# Characteristics of Effluents from Nonpower Industrial Facilities in 1995

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## ABSTRACT

The marine environment of the Southern California Bight (SCB) is used for a variety of recreational, commercial, municipal, and industrial purposes, each of which contributes contaminants to the ocean. This study summarizes effluent constituent concentrations and constituent mass emissions during 1995 from ten nonpower industrial facilities discharging directly into the ocean, into bays and harbors, or within the tidal prisms of storm channels that terminate in the SCB. Mass emissions were estimated from monthly measurements of flow and constituent concentrations. Nonpower industrial facilities are a relatively small source of contaminants to the Bight, usually contributing less than 1% of a constituent's combined mass emissions from municipal wastewater dischargers, power generating stations, and industrial facilities, with the exception of selenium (7%), arsenic (4%), and chromium (1%).

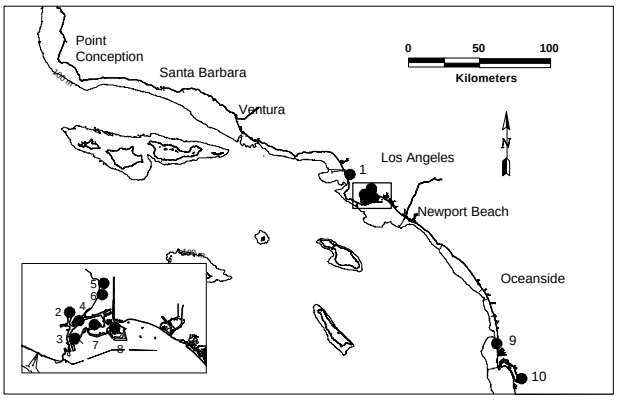

## INTRODUCTION

The southern California coastal region is one of the most densely populated coastal areas in the U.S. and is a resource for a variety of recreational, commercial, municipal, and industrial uses. These uses produce a variety of impacts including inputs of pollutants that can ultimately degrade the environment.

Because pollutants are discharged into the ocean from a variety of sources, pollutant inputs from these different sources are measured to identify the most important sources of contaminants. Measurements of pollutant inputs also provide a basis for developing emission control strategies, and, when measured over time, for assessing the effectiveness of these control strategies. Southern California Coastal Water Research Project (SCCWRP) summarized contributions from the major sources of contaminants to the SCB in a previous report (SCCWRP 1973). Industrial waste from nonpower industries such as petroleum refineries was one pollutant source characterized by SCCWRP (SCCWRP 1973, 1989, 1990).

Nonpower industrial dischargers have the potential to be an important source of ocean contaminants because a large percentage of their effluents can contain chemicals that are discarded as byproducts of the industrial or manufacturing process. Flow discharged from industrial facilities can be substantial in volume. Effluent volume from industrial waste dischargers comprised approximately 18% of the combined municipal wastewater discharged into the SCB during 1971 (SCCWRP 1973).

**FIGURE 1. Locations of industrial facilities that discharged into southern California bays, harbors, tidal prisms of storm channels, or directly into the Southern California Bight in 1995.**




Although industrial facilities are subject to National Pollutant Discharge Elimination System (NPDES) permit requirements, not all operators are required to report yearly constituent concentration averages or calculate yearly mass emissions to the ocean. Furthermore, facilities that do calculate mass emissions to the ocean, frequently do not compare their effluent characteristics with other industrial facilities or with other point sources of contaminants such as municipal wastewater facilities. In this report, we calculate and compare yearly mean constituent concentrations and mass emission estimates among ten industrial facilities that discharged into southern California coastal waters, bays, harbors, or tidal prisms of storm channels in 1995 (Figure 1, Appendix 1). We also compare historical mass emissions of coastal petroleum industries from 1971 to 1995.

## METHODS

Effluent quality data were obtained from discharge monitoring reports on file at the Los Angeles, Santa Ana, and San Diego Regions of the California Regional Water Quality Control Boards.

Industrial facilities measured constituents in their effluents at the following frequencies: (1) general constituents (nonmetallic and nontrace organic constituents) — once per week to once per year; (2) toxicity — once per month to once per five years; (3) metals — once per week to once per year; and (4) organics — once per week to once per year (Table 1).

Reporting limits usually varied by a factor of 2, with a maximum variance factor of 150 among all of the facilities investigated (Table 2).

Two types of assessments were performed. First, annual mean concentrations were calculated by averaging monthly concentrations recorded throughout the year. Zeros were assigned for months with constituent concentrations below reporting limits. Annual mean concentrations were reported even if they were below reporting limits.

For facilities with single outfalls, annual contaminant mass emissions were estimated from the product of the mean daily flow, the mean monthly constituent concentration, and the number of days in each month. These emissions 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*; $C_i$ = mean constituent concentration in month *i*; and $D_i$ = number of days in month *i*.

Months with constituent concentrations below reporting limits were considered to have zero mass emissions. If the constituent was above the reporting limit in one or more months, the mass emission for the month(s) was calculated, summed across all months, and included in the table of mass emissions. If a monthly constituent measurement was deemed unreliable by the discharger's analytical lab, if results were missing, or if a constituent concentration was not analyzed for a certain month, then the annual mean concentration was used in calculating mass for that month.

Mass emissions for facilities with multiple outfalls were calculated using a slightly different methodology. Annual averages of constituent concentrations were flow-weighted by first calculating the product of a particular outfall's monthly flow and constituent concentration. The products from all of the serial outfalls for a facility were then combined by month to obtain the monthly sum. The monthly sum for the facility was divided by the total volume of waste per month to obtain monthly averages. An annual mean and coefficient of variation (CV) was then calculated from the monthly values. The monthly masses were summed over all months to obtain the annual estimate for the facility.

