# Characteristics of effluents from large municipal wastewater treatment facilities in 1997

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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 varying amounts of contaminants to the ocean. This study summarizes constituent concentrations of effluents and constituent mass emissions from the large municipal wastewater facilities in 1997 and describes trends that have occurred in constituent emissions from these facilities over the past 26 years. Sixty-one percent of the constituents discharged to the SCB have declined more than 70% since 1971. However, several constituents at the individual wastewater treatment facilities have significantly increased from 1996 to 1997.

## 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 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.

Historically, municipal wastewater has been one of the major sources of contaminants discharged to the marine environment of the SCB (SCCWRP 1973). In 1995, effluents from the following four facilities comprised 89% of the municipal wastewater discharged directly to the SCB: Hyperion Treatment Plant (HTP) operated by the City of Los Angeles; the Joint Water Pollution Control Plant (JWPCP) operated by the County Sanitation Districts of Los Angeles County (CSDLAC); Wastewater Treatment Plant No. 2 operated by the Orange County Sanitation Districts (OCSD); and Point Loma Wastewater Treatment Plant (PLWTP) operated by the City of San Diego (Figure 1) (Raco-Rands 1997). For at least two decades, these agencies have routinely measured the characteristics of their effluents.

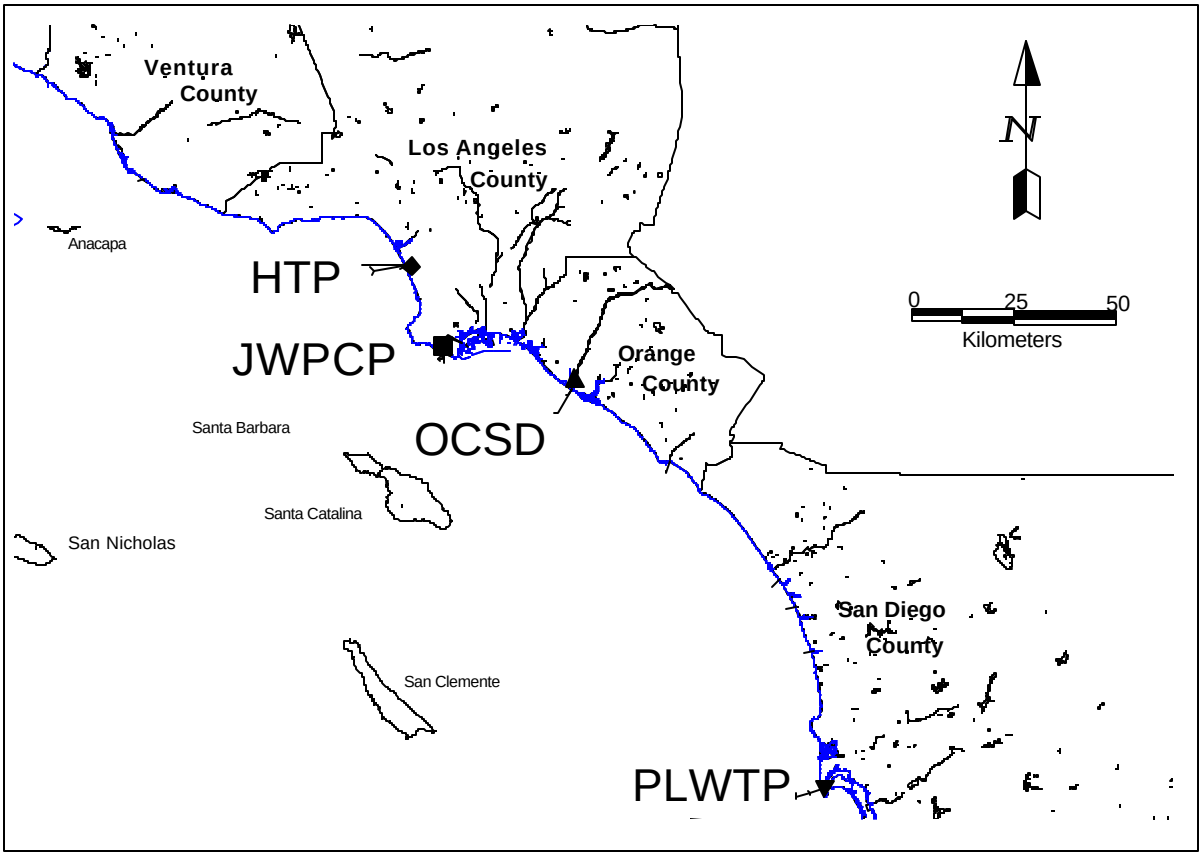
Although constituent concentrations are summarized in the monitoring reports produced by these agencies, not all of the agencies estimate mass loadings. Among those that do, differences exist in the estimation methods used. Since 1973, Southern California Coastal Water Research Project (SCCWRP) has regularly summarized and compared effluent constituent concentrations and mass emissions among these facilities (Raco-Rands 1999; SCCWRP 1973, 1990, 1995). In this report, we continue our analysis from previous years by summarizing the concentrations of effluent constituents and estimating mass emissions for these four wastewater treatment facilities in 1997. Trends in mass emissions of constituents from 1971 to 1997 are also described and discussed.

## MATERIALS AND METHODS

Effluent data were obtained from each discharging agency. Effluent constituent monitoring is mandated under the National Pollutant Discharge Elimination System (NPDES) permits issued through the U.S. Environmental Protection Agency (U.S. EPA) and the Los Angeles, Santa Ana, and San Diego regions of the California Regional Water Quality Control Board (CRWQCB). Population data were obtained from the State of California (1998).

The large municipal wastewater treatment plants measured constituents at the following frequencies: (1) general constituents (e.g., suspended solids, biochemical oxygen demand [BOD], oil and grease, ammonia-N, etc.) — once per month to six times per day; (2) toxicity – one to

**FIGURE 1. Locations of the four largest municipal wastewater facilities that discharge to the Southern California Bight: Hyperion Treatment Plant (HTP, City of Los Angeles); Joint Water Pollution Control Plant (JWPCP, County Sanitation Districts of Los Angeles County); Orange County Sanitation Districts (OCSD); and Point Loma Wastewater Treatment Plant (PLWTP, City of San Diego).**




three times per year to once per month; (3) metals — once per month to seven times per month; and (4) organics — once per quarter to seven times per month (Table 1).

Seventy-two percent of the constituents were analyzed by all of the facilities. Of those, 41% were analyzed using different methods (Table 2); 22% were analyzed using the same method or similar methods (but different reference sources); and 9% were analyzed using the same method, but different reagents or procedures within the method. Reporting limits varied by as much as 490 times (e.g., Benzo[A]Anthracene) among the agencies (Table 3).

Two types of assessments were performed. First, annual mean concentrations were calculated by averaging monthly concentrations recorded throughout the year. For calculating the annual mean, zeros were assigned for monthly concentration values when the results were below reporting limits. Annual mean concentrations were reported even if they were below reporting limits. (This method may differ from methods used by the agencies for compliance reporting to the CRWQCB and the U.S. EPA). Second, annual contaminant mass emissions (ME) were estimated from the product of the mean daily flow, 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*
$C_i$ = Constituent concentration in month *i*, or annual mean concentration (for months not measured)
$D_i$ = Number of days in month *i*

When calculating mass emissions, single constituent concentration measurements below the reporting limit were considered to have zero mass emissions; however, if multiple measurements were performed for a month and the constituent concentration was above the reporting limit in one or more measurements, the average concentration for the month was used for mass calculations even if the

monthly and yearly average concentrations were below the reporting limit. Similarly, if a constituent that was measured only once a month had measurements above the reporting limit in one or more months, the mass emissions for the year were calculated whether or not the yearly mean concentration was below the detection limit. If a constituent concentration was not analyzed for a certain month or the results were unreliable (as determined by the discharging agency), the annual mean concentration was used to calculate mass emissions for that month.

In previous reports, for data prior to 1990, effluent data mass emission estimates were based upon annual mean values and thereafter they were based upon monthly flow and constituent concentration values. For this study, monthly historical data from the four dischargers were reviewed and entered into one database for the first time, for all years (1971-1997). Therefore, all effluent mass emission estimates were based upon monthly data.

In creating the historical database, the dischargers' analyses of their wastewater were used whenever possible. However, SCCWRP analyses of PLWTP's DDTs and PCBs for 1976 and 1977 were used because PLWTP only reported total identifiable chlorinated hydrocarbons (TICH). Also, some DDT and PCB analyses by other laboratories from a series of intercalibration studies were used instead of discharger analyses because they were deemed more reliable. This was the case for 1971 to 1975 data for all four dischargers with the exception of DDT analyses by JWPCP of their own effluent which was deemed to be reliable. In 1971 and 1972, the laboratories participating in the intercalibration study were CSDLAC and the Bodega Marine Laboratory at the University of California at Berkeley. In 1973, participating laboratories were CSDLAC, Bodega Bay Laboratory, SCCWRP, and the University of Washington (Young *et al.* 1980). Over the years, various results were reported to be most representative of the 1971 to 1975 DDT and PCB values for the four facilities. To determine which values to use, the chronology of SCCWRP reports was used as the deciding factor, i.e. values reported in later publications took precedence over earlier reports. For example, for the 1971 results, concentrations reported in SCCWRP (1974) were used rather than those reported in SCCWRP (1973). Because only the mass emissions for the 1971 data were reported in SCCWRP 1974, the mass emissions were back-calculated to determine concentrations. Also, regarding the 1971 data for DDTs and PCBs: (1) Hyperion's and JWPCP's analyses of DDTs and PCBs were used; (2) the 1972 results of OCSD effluent by Bodega Bay Laboratory and JWPCP were used for OCSD (reliable results were not available for 1971); and mass emission estimates were not made for PLWTP because these analyses were deemed unreliable. For the 1972-1975 data, we decided to use the conclusions in Young *et al.* (1980), on which laboratory analyses of DDTs and PCBs were most reliable; therefore, we incorporated the numbers from the Young *et al.* (1980) summary tables (Tables B-1, B-3, and B-4) into our mass emission estimates. It is believed that although these numbers were not incorporated into SCCWRP's annual reports, they were meant to be changed to these values because the footnotes in the historical constituent mass emission tables (Table 4,

**TABLE 1. Frequency of constituent measurements in effluents from the largest municipal wastewater treatment facilities in southern California in 1997.**

| Constituent | HTP | JWPCP | OCSD | PLWTP |
|---|---|---|---|---|
| Suspended Solids | 1/Day | 1/Day | 1/Day | 1/Day |
| Settleable Solids | 6/Day | 3/Day | 1/Day | 1/Day |
| BOD | 1/Day | 1/Day | 1/Day | 1/Day |
| Oil and Grease | 1/Week | 1/Day | 7/Month | 1/Day |
| Nitrate-N | 1/Month | 1/Month | NA | 1/Week |
| Nitrite-N | 1/Month | 1/Month | NA | NA |
| Ammonia-N | 1/Month | 1/Month | 7/Month | 1/Week |
| Organic-N | 1/Month | 1/Month | NA | NA |
| Phosphate | NA | 1/Month | NA | 1/Week |
| Total Phosphorus | 1/Month | NA | NA | NA |
| Cyanide | 1/Month | 1/Month | 1/Month | 1/Week |
| Turbidity | 1/Day | 1/Day | 1/Day | 1/Day |
| Acute Toxicity | | | | |
| *Pimephales promelas* | 1/Month | 1/Month | 1/Month | 1/Month |
| Chronic Toxicity | | | | |
| *Haliotis rufescens* | 1/Month | NA | NA | 1/Month |
| *Macrocystis pyrifera* | 1-3/Year | 1/Month | NA | 1/Month |
| Arsenic | 1/Month | 1/Month | 1/Month | 1/Week |
| Cadmium | 1/Month | 1/Month | 7/Month | 1/Week |
| Chromium | 1/Month | 1/Month | 7/Month | 1/Week |
| Copper | 1/Month | 1/Month | 7/Month | 1/Week |
| Lead | 1/Month | 1/Month | 7/Month | 1/Week |
| Mercury | 1/Month | 1/Month | 1/Month | 1/Week |
| Nickel | 1/Month | 1/Month | 7/Month | 1/Week |
| Selenium | 1/Month | 1/Month | 1/Month | 1/Week |
| Silver | 1/Month | 1/Month | 7/Month | 1/Week |
| Zinc | 1/Month | 1/Month | 7/Month | 1/Week |
| Phenols | NA | 1/Month | 1/Month | NA |
| Chlorinated Phenols | Quarterly | 1/Month | 1/Month | 1/Week |
| Nonchlorinated Phenols | Quarterly | 5/Year | 1/Month | 1/Week |
| Total DDT | Quarterly | 1/Month | 1/Month | 1/Week |
| Total PCB | Quarterly | 1/Month | 7/Month | 1/Week |
| PAHs | Quarterly | Quarterly | 1/Month | 1/Month |

HTP = Hyperion Treatment Plant, City of Los Angeles.
JWPCP = Joint Water Pollution Control Plant, County Sanitation Districts of Los Angeles County.
OCSD = Orange County Sanitation Districts.
PLWTP = Point Loma Wastewater Treatment Plant, City of San Diego.
BOD = Biochemical oxygen demand.
NA = Not analyzed.
NR = Not reported.

