Effluent discharges to the Southern California Bight from large municipal wastewater treatment facilities in 2003 and 2004

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Abstract

Four large municipal wastewater treatment facilities (POTWs) each discharge upwards of 100 million gallons of treated wastewater to the Southern California Bight (SCB) every day and are a primary source of contaminants to the SCB. Since 1971 the Southern California Coastal Water Research Project (SCCWRP) has conducted annual assessments of contaminant loading to the SCB from the large POTWs. This report continues these assessments by characterizing effluents from large POTWs in 2003 and 2004. Data from compliance monitoring reports were used to evaluate large POTW effluents in terms of volume, constituent mass emissions, and average constituent concentration. Estimates were compared to results from previous years, and long-term trends in large POTW effluents were evaluated. Emphasis for historical comparisons focused on selected years from 1982 to 2004 to highlight changes in discharges associated with increases in secondary treatment. Effluent discharges in 2004 were generally lower than previous years in terms of volume, concentrations and mass emissions. The most significant reductions in constituent mass emissions followed increases in secondary treatment capacity. By 2003 both Hyperion Treatment Plant (HTP) and the Joint Water Pollution Control Plant (JWPCP) had converted to full secondary treatment. As a result, these two facilities went from having the greatest proportional discharge of most constituents to having the least, despite accounting for 60% of the total effluent volume. Still, large POTWs remain the leading point source of contaminants to the SCB.

Introduction

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

Nineteen municipal wastewater treatment facilities discharge treated wastewater directly into the SCB. Of these publicly owned treatment works (POTWs), the four largest facilities are classified as large POTWs, each discharging over 100 million gallons per day. The four large POTWs are the Hyperion Treatment Plant (HTP), operated by the City of Los Angeles; the Joint Water Pollution Control Plant (JWPCP), operated by the Los Angeles County Sanitation Districts; Treatment Plant No. 2, operated by the Orange County Sanitation District (OCSD); and the Point Loma Wastewater Treatment Plant (PLWTP), operated by the City of San Diego (Figure 1). These four facilities have historically been the largest contributors of contaminants to the SCB, although effluent quality has improved notably since assessments of large POTW discharges began in 1971 (Steinberger and Stein 2004).

Despite comprehensive regulations on large POTW discharges, regional-level assessments of these discharges are not part of the standard regulatory framework. This poses a challenge when trying to understand long-term trends in cumulative large POTW discharges, which are essential to developing environmentally and economically sound policies regarding this point source. Southern California Coastal Water Research Project (SCCWRP) has conducted annual regional-scale assessments of Southern California's

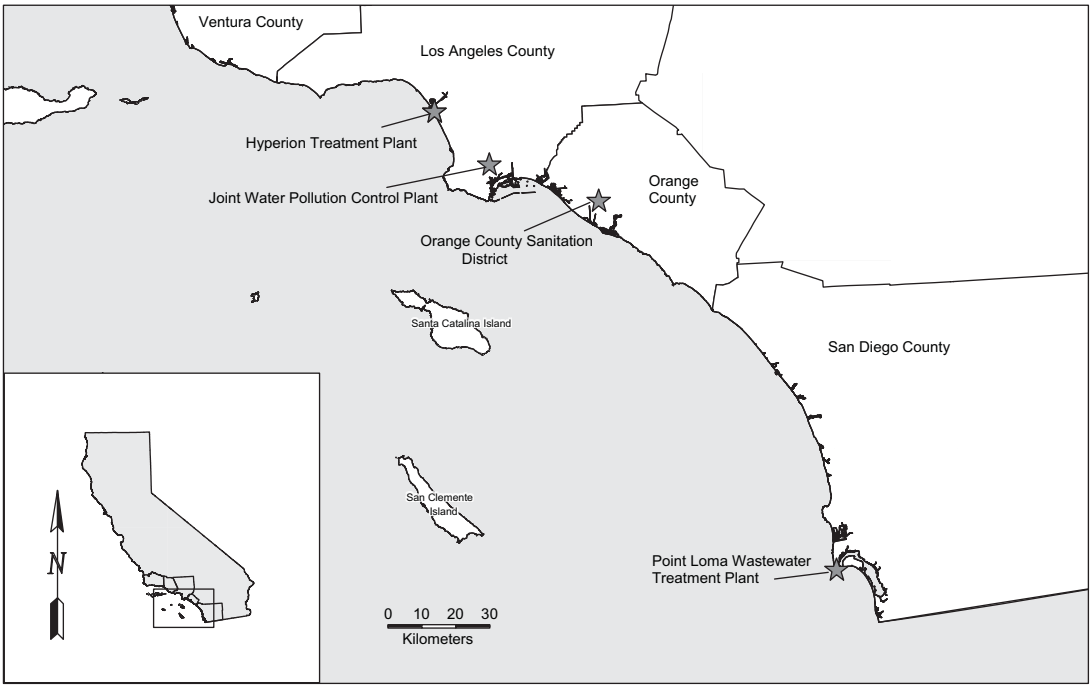

Figure 1. Locations of the four large publicly owned treatment works in the SCB.

large POTWs since 1971, enabling managers to monitor the effectiveness of regulations and compare large POTW effluents to other contaminant sources.

This study represents a continuation of these assessments for large POTW discharges to the SCB. As part of our assessment, we characterized 2003 and 2004 effluents from the four large POTWs in terms of total discharge volumes and treatment levels, annual constituent mass emissions, and average constituent concentrations. We compared mass emission estimates among facilities, examined changes in combined discharges between the two years, and compared discharges to our last assessment period ending in 2002. Further, we looked at historical trends in large POTW discharges, focusing on changes in mass emissions and average concentrations of selected constituents related to changes in treatment level from 1982 to 2004.

METHODS

Effluent data for the large POTWs were obtained from monthly, quarterly, and annual discharge monitoring reports (DMR) prepared by each facility. Analytical methods (Appendix I), reporting levels (Appendix II), and measurement frequencies (Appendix III) were obtained from DMRs, or from laboratory reports or personnel at the individual facilities when information was not available in the DMR. When the frequency of constituent analysis was not noted in the DMR, it was assumed to be the minimum frequency required by the National Pollution Discharge Elimination System (NPDES) permit for that facility. The constituents chosen for this assessment did not represent the entirety of wastewater analysis conducted by the individual agencies. Specific parameters were chosen based on the existence of data for consistent historical comparisons and based on the known influence of these constituents in the marine environment. This report includes an analysis of various metals, nutrients, dichlorodiphenyltrichloroethanes (DDTs), polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), toxicity bioassays, and general constituents such as suspended solids, biological oxygen demand (BOD), and oil and grease.

Annual mass emission estimates and effluent concentrations were calculated for the 2003 and 2004 calendar years. To perform these calculations, the chemistry data were standardized to monthly time steps. For constituents analyzed at a frequency greater than once per month, this entailed calculation of an arithmetic mean of all samples in a given month. Where the frequency of constituent analysis was less than monthly, an arithmetic average of available data within the given year was calculated. This average was then used to populate months for

which no data existed. This latter manipulation was based on the assumption that the given constituent concentrations were consistent for any given month in the year. Constituent measurements below the reporting level (RL) were assigned a value of zero for calculating average effluent concentrations.