## RESULTS

Ten nonpower industrial facilities discharged directly into the ocean or within the tidal prism of a major storm channel in 1995. The California State Water Resources Control Board lists 87 active permittees discharging into storm drains, channels, bays, estuaries, or the Pacific Ocean. However, for the purposes of this study, we eliminated facilities that met one or more of the following criteria: (1) discharged into storm drains before contacting the storm channels; (2) discharged into storm channels above the tidal prism; or (3) discharged solid waste, contaminated groundwater seepage, or stormwater runoff (unless the stormwater effluent was commingled with industrial waste).

General constituents, toxicity, and phenols were detectable in the majority of effluent samples taken from the 10 industrial facilities in 1995, whereas the trace metals and the remaining trace organics were not. General constituents were detectable, on average, in 65% of the effluent samples (Table 3). Biochemical oxygen demand (BOD) was detectable in 100% of the samples, whereas cyanide was consistently nondetectable. Toxicity was detectable, on average, in 55% of the samples. Trace metals were detectable, on average, in 35% of the samples. Phenols analyzed by the colorimetric method were detectable in 56% of the samples. Phenols analyzed by gas chromatography/mass spectrometry (measured at Chevron El Segundo only) were nondetectable. Both DDTs and PCBs were nondetectable at all facilities.

Flow and most constituent concentrations varied considerably among the facilities. Daily flow rates varied among the industrial dischargers by a factor of 3,900 (0.002 to 7.79 million gallons per day (mgd)) in 1995 (Table 4). Concentrations of effluent constituents differed from a factor of 2 (for arsenic and phenols) to a factor of 136 (for ammonia), with 75% of the concentrations varying by a factor of more than 5.

Flow and selected constituents within facilities also varied notably. The CVs for flow varied within facilities by 2 to 346% (Table 4). Forty percent of the facilities

**TABLE 1. Frequency of constituent measurements in effluents from industrial dischargers in southern California.**

| Constituent | Chevron El Segundo Oil Refinery 1[b] | Unocal L.A. Oil Refinery[a] 2 | Mobil Southwestern Terminal 3 | U.S. Borax Wilmington Plant 4 |
|---|---|---|---|---|
| Suspended solids | 1/Week | NA | Quarterly | NA |
| Settleable solids | 1/Month | NA | Quarterly | NA |
| BOD | 1/Week[d] | NA | NA | NA |
| Oil & grease | 1/Week | NA | 6/Year (1/Month) | NA |
| Ammonia-N | 1/Week | NA | NA | Quarterly (0) |
| Cyanide | 1/Month | NA | 1/Year (0) | NA |
| Turbidity | 1/Month | NA | NA | NA |
| Acute toxicity | 1/Month | 3/Year (Quarterly[e]) | Quarterly | Quarterly |
| Chronic toxicity | - | Quarterly | NA | NA |
| *Selenastrum capricornutum* | NA | NA | NA | NA |
| *Macrocystis pyrifera* | NA | 2/Year | NA | NA |
| *Ceriodaphnia*, survival | NA | NA | NA | NA |
| *Ceriodaphnia* reproduction | NA | NA | NA | NA |
| *Dendraster excentricus* | 7/Year | NA | NA | NA |
| *Strongylocentrotus purpuratus* | 4/Year | Quarterly | NA | NA |
| *Pimephales promelas*, larval survival | NA | NA | NA | NA |
| *Pimephales promelas*, larval growth | NA | NA | NA | NA |
| *Menidia beryllina* | NA | 2/Year | NA | NA |
| Arsenic | 1/Month | 1/Year | NF (1/Year) | NA |
| Cadmium | 1/Month | 1/Year | NF (1/Year) | NA |
| Chromium | 1/Month | 1/Year | NF (1/Year) | NA |
| Copper | 1/Month | 1/Year | NF (1/Year) | NA |
| Lead | 1/Month | 1/Year | NF (1/Year) | NA |
| Mercury | 1/Month | 1/Year | NF (1/Year) | NA |
| Nickel | 1/Month | 1/Year | NF (1/Year) | NA |
| Selenium | 1/Month | 1/Year | NF (1/Year) | NA |
| Silver | 1/Month | 1/Year | NF (1/Year) | NA |
| Zinc | 1/Month | 1/Year | NF (1/Year) | NA |
| Phenols | 1/Month | NA | Quarterly | NA |
| Chlorinated phenols | 1/Month[g] | NF (1/Year)[h] | NF (1/Year) | NA |
| Nonchlorinated phenols | 1/Year[i] | NA | NF (1/Year) | NA |
| Total DDT | 1/Year | 1/Year | NF (1/Year) | NA |
| Total PCB | 1/Year | 1/Year | NF (1/Year) | NA |

[a] Serial outfall No. 2 only, only outfall No. 2 had discharge in 1995.
[b] Discharger I.D. number - See Figure 1 for location.
[c] Found only in two analyses.
[d] CBOD = Carbonaceous biochemical oxygen demand.
[e] Numbers in parentheses are frequencies required in permits.
[f] Chromium VI only.

had flows with CVs higher than 50%. Sixty-six percent of the annual mean concentrations had CVs higher than 50%. However, nondetectable monthly concentrations were treated as zero, which inflated the value of the CVs. If CVs utilizing zero monthly concentrations were eliminated, only 20% of the concentrations would have CVs higher than 50%.

Mass emissions differed by a factor of 10 (copper) to a factor of 27,000 (BOD) among all of the facilities (Table 5). Emissions of combined trace metals discharged was 2.2 metric tons (mt) for all 10 facilities. The single most abundant trace metal discharged was zinc (1.1 mt). Of the organics examined, phenols analyzed by the colorimetric method were the only constituents above detection limits; 1.4 mt were discharged.