**TABLE 2. Analytical methods used for measuring constituent levels in effluents of the largest municipal wastewater treatment facilities in southern California in 1997.**

| Constituent | HTP | JWPCP | OCSD | PLWTP |
|---|---|---|---|---|
| Suspended Solids | 2540D(a[a]) | 2540D(b) | 160.2(c) | 2540D(b) |
| Settleable Solids | 2540F(a) | 2540F(b) | 2540F(b) | 2540F(b) |
| BOD | 5210B(a) | 5210B(b) | 5210B(b) | 5210B(b) |
| Oil and Grease | 5520B(a) | 5520B(b) | 413.1(c) | 5520B(b) |
| Nitrate-N | 4500-$NO_3$E(a) | 4500-$NO_3$E(b) | NA | 4110B(b) |
| Nitrite-N | 4500-$NO_2$B(a) | 4500-$NO_2$B(b) | NA | NA |
| Ammonia-N | 4500-$NH_3$ B, & E(a) | 4500-$NH_3$ B, & E(b) | 350.1(c) | 4500-$NH_3$ F(b) |
| Organic N | 4500-N-orgB(a) | 4500-N-orgB(b)& $NH_3$E(b) | NA | NA |
| Phosphate | NA | 4500-P B.5 & E(b) | NA | 4110B(b) |
| Total Phosphorus | 4500-P B & E(a) | NA | NA | NA |
| Cyanide | 335.2(c) | 4500-CN C &E(b) | 335.2(c) | 4500-CN E(b) |
| Turbidity | 2130B(a) | 2130B(b) | 180.1(c) | 2130B(b) |
| Acute Toxicity | | | | |
| *Pimephales promelas* | (d) | (e) | (e) | (d) |
| Chronic Toxicity | | | | |
| *Haliotis rufescens* | (f) | NA | NA | (f) |
| *Macrocystis pyrifera* | | | | |
| Germ Tube Length | (f) | (f) | NA | (f) |
| Germination | (f) | (f) | NA | (f) |
| Trace Metals | | | | |
| Digestion | | | | |
| Arsenic, selenium | 3114B(a) | 3030G(b) | 200(c) | 3114B(b) |
| Cadmium, chromium, nickel, silver | 3030E(a) | 3030H(b) | 200(c) | 200.7(c) |
| Copper, zinc | 3030E(a) | 3030H(b) | 200.7(c) | 200.7(c) |
| Lead | 3030E(a) | 3030H(b) | 200(c) | 3030F(b) |
| Mercury | 3112B(a) | 3112B(b) | 245.1(c) | 3112B(b) |
| Analysis | | | | |
| Arsenic | 3114B(a) | 3114B(b) | 204.2(c) | 3114B(b) |
| Cadmium | 3120(a) | 3111B(b) | 213.2(c) | 200.7(c) |
| Chromium | 3120(a) | 218.1(c) | 218.2(c) | 200.7(c) |
| Copper, zinc | 3120(a) | 3111B(b) | 200.7(c) | 200.7(c) |
| Lead | 3113(a) | 3111B(b) | 239.2(c) | 3111B(b) |
| Mercury | 3112B(a) | 3112B(b) | 245.1(c) | 3112B(b) |
| Nickel | 3120(a) | 3111B(b) | 249.2(c) | 200.7(c) |
| Selenium | 3114B(a) | 3114B(b) | 270.2(c) | 3114B(b) |
| Silver | 3113B(a) | 3111B(b) | 272.2(c) | 200.7(c) |
| Phenols | NA | 420.1(c) | 420.2(c) | NA |
| Chlorinated phenols | 625(g) | 625(h) | 625(h) | 625(g) |
| Nonchlorinated phenols | 625(g) | 625(h) | 625(h) | 625(g) |
| Total DDT | 608(g) | 608(g) | 608(h) | 608(g) |
| Total PCB | 608(g) | 608(g) | 608(h) | 608(g) |
| PAHs | 625(g) | 625 & 610(h) | 625(h) | 625(g) |

[a]Letter in parentheses refers to reference list at the end of the table.

References

(a) Clesceri, L., A.E. Greenberg, and R.R. Trussell. 1989.
(b) Greenberg, A.E., L.S. Clesceri, and A.D. Eaton. 1992.
(c) U.S. EPA. 1983.
(d) U.S. EPA. 1985.
(e) Kopperdahl, F.R. 1976.
(f) Anderson, B.S., J.W. Hunt, S.L. Turpen, A.R. Coulon, M. Martin, D.L. McKeown, and F.H. Palmer. 1990.
(g) U.S. EPA. 1992.
(h) U.S. EPA. 1984.

SCCWRP 1989) state the source of the values are from Young *et. al*. (1980).

Effluent flow, mass emissions, and toxicity differences between 1996 and 1997 were tested for significance using the t-test or the Mann-Whitney test. T-tests were performed when all monthly concentrations were detectable and the data were normally distributed. Mann-Whitney tests were performed when the data were not normally distributed or one or more of the monthly concentrations were non-detectable.

## RESULTS

### 1997 Effluents

In 1997, mean daily flow rates varied by a factor of two among the four largest dischargers. The level of secondary treated effluent ranged from zero (PLWTP) to 55% (JWPCP) of the average daily flow rate (Table 4).

General constituents were detectable in an average of 94% of the monthly measurements among all of the facilities (Table 5). Trace metals were detectable in an average of 61% of the monthly measurements among all of the facilities. Mercury had the lowest frequency of detection for any metal at 10%. Chlorinated phenolic compounds were detectable in an average of 7% of the monthly measurements. Non-chlorinated phenolic compounds were detectable in an average of 11% of the monthly measurements. The DDTs were detectable in an average of 2% of the monthly measurements among all of the facilities. The PCBs were non-detectable for all four facilities. The PAH compounds were detectable in an average of 0.4% of the monthly measurements among all of the facilities.

The majority of concentrations (58%) of effluent constituents varied by a factor of two or less among the four municipal wastewater treatment plants (Table 6). Non-chlorinated phenols demonstrated the widest range of concentration, varying by a factor of 46. Differences in effluent concentrations were attributed to the types of wastes (domestic and industrial), the source control, the volume of water removed for reclamation and inland discharge, and the efficiency and degree of treatment methods and processes (advanced

**TABLE 3. Reporting limits of constituents in effluent from the largest municipal wastewater treatment facilities in southern California in 1997.**

| Constituent | HTP | JWPCP | OCSD | PLWTP |
|---|---|---|---|---|
| Suspended Solids (mg/L) | 2 | 4 | 6 | 0.6 |
| Settleable Solids (ml/L) | 0.1 | 0.1 | 0.1 | 0.1 |
| BOD (mg/L) | 3 | 2.4 | 30 | 2 |
| Oil and Srease (mg/L) | 3 | 0.7 | 5 | ND |
| Nitrate-N (mg/L) | 0.01 | 0.05 | NA | 0.007- 0.09 |
| Nitrite-N (mg/L) | | 0.005 | NA | NA |
| Ammonia-N (mg/L) | 0.1 | 1 | 1 | 1.6 |
| Organic N (mg/L) | 0.1 | 1 | NA | NA |
| Phosphate (mg/L) | NA | 0.16 | NA | 0.05, 0.4 |
| Total Phosphorus (mg/L) | 0.1 | NA | NA | NA |
| Cyanide (ug/L) | 4 | 5 | 5 | 2 |
| Turbidity (NTU) | 0.1 | 1 | 0.05 | ND |
| Chronic toxicity (TUc) | | | | |
| *Haliotis rufescens* | NR | NA | NA | 64 |
| *Macrocystis pyrifera* | | | | |
| Germ tube length | NR | 16.7 | NA | 64 |
| Germination | NR | 16.7 | NA | 64 |
| Arsenic (ug/L) | 1 | 1 | 1, 2 | 0.18 |
| Cadmium (ug/L) | 2 | 1 | 0.1, 0.2 | 1 |
| Chromium (ug/L) | 4 | 10, 13 | 1, 2 | 5 |
| Copper (ug/L) | 10 | 6 | 1 | 4 |
| Lead (ug/L) | 3 | 8, 10 | 1, 2 | 18 |
| Mercury (ug/L) | 0.3 | 0.5 | 0.2 | 0.27 |
| Nickel (ug/L) | 5 | 25 | 2 | 14 |
| Selenium (ug/L) | 1 | 1 | 1, 2 | 0.4 |
| Silver (ug/L) | 0.4 | 5 | 1, 2 | 6.6 |
| Zinc (ug/L) | 10 | 25 | 2 | 4 |
| Phenols (ug/L) | NA | 10 | 5 | NA |
| Chlorinated Phenols (ug/L) | | | | |
| 2-Chlorophenol | 1 | 1, 4 | 5 | 3.6 |
| 2,4-Dichlorophenol | 1 | 1, 3 | 6.9 | 6.1 |
| 4-Chloro-3-methylphenol | 1 | 1, 3 | 5.1 | 3.6 |
| 2,4,6-Trichlorophenol | 1 | 1, 4 | 6.5 | 3.4 |
| Pentachlorophenol | 7 | 1, 16 | 3.3 | 1.6 |
| Nonchlorinated Phenols (ug/L) | | | | |
| Phenol | 1 | 1 | 2.6 | 1.8 |
| 2-Nitrophenol | 1 | 1, 5 | 3.5 | 4.5 |
| 2,4-Dimethylphenol | 1 | 1 | 3.9 | 4.6 |
| 2,4-Dinitrophenol | 34 | 6, 30 | 4.1 | 3.3 |
| 4-Nitrophenol | 6 | 1, 18 | 11 | 6.1 |
| 4,6-Dinitro-2-methylphenol | 8 | 1, 5 | 6.1 | 3 |
| Total DDT (ug/L) | | | | |
| o,p'-DDD | 0.006 | 0.01, 0.02 | 0.02 | 0.02 |
| p,p'-DDD | 0.003 | 0.01, 0.02 | 0.04 | 0.03 |
| o,p'-DDE | 0.004 | 0.02, 0.03 | 0.02 | 0.04 |
| p,p'-DDE | 0.003 | 0.01 | 0.01 | 0.02 |
| o,p'-DDT | 0.004 | 0.01, 0.02 | 0.01 | 0.02 |
| p,p'-DDT | 0.013 | 0.01, 0.02 | 0.04 | 0.02 |
| Total PCB (ug/L) | | | | |
| PCB-1016 | 0.046 | 0.3, 0.5 | 0.3 | 0.6 |
| PCB-1221 | 0.034 | 0.4, 0.8 | 0.3 | ND |
| PCB-1232 | 0.033 | 0.3, 0.5 | 0.3 | ND |
| PCB-1242 | 0.04 | 0.5, 0.9 | 0.3 | 0.07 |
| PCB-1248 | 0.057 | 0.04, 0.08 | 0.3 | ND |
| PCB-1254 | 0.025 | 0.2, 0.4 | 0.3 | ND |
| PCB-1260 | 0.065 | 0.1 | 0.3 | 0.3 |
| PAHs (ug/L) | | | | |
| Acenaphthene | 1 | 1, 5 | 8.4 | 1.2 |
| Acenaphthylene | 1 | 1, 5 | 7.4 | 0.9 |
| Anthracene | 1 | 0.02, 5 | 5.7 | 1.2 |
| Benzo(A)Anthracene | 1 | 0.02, 5 | 9.8 | 1.2 |
| Benzo(A)Pyrene | 1 | 0.02, 1 | 2.6 | 7.4 |

