Characteristics of Effluents from Power Generating Stations in 1995

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ABSTRACT

Power generating stations have a high volume of combined discharge, consisting mostly of cooling water with a small amount of in-plant waste. This study summarizes effluent characteristics of the 13 power generating stations in 1995 and describes trends that have occurred at these stations since 1971. Mass emissions were estimated from monthly measurements of constituent concentrations and flow for 1995. Power generating stations accounted for 84% of the flow, 88% of the mercury mass emissions, and 31% of the cadmium mass emissions discharged to the Southern California Bight (SCB) from municipal wastewater facilities and power generating stations in 1995.

INTRODUCTION

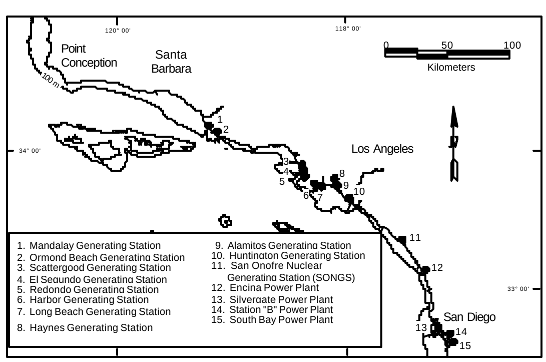
The human population of southern California utilizes the marine environment for a number of commercial, industrial, and recreational uses, including the disposal of wastes (e.g., municipal wastewater, oil platform discharges, and industrial waste). Certain contaminants in waste can harm marine life or humans that swim in the ocean or consume contaminated marine life. To measure the most important sources of contamination, inputs of contaminants from different sources of waste are measured. These measurements provide a basis for developing emission control strategies and, when measured over time, for assessing the effectiveness of these control strategies.

Point source dischargers to the SCB include municipal wastewater treatment facilities, power generating stations, and other industrial dischargers. Power generating stations discharge the largest combined volume of these sources (SCCWRP 1973). Final effluent from power generating stations is termed "combined discharge." This discharge contains two components: cooling water and in-plant waste. The major portion of the discharge is the cooling water or seawater that has circulated through the plant to cool condensers. The cooling water can acquire contaminants as it circulates through the plant from sources such as the condensers or pipe fittings. The combined discharge also contains in-plant waste, which is made up of different components such as boiler blowdown, metal cleaning waste, and sanitary waste. Combined effluent can be discharged from more than one outfall (serial outfalls) at a single generating station.

There are 13 power generating stations that currently discharge to the SCB (Figure 1, Appendix 1). Two additional stations (Silvergate and Station "B") discharged to the SCB until 1995. All except the San Onofre Nuclear Generating Station (SONGS) are conventional thermal power plants that use fossil fuels such as oil or natural gas; SONGS uses nuclear power (SCCWRP 1973).

Although constituent characteristics are summarized in the monitoring reports of the power generating stations, effluent characteristics are not integrated or compared among the generating stations or between the generating stations and municipal wastewater facilities. The SCCWRP summarized flow of the power generating stations for 1970 and 1971, 1987, and 1989 (SCCWRP 1973, 1989, and 1990); and flow and constituent mass emissions of in-plant waste for 1994 (Raco-Rands 1996). In this report, we summarize effluent flows and constituent concentrations, as well as mass emissions from in-plant flow, and mass emissions and percent mass emission contributions from the combined flow from coastal power generating stations discharging to the SCB in 1995. Trends in flow since 1970, and changes in mass emissions and mass emission contributions in in-plant waste since 1994, are also discussed.

FIGURE 1. Locations of power generating stations in southern California in 1995.



MATERIALS AND METHODS

Data on effluent characteristics of the power generating stations were obtained from the effluent monitoring data reports that are required by the Regional Water Quality Control Boards (Los Angeles, Santa Ana, and San Diego regions) under the National Pollutant Discharge Elimination System (NPDES) permits.

The power generating stations usually measured general constituents (nonmetallic and nontrace organic constituents) in their in-plant waste on a monthly basis; however, Huntington Beach measured hourly to weekly, and SONGS, Encina, and South Bay measured semiannually for ammonia-N and cyanide. Metals are usually measured monthly except for Huntington Beach (which measures hourly if metal cleaning waste is present), and SONGS, Encina, and South Bay (which measure semiannually for the total combined in-plant waste). Organics are only measured at five stations at hourly to semiannual intervals (Table 1). Reporting limits only varied up to a factor of 11; however, most reporting limits for the constituents were not reported (Table 2).

Constituent concentrations and mass emission estimates of total in-plant waste were calculated using constituent analyses and flow rate measurements of the in-plant waste.

Monthly contaminant mass emissions of in-plant waste were estimated from the product of the mean daily flow of a particular type of in-plant waste (e.g., low volume, mud sump, metal cleaning) and its respective constituent concentration, and the number of days discharged in month *i*. These were summed over all months to obtain the annual estimate:

$$ME = \sum_{i=1}^{12} (F_i C_i D_i)$$

where F_i = mean daily flow in month *i*; C_i = constituent concentration in month *i*, or annual mean concentration (for months not measured); and D_i = number of days discharged in the month *i*.