## DISCUSSION

The frequency of measurements was found to be highly variable among the 10 industrial facilities examined. The frequency of measurements required in NPDES permits depend upon the magnitude of the flow and the composition of the waste. Both the flow rates and composition of effluents were in turn, highly variable, with flow rates varying by a factor of 3,900.

| ARCO L.A. Oil Refinery 5 | Texaco L.A. Oil Refinery 6 | U.S.Dept. Navy Long Beach Naval Shipyard 7 | Morton Int. Ocean Salt Company 8 | Scripps Institute of Oceanography 9 | Western Salt Company 10 |
|---|---|---|---|---|---|
| 1/Discharge | 1/Week | 1/Month | Quarterly | Semiannually | Semiannually[c] (Quarterly) |
| NA | 1/Week | NA | Quarterly | Semiannually | Semiannually[c] (Quarterly) |
| 1/Discharge | 1/Week | NA | NA | NA | 1/Year (0) |
| 1/Discharge | 1/Week | 1/Month | Quarterly | Semiannually | NA |
| 1/Discharge | 1/Week | NA | NA | NA | 1/Year (0) |
| NA | NA | 1/Year (2/Year) | NA | NA | NA |
| 1/Discharge | NA | 1/Month | NA | Semiannually | NA |
| 1/Discharge | NA | Quarterly | NA | NF (1/5 Years) | NF (Semiannually) |
| 1/Discharge | NA | NA | NA | NA | NF (Semiannually) |
| 1/Discharge | NA | NA | NA | NA | NA |
| NA | NA | NA | NA | NA | NA |
| 1/Discharge | NA | NA | NA | NA | NA |
| 1/Discharge | NA | NA | NA | NA | NA |
| NA | NA | NA | NA | NA | NA |
| NA | NA | NA | NA | NA | NA |
| 1/Discharge | NA | NA | NA | NA | NA |
| 1/Discharge | NA | NA | NA | NA | NA |
| NA | NA | NA | NA | NA | NA |
| 1/Discharge | NA | 1/Year (2/Year) | NA | NA | NA |
| 1/Discharge | NA | 1/Year (2/Year) | NA | NA | NA |
| 1/Discharge | 1/Week | 1/Year (2/Year)[f] | NA | NA | NA |
| 1/Discharge | NA | 1/Year (2/Year) | NA | Monthly | NA |
| 1/Discharge | NA | 1/Year (2/Year) | NA | NA | NA |
| 1/Discharge | NA | 1/Year (2/Year) | NA | NA | NA |
| 1/Discharge | NA | 1/Year (2/Year) | NA | NA | NA |
| 1/Discharge | NA | 1/Year (2/Year) | NA | NA | NA |
| 1/Discharge | NA | 1/Year (2/Year) | NA | NA | NA |
| 1/Discharge | NA | 1/Month | NA | NA | NA |
| 1/Discharge | 1/Week | NA | NA | NA | NA |
| NF(1/Year)[h] | NA | NA | NA | NA | NA |
| NA | NA | NA | NA | NA | NA |
| NF(1/Year) | NA | NA | NA | NA | NA |
| NF(1/Year) | NA | NA | NA | NA | NA |

[h]Only includes 2,4,6-trichlorophenol and pentachlorophenol.
[i]Only includes 3,4-dinitrophenol and 2-methyl-4,6 dinitrophenol.

NA = Not analyzed.
NF = Not found.
BOD = Biochemical oxygen demand.
DDT = Dichloro-diphenyl-trichloroethane.
PCB = Polychlorinated biphenyls.

Composition of wastes ranged from noncontact cooling water (seawater which does not come in contact with any chemicals or manufactured products) to petroleum waste produced as a byproduct of the manufacturing process.

Reporting limits were also found to be highly variable among the facilities. These reporting limits depend upon the discharge limitations required by the facility's NPDES permit. The higher the discharge limitation, the higher the reporting limits are often set. Discharge limitations for each facility's effluent are based upon the initial dilution, depth of discharge, and magnitude of flow of the effluent.

A dramatic decline has been documented in the number of petroleum-related industries discharging directly into the coastal ocean over the last two decades. In 1971, 28 petroleum-related industries (SCCWRP 1973) discharged directly into the ocean; in 1995, only 1 petroleum-related discharger remained (Table 6). In 1971-72, 26 coastal petroleum industries discharged produced water, creating 500 mt of suspended solids and 100 mt of oil and grease from a total flow of 6 mgd. By 1995, no coastal petroleum facilities discharged produced water directly into the ocean. The Chevron El Segundo Refinery was the only coastal petroleum industry with direct discharge into the SCB in 1995 , discharging process waste. During the period from