**TABLE 3 (continued)**

| Constituent | HTP | JWPCP | OCSD | PLWTP |
|---|---|---|---|---|
| Benzo(B)Fluoranthene | 1 | 0.01, 5 | 2.8 | 0.8 |
| Benzo(G,H, I)Perylene | 1 | 0.01, 5 | 10 | 7 |
| Benzo(K)Fluoranthene | 1 | 0.01, 5 | 1.7 | 1 |
| Chrysene | 1 | 0.1, 5 | 2.9 | 1.4 |
| Dibenzo(A,H)Anthracene | 1 | 0.02, 5 | 10 | 7.8 |
| Fluoranthene | 1 | 1, 5 | 5.7 | 1.3 |
| Fluorene | 1 | 0.1, 5 | 8 | 1.1 |
| Indeno(1,2,3-C,D)Pyrene | 1 | 0.01, 5 | 10 | 7.4 |
| Naphthalene | 1 | 1, 5 | 4.6 | 1.6 |
| Phenanthrene | 1 | 0.17, 5 | 6.7 | 0.9 |
| Pyrene | 1 | 0.07, 5 | 5.1 | 1.5 |

NA = Not analyzed.
ND = Not determined.
NR = Not reported.
NTU = Nephelometric turbidity units.
TUc (toxic units chronic) = 100/No observed effect level (NOEL)

primary or secondary).

The coefficients of variation (CVs) for 60% of the monthly constituent concentrations were less than 50% (Table 6). The majority (71%) of the mass emissions of constituents across the four facilities varied by a factor of less than 10 (Table 7).

### Comparison of 1996 and 1997 Effluents

The daily flow rate from the four largest municipal wastewater treatment facilities in southern California increased significantly (using the t-test or the Mann-Whitney test) at PLWTP (6%), JWPCP (5%), and OCSD (3%), but increased only slightly at HTP (0.3%) (Table 8). The 10 mgd flow increase at PLWTP is mainly attributable to a 9 mgd increase in flow from 1996 to 1997 by the Tijuana Interceptor (City of San Diego 1998), which accepts sewage flow from the City of Tijuana. The daily flow rate of combined effluent from all four treatment plants receiving secondary treatment did not significantly decrease from 1996 to 1997 (46 to 44%, respectively) (Table 4).

Twenty-five percent of constituent mass emissions at individual facilities changed significantly from 1996 to 1997 (Table 8). Of the constituent mass emissions that showed significant changes, the majority of constituents (67%) increased. The constituents that significantly increased were suspended solids (10%), BOD (13%), and oil and grease (19%) at Hyperion; suspended solids (9%), BOD (14%), oil and grease (14%), and PAHs (100%, from non-detectable to 290 kg) at JWPCP; suspended solids (9%), BOD (7%), oil and grease (20%), ammonia-N (6%), chromium (7%), silver (11%), and non-chlorinated phenols (50%) at OCSD; and copper (73%) and selenium (29%) at PLWTP. Only suspended solids at OCSD significantly increased in 1997 as well as in 1996 (15%).

## DISCUSSION

### Effluent Trends, 1971-1997

Because mass emission calculation methods in this study used monthly values in place of annual values for data prior to 1990, mass emission estimates may be different from those reported in our previous annual reports. The historical estimates may differ for the following reasons: (1) preliminary data were previously used and later changed in the facilities' monthly or annual reports, which were published too late to be included in our annual reports; or (2) different data sources for the same constituent analyses had different values, so we may have used a different source with a different value than was used previously. Overall, the changes in mass emissions over time were small. The largest discrepancy may be in the

**TABLE 4. Flow rate of municipal wastewater discharged into the ocean by the largest municipal wastewater treatment facilities in southern California in 1996 and 1997.**

| | | | 1996 | | | 1997 | | |
|---|---|---|---|---|---|---|---|---|
| Treatment Plant | Length of Outfall from Shore (m) | Depth of Discharge (m) | Advanced Primary (mgd) | Secondary (mgd) | Total Flow (mgd) | Advanced Primary (mgd) | Secondary (mgd) | Total Flow (mgd) |
| HTP | 8,300 | 57 | 161 | 196 | 357 | 165 | 193 | 358 |
| JWPCP | 2,800/3,600 | 60 | 137 | 194 | 331 | 154 | 192 | 346 |
| OCSD | 7,250 | 60 | 120 | 116 | 236[a] | 125 | 119 | 244[a] |
| PLWTP | 7,285 | 93 | 179 | 0 | 179 | 189 | 0 | 189 |
| Total | | | 597 | 506 | 1,103 | 633 | 504 | 1,137 |

[a]Includes 0.11 mgd for 1996 and 1997 from construction groundwater dewatering sites at Plant 1 and Plant 2.
mgd = Million gallons per day (1 mgd = 3,785,000 L/day).

early years (1971-1975) of DDT and PCB analyses.

The combined flow from the four largest municipal wastewater treatment facilities increased 22% from 1971 (SCCWRP 1973) to 1997 (Table 9, Figure 2), for a mean annual increase of 0.8%. During this time, the volume of wastewater discharged by PLWTP, OCSD, and HTP increased 105, 88, and 6%, respectively, while the volume discharged by JWPCP decreased 7%. Population growth patterns, regional industry types and numbers, and the presence or absence of water reclamation programs and inland discharge sources accounted for the differences found among these agencies. Specifically, since 1970, Los Angeles County has grown by approximately 2.6 million people and Orange and San Diego counties have grown by approximately 1.3 and 1.4 million people, respectively (SCCWRP 1973, State of California 1998). Although the population of Los Angeles County has grown by 37%, flow has increased only 7% at HTP and has decreased by 7% at JWPCP, due, in part, to the CSDLAC and the City of Los Angeles expanding their upstream treatment and reclamation facilities. The CSDLAC reclaimed 189 million gallons per day (mgd) of water in 1997, almost twice the amount reclaimed 15 years ago (95 mgd). The City of Los Angeles has increased the volume of effluent discharged into the Los Angeles River by the Los Angeles-Glendale and Donald C. Tillman Water Reclamation Plants from 25 mgd in 1985 to 70 mgd in 1997 (City of Los Angeles 1998 a, b).

Despite increases in population and increases in the volume of wastewater discharged during the past 26 years, the mass emissions of most effluent constituents have decreased (Table 9). These reductions in contaminant mass emissions are the result of increased source control, land disposal of biosolids, improved sludge dewatering and primary treatment methods, and increased secondary treatment processes. The combined mass emissions of suspended solids, oil and grease, and BOD have decreased 75, 68, and 51%, respectively (Figures 3-5). The decline in JWPCP solids emissions between 1971 and 1997 accounted for 61% of this reduction. Termination of sludge discharge

**TABLE 5. Percent of months with detectable constituent or toxicity measurements in effluents from the largest municipal wastewater treatment facilities in southern California in 1997.**

| Constituent | HTP | JWPCP | OCSD | PLWTP | Percent Average |
|---|---|---|---|---|---|
| Suspended solids | 100 | 100 | 100 | 100 | 100 |
| Settleable solids | 33 | 100 | 100 | 100 | 83 |
| BOD | 100 | 100 | 100 | 100 | 100 |
| Oil and grease | 100 | 100 | 100 | 100 | 100 |
| Nitrate-N | 83 | 92 | NA | 67 | 81 |
| Nitrite-N | NR | 100 | NA | NA | 100 |
| Ammonia-N | 100 | 100 | 100 | 100 | 100 |
| Organic-N | 100 | 100 | NA | NA | 100 |
| Phosphate | NA | 100 | NA | 75 | 88 |
| Total phosphorus | 100 | NA | NA | NA | 100 |
| Cyanide | 75 | 100 | 25 | 100 | 75 |
| Turbidity | 100 | 100 | 100 | 100 | 100 |
| Acute toxicity | | | | | |
| *Pimephales promelas* | 58 | 67 | 100 | 100 | 81 |
| Chronic toxicity | | | | | |
| *Haliotis rufescens* | 100 | NA | NA | 58 | 79 |
| *Macrocystis pyrifera* | | | | | |
| Germ tube length | NR | 25 | NA | 92 | 59 |
| Germination | NR | 0 | NA | 83 | 42 |
| Arsenic | 92 | 100 | 58 | 100 | 88 |
| Cadmium | 0 | 42 | 83 | 33 | 40 |
| Chromium | 25 | 33 | 100 | 17 | 44 |
| Copper | 100 | 100 | 100 | 100 | 100 |
| Lead | 8 | 8 | 33 | 0 | 12 |
| Mercury | 0 | 0 | 17 | 25 | 10 |
| Nickel | 83 | 100 | 100 | 42 | 81 |
| Selenium | 0 | 100 | 67 | 100 | 67 |
| Silver | 100 | 75 | 83 | 8 | 67 |
| Zinc | 100 | 100 | 100 | 100 | 100 |
| Phenols (Colorimetric method) | NA | 100 | 100 | NA | 100 |
| Chlorinated phenols (GC/MS method) | 0 | 25 | 3 | 0 | 7 |
| 2-Chlorophenol | 0 | 67 | 0 | 0 | 17 |
| 2,4-Dichlorophenol | 0 | 0 | 0 | 0 | 0 |
| 4-Chloro-3-methylphenol | 0 | 0 | 0 | 0 | 0 |
| 2,4,6-Trichlorophenol | 0 | 58 | 0 | 0 | 15 |
| Pentachlorophenol | 0 | 0 | 17 | 0 | 4 |
| Nonchlorinated phenols (GC/MS method) | 3 | 11 | 15 | 17 | 11 |
| Phenol | 17 | 33 | 92 | 100 | 60 |
| 2-Nitrophenol | 0 | 0 | 0 | 0 | 0 |
| 2,4-Dimethylphenol | 0 | 33 | 0 | 0 | 8 |
| 2,4-Dinitrophenol | 0 | 0 | 0 | 0 | 0 |
| 4-Nitrophenol | 0 | 0 | 0 | 0 | 0 |
| 4,6-Dinitro-2-methylphenol | 0 | 0 | 0 | 0 | 0 |
| Total DDT | 0 | 7 | 0 | 0 | 2 |
| o,p'-DDD | 0 | 0 | 0 | 0 | 0 |
| p,p'-DDD | 0 | 8 | 0 | 0 | 2 |
| o,p'-DDE | 0 | 0 | 0 | 0 | 0 |
| p,p'-DDE | 0 | 17 | 0 | 0 | 4 |
| o,p'-DDT | 0 | 0 | 0 | 0 | 0 |
| p,p'-DDT | 0 | 17 | 0 | 0 | 4 |
| Total PCB | 0 | 0 | 0 | 0 | 0 |
| PCB-1016 | 0 | 0 | 0 | 0 | 0 |
| PCB-1221 | 0 | 0 | 0 | 0 | 0 |
| PCB-1232 | 0 | 0 | 0 | 0 | 0 |
| PCB-1242 | 0 | 0 | 0 | 0 | 0 |
| PCB-1248 | 0 | 0 | 0 | 0 | 0 |
| PCB-1254 | 0 | 0 | 0 | 0 | 0 |
| PCB-1260 | 0 | 0 | 0 | 0 | 0 |