Monthly constituent concentrations below the reporting limits were treated as zeros in mass calculations for the month. If a constituent concentration was not analyzed for a particular month or had unacceptable results — or if the sampling month was unknown (in the case of some semiannual measurements) — the annual mean constituent concentration was used in calculating mass emissions for that month. Monthly constituent mass emissions from all types of in-plant waste and from all the serial outfalls for a station were then combined by month to obtain the monthly sum. These data were then summed over all months to obtain the annual estimate for the station. The monthly sum for the station was then divided by the total volume of in-plant waste per month to obtain monthly in-plant constituent concentrations. Turbidity means are given for sanitary waste only.

If the annual mean for the total in-plant waste was below the reporting limit, this number was still reported. Mass emissions were estimated for all months with measurable concentrations even though annual mean constituent concentrations may have been below reporting limits.

The SONGS, Encina Power Plant (EPP) and South Bay Power Plant (SBP) report some of their in-plant constituent analyses results only as mass emissions, rather than as concentrations. In these cases, their estimates of mass were used for our mass emission estimates and to back-calculate to concentrations.

To estimate constituent mass emissions in the combined discharge, it was necessary to correct for mass emissions already present in the inlet seawater as it entered the generating station. To accomplish this, the estimate of the monthly constituent mass load in the inlet flow was subtracted from the monthly mass emission in the combined flow. The net monthly combined discharge amounts were then summed for the year. Monthly constituent mass loads of the inlet and combined flow were estimated from the product of the mean daily effluent flow, its respective constituent concentration, and the number of days discharged in the month. For inlet mass emissions, the mean daily effluent flow was calculated from the daily combined effluent flow minus the mean daily effluent flow of the in-plant waste.

Twelve stations measured constituents in their combined flow but only five measured inlet constituent concentrations in the cooling water (Mandalay, Ormond Beach, El Segundo, Redondo, and Alamitos Generating Stations). If the station did not measure its inlet constituent concentrations, the mean constituent concentrations (except for copper) of four stations (Mandalay, Ormond, El Segundo, and Redondo) were used to calculate the inlet mass loads. Copper concentrations from these four stations and inlet measurements from Alamitos Generating Station were not used towards the mean constituent concentration because of higher-than-normal results (due to improper sampling and analysis procedures). If the inlet concentrations were nondetectable for any of the four stations, natural seawater concentrations were used in place of the nondetectable concentration in the calculation of the mean of the four stations. Natural seawater concentrations were also used for stations that did not measure inlet copper. Natural seawater concentrations of arsenic (3 µg/L), copper (2 µg/L), mercury (0.0005 µg/L), and zinc (8 µg/L) were taken from data reported by the State Water Resources Control

Board (SWRCB) (1990). Those concentrations of cadmium (0.1 µg/L), chromium (0.3 µg/L), and lead (0.03 µg/L) were taken from Brewer (1975) because they were not listed in the SWRCB (1990). Only the Encina and South Bay stations measure suspended solids and oil and grease in their combined flow; but they do not measure inlet concentrations. Therefore, suspended solids and oil and grease in the combined flow are not estimated.

RESULTS

In 1995, the total cooling water flow of the 13 coastal power generating stations was 6,506 million gallons per day (mgd) (25 x 10^9 L/day) (Table 3). Daily flow rates of cooling water varied by a factor of 20 among the stations. The flow at SONGS was almost three times that of Alamitos Generating Station, the plant with the next highest flow. The total daily in-plant waste flow of all the generating stations was 4.1 mgd. The average daily flow of in-plant waste for individual stations was 0.3 mgd. Redondo Generating Station, Long Beach Generating Station (LBGS), and Ormond Beach Generating Station had the highest mean in-plant flows (1.38, 1.03, and 0.51 mgd or 5.22, 3.90, and 1.93 L/day, respectively, Table 4). Discharge temperatures ranged from 13 to 53 °C (55 to 128 °F) for all stations.

In-plant concentrations of suspended solids, oil and grease, biochemical oxygen demand (BOD), and ammonia-N were usually above reporting limits (Table 5). Settleable solids were usually nondetectable; cyanide was always nondetectable. Trace metals were detected from 0 to 100% with a slight majority (53%) being nondetectable. Phenols, DDTs, and PCBs were all nondetectable.

Seventy-seven percent of the constituent concentrations from in-plant waste varied by an order of magnitude or more among the power plants (Table 4a). At individual treatment plants, 65% of the annual mean constituent concentrations and toxicity values above reporting limits had coefficients of variation higher than 50%. Only SONGS, EPP, and SBPP analyzed chlorinated and nonchlorinated phenols, dichloro-diphenyl-trichloroethanes (DDTs), and polychlorinated biphenyls (PCBs) in their in-plant waste; all results were below reporting limits.

Mass emissions from in-plant waste also varied considerably among the power generating stations (Table 4b). The LBGS had the highest emissions of the major constituents (i.e., suspended solids and oil and grease). The combined emission of all trace metals from in-plant waste was 53 kg. The highest combined mass emission of trace metals from in-plant waste was copper at 19 kg.

Zinc was the most abundant trace metal discharged in the combined flow in 1995 (Table 6). Power generating stations accounted for 84% of the flow, 88% of the mercury mass emissions, and 31% of the cadmium mass emissions discharged to the SCB from municipal wastewater facilities and power generating stations (Table 7).