**TABLE 2. Reporting limits of constituents in effluents from industrial dischargers in southern California in 1995.**

| Constituent | Chevron El Segundo Oil Refinery [a] | Unocal L.A. Oil Refinery | Mobil Southwestern Terminal | U.S. Borax Wilmington Plant | ARCO L.A. Oil Refinery |
|---|---|---|---|---|---|
| Suspended solids (mg/L) | 2.8 | NA | 5 | NA | NR |
| Settleable solids (mL/L) | 0.2 | NA | 0.1 | NA | NA |
| BOD (mg/L) | 3.6[b] | NA | NA | NA | NR |
| Oil & grease (mg/L) | 1.0 | NA | NR | NA | NR |
| Ammonia-N (mg/L) | 0.13 | NA | NA | 0.1 | NR |
| Cyanide (µg/L) | 15.6 | NA | 25 | NA | NA |
| Turbidity (NTU) | 0.1 | NA | NA | NA | NR |
| Acute toxicity (TUa) | No limit | No limit | No limit | No limit | No limit |
| Chronic toxicity (TUc) | - | - | NA | NA | NR |
| *Selenastrum capricornutum* | NA | NA | NA | NA | NR |
| *Macrocystis pyrifera* | NA | NR | NA | NA | NA |
| *Ceriodaphnia*, survival | NA | NA | NA | NA | NR |
| *Ceriodaphnia,* reproduction | NA | NA | NA | NA | NR |
| *Dendraster excentricus* | 10 | NA | NA | NA | NA |
| *Strongylocentrotus purpuratus* | 10 | NR | NA | NA | NA |
| *Pimephales promelas*, larval survival | NA | NA | NA | NA | NR |
| *Pimephales promelas*, larval growth | NA | NA | NA | NA | NR |
| *Menidia beryllina* | NA | NR | NA | NA | NA |
| Arsenic (µg/L) | 2.9 | 5 | NA | NA | NR |
| Cadmium (µg/L) | 0.26 | 5 | NA | NA | NR |
| Chromium (µg/L) | 1.16 | 10 | NA | NA | NR |
| Copper (µg/L) | 4.68 | 10 | NA | NA | NR |
| Lead (µg/L) | 2.38 | 3 | NA | NA | NR |
| Mercury (µg/L) | 0.198 | 0.2 | NA | NA | NR |
| Nickel (µg/L) | 2.84 | 32 | NA | NA | NR |
| Selenium (µg/L) | 5-50 | 5 | NA | NA | NR |
| Silver (µg/L) | 0.286 | 10 | NA | NA | NR |
| Zinc (µg/L) | 35 | NR | NA | NA | NR |
| Phenols (µg/L) | 12.4 | NA | NR | NA | NR |
| Chlorinated phenols (µg/L) | 84 | NA | NA | NA | NA |
| Nonchlorinated phenols (µg/L) | 50[d] | NA | NA | NA | NA |
| Total DDT (µg/L) | NR[e] | 0.11 | NA | NA | NA |
| Total PCB (µg/L) | NR[e] | 0.53-1.1 | NA | NA | NA |

[a] Method detection limits used are from the monthly reports.
[b] CBOD = Carbonaceous biochemical oxygen demand.
[c] Chromium VI only
[d] Only includes 2,4-dinitrophenol and 2-methyl-4,6-dinitrophenol.
[e] Individual detection limits were not given.
NA = Not analyzed
NR = Not reported in facilities' annual report.

1971-72 to 1995, flow from the Chevron El Segundo Refinery decreased 89%; oil and grease mass emissions decreased 95%; and suspended solids decreased 93%. From 1989 to 1995, flow decreased 11%; suspended solids mass emissions decreased 2%; and oil and grease decreased a notable 31%.

Industrial facilities discharging into tidal prisms of storm channels and rivers are a relatively small source of flow and contaminants discharging into the SCB (Table 7). In 1995, industrial facilities accounted for only 0.2% of the combined total volume of effluent generated by municipal wastewater dischargers (Raco-Rands 1997a, 1997b); power generating stations (Raco-Rands 1997c); and industrial facilities discharging into the Bight combined in 1995. Contributions of constituents from industrial facilities were usually less than 1% of the combined mass emissions from these three sources, with the exception of selenium (7%), arsenic (4%), and chromium (1%).

| Texaco L.A. Oil Refinery | U.S. Dept. Navy Long Beach Naval Shipyard | Morton Int. Ocean Salt Company | Scripps Institute of Oceanography | Western Salt Company |
|---|---|---|---|---|
| NR | 10 | NR | 0.1,1 | 1 |
| NR | NA | 0.1 | 0.1, 0.2 | 0.1 |
| NR | NA | NA | NA | 2.0 |
| NR | 0.04-5 | 6 | 1 | NA |
| NR | NA | NA | NA | 0.1 |
| NA | 20 | NA | NA | NA |
| NA | 1-5 | NA | 0.1 | NA |
| NA | No limit | NA | No limit | NA |
| NA | NA | NA | NA | NA |
| NA | NA | NA | NA | NA |
| NA | NA | NA | NA | NA |
| NA | NA | NA | NA | NA |
| NA | NA | NA | NA | NA |
| NA | NA | NA | NA | NA |
| NA | NA | NA | NA | NA |
| NA | NA | NA | NA | NA |
| NA | NA | NA | NA | NA |
| NA | 5 | NA | NA | NA |
| NA | 5 | NA | NA | NA |
| NR | 20[c] | NA | NA | NA |
| NA | 5 | NA | 9, 10 | NA |
| NA | 5 | NA | NA | NA |
| NA | NR | NA | NA | NA |
| NA | 5 | NA | NA | NA |
| NA | 2 | NA | NA | NA |
| NA | 5 | NA | NA | NA |
| NA | 10-500 | NA | NA | NA |
| NR | NA | NA | NA | NA |
| NA | NA | NA | NA | NA |
| NA | NA | NA | NA | NA |
| NA | NA | NA | NA | NA |
| NA | NA | NA | NA | NA |

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**TABLE 3. Percent of detectable measurements (maximium frequency = monthly) used for calculations of annual means and mass emissions in effluents from industrial dischargers in southern California in 1995.**

