcher Avenue Bridge, Willow Street Bridge], and San Gabriel River) (Figure 1). Each channel has a unique drainage basin, and most of the channels receive wastewater effluent from one or more municipal wastewater treatment plants, which contributes significantly to dry weather flows. Locations were chosen to provide safe sampling, to be used during adverse weather conditions, to provide access to the center channel of the flow, and to be downstream from the major sources of runoff contaminants.

The storm was very early in the rain season and was unpredicted. This made it difficult to take the samples as originally planned; however, low-flow, high-flow, and post-high-flow samples were obtained and concentrations of suspended solids, oil and grease, total extractable organics (TEO), trace metals, DDT, polychlorinated biphenyl compounds (PCBs), polynuclear aromatic hydrocarbons (PAHs), and *n*-alkanes were measured.

With these data, Henry A. Schafer and Richard W. Gossett were able to estimate mass emission of major runoff sources and compare the rates with previous runoff emission estimates and other sources of

Table 1. Flow-proportioned average concentrations and ranges of actual concentrations for storm runoff samples collected from the September 23-25 storm.

Constituent	Station									
	LA River Willow	LA River Fletcher	LA River Tujunga	Ballona Creek	Santa Clara	Calleguas Creek	San Gabriel	Dominguez Channel	Hyperion 5-Mile[a]	Oxnard Plant[a]
No. of samples	10	8	5	6	3	3	8	4	1985 AVE	1985 AVE
Flow (m^3/s)[b]										
Min	3	4		1		<1	2			
Max	240	65		140		2	122			
Susp. Sol. (mg/L)	645	246	229	755	1250	30	206	206		
Min	31	17	3	13	16	3	5	11		
Max	1850	1190	826	2500	1920	85	1080	76		
%Vol. Sol.										
Min	5	22	9	15	8	28	7	28		
Max	69	31	50	46	88	60	100	55		
Oil & Grease (mg/L)	10	3	1	15	3	2	5		29	4
Min	1	1	<0.1	2	1	0.2	0.2	0.2		
Max	22	11	1	36	7	2	8	3		
TEO (mg/L)	35	6	1	27	5	1	4			
Min	1	2	<0.1	2	1	0.4	0.4	0.7		
Max	103	29	4	60	8	2	12	5		
Cd (μg/L)	6	2		7			2		11	13
Min	<1	<1	<1	<1	<1	<1	<1			
Max	21	28		22	1		4			
Cr (μg/L)	45	11		67	56	2	31		60	11
Min	<3	<2	<2	<3	<2	<3	6			
Max	147	107	8	248	80	5	68			
Cu (μg/L)	182	96		267	69	18	86		197	57
Min	12	26	3	43	<2	3	17			
Max	512	667	28	860	106	46				
Ni (μg/L)	47	21		80	19	6	34		82	57
Min	13	12	<2	7	4	3	13			
Max	131	92	5	261	48	12	61			
Pb (μg/L)	264	71		530	88		120		88	285
Min	<8	24	<6	23	8	<9	23			
Max	607	345		1830	134		201			
Zn (μg/L)	718	299		1420	238	10	457		279	71
Min	21	116	2	172	7	6	80			
Max	1970	1360	47	4400	391	14	744			
DDTs (ng/L)	85	46		378	938	6	16		20	
Min	<1	21	3	1	8	1	<1	<1		
Max	169	249	12	1360	1570	10	35	9		
PCBs (ng/L)	291	108		267	162	14	57		102	<1000
Min	11	58	2	18	12	11	<1	15		
Max	695	352	41	632	250	19	75	34		
PAHs (μg/L)	36	2		24	1	0.02	1			
Min	<0.01	<0.01	<0.02	0.4	<0.01	<0.01	<0.01			
Max	120	18		76	2	0.14	1.6			
n-Alkanes (μg/L)	572	42	4	244	6	0.01	29			
Min	1	8	1	9	<0.01	<0.01	1	<0.01		
Max	1000	280	6	440	5		43	240		

[a]Based on 1985 montoring data.
[b]To obtain units in cubic feet per second use the following formula: $ft^3/s = (m^3/s)/0.0283$.