DISCUSSION

The annual combined volume of cooling water discharged from the power generating stations increased 17% from 1970 to 1994 but decreased 10% from 1994 to 1995 (Table 3, Figure 2) (SCCWRP 1973, 1989, 1990; Raco-Rands 1996). The volume of cooling water declined from 1987 to 1989 since utilities started importing more power generated outside of southern California.

In-plant flow from the power generating stations increased 41% from 1994 to 1995 (Table 8). However, the majority (57%) of constituents decreased in in-plant mass emissions from 1994 to 1995. Half (50%) of contributions of constituent mass emissions from in-plant waste of power generating stations to the SCB also decreased from 1994 to 1995.

Units for 1994 in-plant waste concentrations were incorrectly reported for some constituents in Raco-Rands (1996). The correct units are µg/L for cyanide, trace metals, phenols, DDT, and PCB.

Copper concentrations for both in-plant and combined flow in 1995 from Southern California Edison (SCE) generating stations (with the exception of Huntington Beach and SONGS) were unreliable due to improper sampling and analysis procedures, and therefore, not reported. In 1994, copper in combined effluents were nondetectable (<5-<10 µg/L) at SCE generating stations. In 1995, SCE found higher-than-normal results. SCE corrected various analytical lab procedures and removed brass fittings in an effluent sampling tube at Alamitos Generating Station. By April 1997, copper concentrations in the combined discharge were nondetectable (<5 µg/L) once again.

The estimated monthly concentrations of some in-plant waste constituents varied substantially at individual power plants (Table 4a). Coefficients of variation higher than 100% generally were attributable to a high proportion of monthly concentrations below reporting limits.

Estimated concentrations of in-plant waste constituents are calculated as a frame of reference, not as the true concentration at the time of discharge. Estimates of concentrations of most of the constituents are based on calculating mass emissions from various sources of in-plant waste from different serial outfalls for each power plant. These data were combined into one concentration. In reality, each serial outfall of a single power plant may have its own in-plant waste with different concentrations; and each source of in-plant waste (metal cleaning, sanitary

TABLE 1. Sampling frequency of constituents of in-plant waste effluent from power generating stations in southern California in 1995[a].

Constituent	Mandalay	Ormond	Scattergood	El Segundo	Redondo	Harbor
Suspended Solids	M	M	M (excludes CTB)	M	M	M
Settleable Solids	-	-	-	M (SW only)	-	-
BOD	-	-	-	M (SW only)	-	-
Oil and Grease	M	M	M (excludes CTB)	M	M	M
Ammonia-N	-	-	-	-	-	-
Cyanide	-	-	-	-	-	-
Turbidity	-	-	-	-	-	-
Arsenic	-	-	-	-	-	-
Cadmium	-	-	-	-	-	-
Chromium	-	-	M (CTB only)	-	-	-
Copper	M (MC only)	M (MC & NMC only)	M (MC & NMC only)	M (MC & NMC only)	M (MC & NMC only)	M (MC only)
Lead	-	-	-	-	-	-
Mercury	-	-	-	-	-	-
Nickel	-	-	-	-	-	-
Selenium	-	-	-	-	-	-
Silver	-	-	-	-	-	-
Zinc	-	-	M (CTB only)	-	-	-
Phenols[b]	-	-	-	-	-	-
Chlorinated Phenols[c]	-	-	-	-	-	-
Nonchlorinated Phenols[c]	-	-	-	-	-	-
Total DDT	-	-	-	-	-	-
Total PCB	-	-	-	-	-	-

Dash = Not analyzed.
BB = Boiler blowdown waste.
BOD = Biochemical oxygen demand.
CTB = Cooling tower blowdown waste.
H = Hourly.
I = In-plant waste.
M = Monthly.
MC = Metal cleaning waste.
NMC = Nonchemical metal cleaning waste.
NR = Not reported in power generating station's annual report.

waste, boiler blowdown, etc.) may be added to the cooling water at different times. Also, concentrations are diluted (99 to 11,000 times for 1995) by addition to the cooling water before it is discharged into the ocean.

Except for SONGS, EPP, and SBPP, which analyze trace metals in their combined in-plant flow, many of the stations did not have any metal concentrations for in-plant waste. These power generating stations are required only to measure trace metals in certain types of in-plant waste such as metal cleaning wastes, oil recovery system wastes (LBGS), and boiler blowdown wastes. Frequently, discharges of these types of waste do not occur during the year.

The results of this study indicate that the in-plant flow of the power generating stations was a minor source of contaminants to the SCB during 1995. MBC Applied Environmental Services (1988) also found during 1983 and 1984 that mass emissions from in-plant waste contributed by the generating stations to the Santa Monica Bay was small. Contributions of in-plant oil and grease, zinc, copper, nickel, chromium, lead, silver, and cadmium by Scattergood, El Segundo, and Redondo Generating Stations comprised only 0.02 to 0.2% of the combined mass emissions from various point and nonpoint sources to the Bay.