| Constituent | Chevron El Segundo Oil Refinery[a] | Unocal L.A. Oil Refinery[b] | Mobil Southwestern Terminal | U.S. Borax Wilmington Plant | ARCO L.A. Oil Refinery |
|---|---|---|---|---|---|
| Suspended solids | 100% [c] | NA | 50% | NA | 100% |
| Settleable solids | 33% | NA | 0% | NA | NA |
| BOD | 100% [c,f] | NA | NA | NA | 100% |
| Oil & grease | 100% [c] | NA | 80% | NA | 100% |
| Ammonia-N | 100% [c] | NA | NA | 50% | 100% |
| Cyanide | 0% | NA | 0% | NA | NA |
| Turbidity | 100% | NA | NA | NA | 100% |
| Acute toxicity | 67% | 0% | 25% | 25% | 0% |
| Chronic toxicity | - | - | NA | NA | - |
| *Selenastrum capricornutum* | NA | NA | NA | NA | 100% |
| *Macrocystis pyrifera* | NA | 0% | NA | NA | NA |
| *Ceriodaphnia*, survival | NA | NA | NA | NA | 100% |
| *Ceriodaphnia,* reproduction | NA | NA | NA | NA | 100% |
| *Dendraster excentricus* | 14% | NA | NA | NA | NA |
| *Strongylocentrotus purpuratus* | 0% | 25% | NA | NA | NA |
| *Pimephales promelas*, larval survival | NA | NA | NA | NA | 100% |
| *Pimephales promelas*, larval growth | NA | NA | NA | NA | 100% |
| *Menidia beryllina* | NA | 0% | NA | NA | NA |
| Arsenic | 100% | 0% | NA | NA | 100% |
| Cadmium | 58% | 0% | NA | NA | 0% |
| Chromium | 75% | 0% | NA | NA | 100% |
| Copper | 17% | 0% | NA | NA | 100% |
| Lead | 25% | 0% | NA | NA | 100% |
| Mercury | 0% | 0% | NA | NA | 0% |
| Nickel | 100% | 0% | NA | NA | 0% |
| Selenium | 100% | 0% | NA | NA | 100% |
| Silver | 8% | 0% | NA | NA | 0% |
| Zinc | 8% | 100% | NA | NA | 100% |
| Phenols | 100% | NA | 25% | NA | 0% |
| Chlorinated phenols | 0%[h] | NA | NA | NA | NA |
| Nonchlorinated phenols | 0%[i] | NA | NA | NA | NA |
| Total DDT | 0% | 0% | NA | NA | NA |
| Total PCB | 0% | 0% | NA | NA | NA |

[a] Using mdl (from monthly reports).
[b] Serial outfall No. 2 only, only outfall No. 2 had discharge in 1995.
[c] Based on monthly averages.
[d] Corrected for influent.
[e] Found only two out of four quarterly analyses.
[f] CBOD = Carbonaceous biochemical oxygen demand.
[g] Chromium VI only.
[h] Only includes 2,4,6-trichlorophenol.
[i] Only includes 2,4-dinitrophenol and 2-methyl-4,6-dinitrophenol.

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| Texaco L.A. Oil Refinery | U.S.Dept. Navy Long Beach Naval Shipyard | Morton Int. Ocean Salt Company | Scripps Institute of Oceanography | Western Salt Company |
|---|---|---|---|---|
| 100%[c] | 53%[d] | 100% | 100% | 100%[e] |
| 100%[c] | NA | 0% | 0% | 0%[e] |
| 100%[c] | NA | NA | NA | 100% |
| 100%[c] | 13% | 25% | 50% | NA |
| 100%[c] | NA | NA | NA | 100% |
| NA | 0% | NA | NA | NA |
| NA | 66% | NA | 100% | NA |
| NA | 24% | NA | NA | NA |
| NA | NA | NA | NA | NA |
| NA | NA | NA | NA | NA |
| NA | NA | NA | NA | NA |
| NA | NA | NA | NA | NA |
| NA | NA | NA | NA | NA |
| NA | NA | NA | NA | NA |
| NA | NA | NA | NA | NA |
| NA | NA | NA | NA | NA |
| NA | NA | NA | NA | NA |
| NA | NA | NA | NA | NA |
| NA | 0% | NA | NA | NA |
| NA | 0% | NA | NA | NA |
| 100%[c] | 0%[g] | NA | NA | NA |
| NA | 0% | NA | 100% | NA |
| NA | 0% | NA | NA | NA |
| NA | 100% | NA | NA | NA |
| NA | 0% | NA | NA | NA |
| NA | 0% | NA | NA | NA |
| NA | 0% | NA | NA | NA |
| NA | 25%[d] | NA | NA | NA |
| 100%[c] | NA | NA | NA | NA |
| NA | NA | NA | NA | NA |
| NA | NA | NA | NA | NA |
| NA | NA | NA | NA | NA |
| NA | NA | NA | NA | NA |

**TABLE 4. Means and coefficients of variation (CVs) of annual constituent concentrations in effluents from industrial dischargers in southern California in 1995.**