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

$$ME = \sum_{i=1}^{12} uF_iC_iD_i$$

where Fi is the mean daily flow for the month i; Ci is the reported constituent concentration for the month i; Di is the number of days that discharge occurred during the month i; and u is the appropriate unit conversion factor for calculating the ME in metric tons (mt), kilograms (kg), or liters (L).

Annual average flow-weighted concentrations (FWC) were calculated by dividing the annual ME for a given constituent by the total annual effluent volume (AEV). This calculation was then corrected by a unit conversion factor to obtain the proper units for the specific parameter:

$$FWC = u\frac{ME}{AEV}$$

where ME is the annually summed mass emission estimate; AEV is the total annual effluent volume; and u is the unit conversion factor for reporting the FWCs in a specific unit.

The AEV for each discharger was calculated from the sum of the monthly effluent volumes:

$$AEV = \sum_{i=1}^{12} uF_iD_i$$

This approach for estimating FWCs sometimes resulted in estimates that were below the RL for constituents that had one or more non-detected results. In these cases, the FWC was reported as calculated. A constituent that was consistently not detected in a given year resulted in a FWC estimate of zero; these values were expressed as less than the RL provided by the facility during that year for the given constituent.

Reporting levels varied among facilities for individual constituents. When more than one RL was used during the year for a given constituent and facility, the range of values was reported, and the greatest RL was used for reporting non-detectable values in FWC estimates. Method detection limits (MDL) were used in place of RLs whenever RLs were not available. Significant figures were retained in reporting the detection levels used by the facilities, and/or their contract laboratories, for effluent chemical analyses.

Constituent concentrations between the MDL and the practical quantization limit (PQL) were reported by HTP and OCSD as estimates with the designation "detected but not quantified" (DNQ). In our last assessment focusing on discharges in 2001 and 2002, HTP did not report estimated concentrations for the DNQ results. Without the estimated concentrations, MEs and FWCs were calculated as ranges, using the MDL and PQL for each constituent. The PQL for constituents classified as non-carcinogens was ten times the MDL, while the PQL for carcinogens was five times the MDL. Beginning in 2003, facilities reported estimated concentrations along with the DNQ designation. For the current assessment, sensitivity analysis was conducted to compare the cumulative ME totals based on the

Table 1. Annual average primary, secondary, and total flow rates of effluent discharge to the SCB from the four large POTWs in million gallon per day (mgd).

	2003 Flow			2004 Flow		
Facility	Advanced Primary Flow	Secondary Flow	Total Flow	Advanced Primary Flow	Secondary Flow	Total Flow
HTP	0	315	315	0	319	319
JWPCP	0	322	322	0	320	320
OCSD	79	159	238	77	159	236
PLWTP	170	0	170	174	0	174
Combine	249	795	1,044	251	798	1,049

reported concentration estimates, to the totals based on the ranges, using MDL and PQL endpoints. The cumulative totals were not significantly different; therefore, the estimated concentrations were used as reported for the calculation of 2003 and 2004 MEs and FWCs. For trend analysis involving 2001 and 2002 DNQ data, the ranges calculated by Steinberger and Stein (2004) were used in the comparison.

Total effluent volumes and estimated mass emissions calculated for the years of this study were appended to existing historical data in order to establish ongoing trends in large POTW emissions. Additionally, historical annual mass emissions of selected constituents from all large POTWs were examined for changes related to increased treatment levels. Ten individual years, from 1982 to 2004, were selected for this analysis based on increases in the volume of flow treated at the secondary level by the individual facilities. All historical data were taken from Steinberger and Stein (2004) and Raco-Rands and Steinberger (2001).

Table 2. Estimated constituent mass emissions in large POTW effluent discharges to the SCB.

		HTP		JWPCP		OCSD		PLWTP		TOTAL	
Constituent	**Units**	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
Volume	L x 10^9	435	442	444	443	329	326	234	241	1,442	1,453
Settleable Solids	L x 10^6	24	nd	44	44	214	102	43	104	325	250
TSS	mt x 10^3	8.3	8.9	7.4	6.9	11	11	10	10	37	37
BOD	mt x 10^3	7.8	8.3	3.6	2.8	19	19	25	24	55	54
COD	mt x 10^3	--	--	29	27	--	--	55	56	85	83
TOC	mt x 10^3	8.7	9.3	7.7	6.2	--	--	--	--	16	15
Oil/grease	mt x 10^3	nd	0.2	nd	nd	3.7	3.7	2.7	3.4	6.4	7.3
Ammonia-N	mt x 10^3	15	16	14	14	8.9	8.9	6.5	6.6	45	46
Nitrate-N	mt	8.9	9.6	11	2.9	--	--	41	18	61	30
Nitrite-N	mt	--	--	43	24	--	--	--	--	43	24
Organic-N	mt	1,617	1,686	1,387	2,541	--	--	--	--	3,005	4,226
Total Phosphorus[a]	mt	1,096	1,282	763	352	--	--	127	24	1,987	1,659
Phosphate-P	mt	--	--	763	352	--	--	--	--	763	352
Phosphorus	mt	1,096	1,282	--	--	--	--	--	--	1,096	1,282
ortho-Phosphate	mt	--	--	--	--	--	--	127	24	127	24
Cyanide	mt	0.87	0.70	2.5	1.8	0.93	0.65	0.55	0.45	4.8	3.6
Arsenic	mt	1.1	1.2	0.63	0.61	0.67	0.72	0.30	0.26	2.7	2.8
Cadmium	mt	0.01	0.08	0.07	nd	0.11	0.17	0.05	0.02	0.24	0.27
Chromium	mt	0.48	0.65	nd	nd	1.1	1.0	nd	0.49	1.6	2.2
Copper	mt	6.0	9.2	3.8	2.7	14	13	18	10	42	35
Lead	mt	0.59	1.8	0.21	nd	0.41	0.38	nd	nd	1.2	2.1
Mercury	mt	0.02	0.003	nd	nd	0.007	0.007	0.007	nd	0.03	0.01
Nickel	mt	4.0	3.7	14	8.5	9.9	12	nd	1.3	27	25
Selenium	mt	0.49	0.46	3.5	3.1	1.6	1.9	0.25	0.27	5.8	5.8
Silver	mt	0.35	0.62	0.50	nd	0.45	0.49	nd	0.06	1.3	1.2
Zinc	mt	8.0	9.7	1.1	2.1	14	14	5.1	5.7	28	32
Total Phenols[b]	mt	--	--	3.4	2.6	--	--	--	--	3.4	2.6
Chlorinated Phenols	mt	0.05	0.02	nd	nd	nd	nd	nd	nd	0.05	0.02
Nonchlorinated Phenols	mt	0.2	0.01	nd	nd	2.5	2.0	2.5	2.7	5.1	4.7
Total DDT	kg	nd	0.13	nd	nd	nd	nd	nd	nd	nd	0.13
Total PAH	kg	193	23	nd	8.9	nd	nd	nd	39	193	71
Total PCB	kg	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd

[a] Total phosphorus is the sum of the P component all phosphorus/phosphate measurements, where more than one was applicable.