Table 2. Mass emission rates (metric tons) for several runoff constituents of the September 23-25, 1986, storm and average daily emissions from two ocean outfalls (1985 data).

Constituent	Station								
	LA River Willow	LA River Fletcher	LA River Tujunga	Ballona Creek	Santa Clara	Calleguas Creek	San Gabriel	Hyperion 5-Mile	Oxnard Plant
Tot. Vol. ($L \times 10^9$)	11	7.7	0.0014	4.5	0.016	0.32	3.5	1.47	0.070
Susp. Solids	7100	1900	0.32	3400	20	9.7	720	238	2.3
Tot. Solids	10000	3200	0.67	6900	39	460	8400		
Oil & Grease	110	20	0.0009	67	0.045	0.74	17	43	0.030
TEO	380	44	0.0018	120	0.080	0.44	13		
Cd	0.064	0.013	ND[a]	0.030	ND	ND	0.0082	0.016	0.0009
Cr	0.50	0.088	ND	0.31	0.0009	0.0005	0.11	0.088	0.0008
Cu	2.0	0.74	ND	1.2	0.0011	0.0058	0.30	0.29	0.004
Ni	0.52	0.16	ND	0.36	0.0003	0.0022	0.12	0.12	0.004
Pb	2.9	0.55	ND	2.4	0.0014	ND	0.42	0.13	0.002
Zn	7.9	2.3	ND	6.4	0.0038	0.0031	1.6	0.41	0.005
Tot. DDTs (kg)	0.93	0.35	ND	1.7	0.015	0.002	0.056	0.030	
Tot. PCBs (kg)	3.2	0.83	ND	1.2	0.0026	0.0045	0.20	0.15	<0.07
Hexachlorobenzene (kg)	0.044	0.015	ND	0.015	ND	0.0001	0.0060		
Lindane (kg)	0.18	0.16	ND	0.086	0.0004	0.0008	0.022		
Tot. PAHs (kg)	400	15	ND	110	0.018	0.0056	4.0		
n-Alkanes (kg)	6300	320	0.0057	1100	0.41	0.0040	100		

[a]ND, Not detected.

contamination to the Southern California Bight. They also determined how the concentration and mass of contaminants varied throughout the storm to see if significant portions of the mass emissions were concentrated in a small part of the flow. Various sites were sampled to see how contaminant levels varied with land use. In addition, Schafer and Gossett measured concentrations of PAHs. For several channels, this was the first time that PAHs were measured; the molecular weight of the PAHs indicated that crankcase oil was present in the runoff.

Mass emissions and flow-proportioned mean concentrations were calculated for each sampling site. Mass emissions for each sampling period were first determined by multiplying the flow that occurred during the sampling period by the sample contaminant concentrations. Then the total storm emissions were computed by summing all of the interval mass emissions. The flow-proportioned mean concentrations were calculated by dividing the total mass emissions by the total flow.

Table 1 lists flow-proportioned mean contaminant concentrations and ranges for the sites sampled during this storm. The researchers found that the Santa Clara River and Calleguas Creek (both in Ventura County) had the highest and lowest concentrations of suspended solids, respectively. Generally, the Los Angeles River at Willow Street had the highest concentrations of hydrophobic (oil and grease, TEO, PAH, *n*-alkanes, PCBs, and DDT) contaminants. Exceptions occurred at Ballona Creek, which had 50% more oil and grease and a DDT concentration four times that of the Willow Street site, and at Santa Clara, which had a DDT concentration 11 times that of the Willow Street site. Trace metals concentrations were all highest at Ballona Creek followed by the Los Angeles River at Willow. Concentrations at Tujunga Wash were consistently below detection, while the other sites had roughly equal levels. Contami-