**TABLE 5 (continued)**

| Constituent | HTP | JWPCP | OCSD | PLWTP | Percent Average |
|---|---|---|---|---|---|
| PAHs | 0 | 1 | 0.5 | 0 | 0.4 |
| Acenaphthene | 0 | 0 | 0 | 0 | 0 |
| Acenaphthylene | 0 | 0 | 0 | 0 | 0 |
| Anthracene | 0 | 0 | 0 | 0 | 0 |
| Benzo(A)Anthracene | 0 | 0 | 0 | 0 | 0 |
| Benzo(A)Pyrene | 0 | 0 | 0 | 0 | 0 |
| Benzo(B)Fluoranthene | 0 | 0 | 8 | 0 | 2 |
| Benzo(G,H, I)Perylene | 0 | 0 | 0 | 0 | 0 |
| Benzo(K)Fluoranthene | 0 | 0 | 0 | 0 | 0 |
| Chrysene | 0 | 0 | 0 | 0 | 0 |
| Dibenzo(A,H)Anthracene | 0 | 0 | 0 | 0 | 0 |
| Fluoranthene | 0 | 0 | 0 | 0 | 0 |
| Fluorene | 0 | 0 | 0 | 0 | 0 |
| Indeno(1,2,3-C,D)Pyrene | 0 | 0 | 0 | 0 | 0 |
| Naphthalene | 0 | 17 | 0 | 0 | 4 |
| Phenanthrene | 0 | 0 | 0 | 0 | 0 |
| Pyrene | 0 | 0 | 0 | 0 | 0 |

GC/MS = Gas chromatography/mass spectrometry.

from the HTP 7-mile outfall in November 1987 accounted for a 69% reduction in combined solids emissions from 1987 to 1988. Reductions by JWPCP from 1971 to 1997 accounted for approximately 74% of the decline in combined oil and grease emissions.

The combined mass emissions of trace metals decreased 95% from 1971 to 1997 (Table 9, Figure 6). Reductions of individual metals averaged 86% (arsenic was excluded since it was only analyzed for a complete year by HTP and JWPCP in 1971). The largest reductions were: cadmium, chromium, lead, and mercury (≥ 99%), followed by zinc (96%), copper (89%), nickel (89%), silver (63%), and selenium (36%). From 1972 to 1997, arsenic levels decreased 83%.

Several factors affected the combined mass emissions of trace metals during this 26-year period. One factor was the termination of sludge discharge from the HTP 7-mile outfall in 1987. From 1987 to 1988, the combined mass emissions of trace metals declined 36%; the termination of the 7-mile outfall accounted for 61% of this reduction. Another factor was the change in the analytical method used by HTP and OCSD to evaluate trace metals emissions. From 1989 to 1991, both agencies replaced the flame atomic absorption spectrophotometer (AAS) with the graphite furnace AAS, which has less sample matrix interference. Matrix interference causes some of the matrix to appear as lead, resulting in an overestimation of lead concentration. During this period combined metals emissions decreased 31%, while lead emissions decreased 91%.

The combined mass emissions of chlorinated hydrocarbons among all of the facilities decreased more than 99% from 1971 to 1997 (Table 9, Figure 7). Historically, Montrose Chemical Corporation was the largest source of chlorinated hydrocarbons in the SCB, discharging DDT wastes into the JWPCP sewer system from 1947 to 1971 (Chartrand 1988). Residual sediment in the sewer system was the principal source of DDTs in the JWPCP effluent after that time (Schafer 1989). Annual mean concentrations of DDTs at JWPCP were below reporting limits in 1997, although measurable amounts of DDTs were detected in its effluents for three months.

Toxicity has increased an average of 5% across all facilities from 1990 to 1997 (Figure 8). Toxicity has decreased at JWPCP (44%) and Hyperion (20%), but has increased at OCSD (42%), and at PLWTP (0.8%).

**Effect of Non-detectable Concentrations**

One goal of this study was to calculate annual mean concentrations and mass emissions using monthly concentrations and flows reported by each agency and to compare the resulting data among the facilities. Conducting an accurate comparison requires that the reporting agencies use compatible methodologies with similar standards for accuracy and reporting limits. The agencies met these requirements for most of the constituents (77%); however, 23% of the constituents had reporting limits that varied by a factor of two or more, accompanied by a two-fold or more difference in the percent of detectable concentrations reported. For these constituents, it is impossible to differentiate whether the non-detectable measurements result from cleaner effluents or from higher reporting limits.

To evaluate the effect of non-detectable results and bias introduced by different reporting limits, we exchanged the 1997 non-detectable results with the reporting limit when calculating the mass emission estimates and then compared these values with our usual method of estimating mass emissions, using zeros for non-detectable concentrations (Table 10). None of the general constituents increased by more than 18% across all of the facilities. Mass estimates for many of the metals and organics increased by a factor of 10 or more, but most of these increases were for chemicals that were at very low levels relative to their historical levels.

The effect of using reporting limits for non-detectable concentrations had little effect on historical trends for most constituents (Table 11, Figure 9-12). The largest difference in the percent reduction over time was for total PCBs (Figure 12). Some of the increase in PCB mass emissions using the "reporting limit" method starting in 1986 is due to an increase in the number of PCB aroclors measured. The additional aroclors were never measured in detectable concentrations.

**TABLE 6. Means and coefficients of variation (CVs) of annual constituent concentrations in effluents from the largest municipal wastewater treatment facilities in southern California in 1997.**

| | HTP | | JWPCP | | OCSD | | PLWTP | |
|---|---|---|---|---|---|---|---|---|
| Constituent | Mean[a] | CV (%) | Mean[a] | CV (%) | Mean[a] | CV (%) | Mean[a] | CV (%) |
| Flow (mgd) | 358 | 3 | 346 | 4 | 244 | 2 | 189 | 2 |
| Flow (million L/day) | 1,355 | 3 | 1,310 | 4 | 924 | 2 | 715 | 2 |
| Suspended Solids (mg/L) | 30 | 7 | 69 | 8 | 51 | 5 | 39 | 9 |
| Settleable Solids (mL/L) | 0.01 | 183 | 0.1 | 36 | 0.4 | 20 | 0.3 | 45 |
| BOD (mg/L) | 69 | 8 | 102 | 5 | 78 | 5 | 105 | 7 |
| Oil and Grease (mg/L) | 11 | 19 | 13 | 6 | 17.0 | 7 | 9.9 | 17 |
| Nitrate-N (mg/L) | 0.198 | 151 | 0.07 | 45 | NA | -[b] | 0.08[c] | 121 |
| Nitrite-N (mg/L) | NR | - | 0.14 | 41 | NA | - | NA | - |
| Ammonia-N (mg/L) | 26.0 | 14 | 30.0 | 3 | 24 | 5 | 26.4 | 10 |
| Organic-N (mg/L) | 5.0 | 14 | 6.34 | 10 | NA | - | NA | - |
| Phosphate (mg/L) | NA | - | 3.35 | 10 | NA | - | 0.5[c] | 69 |
| Total Phosphorus (mg/L) | 3.94 | 12 | NA | - | NA | - | NA | - |
| Cyanide (µg/L) | 7 | 70 | 8 | 18 | 2 | 183 | 8.0 | 80 |
| Turbidity (NTU) | 22 | 7 | 51 | 7 | 39 | 2 | 37 | 10 |
| Acute Toxicity (TUa) | | | | | | | | |
| *Pimephales promelas* | 0.71 | 97 | 0.79 | 80 | 0.81 | 22 | 1.3 | 11 |
| Chronic Toxicity (TUc) | | | | | | | | |
| *Haliotis rufescens* | 34 | 30 | NA | - | NA | - | 50 | 57 |
| *Macrocystis pyrifera* | | | | | | | | |
| Germ tube length | NR | - | 9 | 190 | NA | - | 95 | 64 |
| Germination | NR | - | <16.7 | - | NA | - | 76 | 46 |
| Arsenic (µg/L) | 3 | 58 | 2 | 21 | 1 | 92 | 1.50 | 23 |
| Cadmium (µg/L) | <2 | - | 0.5 | 135 | 0.4 | 51 | 0.2 | 203 |
| Chromium (µg/L) | 1 | 195 | 4 | 154 | 5 | 18 | 0.3 | 234 |
| Copper (µg/L) | 34 | 27 | 23 | 16 | 35 | 10 | 74 | 49 |
| Lead (µg/L) | 0.5 | 346 | 0.7 | 346 | 0.5 | 160 | <18 | - |
| Mercury (µg/L) | <0.3 | - | <0.5 | - | 0.06 | 236 | 0.037 | 204 |
| Nickel (µg/L) | 8 | 70 | 49 | 17 | 22 | 20 | 3 | 142 |
| Selenium (µg/L) | <1 | - | 16 | 13 | 2 | 78 | 1.37 | 18 |
| Silver (µg/L) | 5.1 | 54 | 5 | 63 | 2 | 49 | 0.15 | 346 |
| Zinc (µg/L) | 40 | 23 | 66 | 54 | 41 | 9 | 64 | 68 |
| Phenols (µg/L)[d] | NA | - | 254 | 38 | 38 | 34 | NA | - |
| Chlorinated[e] | <7[f] | - | 7 | 86 | 0.83 | 249 | <6.1 | - |
| Nonchlorinated[e] | 1.9 | 116 | 88 | 74 | 5.4 | 43 | 12.9 | 23 |
| Total DDT (µg/L) | <0.013[f] | - | 0.004 | 216 | <0.04[f] | - | <0.04[f] | - |
| Total PCB (µg/L) | <0.065[f] | - | <0.9[f] | - | <0.3 | - | <0.6[f] | - |
| PAHs (µg/L) | <1 | - | 0.6 | 149 | 0.31 | 346 | <7.8[f] | - |

[a]The number of significant figures are those reported by the agencies.
[b]Dash = Not applicable.
[c]Only soluble forms of phosphate and nitrate were analyzed.
[d]Colorimetric method.
[e]Gas chromatography/mass spectrometry method.
[f]Maximum reporting limit.

NA = Not analyzed.
NR = Not reported.