[b] Total phenols values are results from analysis of total phenols; not the sum of individually resolved phenols.

Dash = not applicable/ not analyzed.

nd = Not detected.

mt = Metric tons (1 mt = 1000 kg).

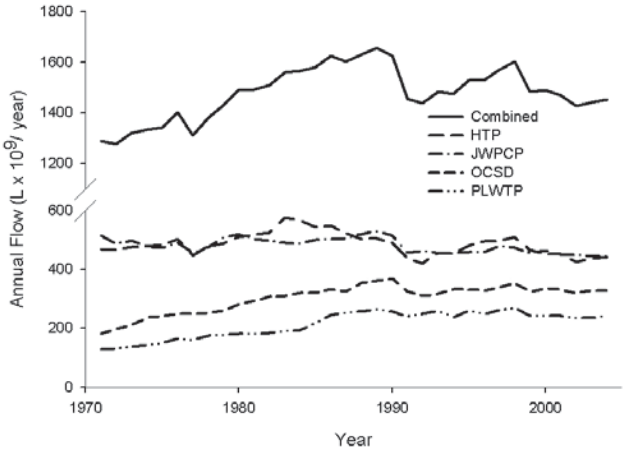

Figure 2. Individual and combined effluent volumes for large POTWs between 1971 and 2004.

RESULTS

Effluent discharges in 2003 and 2004

Combined effluent flows from large POTWs averaged 1,044 mgd in 2003 and 1,049 mgd in 2004 (Table 1). The resulting total discharge of treated wastewater from these facilities was 1,442 and 1,453 billion liters in 2003 and 2004, respectively (Table 2; Figure 2). JWPCP and HTP each contributed slightly more than 30% of the total effluent volume, while OCSD contributed 22.6% and PLWTP contributed 16.4% to the total over the two-year period. The level of treatment varied by facility, but overall 76% of the total effluent flow was treated at the secondary level, in both 2003 and 2004. This is an increase from the 63% of flow receiving secondary treatment in 2002 (Steinberger and Stein 2004). Both HTP and JWPCP treated 100% of their effluent at the secondary level in 2003 and 2004, while OCSD treated 67% of its total flow at the secondary level during both years. PLWTP did not provide any secondary treatment, treating 100% of its effluent at the advanced primary level during both years.

Combined mass emissions from all facilities remained essentially the same between 2003 and 2004 for most constituents included in this assessment (Table 2). The one exception was organic-N, which increased 41% between 2003 and 2004. Although the mass emissions for five individual metals had slight increases from 2003 to 2004, total metals mass emissions decreased 4% in 2004 from the previous year.

Large POTWs discharged a total of 37 thousand mt of suspended solids (TSS) in both 2003 and 2004, down from 54 thousand mt discharged in 2002 (Figure 3). Mass emissions of BOD also declined, from 81 thousand mt in 2002, to 55 and 54 thousand mt in 2003 and 2004, respectively. Combined discharge of Ammonia-N remained relatively stable over this period, between 44 and 46 thousand mt per year. Total metals emissions declined from 2002 to 2004, though determining the actual decrease was complicated by the DNQ reporting procedure used by HTP in 2002. Total metals discharged in 2002 were estimated between 127 and 191 mt, based on the range determined for HTP by Steinberger and Stein (2004). The total metals emissions in 2003 and 2004 were 111 and 106 mt, respectively. Therefore, the decrease in total metals emissions from 2002 to 2004 was at least 17%, but the actual amount could not be determined. DDTs were detected in only one result by HTP, leading to an estimated discharge of 0.13 kg in 2004. Mass emissions of PAHs declined from 193 kg in 2003 to 71 kg in 2004, based primarily on an 88% decrease at HTP. No PCBs were detected by any facility in either year.

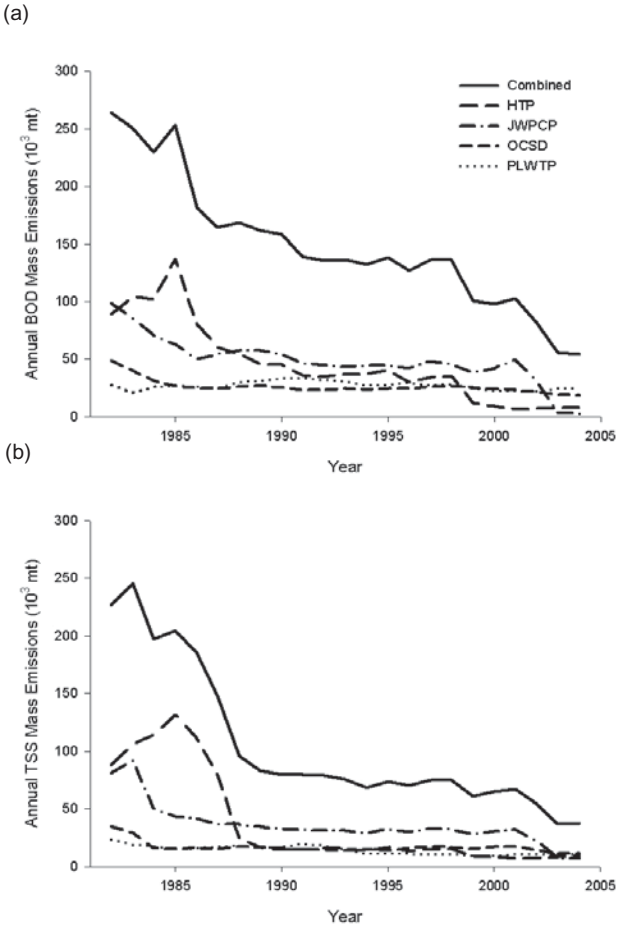

Figure 3. Individual and combined mass emissions of BOD (a) and TSS from large POTWs between 1982 and 2004 (b) .

Table 3. Annual average flow-weighted consituent concentrations in effluents discharged to the SCB from large POTWs in 2003 and 2004. Non-detectable constituents are reported as less than the range of analytical reporting limits used during the given year; where the reporting limit was not provided the method detection limit was used.

