Characteristics of effluents from non-power industrial facilities in 2000

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ABSTRACT - Industrial facilities represent a diverse class of point source dischargers that can be separated into one of two categories: power generating stations and non-power-related industries. In 2000, non-power industries in southern California consisted of facilities such as petroleum refineries, a chemical plant, aquarium/research institutions, and a salt plant. The types of non-power industries that discharge to the SCB can vary yearly, making industrial discharges an unpredictable source of contaminants to the SCB. In 2000, seven non-power industrial facilities discharged treated effluents to harbors, storm channels, and the coastal ocean within the SCB. Emissions from these facilities were characterized for the year 2000, and compared to data from studies conducted in previous years. In 2000, non-power industrial facilities discharged a combined total of 12.4 x 10^9 liters (L) of effluent to the SCB, for which petroleum-related industrial facilities accounted for 83%. The total effluent volume in 2000 represented a 45% decrease from the volume discharged by industrial sources in 1995. Constituent mass emissions also decreased between 7% (arsenic) and over 95% (suspended solids, CBOD, oil/grease, cadmium, chromium, mercury, zinc, and phenols) from 1995 to 2000. Decreases in effluent volumes and contaminants can be attributed to a general decline in the presence of pollutants in the waste stream of industrial facilities, as well as to a decrease in the number of industrial facilities with direct discharge to the coastal ocean. Since 1971, the number of industrial facilities has decreased by approximately 93%, the total volume of non-power industrial effluent has decreased by 93%, and constituent mass emissions have decreased by greater than 98%. Increased regulations placed on industrial facilities, resulting in decreases in the number of facilities with direct discharges to the SCB and improvements in industrial effluent quality, is the primary reason for significant historical changes in emissions from non-power industrial facilities. When compared to large POTWs in 2000, industrial facilities represented a relatively insignificant fraction of the total pollutant load from both sources combined, accounting for only 0.8% of the total effluent volume, and typically less than 0.1% of the load for any given constituent. Ultimately, in 2000, industrial discharges were an insignificant source of pollutants to the SCB.

INTRODUCTION

The coastal ocean within the Southern California Bight (SCB) is an important recreational and economic resource. As home to almost 17 million people (U.S. Census Bureau 2002), Southern California is one of the most densely populated coastal regions in the U.S. (Culliton *et al*. 1990). More than 175 million beach-goer days occur annually, helping to drive a tourism industry that generates an estimated $9 billion in ocean-related activities each year (Schiff *et al*. 2002). The significance of the coastal ocean as a recreational resource is mitigated by its necessity for other purposes, many of which result in the discharge of pollutants to coastal waters. Among these sources of contaminants are treated municipal wastewater, industrial effluents, stormwater runoff, and discharges from power generating stations, oil platforms, and dredging projects.

Industrial facilities represent a diverse class of point source dischargers, which were separated into two categories: power generating stations and non-power industries. In 2000, seven industrial facilities were non-power industries, including three petroleum refineries, a chemical plant, a salt company, and two aquarium/research facilities (Figure 1, Appendix I). Discharges from petroleum-related facilities included refinery process water, cooling tower bleed-off water, and non-contact or contact cooling water. Examples of discharges from other non-power industries included aquarium facility discharges of re-circulated seawater and sand filter backwash water. Unlike discharges from facilities such as wastewater treatment plants, non-power industrial discharges can vary drastically from year to year (Raco-Rands 1999). For this reason, it is important to continually monitor the impact of these discharges to the SCB so that managers have the necessary information to establish relevant policy as needed.

Non-power industrial facilities (hereafter referred to as simply 'industrial facilities') were independently

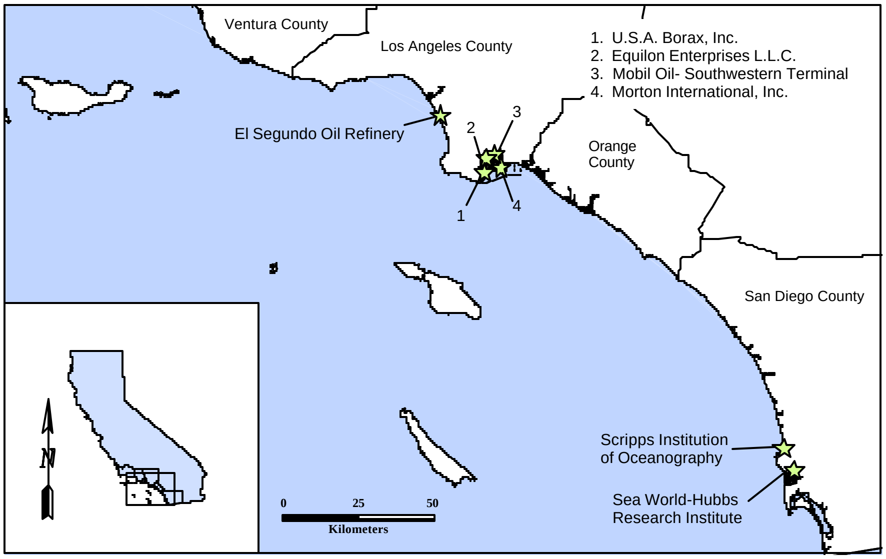

Figure 1. Locations of non-power industrial facilities that discharged to the SCB in 2000.

regulated by separate Regional Water Quality Control Boards (Los Angeles RWQCB or San Diego RWQCB) in 2000, which conducted regulatory assessments on a per-facility basis. Since regional-scale assessments of industrial discharges have not been part of the standard regulatory framework, a standard monitoring program to regulate all industrial facilities has not been developed. While this does not impair the direct regulation of these facilities, it poses a considerable challenge when trying to make regional-scale assessments of industrial facility discharges, and hinders the ability to compare discharges among industrial facilities and to other types of point sources.

The purpose of this study was to compile and characterize effluent information from industrial dischargers to the SCB in 2000. These objectives were accomplished by (1) developing a unified data management system that utilized a single methodology for making effluent characterizations, (2) calculating the average flows, concentrations, and mass emissions for each industrial facility for select constituents in 2000, (3) comparing these estimates to historical discharges from industrial facilities, with particular emphasis on comparing 1995 and 2000 emission estimates, and (4) comparing industrial effluent discharges in 2000 to pollutant load estimates for large municipal wastewater treatment facilities (large publicly owned treatment works, POTWs) during the same year. Comparison to large POTWs provided a frame of reference for assessing the relative significance of industrial discharges to the SCB.

METHODS

Industrial facilities included in this study were selected based on discharge receiving waters and permit classifications. Facilities that discharged directly to the SCB or within the tidal prism of a storm channel or river were included, while facilities that discharged to freshwater were excluded. In addition, industrial facilities that possessed only stormwater permits were excluded.