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Long Beach	Haynes	Alamitos	Huntington Beach	San Onofre	Encina	South Bay
M	M	M	H (MC),W (RB), BB,YD (1/discharge)	M	NR	NR
M (OR only)	M (SW only)	M (SW only)	-	M (SW only)	-	-
M (OR only)	M (SW only)	M (SW only)	-	-	-	-
M	M	M	H (MC),W (RB), BB,YD (1/discharge)	M	NR	NR
-	-	-	-	S	S	S
-	-	-	H (MC only)	S	S	S
-	-	-	-	M (SW only)	-	-
M (OR only)	-	-	H (MC only)	S	S	S
M (OR only)	-	-	H (MC only)	S	S	S
M (OR only)	-	-	H (MC only)	S[d]	S[d] (I), M (MC)	S[d] (I), M (MC)
-	M (MC & NMC only)	M (MC only)	H (MC only)	S	S	S
M (OR only)	-	-	H (MC only)	S	S	S
-	-	-	H (MC only)	S	S	S
-	-	-	H (MC only)	S	S	S
-	-	-	-	S	-	-
-	-	-	H (MC only)	S	S	S
-	-	-	H (MC only)	S	S	S
M (OR only)	-	-	-	-	-	-
-	-	-	H (MC only)	S	S	S
-	-	-	H (MC only)	S	S	S
-	-	-	-	S	S	S
-	-	-	-	S	S	S

OR = Oil recovery system waste.
RB = Retention basin waste.
S = Semiannually.
SW = Sanitary waste.
W = Weekly.
YD = Yard drain waste.
[a]Sampling frequency is for all sources of in-plant waste unless otherwise noted.
[b]EPA Method 420.2 (Colorimetric method).
[c]EPA Method 604 or 625 (GC/MS method).
[d]Only includes chromium VI.

SCCWRP. See Southern California Coastal Water Research Project.

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SWRCB. See State Water Resources Control Board.

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ACKNOWLEDGMENTS

The author thanks Lori Hosaka (formerly of SCCWRP); Steve Farnsworh, David Kay, and Danielle Chupa of the Southern California Edison Company; and the Los Angeles, Santa Ana, and San Diego Regional Water Quality Control Boards for providing monitoring data that were submitted to meet NPDES permit requirements. She also thanks M. James Allen for reviewing the manuscript.

TABLE 2. Reporting limits of in-plant waste effluent from power generating stations in southern California in 1995.

Constituent	Mandalay	Ormond	Scattergood	El Segundo	Redondo	Harbor	Long Beach	Haynes
Suspended Solids (mg/L)	NR	NR	2	NR	NR	2-3.2	1-10	NR
Settleable Solids (ml/L)	-	-	-	0.1	-	-	0.1	0.1
BOD (mg/L)	-	-	-	NR	-	-	4	1-11
Oil and Grease (mg/L)	NR	NR	3	NR	NR	3	1-5	3
Ammonia-N (mg/L)	-	-	-	-	-	-	-	-
Cyanide (µg/L)	-	-	-	-	-	-	-	-
Turbidity (NTU)	-	-	-	-	-	-	-	-
Arsenic (µg/L)	-	-	-	-	-	-	50	-
Cadmium (µg/L)	-	-	-	-	-	-	1-5	-
Chromium (µg/L)	-	-	15	-	-	-	2-10	-
Copper (µg/L)	No MC	NR	No MC or NMC	DNF	NR	No MC	-	NR
Lead (µg/L)	-	-	-	-	-	-	5-10	-
Mercury (µg/L)	-	-	-	-	-	-	-	-
Nickel (µg/L)	-	-	-	-	-	-	-	-
Selenium (µg/L)	-	-	-	-	-	-	-	-
Silver (µg/L)	-	-	-	-	-	-	-	-
Zinc (µg/L)	-	-	NR	-	-	-	-	-
Phenols (µg/L)	-	-	-	-	-	-	-	-
Chlorinated Phenols (µg/L)	-	-	-	-	-	-	-	-
Nonchlorinated Phenols (µg/L)	-	-	-	-	-	-	-	-
Total DDT (µg/L)	-	-	-	-	-	-	-	-
Total PCB (µg/L)	-	-	-	-	-	-	-	-

DNF = Data not found.

APPENDIX 1.
Names, locations, and organizations of the power generating stations that discharge to the Southern California Bight.

Power Generating Station	Location	Organization*
LOS ANGELES REGIONAL WATER QUALITY CONTROL BOARD		
Mandalay Generating Station	Oxnard	SCE
Ormond Beach Generating Station	Port Hueneme	SCE
Scattergood Generating Station	El Segundo	CLADWP
El Segundo Generating Station	El Segundo	SCE
Redondo Generating Station	Redondo Beach	SCE
Harbor Generating Station	Los Angeles Harbor	CLADWP
Long Beach Generating Station	Long Beach Harbor	SCE
Haynes Generating Station	Long Beach	CLADWP
Alamitos Generating Station	Long Beach	SCE
SANTA ANA REGIONAL WATER QUALITY CONTROL BOARD		
Huntington Beach Generating Station	Huntington Beach	SCE
SAN DIEGO REGIONAL WATER QUALITY CONTROL BOARD		
San Onofre Nuclear Generating Station (SONGS)	San Onofre	SCE
Encina Power Plant	Carlsbad	SDGE
Silvergate Power Plant	San Diego Bay	SDGE
Station "B" Power Plant	San Diego Bay	SDGE
South Bay Power Plant	San Diego Bay	SDGE

*CLADWP =City of Los Angeles Department of Water and Power.
SCE = Southern California Edison Company.
SDGE = San Diego Gas and Electric Company.