		HTP				JWPCP				OCSD				PLWTP			
Constituent	Units	2003 mean	CV	2004 mean	CV	2003 mean	CV	2004 mean	CV	2003 mean	CV	2004 mean	CV	2003 mean	CV	2004 mean	CV
TSS	mg/L	19	7.7	20	9.4	17	10	16	8.5	33.7	6.4	34.9	5.7	42	4.4	43	5.9
Settleable Solids	ml/L	0.05	346	< 0.1	--	0.1	0	0.1	0	0.7	37	0.3	31	0.2	46	0.4	43
Turbidity	NTU	8	11	9	12	7	13	6	14	30	7.0	30	13	45	9.0	50	6.7
BOD	mg/L	18	7.3	19	12	8	8.3	6	25	59	5.1	58	5.8	105	7.9	101	7.1
COD	mg/L	--	--	--	--	66	6.6	61	5.3	--	--	--	--	237	7.9	203	11
TOC	mg/L	20	15	21	12	17.3	12	14.0	6.5	--	--	--	--	--	--	--	--
Oil/grease	mg/L	nd	--	0.42	160	< 5	--	< 5	--	11.2	7.5	11.2	14	11.4	26	14.2	14
Ammonia-N	mg/L	34.9	5.1	35.3	5.4	31.6	4.8	32.7	5.0	27	2.8	27	4.3	27.7	6.5	27.3	4.6
Nitrate-N	mg/L	0.02	130	0.02	135	0.02	153	0.006	242	--	--	--	--	0.18	175	0.07	242
Nitrite-N	mg/L	--	--	--	--	0.10	73	0.05	73	--	--	--	--	--	--	--	--
Organic-N	mg/L	3.7	19	3.8	13	3.1	11	5.7	170	--	--	--	--	--	--	--	--
Total Phosphorus																	
Phosphate-P	mg/L	--	--	--	--	1.72	129	0.80	19	--	--	--	--	--	--	--	--
Phosphorus	mg/L	2.5	18	2.9	14	--	--	--	--	--	--	--	--	--	--	--	--
ortho-Phosphate	mg/L	--	--	--	--	--	--	--	--	--	--	--	--	0.54	126	0.10	346
Cyanide	ug/L	2.0	115	1.6	149	5.6	36	4.0	63	2.8	30	2.0	77	2.3	50	1.9	76
Arsenic	ug/L	2.6	39.2	2.8	26	1.4	12	1.4	19	2.0	25	2.2	30	1.3	28	1.1	27
Cadmium	ug/L	0.03	234	0.17	146	0.17	234	< 1	--	0.34	130	0.52	98	0.21	234	0.08	190
Chromium	ug/L	1.1	46.9	1.5	30	< 12	--	< 12	--	3.3	46	3.1	34	< 5	--	2.0	153
Copper	ug/L	13.9	21.5	2.1	35	8.7	25	6.1	65	42.9	50	39.0	16	79	49	43	35
Lead	ug/L	1.4	117	4.0	128	0.47	346	< 8	--	1.3	86	1.2	32	< 18	--	< 18	--
Mercury	ug/L	0.05	131	0.007	199	< 0.5	--	< 0.5	--	0.021	71	0.021	78	0.03	250	< 0.09	--
Nickel	ug/L	9.3	18.2	8.5	47	30	13	19	76	30	45	36	34	< 14	--	5.2	95
Selenium	ug/L	1.1	49.4	1.0	50	7.8	22	7.0	19	4.9	27	6.0	32	1.1	17	1.1	19
Silver	ug/L	0.81	84.9	1.4	31	1.1	241	< 5	--	1.37	19	1.50	14	< 6.6	--	0.23	154
Zinc	ug/L	18	21	22	21	2.6	346	4.8	235	42	26	43	12	22	49	23	38
Total Phenols	ug/L	--	--	--	--	7.5	115	5.9	136	--	--	--	--	--	--	--	--
Chlorinated Phenols	ug/L	0.11	104	0.03	135	< 5-50	--	< 5-50	--	< 0.11-1.5	--	< 0.5-1.5	--	< 1.34-5.87	--	< 1.34-5.87	--
Nonchlorinated Phenols	ug/L	0.48	104	0.03	135	< 5-50	--	< 5-50	--	7.5	8.3	6.0	45	10	18	11	23
Total DDT	ug/L	< 0.0017-0.006	--	0.0003	135	< 0.01	--	< 0.01	--	< 0.007-0.02	--	< 0.007-0.1	--	< 0.02-0.1	--	< 0.02-0.1	--
Total PAH	ug/L	0.44	104	0.05	135	< 0.025-50	--	0.020	73.9	< 0.41-1.6	--	< 0.44-1.9	--	< 1.52-7.68	--	0.16	346
Total PCB	ug/L	< 0.04-0.3	--	< 0.04-0.3	--	< 0.05-0.1	--	< 0.05-0.1	--	< 0.2	--	< 0.2	--	< 2-4	--	< 2-4	--
Acute Toxicity																	
Atherinops affinis	TUa	--	--	--	--	--	--	–	--	--	--	--	--	2.40	138	4.2	--(1)
Menidia beryllina	TUa	--	--	--	--	--	--	–	--	1.84	39	1.62	36	--	--	--	--
Mysidopsis bahia	TUa	--	--	--	--	--	--	–	--	–	--	--	--	2.60	15	4.50	7.6
Pimephales promelas	TUa	0.61	52.5	0.76	21	0.15	181	0.18	189	--	--	--	--	--	--	--	--
Chronic Toxicity																	
Atherinops affinis (growth)	TUc	--	--	--	--	--	--	–	--	--	--	55.56	--(1)	64	0	--	--
Haliotis rufescens (development)	TUc	24.9	70.1	47.4	33	--	--	--	--	55.56	0	55.58	0	64	0	64	0
Macrocystis pyrifera (germ-tube length)	TUc	--	--	--	--	--	--	–	--	--	--	--	--	93.64	93	72.05	27
Macrocystis pyrifera (germination)	TUc	--	--	--	--	--	--	–	--	--	--	55.56	--(1)	76.15	31	64	0
Menidia beryllina (biomass)	TUc	--	--	--	--	52.8	68.8	42	0	--	--	--	--	--	--	--	--
Menidia beryllina (survival)	TUc	--	--	--	--	42	0	42	0	--	--	–	--	--	--	--	--
Mysidopsis bahia (biomass)	TUc	--	--	--	--	--	--	42	0	--	--	--	--	--	--	--	--
Mysidopsis bahia (survival)	TUc	--	--	--	--	--	--	42	0	--	--	--	--	--	--	--	--
Strongylocentrotus purpuratus (fertilization)	TUc	--	--	--	--	--	--	–	--	55.56	0	55.56	0	–	--	--	--
Bacteria																	
Enterococcus	mpn/100mL	41,000	47	67,000	30	--	--	--	--	--	--	--	--	–	--	--	--
Fecal Coliform	mpn/100mL	332,000	37	364,000	34	--	--	--	--	--	--	--	--	–	--	--	--
Total Coliform	mpn/100mL	1,562,000	29	2,016,000	40	--	--	--	--	--	--	--	--	24,000,000	88	24,000,000	122

nd = not detected, no reporting limit provided.

Dash = not applicable, not analyzed.

--(1) = Only one sample taken during year, CV calculation not applicable.