Effluent chemistry and flow data for 2000 were obtained from monthly, quarterly, and annual discharge monitoring reports from the individual industrial facilities. Analytical methods (Appendix II), reporting levels (Appendix III), and analysis frequencies (Appendix IV) were obtained either from laboratory reports or discharge monitoring reports, or from personnel at the individual facilities. Historical data were obtained from previous assessments of industrial discharges to the SCB. Data for 1971, 1987, 1989, and 1995 were obtained from SCCWRP (1973), SCCWRP (1989), Schafer (1989), and Raco-Rands (1999), respectively. Comparison of 1995 and 2000 mass emission estimates were emphasized to highlight particular trends in industrial discharges to the SCB. Data for large POTWs in 2000 were obtained from Steinberger and Schiff (2003).

In 1971, the characterization of industrial effluents included discharges from offshore oil production and transport industries. These types of facilities have since become their own category of point source discharges. Effluents from these facilities had to be removed from the historical data so that 1971 estimates could be directly compared to data for the following years. Because the 1971 data were reported such that direct exclusion of the oil production and transport facilities was not possible, constituent mass emissions had to be estimated from the relative flow rates from several categories of industrial discharges. Consequently, data for 1971 reported herein are relative estimates and are not intended to represent absolute values.

The constituents chosen for this assessment did not represent the entirety of effluent analyses conducted by the individual facilities. Specific parameters were chosen based on the existence of historical data, and based on the known influence of these constituents in the marine environment. Since this assessment was first made in 1973 (SCCWRP 1973), several constituents, or categories of constituents, have been added based on an increase in scientific understanding of their impacts. This report continues this level of assessment, which includes the analysis of various metals, nutrients, DDTs, PAHs, PCBs, toxicity bioassays, and general constituents such as suspended solids, BOD, and oil and grease.

Annual average flow-weighted concentrations (FWC) and mass emission estimates (ME) were calculated for the year 2000. In order to perform these calculations, the chemistry data were standardized to monthly time steps. For constituents analyzed at a frequency greater than once per month, this entailed calculation of an arithmetic mean of all samples in a given month. Where the frequency of constituent analysis was less than monthly, an arithmetic average of available data within the given year was calculated. This average was then used to populate months for which no data existed. This latter manipulation is based on the assumption that given constituent concentrations were temporally consistent for any given month in the year. Furthermore, constituent measurements that were below the reporting level for the analysis were assigned as having zero concentration in the effluent.

Mass emission estimates were calculated from the product of the mean daily flow, the constituent concentration, the number of days in the given month, and a unit conversion factor. Mass emissions were calculated for each constituent for each month, and then summed over all months in the year to obtain an annual estimate:

$$ME_{const} = \sum_{i=1}^{12} \mu\,(F_i * C_i * D_i)$$

where

ME_{const} = Mass emissions of a particular constituent
F_i = Mean daily flow in month *i*
C_i = Constituent concentration for month *i*
D_i = Number of days of discharge in month *i*
μ = Unit conversion factor (varies depending on units of concentration measurement)

Flow-weighted concentrations were calculated by dividing the annual mass emission for a given constituent by the total annual volume of effluent. This calculation was then corrected by a unit conversion factor to obtain the proper units for the specific parameter:

$$FWC_{const} = \mu * \frac{ME_{const}}{AEV}$$

where

FWC_{const} = Flow-weighted concentration of a particular constituent
μ = Unit conversion factor (varies depending on units of concentration measurement)
ME_{const} = Mass emissions of a particular constituent
AEV = Annual effluent volume

Effluent volume was the product of the month-averaged mean daily flow and the number of days of discharge in the given month. Annual effluent volumes were then a sum of these monthly volumes:

$$AEV = \sum_{i=1}^{12} \mu\,(F_i * D_i)$$

where

AEV = Annual effluent volume
F_i = Mean daily flow in month *i*
D_i = Number of days of discharge in month *i*
μ = 3.785×10^{-3}

Annual average concentrations that were less than the reporting level (RL) for a given constituent resulted from the use of zeroes when a result was reported as less than the RL. These concentrations were reported as calculated, even though they were below the detection level. Where FWC calculations resulted in a zero value, the result was reported as not detected (nd), or as less than the RL for that constituent. Where more than one RL was used during the year for a given constituent and facility, the greater RL was used.

Industrial facilities utilized mostly external contract laboratories for chemical analysis of their wastewater effluent. Significant figures were retained in reporting the detection levels used by the contract laboratories for effluent chemical analyses. Reporting levels often changed within the year for several facilities, all of which were tabulated herein. Several facilities only reported method detection limits (MDLs), as opposed to RLs; where this was the case, the MDL was listed. When the actual frequency of constituent analysis was not indicated, the analysis frequency was listed as the frequency of reporting.

Two permitted facilities, the Tosco (Unocal) L.A. Oil Refinery and the Watson (Arco) Oil Refinery, did not discharge any effluent to the SCB in 2000. These facilities were therefore not included in this assessment, although both were operational. U.S. Borax, Inc. was not required to analyze for ammonia-N as in previous years. The only two analyses conducted by this facility were acute toxicity and residual chlorine; as a result, only data from their acute toxicity studies were included. For general assessments, industrial facilities were often grouped into petroleum-related and non-petroleum-related facilities. In 2000, three of the seven facilities were petroleum-related industries.

RESULTS

Effluent Flows and Volume in 2000

The combined total flow from industrial facilities in 2000 was 9.0 million gallons per day (mgd) (Table 1). Average daily flows varied between facilities by four orders of magnitude, ranging from 0.002 mgd (Southwestern Terminal) to 6.7 mgd (El Segundo). Petroleum-related industries accounted for 82% of the total effluent flow from non-power-related industrial facilities in 2000. The El Segundo Oil Refinery discharged 92% of the effluent volume from petroleum-related facilities, and 74% of the total effluent volume from all industrial facilities. The total volume of effluent discharged to the SCB in 2000 was 12.4 x 10^9 L.

Four of the seven facilities in this study discharged effluent ultimately to the Los Angeles/ Long Beach Harbor in 2000 (Table 1). These four facilities discharged a combined total of approximately 1.9 x 10^9 L of effluent. Discharge from the Equilon facility was not consistent throughout the entire year. Intermittent discharges occurred in May (24 d), July-September (8-15 d), and December (1 d); there was no discharge from this facility in June of 2000. Southwestern Terminal did not discharge effluent in February-May and October of 2000. El Segundo discharged 9.3 x 10^9 L of effluent to the Santa Monica Bay. Combined, Scripps Institution of Oceanography (SIO) and Sea World discharged approximately 1.2 x 10^9 L of effluent to the San Diego coastal region. Sea World discharged effluent to Mission Bay, while SIO discharged effluent directly to the Pacific Ocean.