**TABLE 7. Estimated constituent mass emissions from the largest municipal wastewater treatment facilities in southern California in 1997.**

| Constituent | HTP | JWPCP | OCSD | PLWTP | Total |
|---|---|---|---|---|---|
| Flow [a] (L x $10^9$) | 495 | 478 | 338 | 261 | 1,572 |
| Suspended Solids (mt) | 14,628 | 32,898 | 17,306 | 10,273 | 75,105 |
| BOD (mt) | 34,257 | 48,597 | 26,228 | 27,429 | 136,511 |
| Oil and Grease (mt) | 5,310 | 6,170 | 5,731 | 2,582 | 19,793 |
| Nitrate-N (mt) | 98 | 35 | NA | 21 | 154 |
| Nitrite-N (mt) | NR | 68 | NA | NA | 68 |
| Ammonia-N (mt) | 12,848 | 14,308 | 7,985 | 6,875 | 42,016 |
| Organic-N (mt) | 2,456 | 3,028 | NA | NA | 5,484 |
| Phosphate (mt) | NA | 1,607 | NA | 126 | 1,733 |
| Total Phosphorus (mt) | 1,950 | NA | NA | NA | 1,950 |
| Cyanide (mt) | 3.2 | 3.9 | 0.58 | 2.1 | 9.8 |
| Arsenic (mt) | 1.2 | 1.1 | 0.45 | 0.39 | 3.1 |
| Cadmium (mt) | nd | 0.24 | 0.12 | 0.05 | 0.4 |
| Chromium (mt) | 0.65 | 2 | 1.5 | 0.09 | 4.2 |
| Copper (mt) | 17 | 11 | 12 | 19 | 59 |
| Lead (mt) | 0.26 | 0.33 | 0.17 | nd | 0.8 |
| Mercury (mt) | nd | nd | 0.02 | 0.01 | 0.03 |
| Nickel (mt) | 4.1 | 23 | 7.3 | 0.72 | 35 |
| Selenium (mt) | nd | 7.5 | 0.51 | 0.36 | 8.4 |
| Silver (mt) | 2.5 | 2.3 | 0.79 | 0.04 | 5.6 |
| Zinc (mt) | 20 | 31 | 14 | 17 | 82 |
| Phenols [b] (mt) | NA | 121 | 13 | NA | 134 |
| Chlorinated [c] | nd | 3.1 | 0.28 | nd | 3.4 |
| Nonchlorinated [c] | 0.9 | 41.2 | 1.8 | 3.4 | 47 |
| Total DDT (kg) | nd | 2.1 | nd | nd | 2.1 |
| Total PCB (kg) | nd | nd | nd | nd | 0.0 |
| PAHs (kg) | nd | 290 | 104 | nd | 394 |

[a]Annual flow volumes were the sum of mean daily flow per month times the number of days in each month.
[b]Colorimetric method.
[c]Gas chromatography/mass spectrometry method.

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**TABLE 8. Results of significance tests for comparisons of effluent flow, toxicity, and constituent mass emission values between 1996[a] and 1997.**

| Constituent | Test Used | P value | 1996 Mass Emissions | 1997 Mass Emissions | Difference Between 1996-1997 | Percent Change | Significantly Higher Year |
|---|---|---|---|---|---|---|---|
| HTP | | | | | | | |
| Flow (mgd) | t-test | 0.775 | 357 | 358 | 1.0 | 0.3 | - |
| Acute toxicity (TUa) | Mann-Whitney | 0.603 | 1.0 | 0.71 | -0.3 | -29 | - |
| Suspended Solids (mt) | t-test | 0.012 | 13,308 | 14,628 | 1,320.0 | 10 | 1997 |
| BOD (mt) | t-test | 0.002 | 30,299 | 34,257 | 3,958.0 | 13 | 1997 |
| Oil and Grease (mt) | t-test | 0.029 | 4,446 | 5,310 | 864.0 | 19 | 1997 |
| Nitrate-N (mt) | Mann-Whitney | 0.665 | 81 | 98 | 17.0 | 21 | - |
| Ammonia-N (mt) | t-test | 0.706 | 13,063 | 12,848 | -215.0 | -2 | - |
| Organic-N (mt) | t-test | 0.412 | 2,355 | 2,456 | 101.0 | 4 | - |
| Total Phosphorus (mt) | t-test | 0.190 | 1,832 | 1,950 | 118.0 | 6 | - |
| Cyanide (mt) | t-test | 0.671 | 3.7 | 3.2 | -0.5 | -14 | - |
| Arsenic (mt) | Mann-Whitney | 0.004 | 2.2 | 1.2 | -1.0 | -45 | 1996 |
| Cadmium (mt) | Mann-Whitney | 0.976 | nd | nd | - | - | - |
| Chromium (mt) | Mann-Whitney | 1.000 | 0.71 | 0.65 | -0.1 | -8 | - |
| Copper (mt) | t-test | 0.718 | 16 | 17 | 1.0 | 6 | - |
| Lead (mt) | Mann-Whitney | 1.000 | 0.09 | 0.26 | 0.2 | 189 | - |
| Mercury (mt) | Mann-Whitney | 0.746 | 0.01 | 0 | -0.01 | -100 | - |
| Nickel (mt) | t-test | 0.480 | 4.8 | 4.1 | -0.7 | -15 | - |
| Selenium (mt) | Mann-Whitney | 0.976 | nd | nd | - | - | - |
| Silver (mt) | t-test | 0.089 | 1.8 | 2.5 | 0.7 | 39 | - |
| Zinc (mt) | t-test | 0.155 | 22 | 20 | -2.0 | -9 | - |
| Chlorinated Phenols (mt) | - | - | nd | nd | - | - | All nds |
| Nonchlorinated Phenols (mt) | Mann-Whitney | 0.017 | 1.4 | 0.9 | -0.5 | -36 | 1996 |
| DDTs (kg) | Mann-Whitney | 0.976 | nd | nd | - | - | - |
| PCBs (kg) | - | - | nd | nd | - | - | All nds |
| PAHs (kg) | - | - | nd | nd | - | - | All nds |
| JWPCP | | | | | | | |
| Flow (mgd) | t-test | 0.003 | 331 | 346 | 15.0 | 5 | 1997 |
| Acute Toxicity (TUa) | t-test | 0.933 | 0.81 | 0.79 | 0.0 | -2 | - |
| Suspended Solids (mt) | t-test | 0.027 | 30,052 | 32,898 | 2,846.0 | 9 | 1997 |
| BOD (mt) | t-test | <0.001 | 42,452 | 48,597 | 6,145.0 | 14 | 1997 |
| Oil and Grease (mt) | t-test | 0.001 | 5,432 | 6,170 | 738.0 | 14 | 1997 |
| Nitrate-N (mt) | Mann-Whitney | <0.001 | 167 | 35 | -132.0 | -79 | 1996 |
| Nitrite-N (mt) | Mann-Whitney | 0.371 | 104 | 68 | -36.0 | -35 | - |
| Ammonia-N (mt) | t-test | 0.060 | 13,753 | 14,308 | 555.0 | 4 | - |
| Organic-N (mt) | t-test | 0.217 | 2,862 | 3,028 | 166.0 | 6 | - |
| Total Phosphate (mt) | t-test | 0.518 | 1,544 | 1,607 | 63.0 | 4 | - |
| Cyanide (mt) | Mann-Whitney | 0.312 | 5.2 | 3.9 | -1.3 | -25 | - |
| Arsenic (mt) | t-test | 0.553 | 1.2 | 1.1 | -0.1 | -8 | - |
| Cadmium (mt) | Mann-Whitney | 0.353 | 0.11 | 0.24 | 0.1 | 118 | - |
| Chromium (mt) | Mann-Whitney | 0.156 | 4.3 | 2 | -2.3 | -53 | - |
| Copper (mt) | t-test | 0.799 | 11 | 11 | 0.0 | 0 | - |
| Lead (mt) | Mann-Whitney | 0.746 | 0 | 0.33 | 0.33 | 100 | - |
| Mercury (mt) | Mann-Whitney | 0.976 | nd | nd | - | - | All nds |
| Nickel (mt) | t-test | 0.323 | 22 | 23 | 1.0 | 5 | - |
| Selenium (mt) | t-test | 0.053 | 6.6 | 7.5 | 0.9 | 14 | - |
| Silver (mt) | Mann-Whitney | 0.386 | 2.4 | 2.3 | -0.1 | -4 | - |
| Zinc (mt) | Mann-Whitney | 0.371 | 36 | 31 | -5.0 | -14 | - |
| Phenols (mt) | t-test | 0.710 | 126 | 121 | -5.0 | -4 | - |
| Chlorinated Phenols (mt) | Mann-Whitney | 0.977 | 3.0 | 3.1 | 0.1 | 3 | - |
| Nonchlorinated Phenols (mt) | Mann-Whitney | 0.017 | 53 | 41.2 | -11.8 | -22 | 1996 |
| DDTs (kg) | Mann-Whitney | 0.816 | 1.1 | 2.1 | 1.0 | 91 | - |
| PCBs (kg) | - | - | nd | nd | - | - | All nds |
| PAHs (kg) | Mann-Whitney | 0.002 | 0 | 290 | 290.0 | 100 | 1997 |
| OCSD | | | | | | | |
| Flow (mgd) | t-test | 0.002 | 236 | 244 | 8.0 | 3 | 1997 |
| Acute toxicity (TUa) | Mann-Whitney | 0.166 | 0.87 | 0.81 | -0.1 | -7 | - |
| Suspended solids (mt) | t-test | 0.011 | 15,867 | 17,306 | 1,439.0 | 9 | 1997 |
| BOD (mt) | t-test | 0.023 | 24,486 | 26,228 | 1,742.0 | 7 | 1997 |
| Oil and grease (mt) | t-test | <0.001 | 4,788 | 5,731 | 943.0 | 20 | 1997 |
| Ammonia-N (mt) | t-test | 0.006 | 7,531 | 7,985 | 454.0 | 6 | 1997 |