| | Chevron El Segundo Refinery Waste | | Unocal Refinery Wilmington H, CW | | Mobil Terminal Terminal Island Misc. 1 Waste | | U.S. Borax Wilmington H, CW | |
|---|---|---|---|---|---|---|---|---|
| Constituent | Mean | CV | Mean | CV | Mean | CV | Mean | CV |
| Flow (mgd) | 7.79 | 8 | 2.1 | 59 | 0.007 | 157 | 0.73 | 2 |
| Flow (million L/day) | 29.5 | 8 | 8.1 | 59 | 0.03 | 157 | 2.8 | 2 |
| Suspended solids (mg/L) | 18 | 57 | NA | - | 3 | 116 | NA | - |
| Settleable solids (mL/L) | 0.1 | 189 | NA | - | ND | - | NA | - |
| BOD (mg/L) | 13[d] | 53 | NA | - | NA | - | NA | - |
| Oil & grease (mg/L) | 5.9 | 26 | NA | - | 2.3 | 99 | NA | - |
| Ammonia-N (mg/L) | 3.6 | 50 | NA | - | NA | - | 0.16 | 154 |
| Cyanide (µg/L) | <15.6 | - | NA | - | <25 | - | NA | - |
| Turbidity (NTU) | 12 | 122 | NA | - | NA | - | NA | - |
| Acute toxicity (TUa) | 0.6 | 84 | 0 | - | 0.15 | 200 | 0.06 | 200 |
| Chronic toxicity (TUc) | - | - | NA | - | NA | - | NA | - |
| *Selenastrum capricornutum* | NA | - | NA | - | NA | - | NA | - |
| *Macrocystis pyrifera* | NA | - | 1 | - | NA | - | NA | - |
| *Ceriodaphnia,* survival | NA | - | NA | - | NA | - | NA | - |
| *Ceriodaphnia,* reproduction | NA | - | NA | - | NA | - | NA | - |
| *Dendraster excentricus* | 2.9 | 265 | NA | - | NA | - | NA | - |
| *Strongylocentrotus purpuratus* | 0 | - | 1.25 | - | NA | - | NA | - |
| *Pimephales promelas,* larval survival | NA | - | NA | - | NA | - | NA | - |
| *Pimephales promelas,* larval growth | NA | - | NA | - | NA | - | NA | - |
| *Menidia beryllina* | NA | - | 1 | - | NA | - | NA | - |
| Arsenic (µg/L) | 21 | 13 | <5 | - | NA | - | NA | - |
| Cadmium (µg/L) | 0.4 | 98 | <5 | - | NA | - | NA | - |
| Chromium (µg/L) | 1.9 | 110 | <10 | - | NA | - | NA | - |
| Copper (µg/L) | 2.8 | 232 | <10 | - | NA | - | NA | - |
| Lead (µg/L) | 1.3 | 181 | <3 | - | NA | - | NA | - |
| Mercury (µg/L) | <0.198 | - | <0.2 | - | NA | - | NA | - |
| Nickel (µg/L) | 12 | 71 | <32 | - | NA | - | NA | - |
| Selenium (µg/L) | 59 | 43 | <5 | - | NA | - | NA | - |
| Silver (µg/L) | 0.04 | 346 | <10 | - | NA | - | NA | - |
| Zinc (µg/L) | 12 | 346 | 260 | - | NA | - | NA | - |
| Phenols[f] (µg/L) | 88.5 | 41 | NA | - | 150 | 200 | NA | - |
| Chlorinated phenols[g] (µg/L) | <84 | - | NA | - | NA | - | NA | - |
| Nonchlorinated phenols[g] (µg/L) | <50[c] | - | NA | - | NA | - | NA | - |
| Total DDT (µg/L) | ND | - | <0.11 | - | NA | - | NA | - |
| Total PCB (µg/L) | ND | - | <1.1[c] | - | NA | - | NA | - |

[a]Flow weighted.
[b]Corrected for mass found in receiving water.
[c]Maximum of the range of detection limits reported.
[d]CBOD = Carbonaceous biochemical oxygen demand.
[e]Chromium VI only.
[f]Colorimetric method.
[g]Gas chromatography/mass spectrometry (GC/MS) or gas chromatography (GC) method.
CW = Cooling water.
H = Hazardous: contains toxic, corrosive, ignitable, or reactive substances and must be managed according to Department of Health Services standards.
LBNSY = Long Beach Naval Shipyard.

| ARCO Refinery Carson Process Waste | | Texaco Refinery Wilmington H, CW | | LBNSY[a] Terminal Island NONCON | | Morton Ocean Salt Long Beach Process Waste | | SIO La Jolla Misc. Waste 2 | | Western Salt Chula Vista Process Waste | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean | CV | Mean | CV | Mean | CV | Mean | CV | Mean | CV | Mean | CV |
| 0.72 | 346 | 2 | 36 | 2.4 | 12 | 0.002 | 18 | 0.52 | 11 | 0.006 | 96 |
| 2.73 | 46 | 7.7 | 36 | 9.1 | 12 | 0.006 | 18 | 2 | 11 | 0.02 | 96 |
| 7.8 | - | 6 | 59 | 29[b] | 176 | 89 | 49 | 2.3 | 0.4 | 100 | 45 |
| NA | - | 0.1 | 0 | NA | - | <0.1 | - | <0.2[c] | - | <0.1 | - |
| 8 | - | 12 | 47 | NA | - | NA | - | NA | - | 0.58 | - |
| 3 | - | 7.1 | 17 | 0.1 | 166 | 4 | 181 | 5.3 | 42 | NA | - |
| 2 | - | 6 | 103 | NA | - | NA | - | NA | - | 21.7 | - |
| NA | - | NA | - | <20 | - | NA | - | NA | - | NA | - |
| 15 | - | NA | - | 6.3 | 66 | NA | - | 0.3 | 16 | NA | - |
| ND | - | NA | - | 0.12 | 200 | NA | - | NA | - | NA | - |
| 2 | - | NA | - | - | - | NA | - | NA | - | NA | - |
| 2.5 | - | NA | - | NA | - | NA | - | NA | - | NA | - |
| NA | - | NA | - | NA | - | NA | - | NA | - | NA | - |
| 1.5 | - | NA | - | NA | - | NA | - | NA | - | NA | - |
| 9 | - | NA | - | NA | - | NA | - | NA | - | NA | - |
| NA | - | NA | - | NA | - | NA | - | NA | - | NA | - |
| NA | - | NA | - | NA | - | NA | - | NA | - | NA | - |
| 2.5 | - | NA | - | NA | - | NA | - | NA | - | NA | - |
| 2.5 | - | NA | - | NA | - | NA | - | NA | - | NA | - |
| NA | - | NA | - | NA | - | NA | - | NA | - | NA | - |
| 10.8 | - | NA | - | <5 | - | NA | - | NA | - | NA | - |
| ND | - | NA | - | <5 | - | NA | - | NA | - | NA | - |
| 2.2 | - | 24 | 150 | <20[e] | - | NA | - | NA | - | NA | - |
| 3 | - | NA | - | <5 | - | NA | - | 14 | 23 | NA | - |
| 0.5 | - | NA | - | <5 | - | NA | - | NA | - | NA | - |
| ND | - | NA | - | 0.02 | 0 | NA | - | NA | - | NA | - |
| ND | - | NA | - | <5 | - | NA | - | NA | - | NA | - |
| 6.2 | - | NA | - | <2 | - | NA | - | NA | - | NA | - |
| ND- | NA | - | <5 | - | NA | - | NA | - | NA | - | |
| 91 | - | NA | - | 12[b] | 103 | NA | - | NA | - | NA | - |
| ND | - | 167 | 98 | NA | - | NA | - | NA | - | NA | - |
| NA | - | NA | - | NA | - | NA | - | NA | - | NA | - |
| NA | - | NA | - | NA | - | NA | - | NA | - | NA | - |
| NA | - | NA | - | NA | - | NA | - | NA | - | NA | - |
| NA | - | NA | - | NA | - | NA | - | NA | - | NA | - |