The most dramatic changes in mass emissions occurred at JWPCP, which increased secondary treatment of its effluent from 70% in 2002 to 100% in 2003 and 2004. Between 2002 and 2004, 96% of constituent mass emissions decreased or were undetected. The only constituent that showed an increase in mass discharge during this period was total PAH, which increased from not detected in 2002 and 2003 to 8.9 kg in 2004. Total metals emissions from JWPCP decreased 64% between 2002 and 2004. Emissions of general constituents during this period showed a median decrease of 67%, with oil/grease, BOD, nitrate-N, phosphate-P, and TSS exhibiting the most significant declines. Among the organic constituents, total phenolic compounds decreased 97%, while individually resolved chlorinated and non-chlorinated phenols and DDTs declined to non-detectable levels.

Among general constituents, the majority of FWCs in 2003 and 2004 were highest at PLWTP (Table 3). Notable exceptions were cyanide concentrations, which were highest in JWPCP effluents; and ammonia-N concentrations, which remained relatively stable in both years and were highest in HTP effluents. Concentrations of all general constituents at HTP, except cyanide, increased in 2004, while at JWPCP concentrations increased only for ammonia-N and organic-N. All metals included in this assessment were detected in both years by HTP and OCSD. However, JWPCP had no detectable chromium or mercury in either year, and no detectable cadmium, lead, or silver in 2004. Similarly, PLWTP did not detect chromium, lead, nickel, or silver in 2003; while all metals, except lead and mercury, were detected in 2004.

Four species were used by large POTWs to conduct acute toxicity bioassays (Table 3). The lowest acute toxicity results were obtained by JWPCP, using the test species *Pimephales promelas*, 0.15 TUa and 0.18 TUa, in 2003 and 2004, respectively. HTP tested the same species, with all results also being not toxic (TUa <1). The highest acute toxicity results were measured by PLWTP in 2004, with *Atherinops affinis* and *Mysidopsis bahia* results of 4.2 TUa and 4.5 TUa, respectively. However, in all cases, the acute toxicity results were within the compliance standards of the facility's NPDES permit.

Six different species were used for chronic toxicity studies by the large POTWs in 2003 and 2004 (Table 3). Development of *Haliotis rufescens* was tested in both years, by all facilities except JWPCP. Results using this species ranged from 24.9 TUc (HTP in 2003) to 64 TUc (PLWTP in 2003 and 2004). All chronic toxicity results by OCSD using four different species across the two years were consistent at 55.6 TUc. The highest chronic toxicities for both years were observed in PLWTP effluents, with results for three different species ranging from 64 TUc to 93.64 TUc, although chronic toxicity to *Macrocystis pyrifera* (both germination and germ-tube length) declined in 2004. As with the acute toxicity results, all chronic toxicity results were well below NPDES permit compliance limits.

Historical discharges from large POTWs

During the years selected for this assessment, combined flow volumes ranged from a high of 1,658 billion liters in 1989, to a low of 1,426 billion liters in 2002, with a CV of 5.9% (Table 4). Total volume has generally decreased over the selected years, with discharges greater than 1,500 billion liters in 5 of the first 6 years, and discharges less than 1,500 billion liters in each of the last 4 selected years. The percentage of the total combined volume treated at the

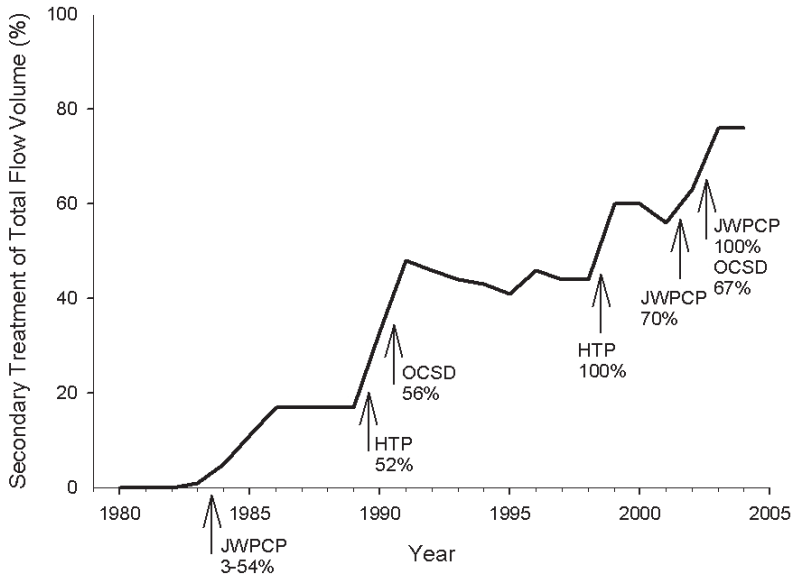

Figure 4. Combined large POTW effluent volume treated at the secondary level between 1980 and 2004. Arrows indicate time when percent of secondary treated effluent by facility increased to the specified level.

Table 4. Estimated combined mass emissions from the large POTWs from selected years between 1982 and 2004. Data for excluded years can be found in Raco-Rands and Steinberger (2001), Steinberger and Schiff (2003a) and Steinberger and Stein (2004).

Constituent	1982[a]	1986[a]	1989[a]	1990[a]	1991[a]	1998[a]	1999[a]	2002[a]	2003	2004
Volume (L x 10^9)	1,509	1,624	1,658	1,625	1,455	1,602	1,485	1,426	1,442	1,453
Suspended Solids (mt x 10^3)	227	185	83	80	79	75	61	54	37	37
BOD[b] (mt x 10^3)	264	182	162	159	139	137	101	81	55	54
Oil/Grease (mt x 10^3)	37	29	22	21	19	19	15	10	6.4	7
Ammonia-N (mt x 10^3)	40	45	45	46	44	42	41	44	45	46
Nitrate-N (mt x 10^3)	0.14	0.41	0.34	0.21	0.24	0.23	0.57	0.24	0.06	0.03
Nitrite-N (mt x 10^3)	0.04	0.07	0.08	0.29	0.11	0.30	0.51	0.03	0.04	0.02
Organic-N (mt x 10^3)	12	11	7.2	6.4	6.0	5.8	4.1	4.0	3.0	4.2
Total P[b] (mt x 10^3)	9.2	9.2	6.3	6.5	6.0	2.6	1.9	2.6	2.0	1.7
Cyanide (mt)	72	27	12	13	16	8.1	8.2	6.3	4.8	3.6
Arsenic (mt)	7.6	12	7.4	8.2	5.4	3.3	2.5	3.0-3.6	2.7	2.8
Cadmium (mt)	22	14	1.7	1.4	1.2	0.63	0.16	0.19	0.24	0.27
Chromium (mt)	197	86	22	14	10	9.3	3.8	1.7-2.7	1.6	2.2
Copper (mt)	283	203	67	59	47	55	46	40-62	42	35
Lead (mt)	123	104	27	8.1	2.4	1.1	0.32	0.83-4.2	1.2	2.1
Mercury (mt)	1.1	0.71	0.39	0.25	0.23	0.03	0.02	0.02-0.03	0.03	0.01
Nickel (mt)	170	130	54	40	33	35	27	28-40	27	25
Selenium (mt)	6.4	8.1	7.4	7.3	7.1	7.5	7.4	6.7-7.1	5.8	5.8
Silver (mt)	25	22	10	10	8.0	6.2	3.9	3.2-3.7	1.3	1.2
Zinc (mt)	550	341	145	115	125	75	63	43-67	28	32
Total Metals (mt)	1385	920	342	263	239	193	154	127-191	110	106
DDT (kg)	297	50	22	17	6.4	4.0	3.0	2.7	--[c]	0.13
PCB (kg)	782	35	--[c]	--[c]	--[c]	--[c]	--[c]	--[c]	--[c]	--[c]

[a]Reproduced from Steinberger and Stein (2004).