**TABLE 8 (continued)**

| Constituent | Test Used | P value | 1996 Mass Emissions | 1997 Mass Emissions | Difference Between 1996-1997 | Percent Change | Significantly Higher Year |
|---|---|---|---|---|---|---|---|
| Cyanide (mt) | Mann-Whitney | 0.448 | 0.17 | 0.58 | 0.4 | 241 | - |
| Arsenic (mt) | Mann-Whitney | 0.977 | 0.55 | 0.45 | -0.1 | -18 | - |
| Cadmium (mt) | t-test | 0.862 | 0.11 | 0.12 | 0.0 | 9 | - |
| Chromium (mt) | Mann-Whitney | 0.040 | 1.4 | 1.5 | 0.1 | 7 | 1997 |
| Copper (mt) | t-test | 0.204 | 11 | 12 | 1.0 | 9 | - |
| Lead (mt) | Mann-Whitney | 0.030 | 0.52 | 0.17 | -0.4 | -67 | 1996 |
| Mercury (mt) | Mann-Whitney | 0.792 | 0.02 | 0.02 | 0.0 | 0 | - |
| Nickel (mt) | t-test | 0.143 | 6.6 | 7.3 | 0.7 | 11 | - |
| Selenium (mt) | Mann-Whitney | 0.623 | 0.47 | 0.51 | 0.0 | 9 | - |
| Silver (mt) | Mann-Whitney | 0.017 | 0.71 | 0.79 | 0.1 | 11 | 1997 |
| Zinc (mt) | Mann-Whitney | 0.260 | 14 | 14 | 0.0 | 0 | - |
| Phenols (mt) | t-test | 0.664 | 13 | 13 | 0.0 | 0 | - |
| Chlorinated Phenols (mt) | Mann-Whitney | 0.500 | 0 | 0.28 | 0.3 | 100 | - |
| Nonchlorinated Phenols (mt) | Mann-Whitney | 0.035 | 1.2 | 1.8 | 0.6 | 50 | 1997 |
| DDTs (kg) | - | - | nd | nd | - | - | All nds |
| PCBs (kg) | - | - | nd | nd | - | - | All nds |
| PAHs (kg) | Mann-Whitney | 0.746 | 0 | 104 | 104.0 | 100 | - |
| PLWTP | | | | | | | |
| Flow (mgd) | t-test | <0.001 | 179 | 189 | 10.0 | 6 | 1997 |
| Acute Toxicity (TUa) | Mann-Whitney | 0.285 | 1.2 | 1.3 | 0.1 | 5 | - |
| Suspended Solids (mt) | t-test | 0.198 | 10,713 | 10,273 | -440.0 | -4 | - |
| BOD (mt) | t-test | 0.003 | 29,412 | 27,429 | -1,983.0 | -7 | 1996 |
| Oil and Grease (mt) | t-test | 0.119 | 2,926 | 2,582 | -344.0 | -12 | - |
| Nitrate-N (mt) | t-test | 0.036 | 50 | 21 | -29.0 | -58 | 1996 |
| Ammonia-N (mt) | t-test | 0.242 | 6,632 | 6,875 | 243.0 | 4 | - |
| Phosphate (mt) | t-test | 0.605 | 110 | 126 | 16.0 | 15 | - |
| Cyanide (mt) | Mann-Whitney | 0.078 | 1.2 | 2.1 | 0.9 | 75 | - |
| Arsenic (mt) | t-test | 0.101 | 0.33 | 0.39 | 0.1 | 18 | - |
| Cadmium (mt) | Mann-Whitney | 0.193 | 0.19 | 0.05 | -0.1 | -74 | - |
| Chromium (mt) | Mann-Whitney | 0.977 | 0.10 | 0.09 | 0.0 | -10 | - |
| Copper (mt) | t-test | 0.008 | 11 | 19 | 8.0 | 73 | 1997 |
| Lead (mt) | Mann-Whitney | 0.500 | 0.62 | 0.00 | -0.62 | -100 | - |
| Mercury (mt) | Mann-Whitney | 0.306 | 0 | 0.01 | 0.01 | 100 | - |
| Nickel (mt) | Mann-Whitney | 0.486 | 0.42 | 0.72 | 0.3 | 71 | - |
| Selenium (mt) | t-test | 0.006 | 0.28 | 0.36 | 0.1 | 29 | 1997 |
| Silver (mt) | Mann-Whitney | 0.746 | 0 | 0.04 | 0.0 | 100 | - |
| Zinc (mt) | t-test | 0.747 | 19 | 17 | -2.0 | -11 | - |
| Chlorinated Phenols (mt) | - | - | nd | nd | - | - | All nds |
| Nonchlorinated Phenols (mt) | t-test | <0.001 | 4.5 | 3.4 | -1.1 | -24 | 1996 |
| DDTs (kg) | Mann-Whitney | 0.746 | 0.25 | 0 | -0.3 | -100 | - |
| PCBs (kg) | - | - | nd | nd | - | - | All nds |
| PAHs (kg) | Mann-Whitney | 0.500 | 161 | 0 | -161.0 | -100 | - |

[a] Raco-Rands (1999).
All nds = All nondetectable quantities.


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**TABLE 9. Estimated combined constituent mass emissions for HTP, JWPCP, OCSD, and PLWTP from 1971 through 1997.**

| Constituent | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Flow (L x $10^9$) | 1,289 | 1,278 | 1,319 | 1,334 | 1,343 | 1,402 | 1,310 | 1,381 | 1,431 | 1,489 | 1,491 | 1,509 |
| Flow (mgd) | 932 | 922 | 955 | 965 | 972 | 1,013 | 948 | 1,000 | 1,036 | 1,075 | 1,079 | 1,092 |
| Suspended Solids[a] (mt x $10^3$) | 295 | 286 | 292 | 271 | 284 | 285 | 240 | 254 | 246 | 231 | 224 | 227 |
| BOD[b] (mt x $10^3$) | 282 | 252 | 227 | 222 | 231 | 255 | 239 | 234 | 236 | 254 | 261 | 264 |
| Oil and Grease (mt x $10^3$) | 63 | 61 | 61 | 55 | 56 | 57 | 48 | 48 | 46 | 38 | 36 | 37 |
| $NO_3^{-1}$-N (mt x $10^3$) | 0.31 | 0.13 | 0.17 | 0.20 | 0.07 | 0.14 | 0.16 | 0.28 | 0.14 | 0.24 | 0.21 | 0.14 |
| $NO_2^{-1}$-N (mt x $10^3$) | 0.16 | 0.04 | 0.01 | 0.04 | 0.01 | 0.01 | 0.06 | 0.07 | 0.03 | 0.07 | 0.03 | 0.04 |
| $NH_3$-N (mt x $10^3$) | 54 | 41 | 46 | 37 | 36 | 37 | 38 | 39 | 39 | 41 | 41 | 40 |
| Organic N (mt x $10^3$) | 17 | 10 | 11 | 3.0 | 44 | 13 | 12 | 12 | 13 | 13 | 12 | 12 |
| Total P[c] (mt x $10^3$) | 11.7 | 11.8 | 11.6 | 11.2 | 10.9 | 9.7 | 10.0 | 10.1 | 9.9 | 10.0 | 9.5 | 9.2 |
| MBAS (mt x $10^3$) | 6.7 | 6.3 | 6.0 | 6.8 | 6.1 | 6.1 | 5.3 | 5.8 | 6.3 | 6.5 | 5.6 | 5.6 |
| Cyanide (mt) | 194 | 242 | 266 | 322 | 252 | 244 | 203 | 173 | 139 | 131 | 91 | 72 |
| Arsenic (mt) | 7.9 | 15 | 16 | 20 | 12 | 11 | 11 | 13 | 15 | 12 | 11 | 7.6 |
| Cadmium (mt) | 53 | 34 | 49 | 58 | 49 | 42 | 42 | 44 | 42 | 37 | 32 | 22 |
| Chromium (mt) | 666 | 678 | 691 | 691 | 571 | 591 | 361 | 283 | 237 | 272 | 187 | 197 |
| Copper (mt) | 535 | 488 | 508 | 572 | 510 | 504 | 404 | 416 | 358 | 333 | 336 | 283 |
| Lead (mt) | 240 | 254 | 178 | 197 | 196 | 173 | 146 | 218 | 217 | 173 | 130 | 123 |
| Mercury (mt) | 2.9 | 2.7 | 3.1 | 3.1 | 2.3 | 2.5 | 3.9 | 1.9 | 2.7 | 2.0 | 1.3 | 1.1 |
| Nickel (mt) | 327 | 262 | 316 | 310 | 271 | 313 | 258 | 320 | 252 | 229 | 183 | 170 |
| Selenium (mt) | 13 | 12 | 14 | 18 | 17 | 20 | 23 | 21 | 6.6 | 6.0 | 5.8 | 6.4 |
| Silver (mt) | 15 | 21 | 25 | 22 | 26 | 20 | 33 | 31 | 42 | 29 | 27 | 25 |
| Zinc (mt) | 1,834 | 1,201 | 1,355 | 1,323 | 1,130 | 1,055 | 834 | 896 | 705 | 727 | 538 | 550 |
| DDT[e] (kg) | 21,580 | 6,700 | 3,825 | 1,565 | 1,163 | 1,640 | 866 | 1,144 | 808 | 620 | 498 | 297 |
| PCB[e] (kg) | 8946 | 19,102 | 3,390 | 5,418 | 3,044 | 4,672 | 2,166 | 3,020 | 1,094 | 1,082 | 1,247 | 782 |

[a]Solids from HTP's 7-mile outfall are total solids.
[b]Hyperion's 7-mile outfall is not included.
[c]Sum of total phosphorus (HTP), phosphate-P (JWPCP), and soluble phosphate-P (PLWTP).
[d]Analyses discontinued.

**FIGURE 2. Combined effluent flow and individual effluent flows from the four largest municipal wastewater treatment facilities in southern California (mgd = millions of gallons per day, L = liters).**

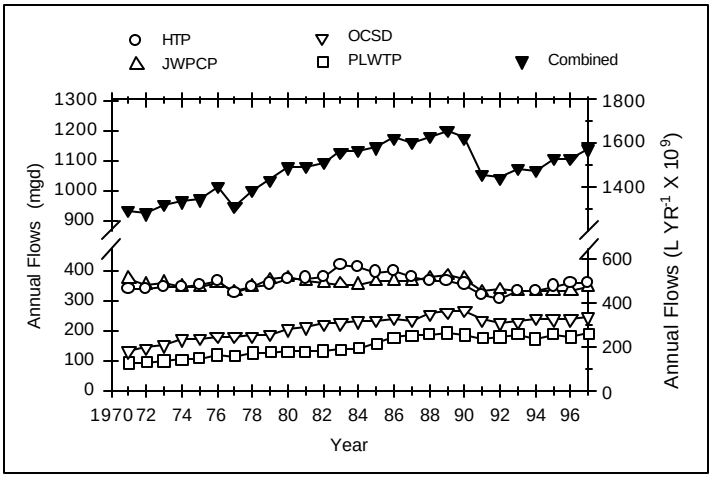
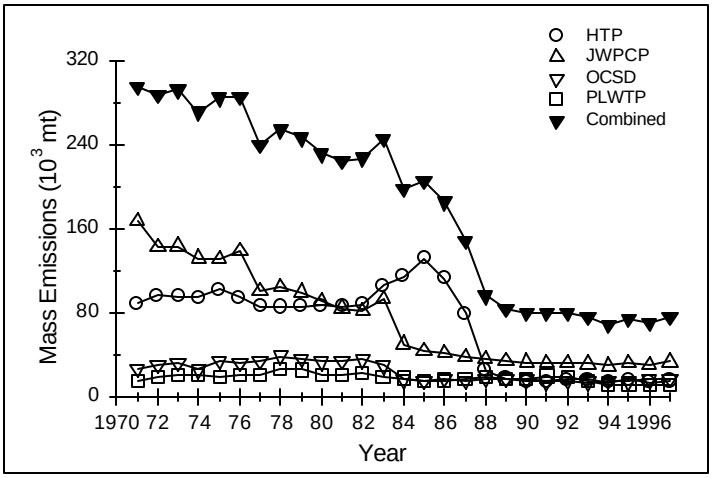