MISC 1 = Steam condensate, tank washing waste, and ship ballast water.
MISC 2 = Aquarium seawater to which copper sulfate and antibiotics have been added, seawater from a physiological research laboratory, and storage tank seawater.
NA = Not analyzed.
ND = Not detected.
NONCON = Noncontact cooling water.
PROC = Process waste (waste produced as part of the industrial/ manufacturing process).
SIO = Scripps Institute of Oceanography.
SW = Stormwater runoff.

**TABLE 5. Estimated constituent mass emissions from industrial dischargers in southern California in 1995.**

| Constituent | Chevron El Segundo Oil Refinery | Unocal L.A. Oil Refinery | Mobil Southwestern Terminal | U.S. Borax Wilmington Plant | ARCO L.A. Oil Refinery | Texaco L.A. Oil Refinery |
|---|---|---|---|---|---|---|
| Flow (L x $10^9$) | 10.8 | 3 | 0.01 | 1 | 1 | 2.8 |
| Suspended solids (mt) | 193 | NA | 0.02 | NA | 8 | 17 |
| BOD (mt) | 137[a] | NA | NA | NA | 8.2 | 33 |
| Oil and grease (mt) | 63 | NA | 0.03 | NA | 3.1 | 20 |
| Ammonia-N (mt) | 39 | NA | NA | 0.05 | 2 | 16 |
| Cyanide (kg) | ND | NA | ND | NA | NA | NA |
| Arsenic (kg) | 224 | ND | NA | NA | 11 | NA |
| Cadmium (kg) | 4.3 | ND | NA | NA | ND | NA |
| Chromium (kg) | 21 | ND | NA | NA | 2.2 | 73 |
| Copper (kg) | 32 | ND | NA | NA | 3.1 | NA |
| Lead (kg) | 15 | ND | NA | NA | 0.5 | NA |
| Mercury (kg) | ND | ND | NA | NA | ND | NA |
| Nickel (kg) | 134 | ND | NA | NA | ND | NA |
| Selenium (kg) | 625 | ND | NA | NA | 6.3 | NA |
| Silver (kg) | 0.4 | ND | NA | NA | ND | NA |
| Zinc (kg) | 161 | 773 | NA | NA | 93 | NA |
| Phenols (kg) | 946 | NA | 0.9 | NA | ND | 455 |
| Chlorinated phenols (kg) | ND | NA | NA | NA | NA | NA |
| Nonchlorinated phenols (kg) | ND | NA | NA | NA | NA | NA |
| Total DDT (kg) | ND | ND | NA | NA | NA | NA |
| Total PCB (kg) | ND | ND | NA | NA | NA | NA |

[a] CBOD = Carbonaceous biochemical oxygen demand.
[b] Corrected for mass found in intake water.
NA = Not analyzed.
ND = Not detected.

**TABLE 6. Combined mass emission estimates for coastal petroleum industries with direct discharge* into the Southern California Bight.**

| Constituent | Mass Emissions 1971-1972 | 1987 | 1989 | 1995 |
|---|---|---|---|---|
| Produced water | | | | |
| Number of facilities | 26 | 3 | 4 | 0 |
| Flow (mgd) | 6 | 3 | 4 | 0 |
| Suspended solids (mt) | 500 | - | 38 | 0 |
| Oil and grease (mt) | 100 | 40 | 54 | 0 |
| Process waste (Chevron El Segundo Refinery) | | | | |
| Flow (mgd) | 72 | 6 | 9 | 8 |
| Suspended solids (mt) | 2,800 | - | 196 | 193 |
| Oil and grease (mt) | 1,290 | 60 | 91 | 63 |

*Does not include harbor, storm channel (e.g., ARCO L.A. Refinery), or river discharges.

| U.S.Dept. Navy Long Beach Naval Shipyard | Morton Int. Ocean Salt Company | Scripps Institute of Oceanography | Western Salt Company | Total |
|---|---|---|---|---|
| 3.3 | 0.002 | 0.7 | 0.009 | 23 |
| 91[b] | 0.2 | 1.7 | 0.9 | 312 |
| NA | NA | NA | 0.005 | 178 |
| 0.4 | 0.008 | 3.7 | NA | 90 |
| NA | NA | NA | 0.2 | 57 |
| ND | NA | NA | NA | 0 |
| ND | NA | NA | NA | 235 |
| ND | NA | NA | NA | 4.3 |
| ND | NA | NA | NA | 96 |
| ND | NA | 10 | NA | 45 |
| ND | NA | NA | NA | 16 |
| 0.07 | NA | NA | NA | 0.07 |
| ND | NA | NA | NA | 134 |
| ND | NA | NA | NA | 631 |
| ND | NA | NA | NA | 0.4 |
| 41[b] | NA | NA | NA | 1,068 |
| NA | NA | NA | NA | 1,402 |
| NA | NA | NA | NA | 0 |
| NA | NA | NA | NA | 0 |
| NA | NA | NA | NA | 0 |
| NA | NA | NA | NA | 0 |