[b]Sum of total phosphorus (HTP), phosphate-P (JWPCP), and soluble phosphate-P (PLWTP).

[c]Results reported by dischargers were below method detection limits.

secondary level increased from 0% in 1982, to 76% in 2003 and 2004 (Figure 4). The overall increase occurred incrementally as individual facilities increased secondary treatment capacity.

JWPCP was the first large POTW facility to implement secondary treatment, beginning in 1983, treating 3% of their effluent at the secondary level. JWPCP increased secondary treatment capacity in each of the following 3 years to a total of 54% of their total volume in 1986. As a result, 17% of the combined volume discharged into the SCB was treated at the secondary level annually from 1986 to 1989. In 1990, HTP began treating 52% of its effluent at the secondary level, increasing the combined volume of secondary treated effluent to 33%. The following year, OCSD began secondary treatment of 56% of its effluent, contributing to an overall increase in secondary treatment to 48% of the combined effluent discharge. Treatment levels remained relatively stable until 1999 when HTP increased capacity to 100% secondary treatment, raising the overall level of secondary treatment to 60% of the combined total effluent volume. By 2003, JWPCP increased secondary treatment capacity to 100%, while OCSD increased to 67%. During the entire period of this assessment PLWTP treated all effluents at the advanced primary level.

Combined mass emissions of BOD from large POTWs into the SCB decreased 79% between 1982 and 2004. During this period the facilities that now treat all effluent at the secondary level, JWPCP and HTP, reduced annual BOD emissions by 97% and 91%, respectively. OCSD reduced BOD emissions 62% with partial secondary treatment, while PLWTP emissions of BOD decreased 12% with advanced primary treatment. The greatest annual reduction by any facility occurred when JWPCP increased to full secondary treatment capacity, with BOD emissions decreasing 88% from 2002 to 2003. JWPCP was the greatest contributor of BOD in

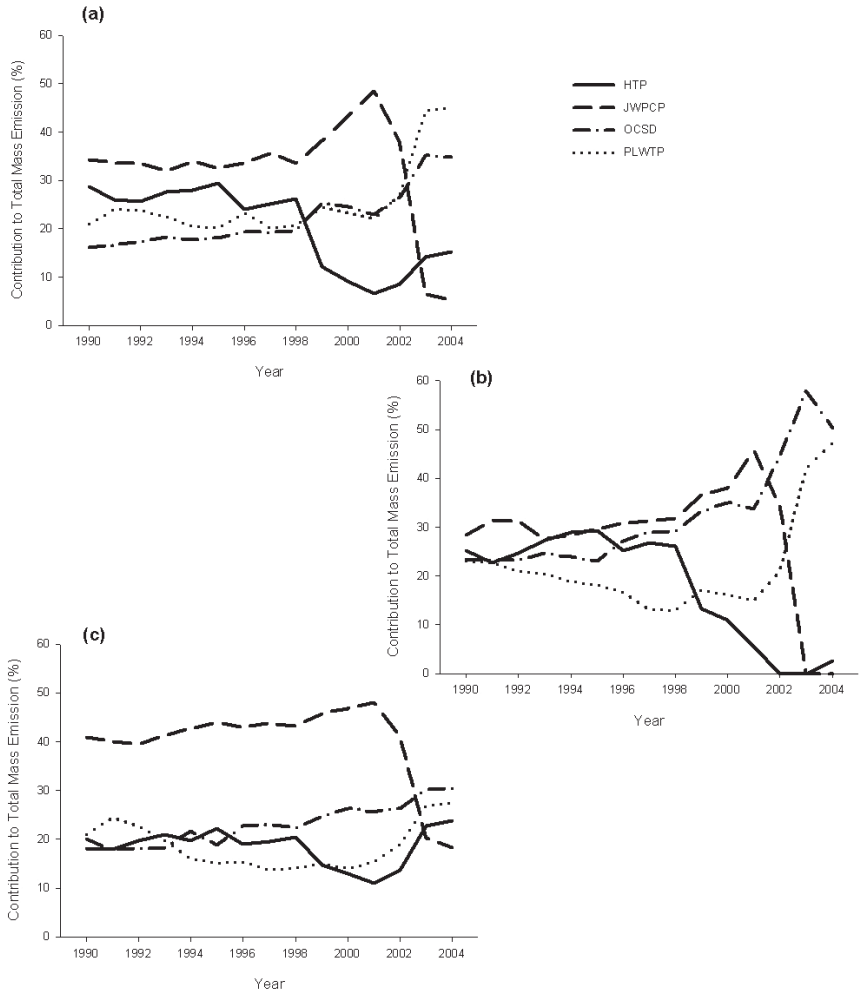

Figure 5. Relative contribution of each facility to total BOD (a), oil and grease (b), and TSS mass emissions from large POTWs between 1990 and 2004 (c).

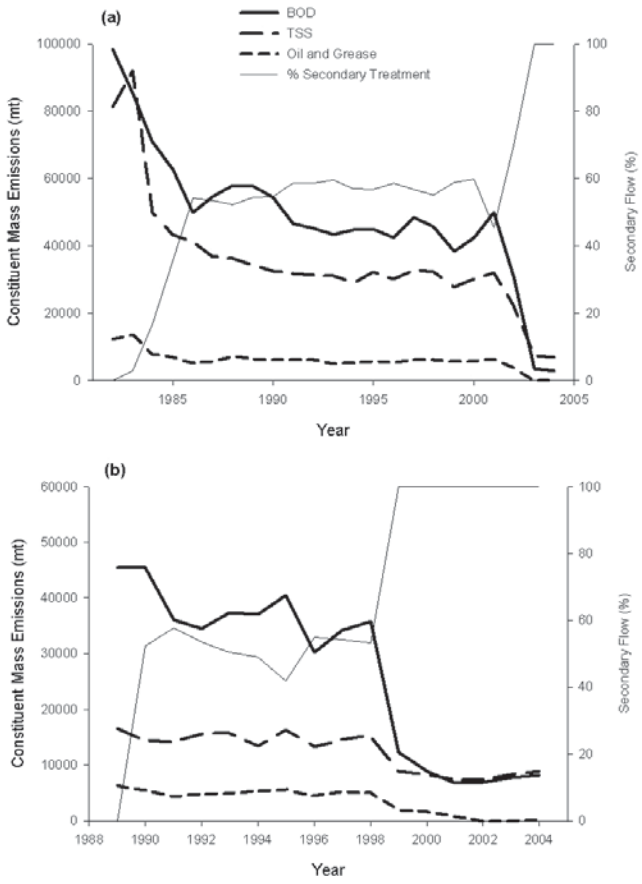

Figure 6. Comparison of secondary treatment and constituent mass emissions from JWPCP between 1982 and 2004 (a) and HTP between 1989 and 2004 (b).