Alamitos	Huntington Beach	San Onofre	Encina	South Bay
NR	NR	2.5-10	NR	NR
NR	-	0.1	-	-
NR	-	-	-	-
NR	NR	2-2.8	0.2	NR
-	-	0.1	NR	NR
-	No MC	5	NR	NR
-	-	NR	-	-
-	No MC	10	NR	NR
-	No MC	5	NR	NR
-	No MC	10	NR	NR
NR	No MC	10	NR	NR
-	No MC	5	NR	NR
-	No MC	0.1-0.2	NR	NR
-	No MC	50	NR	NR
-	-	5	-	-
-	No MC	1	NR	NR
-	No MC	10	NR	NR
-	-	-	-	-
-	No MC	2	NR	NR
-	No MC	50	NR	NR
-	-	0.001	NR	NR
-	-	0.002	NR	NR

TABLE 3. Cooling water flows for power generating stations discharging to the Southern California Bight in 1970, 1987, 1989, 1994, and 1995.

	Cooling Water Flow [a] (mgd)				
Power Generating Station	1970[b]	1987[c]	1989[d]	1994[e]	1995
Mandalay Generating Station	230	200	167	201	203
Ormond Beach Generating Station	740	583	501	622	494
Scattergood Generating Station	180	273	71	344[f]	330
El Segundo Generating Station	360	316	306	283	306
Redondo Generating Station	710	618	541	587	470
Harbor Generating Station	80	182	27	64	110
Long Beach Generating Station	60[g]	102	75	112	102
Haynes Generating Station	760	910	193	785	655
Alamitos Generating Station	840	930	683	718	746
Huntington Beach Generating Station	470	201	170	146	145
San Onofre Nuclear Generating Station	400	2,310	2,467	2,436	2,061
Encina Power Plant	160[g]	404	400	462	453
Silvergate Power Plant	160[g]	3	5	2	-[h]
Station “B” Power Plant	70[g]	2	1	1	-[h]
South Bay Power Plant	360[g]	392	390	472	431
Total	5,580	7,426	5,997	7,235[f]	6,506

[a]Values do not include in-plant waste.
[b]SCCWRP (1973).
[c]SCCWRP (1989).
[d]SCCWRP (1990).
[e]Raco-Rands (1996).
[f]Correction of Raco-Rands (1996).
[g]Estimated values for the year 1971.
[h]No longer in operation.
mgd = million gallons per day (1 mgd= 3,785,000 L/day).

TABLE 4. In-plant waste effluents from power generating stations discharging to the Southern California Bight in 1995.

a) Flow and annual constituent concentrations[a]

	Mandalay		Ormond Beach		Scattergood		El Segundo		Redondo		Harbor		Long Beach	
Constituent	Mean[a]	CV	Mean[a]	CV	Mean[a]	CV	Mean[a]	CV	Mean[a]	CV	Mean[a]	CV	Mean[a]	CV
In-plant Flow (mgd)	0.07	103	0.51	44	0.17	42	0.15	3	1.38	40	0.06	57	1.03	39
In-plant Flow (million L/day)	0.26	103	1.93	44	0.64	42	0.57	3	5.22	40	0.23	57	3.90	39
Suspended Solids (mg/L)	7	33	5.20	31	7	88	41.9	163	15.6	140	1.6	107	26.6	85
Settleable Solids(mL/L)	-	-	-	-	-	-	<0.001	-	-	-	-	-	<0.1	-
BOD (mg/L)	-	-	-	-	-	-	0.06	51	-	-	-	-	0.16	50
Oil and Grease (mg/L)	6	33	5.74	38	0.6	159	5.8	60	4.6	39	<3	-	7.1	53
Ammonia-N (mg/L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cyanide (µg/L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Toxicity (TUa)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic (µg/L)	-	-	-	-	-	-	-	-	-	-	-	-	0.28	52
Cadmium (µg/L)	-	-	-	-	-	-	-	-	-	-	-	-	<5[e]	-
Chromium (µg/L)	-	-	-	-	<15	-	-	-	-	-	-	-	0.077	109
Copper (µg/L)	-	-	nd	-	-	-	-	-	nd	-	-	-	-	-
Lead (µg/L)	-	-	-	-	-	-	-	-	-	-	-	-	<10[e]	-
Mercury (µg/L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel (µg/L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Selenium (µg/L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Silver (µg/L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zinc (µg/L)	-	-	-	-	16.9	100	-	-	-	-	-	-	-	-
Phenols (µg/L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chlorinated	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nonchlorinated	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DDT (µg/L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PCB (µg/L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-

b) Estimated flow volume and constituent mass emissions.