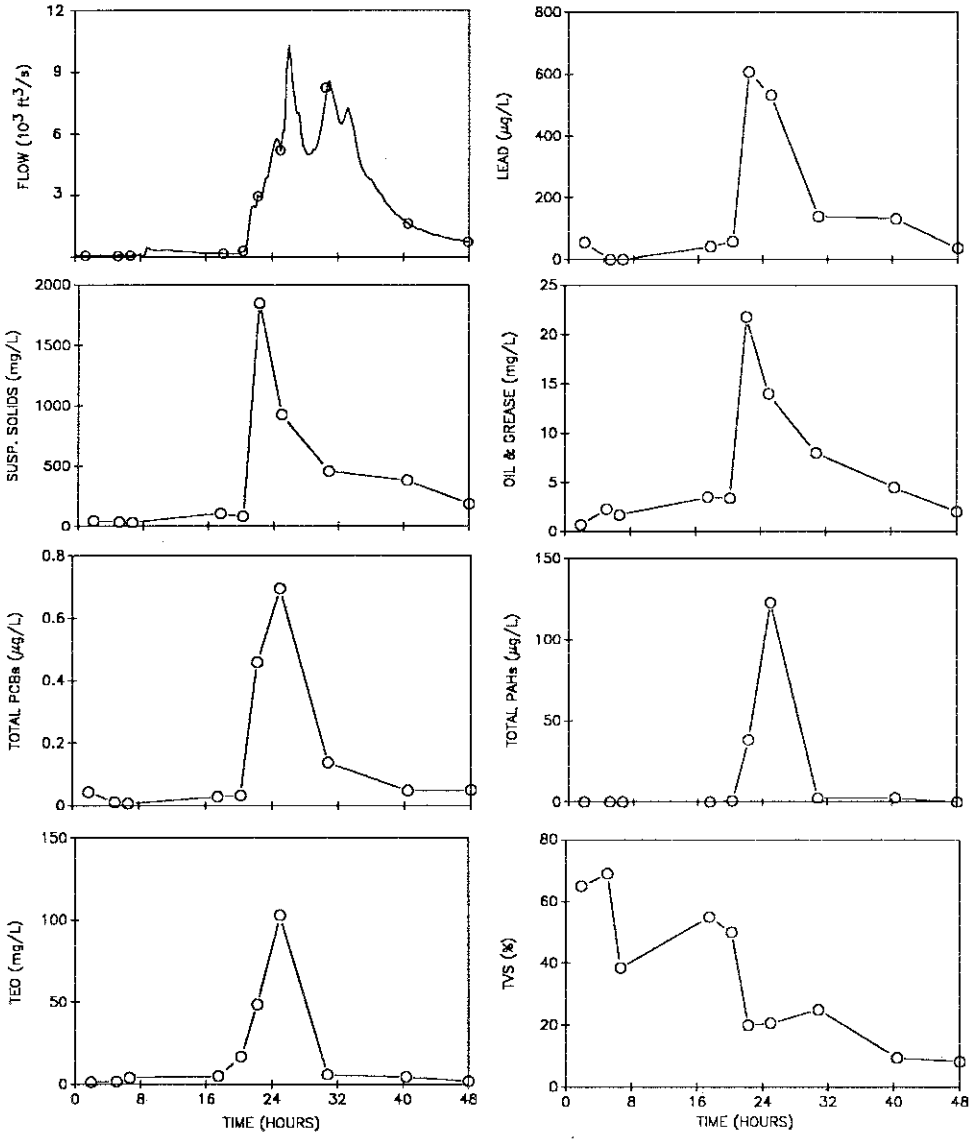

Figure 2. Flow and contaminant concentrations at the Los Angeles River at Willow Street during the storm on September 23-25, 1986. TVS, Total volatile solids.

Table 3. Flow-weighted mean concentrations of trace metals and chlorinated hydrcarbons in Los Angeles River storm runoff.[a]

Constituent	1971-72		1979-80			1986-87
(µg/L)	Storm 1	Storm 2	Storm 1	Storm 2	Storm 3	Storm 1
Ag	1.9	2.6	1.3	0.7	0.4	
Cd	16	9.3	1.6	8.7	1.8	5.8
Cr	86	80	140	120	52	45.4
Cu	120	140	110	110	44	182
Hg			1.8	0.4	0.2	
Ni	83	72	73	77	34	47.3
Pb	910	980	74	210	180	164
Zn	940	1100	760	450	230	718
Fe (mg/L)	10	25	68	57	28	
Mn	450	500	640	860	450	
DDT	0.93[b]		0.51	0.38	0.10	0.08
PCB	2.6[b]		0.35	0.47	0.12	0.29
Vol. (10^9 L)	1.4	7.2	2.8	21.8	14.5	11
Susp. Sol. (mg/L)			2700	1900	1500	645

[a]From Young et al. 1981.
[b]These values are the average measurements of the two storms.

nant concentrations along the Los Angeles River increased significantly from the upper to lower stations.