Annual Average Concentrations and Toxicity in 2000

Estimated annual average concentrations for the majority of constituents varied by less than a factor of 10 among facilities in 2000 (Table 2). The greatest variances occurred for constituents that were often not detected. Approximately 40% of general constituent measurements (i.e., suspended solids, oil/ grease, BOD) were below detection levels. For detectable measurements of these constituents, average annual concentrations were typically less than 10 mg/L. The only exceptions were in discharges of suspended solids (49 mg/L) and BOD (23 mg/L) from Morton Salt and Equilon, respectively. Petroleum-related industries generally analyzed

Table 1. Flow rates and receiving waters of non-power industrial effluents in 2000.

Facility	Outfall	Flow (mgd)	Receiving Waters
Southwestern Terminal	-	0.002	Los Angeles Inner Harbor
El Segundo	-	6.7	Santa Monica Bay
Equilon	-	0.65	Dominguez Channel
Morton Salt	-	0.004	Long Beach Harbor
Borax	003	0.34	Los Angeles Inner Harbor
	009	0.36	
SIO	001	0.42	Pacific Ocean
	002	0.002	
	003	0.17	
Sea World	-	0.27	Mission Bay
Total Flow		**9.0**	

Dash = Not applicable, only one outfall.
SIO = Scripps Institution of Oceanography.

Table 2. Annual average constituent concentrations and coefficients of variance (CV) for non-power industrial facilities in 2000.

	Southwestern Terminal		El Segundo Oil Refinery		Equilon		Morton Salt		Borax				Scripps Institution of Oceanography						Sea World	
									003		009		001		002		003			
Constituent	Mean	CV%	Mean	CV%	Mean	CV%	Mean	CV%	Mean	CV%	Mean	CV%	Mean	CV%	Mean	CV%	Mean	CV%	Mean	CV%
Flow (mgd)	0.002	140	6.7	10	0.65	92	0.004	106	0.34	17	0.36	1	0.42	4	0.002	0.01	0.17	0	0.27	30
Suspended Solids (mg/L)	1.2	98	< 15	-	7.7	72	49	48	na	-	na	-	< 20	-	< 20	-	< 20	-	0.90	92
Settleable Solids (mL/L)	< 1	-	< 0.2	-	< 0.08	-	< 0.1	-	na	-	na	-	< 0.2	-	< 0.2	-	< 0.2	-	0.03	174
BOD (mg/L)	5.0	107	na	-	23	39	na	-	na	-	na	-	na	-	na	-	na	-	na	-
CBOD (mg/L)	na	-	< 20	-	na	-	na	-	na	-	na	-	na	-	na	-	na	-	na	-
Oil/Grease (mg/L)	5.2	66	< 5	-	4.6	59	2.5	63	na	-	na	-	< 1	-	< 1	-	< 1	-	na	-
Ammonia-N (mg/L)	na	-	2.2	122	2.1	47	na	-	na	-	na	-	na	-	na	-	na	-	0.04	84
Cyanide (mg/L)	na	-	< 0.0156	-	na	-	na	-	na	-	na	-	na	-	na	-	na	-	na	-
Turbidity (NTU)	24	67	3.5	29	na	-	na	-	na	-	na	-	0.77	42	0.47	19	0.87	55	0.47	42
Arsenic (ug/L)	na	-	23	40	1.5	95	na	-	na	-	na	-	na	-	na	-	na	-	na	-
Cadmium (ug/L)	na	-	< 1.3	-	0.02	296	na	-	na	-	na	-	na	-	na	-	na	-	na	-
Chromium (ug/L)	na	-	< 5.8	-	1.4	109	na	-	na	-	na	-	na	-	na	-	na	-	na	-
Copper (ug/L)	na	-	2.0	346	3.0	64	na	-	na	-	na	-	3.8[a]	200	na	-	na	-	na	-
Lead (ug/L)	na	-	< 2.38	-	1.3	134	na	-	na	-	na	-	na	-	na	-	na	-	na	-
Mercury (ug/L)	na	-	< 0.20	-	< 0.2	-	na	-	na	-	na	-	na	-	na	-	na	-	na	-
Nickel (ug/L)	na	-	1.4	346	5.5	35	na	-	na	-	na	-	na	-	na	-	na	-	na	-
Selenium (ug/L)	na	-	99	24	3.3	316	na	-	na	-	na	-	na	-	na	-	na	-	na	-
Silver (ug/L)	na	-	< 1.4	-	0.25	316	na	-	na	-	na	-	na	-	na	-	na	-	na	-
Zinc (ug/L)	na	-	< 175	-	63	47	na	-	na	-	na	-	na	-	na	-	na	-	na	-
Acute Toxicity (TUa)	na	-	-	-	-	-	na	-	-	-	-	-	na	-	na	-	na	-	-	-
Macrocystis pyrifera (germination)	-	-	na	-	na	-	-	-	na	-	na	-	-	-	-	-	-	-	< 1	-
Macrocystis pyrifera (growth)	-	-	na	-	na	-	-	-	na	-	na	-	-	-	-	-	-	-	< 1	-
Gasterosteus aculeatus (survival)	-	-	na	-	na	-	-	-	0.44	81	0.25	119	-	-	-	-	-	-	na	-
Pimephales promelas (survival)	-	-	0.17	158	1.0	0	-	-	na	-	na	-	-	-	-	-	-	-	na	-
Strongylocentrotus purpuratus (fertilization)	-	-	na	-	na	-	-	-	na	-	na	-	-	-	-	-	-	-	< 1	-
Atherinops affinis (growth)	-	-	na	-	na	-	-	-	na	-	na	-	-	-	-	-	-	-	< 1	-
Atherinops affinis (survival)	-	-	na	-	na	-	-	-	na	-	na	-	-	-	-	-	-	-	< 1	-
Chronic Toxicity (TUc)	na	-	-	-	-	-	na	-	na	-	na	-	na	-	na	-	na	-	na	-
Pimephales promelas (growth)	-	-	na	-	6.2	116	-	-	-	-	-	-		-		-	-	-	-	-
Strongylocentrotus purpuratus (fertilization)	-	-	1.8	346	na	-	-	-	-	-	-	-		-		-	-	-	-	-
Phenols (ug/L)	na	-	< 62	-	8.6	170	na	-	-	-	-	-	na	-	na	-	na	-	na	-
Nonchlorinated Phenols	na	-	< 50	-	4.7	127	na	-	-	-	-	-	na	-	na	-	na	-	na	-
Chlorinated Phenols	na	-	< 422	-	< 1	-	na	-	-	-	-	-	na	-	na	-	na	-	na	-
Total DDT (ug/L)	na	-	< 0.92	-	< 0.03	-	na	-	-	-	-	-	na	-	na	-	na	-	na	-
Total PAH (ug/L)	na	-	< 135	-	< 7.8	-	na	-	-	-	-	-	na	-	na	-	na	-	na	-
Total PCB (ug/L)	na	-	< 6.137	-	< 0.5	-	na	-	-	-	-	-	na	-	na	-	na	-	na	-

[a] Background seawater concentration of copper (2.0 ug/L; SCWRB-Cal EPA 1997) not subtracted out of reported result.