Constituent	Mandalay	Ormond Beach	Scattergood	El Segundo	Redondo	Harbor	Long Beach	Haynes
In-plant Flow (L x 10^9/ yr)	0.09	0.71	0.24	0.21	1.92	0.08	1.42	0.10
Suspended Solids (mt)	0.60	3.5	1.7	8.9	33	0.15	44	1.3
BOD (mt)	-	-	-	0.01	-	-	0.05	0.02
Oil and Grease (mt)	0.65	4.6	0.18	1.2	8.5	-	9.5	0.03
Ammonia-N (mt)	-	-	-	-	-	-	-	-
Cyanide (kg)	-	-	-	-	-	-	-	-
Arsenic (kg)	-	-	-	-	-	-	0.10	-
Cadmium (kg)	-	-	-	-	-	-	-	-
Chromium (kg)	-	-	-	-	-	-	0.02	-
Copper (kg)	-	-	-	-	-	-	-	0.24
Lead (kg)	-	-	-	-	-	-	-	-
Mercury (kg)	-	-	-	-	-	-	-	-
Nickel (kg)	-	-	-	-	-	-	-	-
Selenium (kg)	-	-	-	-	-	-	-	-
Silver (kg)	-	-	-	-	-	-	-	-
Zinc (kg)	-	-	3.7	-	-	-	-	
Phenols (kg)	-	-	-	-	-	-	-	-
Chlorinated	-	-	-	-	-	-	-	-
Nonchlorinated	-	-	-	-	-	-	-	-
DDT (kg)	-	-	-	-	-	-	-	-
PCB (kg)	-	-	-	-	-	-	-	-

[a]The number of significant figures of constituent concentrations are those reported by the power generating stations.
[b]Includes only retention basin data. Data does not include yard drains or boiler blowdown wastes.
[c]Calculated from estimates of discharges given in units of pounds per day.
[d]Unit 1 in-plant waste was not analyzed for 1995.
[e]Maximum detection limit reported.
CV = Coefficient of variation.
NTU = Nephelometric turbidity units.
TUa = (toxic units acute) = 100/96hr LC50 (percent waste giving 50% survival). If greater than 50% survival: TUa= Log (100-percent survival in 100% waste)/1.7.
UR = Unreliable results due to improper sampling and analysis procedures.
nd = not detected.

Haynes		Alamitos		Huntington Beach		San Onofre		Encina		South Bay	
Mean[a]	CV	Mean[a]	CV	Mean[a,b]	CV	Mean[a]	CV	Mean[a]	CV	Mean[a]	CV
0.07	54	0.07	14	0.05	167	0.44	16	0.05	32	0.05	25
0.26	54	0.26	14	0.19	167	1.67	16	0.19	32	0.19	25
12	65	14.4	32	11.8	23	7.8[c]	54	1.8	239	6.7	110
<0.1	-	0.002	17	-	-	0.04	343	-	-	-	-
0.2	112	0.3	150	-	-	-	-	-	-	-	-
0.4	233	4.0	56	4.2	62	2.1[c]	65	0.5	94	1.9	26
-	-	-	-	-	-	<0.1[d]	-	2.5[c]	4	3.2[c]	39
-	-	-	-	-	-	<5[d]	-	nd	-	nd	-
-	-	-	-	-	-	22	107	-	-	-	-
-	-	-	-	-	-	-	-	nd	-	-	-
-	-	-	-	-	-	<10[d]	-	7[c]	141	nd	-
-	-	-	-	-	-	<5[d]	-	7[c]	65	2[c]	141
-	-	-	-	-	-	<10[d]	-	4[c]	141	34[c]	9
45	114	UR	-	-	-	<10[d]	-	98[c]	39	188[c]	47
-	-	-	-	-	-	<5[d]	-	30[c]	91	80[c]	3
-	-	-	-	-	-	<0.2[d,e]	-	4[c]	141	nd	-
-	-	-	-	-	-	<50[d]	-	53[c]	70	67[c]	3
-	-	-	-	-	-	<5[d]	-	-	-	-	-
-	-	-	-	-	-	<1[d]	-	nd	-	nd	-
-	-	-	-	-	-	<10[d]	-	20[c]	141	173[c]	28
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	nd[d]	-	nd	-	nd	-
-	-	-	-	-	-	nd[d]	-	nd	-	nd	-
-	-	-	-	-	-	nd[d]	-	nd	-	nd	-
-	-	-	-	-	-	nd[d]	-	nd	-	nd	-

Alamitos	Huntington Beach[b]	San Onofre	Encina	South Bay	Total
0.10	0.07	0.67	0.07	0.07	5.74
1.4	0.91	4.7[c]	0.12	0.41	101
0.03	-	-	-	-	0.11
0.40	0.14	1.3[c]	0.03	0.13	27
-	-	-	0.16[c]	0.21[c]	0.37
-	-	-	-	-	-
-	-	-	0.48[c]	-	0.58
-	-	-	0.48[c]	0.14[c]	0.62
-	-	-	0.28[c]	2.2[c]	2.5
UR	-	-	6.3[c]	12[c]	19
-	-	-	2.0[c]	5.2[c]	7.2
-	-	-	0.25[c]	-	0.25
-	-	-	3.4[c]	4.3[c]	7.7
-	-	-	-	-	0
-	-	-	-	-	0
-	-	-	1.3[c]	11[c]	16
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-

TABLE 5. Percent of detectable constituent measurements[a] which were used to calculate annual means and mass emissions of in-plant waste effluent from power generating stations in southern California in 1995.