Table 2 shows the calculated flow-proportioned mass emissions. The Los Angeles River is the largest source of runoff to the Southern California Bight. The flow rate at the Willow site is about 30% greater than that at Fletcher and contaminant emissions are 3 to 10 times greater, which indicates that for all constituents except DDT, there is a consistent pattern of greatest emissions coming from the Los Angeles River, then Ballona Creek followed by Fletcher and San Gabriel. The remaining sample stations had minimal inputs.

Emissions from the San Gabriel River were underestimated because the flow data were available only from the Coyote Creek branch of the San Gabriel River. Therefore, estimates for that station could be low by a factor of 2 or more.

Figure 2 shows the flow and concentrations of suspended solids, oil and grease, TEO, lead, total PAHs, total PCBs, and volatile solids for the Los Angeles River during the 48 h of sampling. There were two peaks in flow that occurred about 6 h apart. Peak contaminant concentrations (except percent volatile solids) occurred at either hour 22 or 24, which was before the first peak in flow. Although the

sample taken at hour 30 was at the second peak flow, the concentrations of all contaminants dropped. This may be due to a washout of contaminants.

The cumulative percent flow and cumulative percent emissions of suspended solids, oil and grease, chlorinated hydrocarbons, and combined trace metals for the Willow station and Ballona Creek are compared in Figure 3. Approximately 80% of the flow and suspended solids was discharged within 10 h. In general, the first 25% of flow produced 50% of the contaminant emissions, and when 50% of the flow had occurred, 75% of the contaminant emissions had occurred. This pattern is representative of the other sites studied.

As contaminant emissions from outfalls continue to decrease, runoff emissions become a more important source of marine inputs. Variations in runoff concentrations were not significantly different in the Los Angeles River between 1971 and 1979 except for lead and PCBs, which were reduced by factors of 6 and 8, respectively (Young et al. 1981). Table 3 shows concentrations for the five storms measured in 1971 and 1979 and the present 1986 results. Between 1979 and 1986 copper and lead concentrations increased by about a factor of 2, while suspended solids and chromium were reduced by two-thirds and one-half, respectively. The rest