**TABLE 7. Estimates of constituent mass emissions and percent contributions from industrial facilities, power plants, and publicly owned treatment works (POTWs) that discharged into the Southern California Bight in 1995.**

| | Mass Emissions | | | | Percent of Total[d] | | |
|---|---|---|---|---|---|---|---|
| Constituent | Industrial Facilities (n=10) | Power Plants[a,b] (n=13) | POTWs[c] (n=19) | Total | Industrial Facilities | Power Plants | POTWs |
| Total flow (mgd) | 16 | 6511 | 1,249 | 7,776 | 0.21 | 84 | 16 |
| Suspended solids (mt) | 312 | 101 | 75,387 | 75,800 | 0.41 | 0.13 | 99 |
| BOD (mt) | 178 | 0.11 | 140,363 | 140,541 | 0.13 | 0.00008 | 100 |
| Oil & Grease (mt) | 90 | 27 | 19,661 | 19,778 | 0.46 | 0.14 | 99 |
| Nitrate-N (mt) | nd | 6.5 | 417 | 424 | 0 | 1.53 | 98 |
| Ammonia-N (mt) | 57 | 5 | 44,896 | 44,958 | 0.13 | 0.0111 | 100 |
| Cyanide (kg) | nd | nd | 8,000 | 8,000 | nd | nd | 100 |
| Arsenic (kg) | 235 | 57 | 5,380 | 5,672 | 4.14 | 1 | 95 |
| Cadmium (kg) | 4.3 | 645 | 1,430 | 2,079 | 0.21 | 31 | 69 |
| Chromium (kg) | 96 | 402 | 8,400 | 8,898 | 1.08 | 4.52 | 94 |
| Copper (kg) | 45 | 1,954 | 59,800 | 61,799 | 0.07 | 3.16 | 97 |
| Lead (kg) | 16 | 1,177 | 4,800 | 5,993 | 0.27 | 19.64 | 80 |
| Mercury (kg) | 0.07 | 224 | 30 | 254 | 0.03 | 88 | 12 |
| Nickel (kg) | 134 | 7.7 | 32,700 | 32,842 | 0.41 | 0.02 | 100 |
| Selenium (kg) | 631 | nd | 8,581 | 9,212 | 6.85 | nd | 93 |
| Silver (kg) | 0.4 | nd | 6,030 | 6,030 | 0.01 | nd | 100 |
| Zinc (kg) | 1068 | 18,513 | 102,000 | 121,581 | 0.88 | 15 | 84 |
| Phenols (kg) | 1402 | nd | 172,433 | 173,835 | 0.81 | 0 | 99 |
| DDT (kg) | nd | nd | 3 | 3 | nd | nd | 100 |
| PCB (kg) | nd | nd | nd | nd | nd | nd | nd |

nd = Not detectable.

[a]Estimates are for combined discharge (cooling water and in-plant waste discharge) except suspended solids and oil and grease which is in-plant waste only.

[b]Raco-Rands, V.E. (1997c)

[c]Raco-Rands, V.E. (1997a, 1997b)

[d]"Total" is the sum of the mass emissions from the industrial facilities, power plants, and POTWs.

## APPENDIX 1.

**Industrial facilities that discharged into southern California bays, harbors, tidal prisms of storm channels, or directly into the Southern California Bight in 1995**.

| Agency | Industrial Facility | I.D. No.* | Discharge Type** | Facility Location | Initial Discharge Location | Permit No. |
|---|---|---|---|---|---|---|
| **LOS ANGELES REGIONAL WATER QUALITY CONTROL BOARD** | | | | | | |
| Chevron U.S.A. Inc. | El Segundo Oil Refinery | 1 | PROC/SW | El Segundo | Pacific Ocean | 0000337 |
| Unocal Corp. | Los Angeles Oil Refinery | 2 | HCW | Wilmington | L.A. Harbor | 0000035 |
| Mobil Oil Corp. | Southwestern Terminal-Area 1 | 3 | MISC 1/SW | Terminal Is. | L.A. Harbor | 0003689 |
| U.S. Borax Inc. | Wilmington Plant | 4 | HCW | Wilmington | L.A. Harbor | 0000787 |
| ARCO Products Co. | Los Angeles Refinery | 5 | PROC | Carson | Dominguez Channel | 0000680 |
| Texaco Incorporated | Los Angeles Plant | 6 | HCW | Wilmington | Dominguez Channel | 0003778 |
| U.S. Dept. of the Navy | Long Beach Naval Shipyard | 7 | NONCON | Terminal Is. | Long Beach Harbor | 0003786 |
| Morton Int. Inc. | Ocean Salt Company | 8 | PROC | Long Beach | Long Beach Harbor | 0061476 |
| **SAN DIEGO REGIONAL WATER QUALITY CONTROL BOARD** | | | | | | |
| University of California | Scripps Inst. of Oceanography | 9 | MISC 2 | La Jolla | Pacific Ocean | 0107239 |
| Western Salt Company | Western Salt Company | 10 | PROC | Chula Vista | San Diego Bay | 0107352 |

*Key to location on Figure 1.
**Type refers to wastes discharged in 1995. Other types of wastes may be allowed to be discharged under the same permit.
HCW = Hazardous cooling water which contains toxic, corrosive, ignitable, or reactive substances and must be managed according to Department of Health Services standards.
MISC 1 = Steam condensate, tank washing waste, and ship ballast water.
MISC 2 = Aquarium seawater to which copper sulfate and antibiotics have been added, seawater from a physiological research laboratory, and storage tank seawater.
NONCON = Noncontact cooling water.
PROC = Process waste (waste produced as part of the industrial/manufacturing process).
SW = Stormwater runoff.

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