Dash = Not applicable.

na = Not analyzed.

< = Less then the maximum detection level (RL or MDL) (Appendix II) used in 2000.

discharge effluent more often than non-petroleum-related industries, measuring general constituents on a weekly to quarterly basis. Non-petroleum-related facilities measured general constituents monthly to semi-annually.

Approximately one-third of annual average metal concentrations were below detection limits (Table 2). Metals analyses were only conducted by two facilities, Equilon and El Segundo; SIO was only required to test for copper. Metal analyses were conducted weekly to monthly; SIO analyzed copper quarterly. El Segundo detected four of the ten metals they analyzed, while Equilon detected all metals with the exception of mercury. Reporting levels used for analyses of metals in El Segundo effluent were typically higher than those used for Equilon analyses (Appendix III).

Organic compounds were only measured by Equilon and El Segundo, several of which were not detected in effluents (Table 2). These facilities conducted analyses of organic constituents monthly to semiannually, with the exception of phenols, which Equilon measured weekly. Only total phenols and non-chlorinated phenols were detected (Equilon) in 2000. Reporting levels for these constituents were one to two orders of magnitude higher for the El Segundo facility than for Equilon (Appendix III). Total DDTs, PAHs, and PCBs were not detected in effluent from El Segundo or Equilon.

Four out of seven facilities conducted acute toxicity bioassays in 2000, including El Segundo, Equilon, Borax, and Sea World (Table 2). Acute toxicity was detected at three of these facilities, and ranged from 0.17 TUa (El Segundo) to 1.0 TUa (Equilon). Equilon and El Segundo used the same test species, *Pimephales promelas*, for acute toxicity bioassays; Borax used the species *Gasterosteus aculeatus*. Five different species were used for acute toxicity studies at Sea World; however, no toxicity was detected by this facility in 2000. Chronic toxicity was only analyzed by El Segundo and Equilon, and was found to be 1.8 TUc and 6.2 TUc, respectively. *Strongylocentrotus purpuratus* (El Segundo) and *Pimephales promelas* (Equilon) were the test species used for chronic toxicity bioassays.

Effluent Mass Emissions in 2000

Of the eight constituents analyzed by both petroleum-related and non-petroleum-related facilities, petroleum-related facilities accounted for 80-100% of the total mass emissions in all but one case (settleable solids) (Table 3). The most significant discharges of general constituents from industrial facilities were emissions of ammonia-N (22 mt) and BOD (20 mt); all other emissions of general constituents were below 10 mt. The greatest metal emissions in 2000 were selenium (933 kg), arsenic (218 kg), and zinc (57 kg). All other metal emissions were less than 25 kg. Mass emissions of organic compounds were limited to phenolic compounds, 11.9 kg of which were discharged to the SCB in 2000. No other organic compounds were discharged by industrial facilities in measurable quantities in 2000.

El Segundo had the overall highest constituent loads on account of discharging the greatest total volume of effluent (9.3×10^9 L) (Table 3), even though only five constituents (ammonia-N, arsenic, copper, nickel, and selenium) were discharged by El Segundo in measurable quantities in 2000. The Equilon facility, on the other hand, had measurable emissions of fifteen constituents. For constituents discharged by both El Segundo and Equilon, El Segundo accounted for over 70% of the total mass emissions.

Historical Mass Emissions

In 1971, approximately 96 industrial sources contributed to a total effluent volume of 185×10^9 L (Table 4). By 2000, the total effluent volume had decreased by 93%, and the number of industrial dischargers had decreased to seven. The percent of effluent volume from petroleum-related facilities did not, however, change dramatically from 1971 to 2000. In fact, the percent of volume attributable to petroleum-related facilities in 2000 (83%) was marginally greater than in 1971 (81%). In 1971, mass emission estimates were only calculated for five constituents: suspended solids, BOD, oil/grease, ammonia-N, and non-chlorinated phenols. Mass emissions of each of these constituents decreased by greater than 98% by the year 2000.

Estimates of trace metal mass emissions were not included in this assessment until 1989. From 1989 to 2000, emissions of metal constituents decreased between 33% and over 99% for most constituents. Emissions of mercury decreased to non-detectable levels during this time period, and emissions of arsenic increased approximately 46%.

Changes in constituent mass emissions from industrial facilities between 1995 and 2000 were of particular interest since we found that emissions were reduced notably for most constituents (Table 4).

Table 3. Estimated constituent mass emissions from non-power industrial facilities in 2000.

Constituent	Southwestern Terminal	El Segundo Oil Refinery	Equilon	Morton Salt	Borax[a]		Scripps Institution of Oceanography			Sea World	**TOTAL**
					003	009	001	002	003		
Volume (L x 10^9)	0.003	9.3	0.90	0.006	0.47	0.49	0.58	0.002	0.24	0.37	12.4
Suspended Solids (mt)	0.004	nd	6.9	0.28	na	na	nd	nd	nd	0.33	7.5
Settleable Solids (L x 10^3)	nd	nd	nd	nd	na	na	nd	nd	nd	9.2	9.2
BOD (mt)	0.01	na	20	na	na	na	na	na	na	na	20
CBOD (mt)	na	nd	na	na	na	na	na	na	na	na	nd
Oil/Grease (mt)	0.02	nd	4.2	0.01	na	na	nd	nd	nd	na	4.2
Ammonia-N (mt)	na	21	1.9	na	na	na	na	na	na	0.02	22
Cyanide (mt)	na	nd	na	na	na	na	na	na	na	na	nd
Arsenic (kg)	na	217	1.4	na	na	na	na	na	na	na	218
Cadmium (kg)	na	nd	0.02	na	na	na	na	na	na	na	0.02
Chromium (kg)	na	nd	1.3	na	na	na	na	na	na	na	1.3
Copper (kg)	na	19	2.7	na	na	na	2.2	na	na	na	24
Lead (kg)	na	nd	1.1	na	na	na	na	na	na	na	1.1
Mercury (kg)	na	nd	nd	na	na	na	na	na	na	na	nd
Nickel (kg)	na	13	4.9	na	na	na	na	na	na	na	18
Selenium (kg)	na	930	3.0	na	na	na	na	na	na	na	933
Silver (kg)	na	nd	0.2	na	na	na	na	na	na	na	0.2
Zinc (kg)	na	nd	57	na	na	na	na	na	na	na	57
Phenols (kg)	na	nd	7.7	na	na	na	na	na	na	na	7.7
Nonchlorinated Phenols	na	nd	4.2	na	na	na	na	na	na	na	4.2
Chlorinated Phenols	na	nd	nd	na	na	na	na	na	na	na	nd
Total DDT (kg)	na	nd	nd	na	na	na	na	na	na	na	nd
Total PAH (kg)	na	nd	nd	na	na	na	na	na	na	na	nd
Total PCB (kg)	na	nd	nd	na	na	na	na	na	na	na	nd

[a] Borax only measures toxicity and residual chlorine.

na = Not analyzed.

nd = Not detected.