Constituent	Mandalay	Ormond	Scattergood	El Segundo	Redondo	Harbor
Suspended Solids	100	100	67	97	100	67
Settleable Solids	-	-	-	8	-	-
BOD	-	-	-	96	-	-
Oil and Grease	100	100	17	89	100	0
Ammonia-N	-	-	-	-	-	-
Cyanide	-	-	-	-	-	-
Turbidity	-	-	-	-	-	-
Arsenic	-	-	-	-	-	-
Cadmium	-	-	-	-	-	-
Chromium	-	0	0	-	-	-
Copper	No MC	0	No MC or NMC	DNF	0	No MC
Lead	-	-	-	-	-	-
Mercury	-	-	-	-	-	-
Nickel	-	-	-	-	-	-
Selenium	-	-	-	-	-	-
Silver	-	-	-	-	-	-
Zinc	-	-	100	-	-	-
Phenols	-	-	-	-	-	-
Chlorinated Phenols	-	-	-	-	-	-
Nonchlorinated Phenols	-	-	-	-	-	-
Total DDT	-	-	-	-	-	-
Total PCB	-	-	-	-	-	-

[a]Measurements from all sources of in-plant waste at the individual plants were combined.

TABLE 6. Estimated mass emissions in combined discharge[a] corrected for mass emissions in the inlet seawater from power generating stations discharging to the Southern California Bight in 1995.

Constituent	Mandalay	Ormond Beach	Scattergood[b]	El Segundo	Redondo	Harbor[b]	Long Beach[b]
Nitrate (mt)	-	0.2	6.2	0.1	-	-	NA
Ammonia-N (mt)	-	-	-	-	-	NA	-
Arsenic (kg)	-	-	-	-	-	-	-
Cadmium (kg)	374	-	-	-	5	-	-
Chromium (kg)	-	-	-	-	-	-	-
Copper (kg)	-	UR	-	UR	UR	1,766	UR
Lead (kg)	-	-	-	-	-	443	-
Mercury (kg)	-	-	37	82	6.2	12	-
Zinc (kg)	-	-	9,393	-	-	4,536	761

Constituent	Haynes[b]	Alamitos	Huntington Beach	San Onofre	Encina[b]	South Bay[b]	Total
Nitrate-N (mt)	NA	NA	NA	NA	NA	NA	6.5
Ammonia-N (mt)	NA	-	NA	-	5.0	-	5.0
Arsenic (kg)	-	-	NA	-	-	57	57
Cadmium (kg)	-	266[c]	NA	-	-	-	645
Chromium (kg)	-	-	NA	-	-	402	402
Copper (kg)	-	UR	NA	-	-	188	1,954
Lead (kg)	-	-	NA	-	-	734	1,177
Mercury (kg)	66	21[c]	NA	-	-	-	224
Zinc (kg)	3,823	-	NA	-	-	-	18,513

Dash = Nondetectable concentration or mass in the inlet seawater was greater than in the combined flow.
[a]Includes low volume waste and cooling water.
[b]These generating stations do not measure inlet concentrations. The mean of Mandalay, Ormond, El Segundo, and Redondo measurements were used to correct for inlet mass emissions. Alamitos measurements were not used towards the mean due to improper sampling and analysis procedures.
[c]Possibly high readings.
NA = Not analyzed.
UR = Unreliable results due to improper sampling and analysis prodedures.

Long Beach	Haynes	Alamitos	Huntington Beach	San Onofre	Encina	South Bay
100	100	100	100	58	36	92
0	0	100	-	10	-	-
100	67	100	-	-	-	-
93	10	100	100	43	64	100
-	-	-	-	0	100	100
-	-	-	No MC	0	0	0
-	-	-	-	100	-	-
100	-	-	No MC	0	50	0
0	-	-	No MC	0	100	50
100	-	-	No MC	0	50	100
-	100	UR	No MC	0	100	100
0	-	-	No MC	0	100	100
-	-	-	No MC	0	50	0
-	-	-	No MC	0	100	100
-	-	-	-	0	-	-
-	-	-	No MC	0	0	0
-	-	-	No MC	0	50	100
0	-	-	-	-	-	-
-	-	-	No MC	0	0	0
-	-	-	No MC	0	0	0
-	-	-	-	0	0	0
-	-	-	-	0	0	0

TABLE 7. Comparison of constituent mass emissions of effluent from power generating stations, and large (>150 mgd) and small (<25 mgd) municipal wastewater treatment facilities that discharged to the Southern California Bight in 1995.