1982, discharging over 98 thousand mt, but with full secondary treatment JWPCP now contributes the least amount of BOD of the four large POTWs, less than 3,000 mt in 2004 (Figure 5).

Similar reductions in TSS and oil and grease emissions occurred between 1982 and 2004. Combined TSS emissions decreased 83%, while oil and grease emissions declined 80% over the time period. The greatest individual reductions occurred when facilities increased secondary treatment capacity. TSS emissions from JWPCP declined 49% from 1982 to 1986 and 67% from 2002 to 2003 (Figure 6). Oil and grease emissions from HTP decreased 60% from 1998 to 1999, while JWPCP emissions declined 58% from 1982 to 1986. However significant reductions were also observed when no change in secondary treatment level occurred. From 1982 to 1986, emissions of TSS from OCSD decreased 53%, a greater percent reduction than JWPCP during the same period. TSS emissions from PLWTP also decreased 55% from 1982 to 2004 with no secondary treatment.

Discussion

Decreases in contaminant mass emissions to the SCB from large POTWs can result from any of three factors: (1) pre-treatment source control, (2) decreases in discharge volumes, or (3) improvements in treatment processes that result in improved effluent quality. Source control contributed significantly to reductions in mass emissions of constituents such as PCBs, DDTs, and lead in the 1970s and 1980s (Steinberger and Schiff 2003a). Discharge volumes have generally increased since 1971, yet the majority of constituent mass emissions have continued to decrease. When examining trends in constituent mass emissions it is clear that changes in wastewater treatment practices have played an important role in improving effluent quality.

During the current assessment period, the effect of improved treatment was most apparent following the conversion of JWPCP to full secondary treatment capacity. Significant reductions in MEs and FWCs were observed within the first year. By the second year of 100% secondary treatment, all constituents included in this assessment had decreased or were undetected, except for PAH compounds that were detected in only 3 of 64 samples tested in 2004. Prior to implementing full secondary treatment, JWPCP was the largest discharger of several constituents, including BOD, TSS, and total metals. By 2004, JWPCP emissions of these constituents had declined to the lowest levels of any facility, while still discharging the largest flow volume. Similar improvements in effluent quality were also observed when HTP began treating 100% of its effluent at the secondary level. HTP was the second largest overall contributor of BOD in 1998, but with the increase to full secondary treatment, BOD emissions declined to the lowest levels of any facility in 1999. HTP and JWPCP together account for over 60% of the total effluent volume, yet in 2004 they contributed only 20% of the total BOD discharged to the SCB. The same pattern is evident with other constituents, including TSS, oil and grease, and total metals. The two largest facilities discharged only 42% of both TSS and total metals, and only 3% of oil and grease emissions. These results indicate that significant increases in effluent quality can result from improved treatment processes in a short period of time.

Recent difficulties in tracking long-term trends in effluent quality have largely been addressed in the past two years due to the revised method of reporting results as DNQ. In our last assessment, the

reporting of DNQ results without estimated concentrations confounded our ability to accurately compare mass emissions and constituent concentrations among facilities. It also impacted our ability to determine the cumulative emissions of several constituents to the SCB and track changes in emissions over time. The new reporting procedure employed by HTP and OCSD, which provides estimated concentrations along with the DNQ result, again allows us to effectively track changes in constituent mass emissions and assess the efficacy of treatment measures. Although the inherent uncertainty associated with these estimated concentrations must be recognized, it is important that they be included to allow for the long-term regional monitoring of the SCB.

Acute toxicity values reported by all four POTWs are typically low. However, regional comparisons are not possible due to the lack of consistency between test organisms between facilities. Because different test organisms have different levels of sensitivity to various classes of compounds patterns in toxicity can be evaluated for each facility individually, but not between facilities. For example, JWPCP and HTP use the freshwater species *Pimephales promelas* to test for acute toxicity, while PLWTP and OCSD use the marine species *Atherinops affinis* and *Mysidopsis bahia.* Furthermore, Pimephales is generally considered to be a less sensitive indicator than Atherinops or Mysidopsis further complicating intra-facility comparisons. The use of different test organisms results from differences in the permit requirements for each facility. For example, the permit under which JWPCP has been operating prior to May 2006 was implemented under the 1990 California Ocean Plan and requires the use of Pimephales for acute toxicity testing. In contrast, the OCSD and PLWTP permits are implemented under the 2001 Ocean Plan. These differences should be remedied once permits for all the facilities are updated based on the most recent Ocean Plan.

Improved source control and treatment have resulted in tremendous improvements in effluent quality from large POTWs over the last 30 years, and these improvements continue to be observed. However, large POTWs continue to be the leading point source of contaminant inputs to the SCB, mainly due to the large volumes they discharge daily. Discharges from other known point sources such as small POTWs, industrial facilities, dredge materials, oil platforms, and power generating stations are consistently minor compared to large POTWs (Steinberger and Schiff 2003a, 2003b, 2003c, Steinberger *et al*. 2003). Only non-point source inputs, such as stormwater runoff, are a greater source of contaminants to the coastal ocean in Southern California than large POTWs (Schiff *et al*. 2000).

Literature Cited

Culliton, T., M. Warren, T. Goodspeed, D. Remer, C. Blackwell and J. McDonough III. 1990. Fifty years of population changes along the nations coasts. Report No. 2: Coastal Trends Series. National Oceanic and Atmospheric Administration, Strategic Assessment Branch. Rockville, MD.

Raco-Rands, V.E. and A. Steinberger. 2001. Characteristics of effluents from large municipal wastewater treatment facilities in 1997. pp. 28-44 *in*: D. Elmore and S.B. Weisberg (eds.), Southern California Coastal Water Research Project Biennial Report 1999-2000. Southern California Coastal Water Research Project. Westminster, CA.

Schiff, K., J. Brown and S.B. Weisberg. 2002. Model Ocean Monitoring Program. Technical Report 365. Southern California Coastal Water Research Project. Westminster, CA.

Schiff, K.C., M.J. Allen, E.Y. Zeng and S.M. Bay. 2000. Southern California. *Marine Pollution Bulletin* 41:76-93.