1 mt = 1000 kg.

Table 4. Historical mass emissions from industrial facilities, and percent changes in constituent emissions from 1995 to 2000.

	Mass Emissions					
	1971[a]	1987[b]	1989[c]	1995[d]	2000	**Percent of Change from**
Constituent	n = 96[e]	n = 3	n = 5	n = 10	n = 7	**1995 to 2000[h]**
Volume (L x 10^9)	185	12.7	13.9	23	12.4	(45)
Percent of volume from petroleum-related industries (%)	81	100	100	77	83	8
Suspended Solids (mt)	6,206	-	234.3	312	7.5	(98)
Settleable Solids (L x 10^3)	-	-	-	nd	9.2	100
BOD (mt)	1,342[f]	-	247	41	20.4	(51)
CBOD (mt)	-	-	-	137	nd	(100)
Oil/Grease (mt)	1,789	-	145	90	4.2	(95)
Ammonia-N (mt)	1,206[f]	-	176	57	22	(61)
Cyanide (mt)	-	-	973	nd	nd	nc
Arsenic (kg)	-	-	149	235	218	(7)
Cadmium (kg)	-	-	28	4.3	0.02	(100)
Chromium (kg)	-	-	28	96	1.3	(99)
Copper (kg)	-	-	201	45	24	(47)
Lead (kg)	-	-	4.8	16	1.1	(93)
Mercury (kg)	-	-	0.20	0.07	nd	(100)
Nickel (kg)	-	-	882	134	18	(87)
Selenium (kg)	-	-	-	631	933	48
Silver (kg)	-	-	0.30	0.40	0.20	(50)
Zinc (kg)	-	-	391	1,068	57	(95)
Phenols (kg)	-	-	3,883	1,402	7.7	(99)
Nonchlorinated Phenols	20,000[f,g]	-	-	nd	4.2	100
Chlorinated Phenols	-	-	-	nd	nd	nc
Total DDT (kg)	-	-	-	nd	nd	nc
Total PAH (kg)	-	-	-	-	nd	-
Total PCB (kg)	-	-	-	nd	nd	nc

[a] (SCCWRP 1973)
[b] (SCCWRP 1989)
[c] (Schafer 1990)
[d] (Raco-Rands 1999)
[e] This is an approximate value based on information provided in SCCWRP (1973); this number was not specified exactly in the historical data.
[f] Data only from discharges to San Pedro Bay (n » 94) in 1971; discharge from remaining facilities not quantified.
[g] Quantity represents phenol only.
[h] Values in parentheses represent decreases from 1995 to 2000.

Dash = Not included in assessment, or not analyzed.
nd = Not detected.
nc = No change.

During this time, the total effluent volume from industrial dischargers decreased 45%, and percent decreases in constituent emissions ranged from 7% (arsenic) to over 98% (suspended solids, CBOD, oil/grease, cadmium, chromium, mercury, and phenols). Exceptions included selenium emissions (increased by 48%), and emissions of settleable solids and nonchlorinated phenols (not detected in 1995 but discharged in 2000).

Changes in discharges between 1995 and 2000 were primarily a result of changes in discharges from petroleum-related facilities (Figure 2). In only three cases (volume, copper, and mercury) were changes from other industrial sources noticeable. Historical trends in effluent from the El Segundo facility exemplify this point. Effluent volume from El Segundo

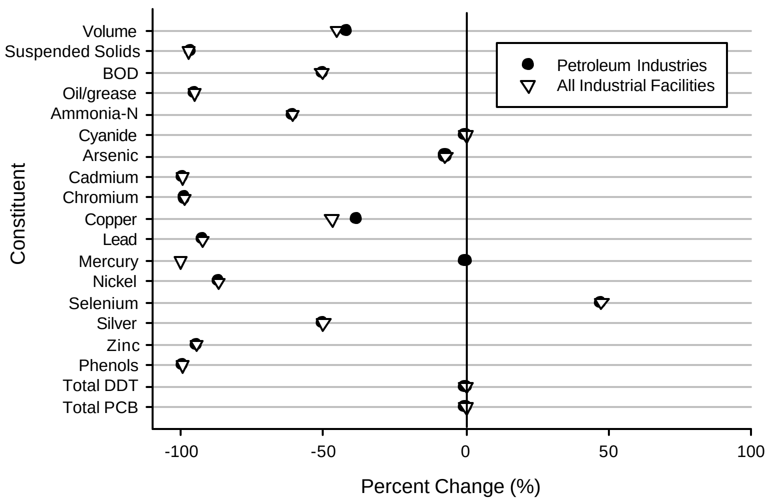

Figure 2. Percent change in volume and constituent mass emissions from petroleum-related facilities (circles) and from all industrial facilities (triangles) from 1995 to 2000. Negative values indicate a decrease in emissions, positive values indicate an increase in emissions from 1995 to 2000; zero values indicate no change from 1995 to 2000.

decreased by 24% (Table 5), while total effluent volume decreased by 45%. A portion of the change in effluent volumes resulted from reductions in effluent volume from other industrial facilities, including other petroleum-related facilities (Figure 2). Decreases in pollutant loads from El Segundo ranged from 3% (arsenic) to essentially 100% for suspended solids, CBOD, oil/grease, cadmium, chromium, lead, silver, zinc, and phenols. Mercury emissions from El Segundo did not change between 1995 and 2000, and copper emissions decreased 41%. Selenium emissions from El Segundo increased 49% between 1995 and 2000.

Industrial Facilities vsersus Large POTWs

When compared to large POTWs in 2000, industrial facilities represented a relatively insignificant fraction of the total pollutant load (Table 6). Industrial facilities accounted for only 0.8% of the total effluent volume, and typically less than 0.1% of the load for any given constituent, with the exception of arsenic (6.0%), lead (0.18%), and selenium (9.9%).

DISCUSSION

Mass emissions and effluent volumes from non-power industrial facilities have decreased measurably since 1971. These decreases are the result of two main factors: (1) the number of industrial facilities with direct discharge to the SCB has decreased since 1971, and (2) effluent quality from industrial dischargers has improved.