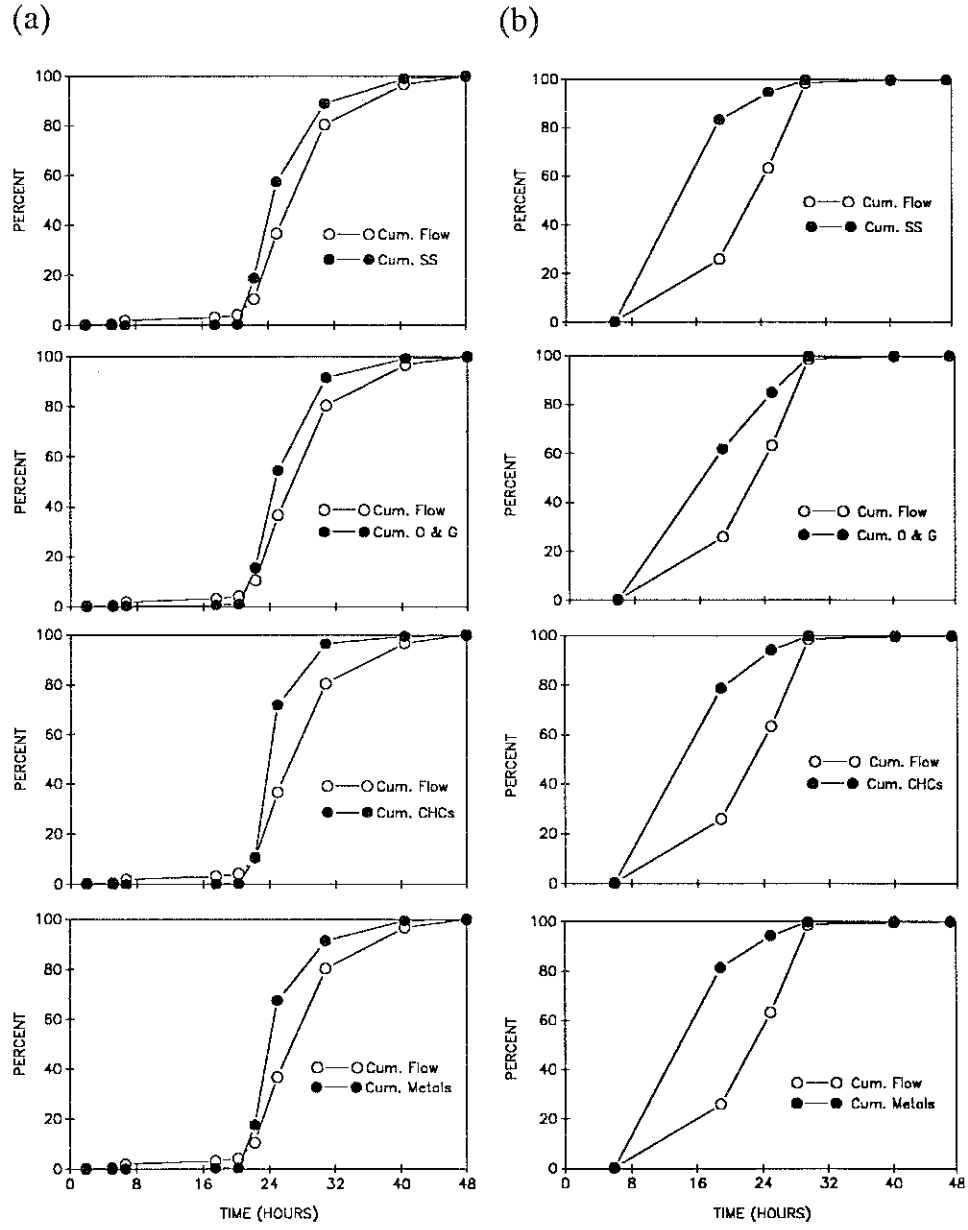

Figure 3. Cumulative percent flow and cumulative percent emissions of suspended solids (SS), oil and grease (O & G), chlorinated hydrocarbons (CHCs), and combined trace metals. (a) Los Angeles River at Willow Street. (b) Ballona Creek.

of the trace metals and PCBs varied by less than one-third. Levels of DDT changed the most; they were reduced by a factor of 4.

The highest concentrations of contaminants are associated with peak flows. Because the two Ventura sites were sampled while they had relatively low flow, these annual emission data may be less representative than those sites that were sampled during high flow. The two channels with the highest flows, Los Angeles River Willow and Ballona Creek, had the highest mean contaminant concentrations and consequently had the highest emissions

of oil and grease, TEO, cadmium, chromium, copper, nickel, lead, zinc, PCBs, PAHs, resolved hydrocarbons, and *n*-alkanes.

Estimation of runoff should be viewed with the awareness of certain limitations. Factors that need further examination include annual variations in total rainfall within a drainage basin, the intentional retention of runoff for groundwater recharge, and diversions between drainage basin. These factors can combine to make each storm and year difficult to compare with other storms and years.

Acknowledgments

We appreciate the financial and field support that was provided by the Los Angeles Regional Water Quality Control board, especially A. Chartrand and M. Sowby. The Hyperion Laboratory kindly allowed us to use their facilities to measure oil and grease. We thank our fellow staff members who interrupted their work and sleep patterns to make this study possible.

Reference

Young, D. R., T.-K. Jan, R. W. Gossett, and G. P. Hershelman. 1981. Trace pollutants in surface runoff, pp. 163-169. *In* Coastal Water Research Project, Biennial Report, 1979-1980 (W. Bascom, Ed.). Southern California Coastal Water Research Project, Long Beach, CA.