	Mass Emissions				Percent of Total		
Constituent	Power Plants (n=13)	Large POTWs[b] (n=4)	Small POTWs[c] (n=15)	Total	Power Plants	Large POTWs	Small POTWs
Total Flow (mgd)	6,511[d]	1,106	143	7,760	84	14	2
Cooling Water	6,506	-	-	-	-	-	-
Effluent	4.1[e]	1,106	143	1,253	0.3	88	11
Suspended Solids (mt)	101[f]	73,463	1,924	75,488	0.13	97	3
BOD (mt)	0.11	137,999	2,364	140,363	<0.001	98	2
Oil and Grease (mt)	27[f]	19,198	463	19,688	0.14	98	2
Nitrate-N	6.5	265	152	424	1.53	63	36
Ammonia-N (mt)	5.0	41,337	3,559	44,901	<0.001	92	8
Cyanide (kg)	nd	6,500	1,500	8,000	-	81	19
Arsenic (kg)	57	5,000	380	5,437	1.05	92	7
Cadmium (kg)	645	980	450	2,075	31	42	22
Chromium (kg)	402	7,000	1,400	8,802	5	80	16
Copper (kg)	1,954	53,000	6,800	61,754	3	86	11
Lead (kg)	1,177	2,400	2,400	5,977	20	40	40
Mercury (kg)	224	20	10	254	88	8	4
Nickel (kg)	7.7	30,000	2,700	32,708	0.02	92	8
Silver (kg)	nd	5,400	630	6,030	-	90	10
Zinc (kg)	18,513	86,000	16,000	120,513	15	71	13
DDT (kg)	nd	3.1	0.3	3	-	91	9
PCB (kg)	nd	nd	nd	-	-	-	-

[a]Corrected for constituent mass emissions in the inlet water.
[b]Hyperion Wastewater Treatment Plant (City of Los Angeles), Joint Water Pollution Control Plant (County Sanitation Districts of Los Angeles County), Wastewater Treatment Plants 1 and 2 (County Sanitation Districts of Orange County), and Point Loma Wastewater Treatment Plant (City of San Diego). See *Characteristics of effluents of large municipal wastewater facilities in 1995* in this report.
[c]See *Characteristics of effluents from small municipal wastewater facilities in 1995* in this report.
[d]Combined discharge (includes cooling water and in-plant waste effluent flow).
[e]In-plant waste effluent.
[f] Only includes in-plant waste effluent. Encina and South Bay's measurements of combined discharge are not included because there are no inlet measurements to correct for the mass found in seawater coming into the plants.
POTWs = Publicly owned treatments works.

FIGURE 2. Cooling water flow from coastal power generating stations in southern California from 1970 to 1995 (MGD = millions of gallons per day). CLADWP = City of Los Angeles, Department of Water and Power; SCE = Southern California Edison Company; SDGE = San Diego Gas and Electric Company.

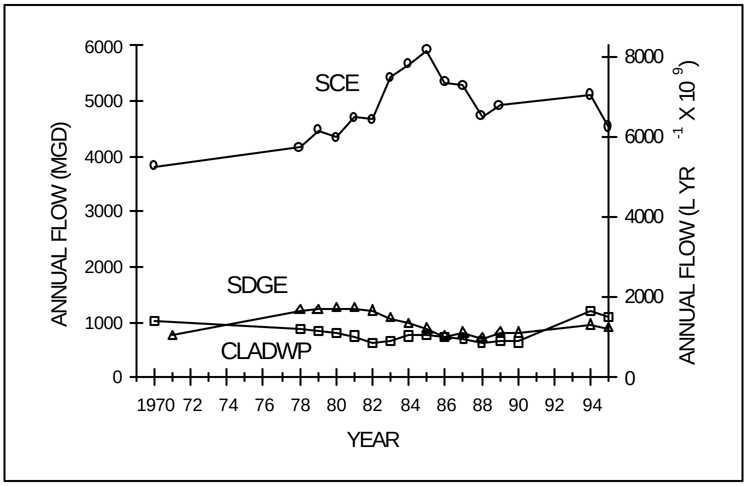

TABLE 8. Estimates of mass emissions of constituents of in-plant waste from the power generating stations that discharged to the Southern California Bight from 1994 to 1995.

Constituent	1994[b]	1995	Percent Change 1994-1995	Contribution of Power Plants as Percent of Total POTW & Power Plant Effluents[a] 1994[b]	1995	Difference in Percent Contribution 1994-1995
In-plant Flow (mgd)	2.9	4.1	41	0.2[c]	0.3	0.1
Suspended Solids (mt)	46[c]	101	120	0.07	0.13	0.06
BOD (mt)	0.06	0.11	83	0.00004	0.00008	0.00004
Oil and Grease (mt)	15	27	80	0.08	0.14	0.06
Ammonia-N (mt)	0.31	0.37	19	0.0007	0.0008	0.0001
Cyanide (kg)	0.025	nd	-100	0.0002	0	-0.0002
Arsenic (kg)	1.4	0.58	-59	0.03	0.01	-0.02
Cadmium (kg)	0.006	0.62	10,233	0.0004	0.04	0.04
Chromium (kg)	9.1	2.5	-73	0.1	0.03	-0.08
Copper (kg)	1,277	19	-99	2.4	0.03	-2.4
Lead (kg)	329	7.2	-98	7.4	0.15	-7.3
Mercury (kg)	0.17	0.25	47	0.4	0.83	0.4
Nickel (kg)	12	7.7	-36	0.004	0.02	0.02
Silver (kg)	19	nd	-100	0.3	0	-0.3
Zinc (kg)	119	16	-87	0.1	0.02	-0.1
DDT (kg)	nd	nd	-	-	-	-
PCB (kg)	nd	nd	-	-	-	-

[a]Total of effluent from in-plant waste of the power generating stations and final effluent of the small and large municipal wastewater treatment facilities.
[b]Raco-Rands (1996).
[c]Correction of Raco-Rands (1996).