Reductions in the number of industrial facilities have had a significant effect on historical changes in industrial effluents. Historically, oil platforms and other offshore oil production, transport, and processing industries were included in the characterization of discrete industrial discharges to the SCB (SCCWRP 1973). These broader classifications led to the identification of 185 industrial sources in 1971. Although all offshore oil production and transport industries were excluded from the 1971 data reported in this study, still approximately 96 industrial facilities discharged effluents to the SCB in 1971. As a direct result of legislature such as the Clean Water Act (CWA) (1972), the types and quantities of these industrial discharges to the SCB came under strict regulation. These regulations prohibited the discharge of bulk wastes and sludge, which has been a primary reason for the decrease in facility numbers, as well as for reductions in contaminant loadings from this point source. Additionally, historical reductions in facility numbers have also been a result of economic circumstances. This seems to have been the primary reason for the 30% reduction in facilities between 1995 and 2000.

Improvements in the quality of effluents from industrial facilities have also been critical in reducing the amount of contaminants entering the SCB from this point source. The prohibition of solid wastes as a result of the CWA was the pivotal reason for dramatic historical reductions; however, industrial facilities continue to reduce their impact on the coastal environment. This is especially noticeable in the comparison of 1995 and 2000 constituent mass emissions. Since 1995, the discharge load for only one constituent increased, three remained unchanged, and the remainder of constituent loads decreased, most by well over 50% despite only a 30% decrease in the number of facilities from 1995 to 2000. These changes were primarily the result of changes in emissions from petroleum-related facilities. Individual facility emissions decreased for all three petroleum-related industries in 2000; however, changes in

Table 5. Estimated mass emissions for the El Segundo Oil Refinery in 1995 and 2000, and the percent changes in emissions between these two years.

	El Segundo Oil Refinery		
	Mass Emissions		**Percent Change in Mass Emissions**
Constituent	1995[a]	2000	**1995-2000[c]**
Volume (L x 10^9)	10.8	9.3	(14)
Suspended Solids (mt)	193	nd	(100)
CBOD (mt)	137	nd	(100)
Oil/Grease (mt)	63	nd	(100)
Ammonia-N (mt)	39	21	(46)
Cyanide (kg)	nd	nd	nc
Arsenic (kg)	224	217	(3)
Cadmium (kg)	4.3	nd	(100)
Chromium (kg)	21	nd	(100)
Copper (kg)	32	19	(41)
Lead (kg)	15	nd	(100)
Mercury (kg)	nd	nd	nc
Nickel (kg)	134	13	(90)
Selenium (kg)	625	930	49
Silver (kg)	0.4	nd	(100)
Zinc (kg)	161	nd	(100)
Phenols(kg)	946	nd	(100)
Nonchlorinated Phenols	nd	nd	nc
Chlorinated Phenols	nd	nd	nc
Total DDT (kg)	nd	nd	nc
Total PAH[b] (kg)	-	nd	-
Total PCB (kg)	nd	nd	nc

[a] (Raco-Rands 1999)
[b] PAHs not included in 1995 study.
[c] Values in parentheses represent decreases from 1995 to 2000.
nc = No change.
Dash = Not applicable/not analyzed.

emissions from the El Segundo Oil Refinery were the most noteworthy. Improvements in effluents from non-petroleum-related facilities were only significant in the case of mercury emissions, which were reduced to non-detectable quantities from 1995 to 2000. This decrease was a direct result of the termination of discharge from the Long Beach Naval Shipyards after 1995. Because petroleum-related facilities account for the majority of industrial effluent volumes, changes in discharge trends are more strongly influenced by discharges from these types of facilities. Improvement in effluent quality from these facilities has played an important role in decreasing contaminant inputs to the SCB from non-power industries.

Ultimately, industrial discharges are negligible compared to discharges from large POTWs, historically the most significant point source of contaminants to the SCB. Provided the number of industrial facilities does not increase dramatically, and also given that the petroleum-related industries continue to improve the quality of their effluents, industrial dischargers can be expected to remain an insignificant source of pollutants to the SCB in future years.

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Table 6. Comparison of estimated mass emissions from industrial facilities and large POTWs in 2000.

Constituent	*Mass Emissions* Large POTWs (n=4)	Industrial Facilities (n=7)	**Total**	*Percent of Total* Large POTWs	Industrial Facilities
Volume (L x 10^9)	1,489	12.0	1,501	99.2	0.8
Suspended Solids (mt)	64,631	7.5	64,638	99.99	0.01
Settleable Solids (L x 10^3)	307,549	9.2	307,558	99.997	0.003
BOD (mt)	97,744	20	97,764	99.98	0.02
Oil/Grease (mt)	14,840	4.2	14,844	99.97	0.03
Ammonia-N (mt)	42,567	22	42,589	99.95	0.05
Nitrate-N (mt)	279	na	279	100	na
Nitrite-N (mt)	435	na	435	100	na
Organic-N (mt)	4,524	na	4,524	100	na
Total Phosphorus (mt)	1,898	na	1,898	100	na
Cyanide (mt)	9.2	nd	9.2	100	nd
Arsenic (mt)	3.4	0.22	3.6	94.0	6.0
Cadmium (mt)	0.08	0.00002	0.1	99.98	0.02
Chromium (mt)	4.8	0.001	4.8	99.97	0.03
Copper (mt)	51	0.02	51	99.95	0.05
Lead (mt)	0.64	0.001	0.6	99.82	0.18
Mercury (mt)	0.02	nd	0.02	100	nd
Nickel (mt)	32	0.02	32	99.94	0.06
Selenium (mt)	8.5	0.93	9.4	90.1	9.9
Silver (mt)	4.1	0.0002	4.1	99.995	0.005
Zinc (mt)	66	0.06	66	99.9	0.1
Phenols (mt)	113	0.01	113	99.99	0.01
Nonchlorinated	58	0.004	58	99.99	0.01
Chlorinated	4.2	nd	4.2	100	nd
Total DDT (kg)	1.5	nd	1.5	100	nd
Total PAH (kg)	740	nd	740	100	nd
Total PCB (kg)	nd	nd	nd	nd	nd

na = Not analyzed.
nd = Not detected.

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Appendix I. Non-power industrial facilities with discharges to the SCB in 2000.