**FIGURE 3. Individual and combined suspended solids emissions from the four largest municipal wastewater treatment facilities in southern California (mt = metric tons).**



| 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1,561 | 1,566 | 1,580 | 1,624 | 1,604 | 1,632 | 1,658 | 1,625 | 1,455 | 1,440 | 1,484 | 1,474 | 1,528 | 1,528 | 1,571 |
| 1,130 | 1,130 | 1,144 | 1,176 | 1,161 | 1,179 | 1,200 | 1,177 | 1,054 | 1,039 | 1,075 | 1,067 | 1,106 | 1,103 | 1,137 |
| 245 | 197 | 205 | 185 | 148 | 96 | 83 | 80 | 79 | 79 | 75 | 68 | 73 | 70 | 75 |
| 251 | 230 | 254 | 182 | 164 | 168 | 162 | 159 | 139 | 135 | 136 | 132 | 138 | 127 | 137 |
| 36 | 30 | 34 | 29 | 25 | 25 | 22 | 21 | 19 | 19 | 18 | 19 | 19 | 18 | 20 |
| 0.03 | 0.07 | 0.33 | 0.41 | 0.50 | 0.48 | 0.34 | 0.21 | 0.24 | 0.21 | 0.24 | 0.21 | 0.27 | 0.30 | 0.15 |
| 0.03 | 0.06 | 0.06 | 0.07 | 0.14 | 0.03 | 0.08 | 0.29 | 0.11 | 0.06 | 0.07 | 0.02 | 0.13 | 0.10 | 0.07 |
| 40 | 41 | 42 | 45 | 44 | 44 | 45 | 46 | 44 | 42 | 41 | 41 | 41 | 41 | 42 |
| 12 | 13 | 13 | 11 | 9.2 | 7.0 | 7.2 | 6.4 | 6.0 | 5.7 | 5.5 | 5.5 | 5.8 | 5.2 | 5.5 |
| 9.0 | 9.2 | 8.6 | 9.2 | 7.8 | 6.9 | 6.3 | 6.5 | 6.0 | 5.2 | 4.1 | 3.5 | 3.5 | 3.4 | 3.6 |
| 5.2 | 4.6 | 5.2 | 4.8 | 3.9 | 3.2 | 3.3 | 3.5 | 3.5 | 3.2 | -[d] | -[d] | -[d] | -[d] | -[d] |
| 47 | 43 | 30 | 27 | 29 | 26 | 12 | 13 | 16 | 18 | 15 | 12 | 6.5 | 10 | 9.8 |
| 9.7 | 18 | 15 | 12 | 11 | 9.1 | 7.4 | 8.2 | 5.4 | 5.5 | 5.2 | 4.0 | 4.9 | 4.2 | 3.2 |
| 23 | 16 | 16 | 14 | 9.1 | 3.9 | 1.7 | 1.4 | 1.2 | 0.56 | 0.67 | 0.61 | 1.0 | 0.42 | 0.41 |
| 165 | 137 | 112 | 86 | 59 | 29 | 22 | 14 | 10 | 11 | 6.7 | 6.7 | 7.0 | 6.5 | 4.3 |
| 277 | 234 | 237 | 203 | 123 | 79 | 67 | 59 | 47 | 47 | 44 | 49 | 52 | 49 | 59 |
| 97 | 93 | 120 | 104 | 62 | 47 | 27 | 8.1 | 2.4 | 3.4 | 1.8 | 1.3 | 2.4 | 1.2 | 0.76 |
| 1.1 | 0.95 | 0.92 | 0.71 | 0.38 | 0.41 | 0.39 | 0.25 | 0.23 | 0.04 | 0.01 | 0.03 | 0.02 | 0.03 | 0.03 |
| 157 | 131 | 120 | 130 | 75 | 64 | 54 | 40 | 33 | 31 | 31 | 28 | 30 | 33 | 35 |
| 7.3 | 6.3 | 6.1 | 8.1 | 7.6 | 7.6 | 7.4 | 7.3 | 7.1 | 7.3 | 6.6 | 7.4 | 7.8 | 7.4 | 8.3 |
| 25 | 22 | 27 | 22 | 15 | 11 | 10 | 9.5 | 8.0 | 6.9 | 6.1 | 5.8 | 5.4 | 4.9 | 5.6 |
| 497 | 368 | 361 | 341 | 240 | 151 | 145 | 115 | 125 | 99 | 82 | 72 | 86 | 90 | 81 |
| 227 | 293 | 51 | 50 | 56 | 26 | 22 | 17 | 6.4 | 13 | 9.2 | 8.0 | 1.9 | 1.4 | 2.1 |
| 633 | 1,236 | 705 | 35 | 5.7 | -[f] | -[f] | -[f] | -[f] | -[f] | -[f] | -[f] | -[f] | -[f] | -[f] |

[e]Estimates for OCSD for 1971, and all POTWs for 1972 through 1975 were based upon Bodega Bay Marine Laboratories, and University of Washington analyses, except DDT estimates for JWPCP were based on JWPCP's own analyses. Estimates for PLWTP for 1976 and 1977 were based upon SCCWRP analyses. Estimates for remaining years are based upon discharger data.

No analyses were used for PLWTP for 1971.

[f]Concentrations were below method detection limits.

MBAS = Methylene blue active substances.

**FIGURE 4. Individual and combined oil and grease emissions from the four largest municipal wastewater treatment facilities in southern California.**

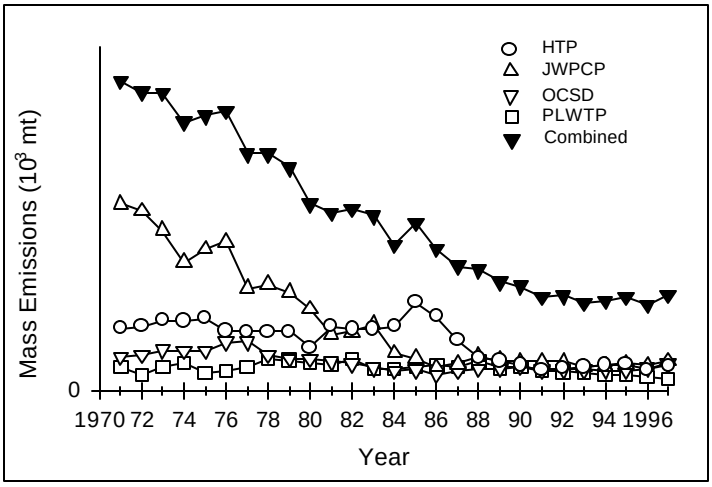



**FIGURE 5. Combined and individual mass emissions of biochemical oxygen demand from the four largest municipal wastewater treatment facilities in southern California.**

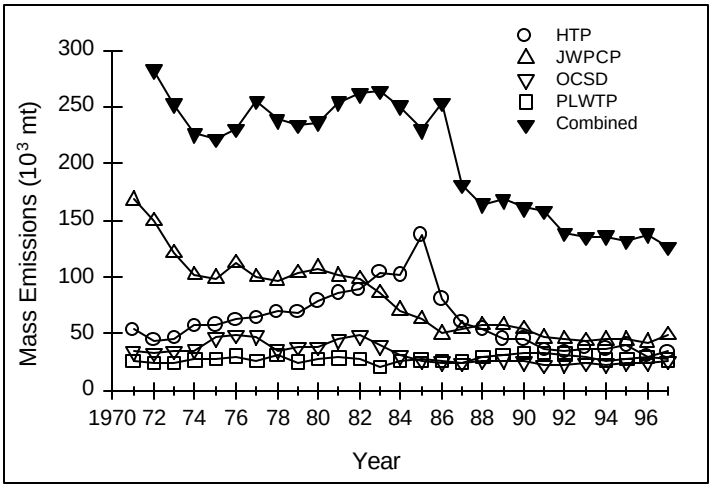


**FIGURE 6. Combined mass emissions of trace metals from the four largest wastewater treatment facilities in southern California.**

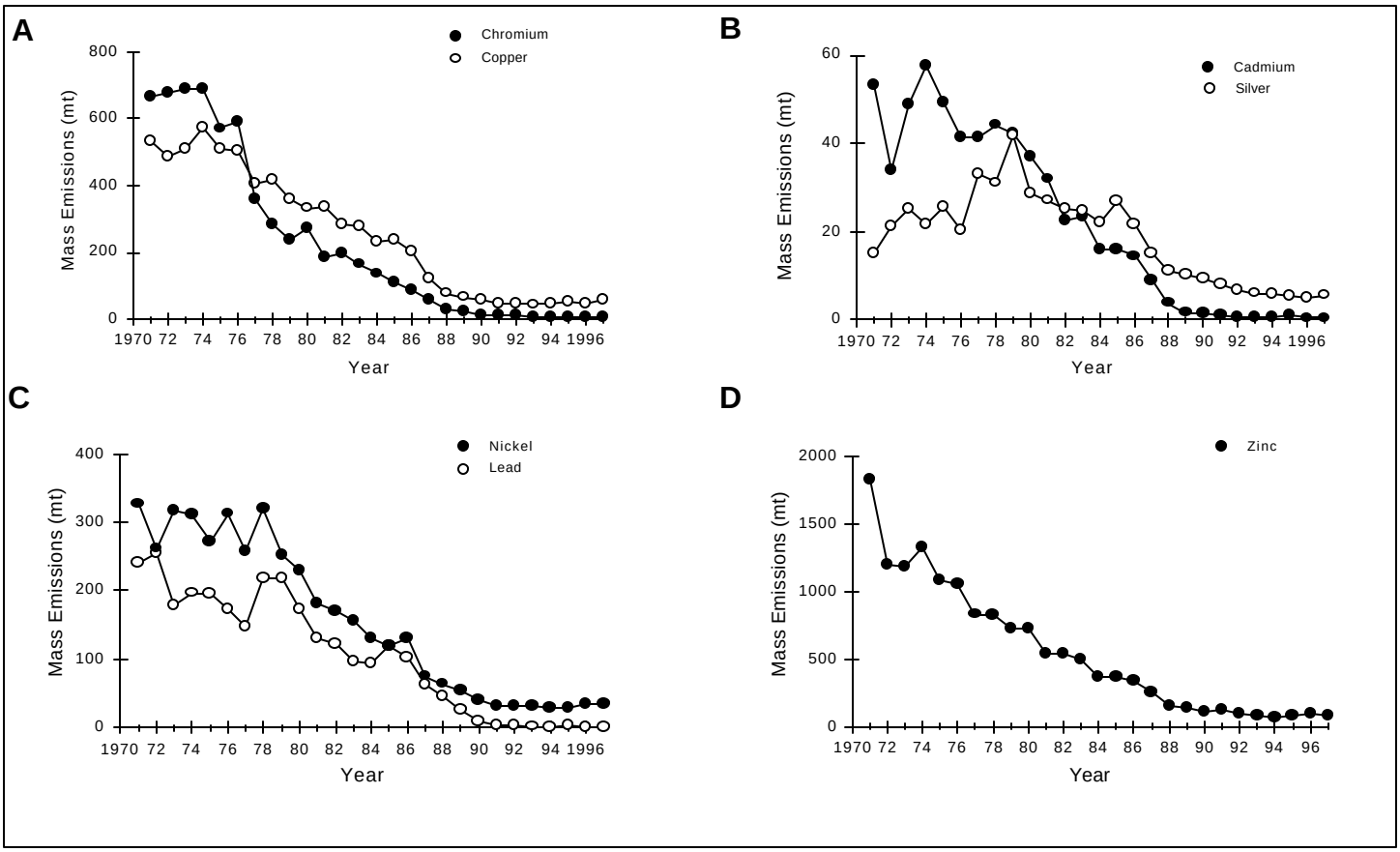



**FIGURE 7. Combined mass emissions of DDTs and PCBs from the four largest wastewater treatment facilities in southern California (BRL = below reporting limits).**

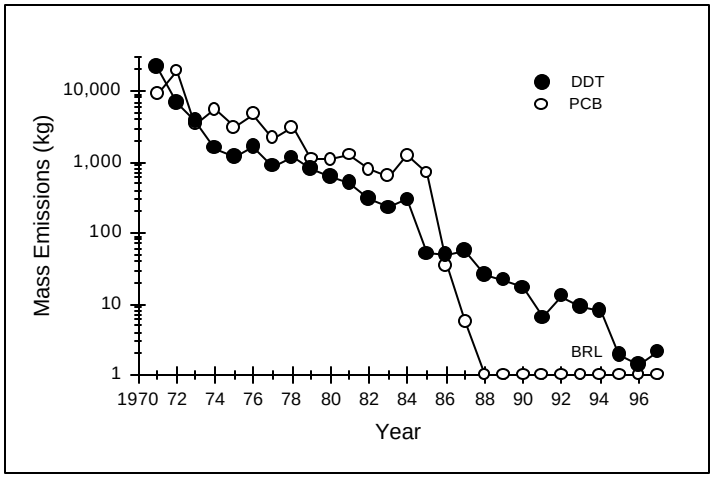



**FIGURE 8. Effluent acute toxicity to fathead minnows (*Pimephales promelas)* at the four largest wastewater treatment facilities in southern California.**