NPDES Permit Number	Name of Facility	Waste Type[a]	Waste Code[b]	City	Agency	Description
Los Angeles Regional Water Quality Control Board						
CA0000337	El Segundo Oil Refinery	Hazardous	Storms/ proces	El Segundo	Chevron U.S.A. Products Co.	Crude oil refinery
CA0061476	Morton Salt Company	Designated	Storms/ miscel	Long Beach	Morton International Inc.	Salt production facility
CA0003689	Mobil Oil Southwestern Terminal - Area 1	Designated	Proces	Terminal Island	Mobil Oil Corp.	Crude oil and refined pertoleum product storage
CA0003778	Equilon Enterprises LLC.	Hazardous	Contac	Wilmington	Texaco Refining and Marketing Inc.	Petroleum refinery
CA0000787	U.S. Borax, Inc.	Hazardous	Noncon	Wilmington	U.S. Borax and Chemical Corp.	Chemical refinery that produces boron- based compounds
San Diego Regional Water Quality Control Board						
CA0107239	Scripps Institution of Oceanography (SIO)	Designated	Miscel/ filbri	La Jolla	University of California, San Diego	Aquarium, oceanographic institute
nf	Sea World-Hubbs Research Institute	nf	nf	San Diego	Sea World-Hubbs Research Institute	Aquarium, oceanographic institute

[a]Waste types classify the nature of the waste or influent prior to treatment and/or disposal: Hazardous = influent or solid wastes that contain toxic, corrosive, ignitable, or reactive substances and must be managed according to applicable Department of Health Services standards; Designated = influent or solid wastes that contain nonhazardous wastes that pose a significant threat to water quality because of their high concentrations (i.e. BOD, TRF, chloride, hardness). “Manageable” hazardous wastes (i.e. inorganic salts and heavy metals) are included in this category (CWQCB 1996).

[b]Waste codes identify the waste treated, stored, or disposed of at the facility: Storms = stormwater runoff; Proces = process waste (waste produced as part of the industrial manufaturing process); Miscel = miscellaneous (includes waste from dewatering, recreational lake over-flow, swimming pool wastes, water ride wastewater, groundwater seepage, etc.); Contac = cooling water (contact); Noncon = non-contact cooling water; Filbri = filter backwash brine water (CWQCB 1996).

nf = Information not found.

Appendix II. Analytical methods used for constituent analyses of industrial facility effluent in 2000.

Constituent	Southwestern Terminal	El Segundo Oil Refinery	Equilon	Morton Salt	Borax	Scripps Institution of Oceanography	Sea World
TSS	nf	EPA 160.2	EPA 160.2	EPA 160.2	-	SM 2540 D	nf
Settleable Solids	nf	EPA 160.5	EPA 160.5	EPA 160.5	-	SM 2540 F	nf
BOD	nf	-	EPA 405.1	-	-	-	-
CBOD	-	SM 5210 B	-	-	-	-	-
Oil/Grease	nf	HEM 1664SPE	EPA 413.1	EPA 413.2	-	EPA 413.1	-
Ammonia-N	-	SM 4500-NH3 F	SM 4500 NH3	-	-	-	nf
Cyanide	-	EPA 335.9	-	-	-	-	
Turbidity	nf	EPA 180.1	-	-	-	SM 2130 B	nf
Arsenic	-	EPA 206.2	EPA 6020 M	-	-	-	-
Cadmium	-	EPA 213.2	EPA 6020 M	-	-	-	-
Chromium	-	EPA 218.2	EPA 6020 M	-	-	-	-
Copper	-	EPA 220.2	EPA 6020 M	-	-	EPA 3010/6010	-
Lead	-	EPA 239.2	EPA 6020 M	-	-	-	-
Mercury	-	EPA 245.1	EPA 6020 M	-	-	-	-
Nickel	-	EPA 249.2	EPA 6020	-	-	-	-
Selenium	-	EPA 270.2	EPA 6020 M	-	-	-	-
Silver	-	EPA 272.2	EPA 6020 M	-	-	-	-
Zinc	-	EPA 200.7	EPA 6020 M	-	-	-	-
Acute Toxicity	-	-	-	-	-	-	-
Gasterosteus aculeatus (survival)	-	-	-	-	(a)	-	-
Pimephales promelas (survival)	-	(a)	(b)	-	-	-	-
Macrocystis pyrifera (germination)	-	-	-	-	-	-	nf
Macrocystis pyrifera (growth)	-	-	-	-	-	-	nf
Strongylocentrotus purpuratus (fertilization)	-	-	-	-	-	-	nf
Topsmelt (growth)	-	-	-	-	-	-	nf
Topsmelt (survival)	-	-	-	-	-	-	nf
Chronic Toxicity	-	-	-	-	-	-	-
Pimephales promelas (growth)	-	-	(c)	-	-	-	-
Strongylocentrotus purpuratus (fertilization)	-	nf	-	-	-	-	-
Phenols	-	SM 510 A,C	EPA 625	-	-	-	-
Nonchlorinated Phenols	-	EPA 625	EPA 625	-	-	-	-
Chlorinated Phenols	-	EPA 625	EPA 625	-	-	-	-
Total DDT	-	EPA 608	EPA 608	-	-	-	-
Total PAH	-	EPA 625	EPA 3520	-	-	-	-
Total PCB	-	EPA 608	EPA 608	-	-	-	-

[a] (U.S. EPA 1985).
[b] (U.S. EPA 1991).
[c] (U.S. EPA 1989).
Dash = Not applicable.
nf = Information not found.
SM refers to protocols found in the Standard Methods for the Examination of Water and Wastewater (Clesceri 1992).
EPA refers to protocols established in the California Ocean Plan: Water Quality Control Plan, Ocean Waters of California (SWRCB-Cal EPA 1997).

Appendix III. Reporting limits used for constituent analysis of industrial effluents in 2000.

ParameterCode	Southwestern Terminal	El Segundo Oil Refinery[f]	Equilon	Morton Salt	Borax[a]	Scripps Institute of Oceanography[a]	Sea World
Suspended Solids (mg/L)	np	2.8[c], 14[d], 15[e]	np	10	na	20	1
Settleable Solids (mL/L)	1	0.2	0.08	0.1	na	0.2	0.1
BOD (mg/L)	np	na	np	na	na	na	na
CBOD (mg/L)	na	3.6[c], 18[d], 20[e]	na	na	na	na	na
Oil/Grease (mg/L)	np	5	np	1.1	na	1	np
Ammonia-N (mg/L)	na	0.13[c], 0.65[d], 3.5[e]	np	na	na	na	0.1
Cyanide (mg/L)	na	0.0156[c]	na	na	na	na	na
Turbidity (NTU)	np	0.1	na	na	na	np	np
Arsenic (ug/L)	na	2.9[c], 14.5[d]	5	na	na	na	na
Cadmium (ug/L)	na	0.26[c], 1.3[d]	1	na	na	na	na
Chromium (ug/L)	na	1.16[c], 5.8[d]	5.5	na	na	na	na
Copper (ug/L)	na	4.68[c], 23.4[d]	np	na	na	10[b]	na
Lead (ug/L)	na	2.38[c]	1	na	na	na	na
Mercury (ug/L)	na	0.20[c]	0.2	na	na	na	na
Nickel (ug/L)	na	2.84[c], 14.2[d]	np	na	na	na	na
Selenium (ug/L)	na	5-25	20	na	na	na	na
Silver (ug/L)	na	0.28[c], 1.4[d]	1	na	na	na	na
Zinc (ug/L)	na	35[c], 175[d]	np	na	na	na	na
Acute Toxicity (TUa)	na	-	-	na	-	na	-
Gasterosteus aculeatus (survival)	-	nr	-	-	np	-	-
Macrocystis pyrifera (germination)	-	nr	-	-	-	-	1
Macrocystis pyrifera (growth)	-	nr	-	-	-	-	1
Pimephales promelas (survival)	-	0	np	-	-	-	nr
Strongylocentrotus purpuratus (fertilization)	-	nr	-	-	-	-	1
Topsmelt (growth)	-	nr	-	-	-	-	1
Topsmelt (survival)	-	nr	-	-	-	-	1
Chronic Toxicity (TUc)	na	-	-	na	na	na	na
Pimephales promelas (growth)	-	nr	np	-	-	-	-
Strongylocentrotus purpuratus (fertilization)	-	10	nr	-	-	-	-
Phenols (ug/L)	na	12.4[c], 62[d]	1	na	na	na	na
Nonchlorinated	-	-	-	-	-	-	-
Phenol	-	na	1	-	-	-	-
2,4-Dimethylphenol	-	10	na	-	-	-	-
2,4-Dinitrophenol	-	50	1	-	-	-	-
2-Methyl-4,6-dinitrophenol	-	50	na	-	-	-	-
2-Nitrophenol	-	10	1	-	-	-	-
Chlorinated	-	84.4[c], 422[d]	-	-	-	-	-
2,4,6-Trichlorophenol	-	10	1	-	-	-	-
2,4-Dichlorophenol	-	na	1	-	-	-	-
2-Chlorophenol	-	na	1	-	-	-	-
Pentachlorophenol	-	na	1	-	-	-	-
Total PAH (ug/L)	na	135	-	na	na	na	na
Acenaphthene	-	10	1	-	-	-	-
Acenaphthylene	-	na	1	-	-	-	-
Anthracene	-	na	1	-	-	-	-
Benzo(a)anthracene	-	na	1, 7.8[c]	-	-	-	-
Benzo(b)fluoranthene	-	na	1, 2.5[c]	-	-	-	-
Benzo(g,h,i)perylene	-	na	1	-	-	-	-
Benzo(k)fluoranthene	-	na	1, 4.8[c]	-	-	-	-
Chrysene	-	na	1	-	-	-	-
Dibenzo(a,h)anthracene	-	na	1	-	-	-	-
Fluoranthene	-	10	1	-	-	-	-
Fluorene	-	na	1	-	-	-	-
Indeno[1,2,3-cd]pyrene	-	na	1	-	-	-	-
Naphthalene	-	10	1	-	-	-	-
Phenanthrene	-	na	1	-	-	-	-
Pyrene	-	na	1	-	-	-	-
Total DDT (ug/L)	na	0.92	na	na	na	na	na
p,p'-DDD	-	na	0.02	-	-	-	-
p,p'-DDE	-	na	0.03	-	-	-	-
p,p'-DDT	-	na	0.03	-	-	-	-
o,p'-DDD	-	na	na	-	-	-	-
o,p'-DDE	-	na	na	-	-	-	-
o,p'-DDT	-	na	na	-	-	-	-
Total PCB (ug/L)	na	6.137	0.5	na	na	na	na

[a] Reporting level data the same for all outfalls.
[b] Copper only analyzed for outfall 001.
[c] Method detection limit.
[d] Practical quantitation limit.
[e] Reporting level.
[f] El Segundo used MDLs, PQLs and RLs interchangeably during the year, when this was the case all of these values are listed.
Dash = Not applicable.
np = Not provided.
na = Not analyzed.

Appendix IV. Frequency of constituent analysis for industrial facilities in 2000.

Constituent	Southwestern Terminal	El Segundo Oil Refinery	Equilon	Morton Salt	Borax[a]	Scripps Institution of Oceanography[a]
Suspended Solids	Quarterly	Weekly	Weekly	Quarterly	na	Semiannually
Settleable Solids	Quarterly	Monthly	Weekly	Quarterly	na	Semiannually
BOD	Monthly	na	Weekly	na	na	na
CBOD	na	Weekly	na	na	na	na
Oil/Grease	Monthly	Weekly	Weekly	Quarterly	na	Semiannually
Ammonia-N	na	Weekly	Weekly	na	na	na
Cyanide	na	Monthly	na	na	na	na
Turbidity	Monthly	Monthly	na	na	na	Semiannually
Acute Toxicity	na	Monthly	Quarterly	na	Quarterly	Semiannually
Strongylocentrotus purpuratus	-	-	-	-	-	-
Gasterosteus aculeatus (survival)	-	-	-	-	Quarterly	-
Topsmelt (growth)	-	-	-	-	-	-
Topsmelt (survival)	-	-	-	-	-	-
Macrocystis pyrifera	-	-	-	-	-	-
Macrocystis pyrifera (germination)	-	-	-	-	-	-
Macrocystis pyrifera (growth)	-	-	-	-	-	-
Pimephales promelas (survival)	-	Monthly	Quarterly	-	-	-
Menidia beryllina	-	-	-	-	-	-
Chronic Toxicity	na	Monthly	Quarterly	na	na	na
Strongylocentrotus purpuratus (fertilization)	-	Monthly	-	-	-	-
Gasterosteus aculeatus	-	-	-	-	-	-
Pimephales promelas (growth)	-	-	Quarterly	-	-	-
Arsenic	na	Monthly	Weekly	na	na	na
Cadmium	na	Monthly	Weekly	na	na	na
Chromium	na	Monthly	Weekly	na	na	na
Copper	na	Monthly	Weekly	na	na	Quarterly[b]
Lead	na	Monthly	Weekly	na	na	na
Mercury	na	Monthly	Weekly	na	na	na
Nickel	na	Monthly	Weekly	na	na	na
Selenium	na	Monthly	Weekly	na	na	na
Silver	na	Monthly	Weekly	na	na	na
Zinc	na	Monthly	Weekly	na	na	na
Phenols	na	Monthly	Weekly	na	na	na
Nonchlorinated Phenols	na	Semiannually	Monthly	na	na	na
Chlorinated Phenols	na	5/year	Quarterly	na	na	na
Total DDT	na	Semiannually	Quarterly	na	na	na
Total PAH	na	5/year	Quarterly	na	na	na
Total PCB	na	Semiannually	Quarterly	na	na	na

[a] Frequency of analysis same for all outfalls.
[b] Copper only analyzed for outfall 001.
Dash = Not applicable.