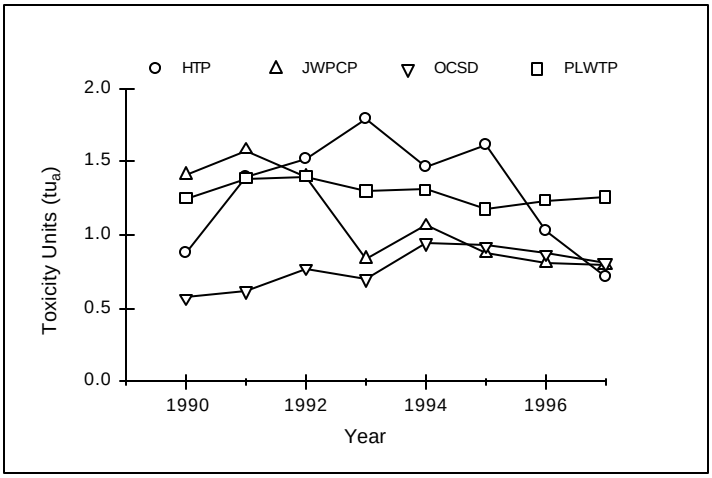


**TABLE 10. Increase in mass estimates for 1997 replacing ND=0 with ND=reporting limit. Current estimate uses ND=0.**

| | HTP | | JWPCP | | OCSD | | PLWTP | | TOTAL | |
|---|---|---|---|---|---|---|---|---|---|---|
| Constituent | Increase in Mass | Increase % Over Current Estimate | Increase in Mass | Increase % Over Current Estimate | Increase in Mass | Increase % Over Current Estimate | Increase in Mass | Increase % Over Current Estimate | Increase in Mass | Increase % Over Current Estimate |
| Suspended Solids (mt) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| BOD (mt) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Oil and Grease (mt) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Nitrate-N (mt) | 8.0 | 8 | 2.0 | 6 | NA | NA | 5.0 | 24 | 15 | 10 |
| Nitrite-N (mt) | NR | NR | 0 | 0 | NA | NA | NA | NA | 0 | 0 |
| Ammonia-N (mt) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Organic-N (mt) | 0 | 0 | 0 | 0 | NA | NA | NA | NA | 0 | 0 |
| Total Phosphorus (mt) | 0 | 0 | 0 | 0 | 0 | 0 | 3.7 | 9 | 3.7 | 0.10 |
| MBAS (mt) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Cyanide (mt) | 0.49 | 15 | 0 | 0 | 1.3 | 218 | 0 | 0 | 2 | 18 |
| Arsenic (mt) | 0.04 | 3 | 0 | 0 | 0.28 | 62 | 0 | 0 | 0.3 | 10 |
| Cadmium (mt) | 0.99 | NC | 0.28 | 118 | 0.01 | 10 | 0.17 | 332 | 1 | 358 |
| Chromium (mt) | 1.5 | 230 | 3.7 | 187 | 0 | 0 | 1.1 | 1205 | 6 | 148 |
| Copper (mt) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lead (mt) | 1.4 | 524 | 3.6 | 1077 | 0.45 | 258 | 4.7 | NC | 10 | 1320 |
| Mercury (mt) | 0.15 | NC | 0.24 | NC | 0.06 | 281 | 0.05 | 564 | 0.5 | 1687 |
| Nickel (mt) | 0.42 | 10 | 0 | 0 | 0 | 0 | 2.1 | 298 | 3 | 7 |
| Selenium (mt) | 0.49 | NC | 0 | 0 | 0.22 | 43 | 0 | 0 | 0.7 | 9 |
| Silver (mt) | 0 | 0 | 0.62 | 27 | 0.11 | 14 | 1.6 | 3728 | 2 | 41 |
| Zinc (mt) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total DDT (kg) | 16 | NC | 52 | 2450 | 47 | NC | 39 | NC | 155 | 7289 |
| Total PCB (kg) | 148 | NC | 1512 | NC | 709 | NC | 254 | NC | 2623 | NC |

NA=Not analyzed.
NC=Not calculable, original mass emission estimate equals zero.
ND=Non-detectable results.

**TABLE 11. Comparison of mass emission trends using reporting limits for non-detectable concentrations against estimates using zero for NDs.**

| | | 0 for NDs | | RL for NDs | |
|---|---|---|---|---|---|
| Constituent | 1971 | 1997 Mass (mt) | 1971 vs. 1997 Percent Reduction | 1997 Mass (mt) | 1971 vs. 1997 Percent Reduction |
| Suspended Solids (mt) | 295,236 | 75,105 | 75 | 75,105 | 75 |
| BOD (mt) | 282,412 | 136,512 | 52 | 136,512 | 52 |
| Nitrate-N (mt) | 308 | 154 | 50 | 169 | 45 |
| Nitrite-N (mt) | 159 | 68 | 57 | 68 | 57 |
| Oil and Grease (mt) | 63,189 | 19,793 | 69 | 19,793 | 69 |
| Ammonia-N (mt) | 53,551 | 42,015 | 22 | 42,015 | 22 |
| Organic N (mt) | 17,234 | 5,485.0 | 68 | 5,485 | 68 |
| Total Phosphorus (mt) | 11,719 | 3,598 | 69 | 3,602 | 69 |
| MBAS (mt) | 6,684 | NA | NA | NA | NA |
| Cyanide (mt) | 194 | 10 | 95 | 12 | 94 |
| Arsenic (mt) | 7.9 | 3.2 | 59 | 3.5 | 56 |
| Cadmium (mt) | 53 | 0.4 | 99 | 1.9 | 96 |
| Chromium (mt) | 666 | 4.3 | 99 | 11 | 98 |
| Copper (mt) | 535 | 59 | 89 | 59 | 89 |
| Lead (mt) | 240 | 0.76 | 100 | 11 | 95 |
| Mercury (mt) | 2.9 | 0.03 | 99 | 0.53 | 82 |
| Nickel (mt) | 327 | 35 | 89 | 38 | 88 |
| Selenium (mt) | 13 | 8.3 | 36 | 9.1 | 30 |
| Silver (mt) | 15 | 5.6 | 63 | 7.9 | 47 |
| Zinc (mt) | 1,834 | 81 | 96 | 81 | 96 |
| Total DDT (kg) | 22 | 0.002 | 100 | 0.2 | 99 |
| Total PCB (kg) | 8.9 | 0 | 100 | 2.6 | 71 |

NA=Not analyzed.

**FIGURE 9. Comparison of lead mass emissions estimates if using RLs for NDs versus using zeros for NDs.**

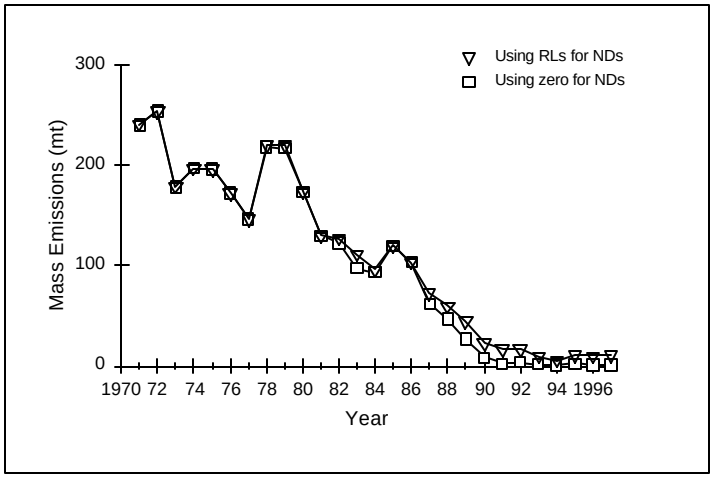



**FIGURE 10. Comparison of zinc mass emissions estimates if using RLs for NDs versus using zeros for NDs.**

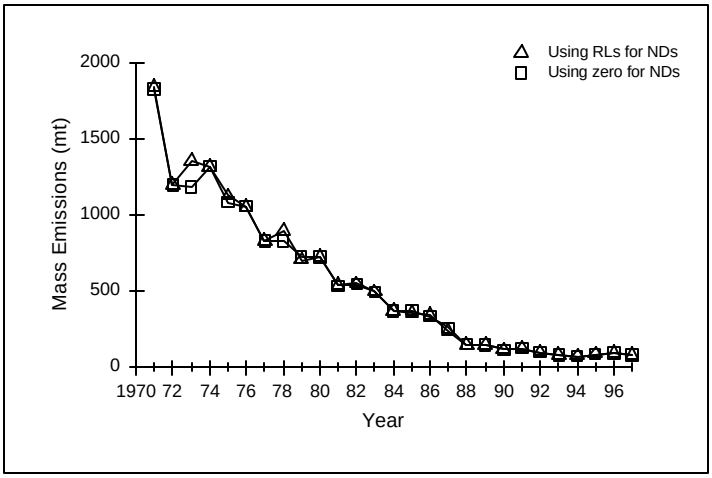



**FIGURE 11. Comparison of total DDT mass emissions estimates if using RLs for NDs versus using zeros for NDs.**

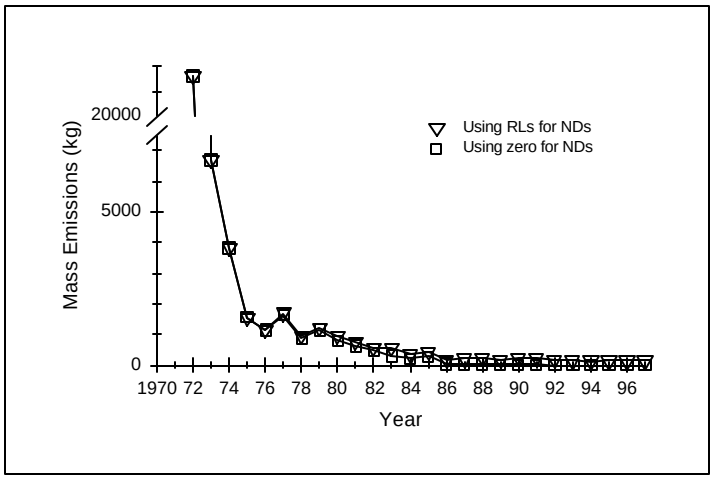
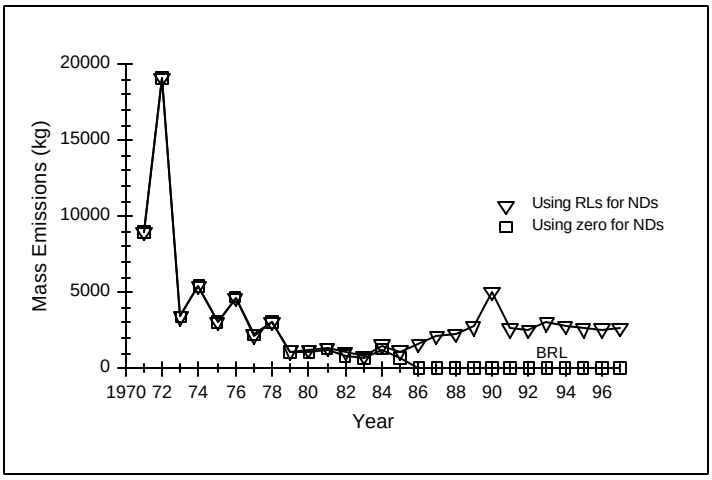



**FIGURE 12. Comparison of total PCB mass emissions estimates if using RLs for NDs versus using zeros for NDs.**

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