Steinberger, A. and K. Schiff. 2003a. Characteristics of effluents from large municipal wastewater treatment facilities between 1998 and 2000. pp. pp. 2-13 *in*: D. Elmore and S.B. Weisberg (eds.), Southern California Coastal Water Research Project Biennial Report 2001-2002. Southern California Coastal Water Research Project. Westminster, CA.

Steinberger, A. and K. Schiff. 2003b. Characteristics of effluents from non-power industrial facilities in 2000. pp. 31-46 *in*: D. Elmore and S.B. Weisberg (eds.), Southern California Coastal Water Research Project Biennial Report 2001-2002. Southern California Coastal Water Research Project. Westminster, CA.

Steinberger, A. and K. Schiff. 2003c. Characteristics of effluents from small municipal wastewater treatment facilities in 2000. pp. 14-30 *in*: D. Elmore and S.B. Weisberg (eds.), Southern

California Coastal Water Research Project Biennial Report 2001-2002. Southern California Coastal Water Research Project. Westminster, CA.

Steinberger, A. and E.D. Stein. 2004. Effluent discharges to the Southern California Bight from large municipal wastewater treatment facilities in 2001 and 2002. pp. 2-15 *in*: D. Elmore and S.B. Weisberg (eds.), Southern California Coastal Water Research Project Biennial Report 2003-2004. Southern California Coastal Water Research Project. Westminster, CA.

Steinberger, A., E.D. Stein and K. Schiff. 2003. Characteristics of dredged material disposal to the Southern California Bight between 1991 and 1997. pp. 47-57 *in*: D. Elmore and S.B. Weisberg (eds.), Southern California Coastal Water Research Project Biennial Report 2001-2002. Southern California Coastal Water Research Project. Westminster, CA.

US Census Bureau. 2002. 2000 Census of population and housing, demographic profile: technical documentation. Van Nuys, CA.

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Appendix I. Analytical methods used for constituent analyses conducted by the large POTWs and/or contract laboratories in 2003 and 2004.

	HYP5		JWPCP		OCSD		PLWTP	
Suspended Solids	SM 2540 D	SM 2540 D	SM 2540 D	SM 2540 D	SM 2540 D / EPA 160.2	SM 2540 D / EPA 160.2	SM 2540 D	SM 2540 D
Settleable Solids	nf	nf	SM 2540 F	SM 2540 F	EPA 160.5	EPA 160.5	SM 2540 F	SM 2540 F
Turbidity	nf	nf	SM 2130 B	SM 2130 B	EPA 180.1	EPA 180.1	SM 2130 B	SM 2130 B
TOC	SM 5310 B,C,D	SM 5310 B	nf	nf	na	na	na	na
BOD	SM 5210 B	SM 5210 B	SM 5210 B	SM 5210 B	EPA 405.1	EPA 405.1	SM 5210 B	SM 5210 B
COD	na	na	nf	nf	na	na	SM 5220 D	SM 5220 D
Oil/grease	EPA 1664	EPA 1664	SM 5520 B	SM 5520 B, EPA 1664	EPA 1664	EPA 1664	SM 5520 B, EPA 1664	EPA 1664
Cyanide	SM 4500 CN E	SM 4500 CN E, EPA 335.4	SM 4500 CN B,C,E	SM 4500 CN B,C,E	EPA 335.2	EPA 335.2	SM 4500 CN E	SM 4500 CN E
Ammonia-N	SM 4500 NH3 B,E	SM 4500 NH3 B,C, EPA 350.1	SM 4500 NH3 B,E	SM 4500 NH3 B,E	EPA 350.1	EPA 350.1	SM 4500 NH3 B&E	SM 4500 NH3 B&E
Nitrate-N	SM 4500 NO3 E, EPA 300.0	EPA 300.0	SM 4500 NO3 E	SM 4500 NO3 E	na	na	EPA 300.0	EPA 300.0
Nitrite-N	na	na	SM 4500 NO2	SM 4500 NO2	na	na	na	na
Organic-N	SM 4500 Norg B	EPA 351.2	SM 4500 Norg B	SM 4500 Norg B	na	na	na	na
Phosphate-P (Phosphorus)	SM 4500 P B5,E	SM 4500 P B5,E	SM 4500 P B5,E	SM 4500 P B5,E	na	na	na	na
ortho-Phosphate	na	na	na	na	na	na	EPA 300.0	EPA 300.0
Arsenic	SM 3114 B	SM 3114 B	SM 3114 B4, D	SM 3114 B4, D	EPA 200.8	EPA 200.8	SM 3114 B	SM 3114 B
Cadmium	SM 3120 B	EPA 200.7	SM 3111 B	SM 3111 B	EPA 200.8	EPA 200.8	EPA 200.7	EPA 200.7
Chromium	SM 3120 B	EPA 200.7	EPA 218.1	EPA 218.1	EPA 200.8	EPA 200.8	EPA 200.7	EPA 200.7
Copper	SM 3120 B	EPA 200.7/200.8	SM 3111 B	SM 3111 B	EPA 200.8	EPA 200.8	EPA 200.7	EPA 200.7
Lead	SM 3113 B	EPA 200.7/200.8	SM 3111 B	SM 3111 B	EPA 200.8	EPA 200.8	EPA 200.7	EPA 200.7
Mercury	SM 3112 B	SM 3112 B	SM 3112 B	SM 3112 B	EPA 245.1	EPA 245.1	SM 3112 B	SM 3112 B
Nickel	SM 3120 B	EPA 200.7	SM 3111 B	SM 3111 B	EPA 200.8	EPA 200.8	EPA 200.7	EPA 200.7
Selenium	SM 3114 B	SM 3114 B	SM 3114 B	SM 3114 B	EPA 200.8	EPA 200.8	SM 3114 C	SM 3114 C
Silver	SM 3113 B	EPA 200.8/200.7	SM 3111 B	SM 3111 B	EPA 200.8	EPA 200.8	EPA 200.7	EPA 200.7
Zinc	SM 3120 B	EPA 200.7/200.8	SM 3111 B	SM 3111 B	EPA 200.8	EPA 200.8	EPA 200.7	EPA 200.7
Phenols	na	na	EPA 625	EPA 625	na	na	na	na
Nonchlorinated Phenols	EPA 625	EPA 625	EPA 625	EPA 625	GCMS/ EPA 625	GCMS/ EPA 625	EPA 625	EPA 625
Chlorinated Phenols	EPA 625	EPA 625	EPA 625	EPA 625	GCMS/ EPA 625	GCMS/ EPA 625	EPA 625	EPA 625
Total DDT	EPA 608	EPA 608	EPA 608	EPA 608	EPA 608	EPA 608	EPA 608	EPA 608
Total PAH	EPA 625	EPA 625	EPA 625	EPA 625	GCMS/ EPA 625	GCMS/ EPA 625	EPA 625	EPA 625
Total PCB	EPA 608	EPA 608	EPA 608	EPA 608	EPA 608	EPA 608	EPA 608	EPA 608
Toxicity								
Atherinops affinis	na	na	na	na	na	EPA/600/4-90/027F	EPA/600/4-90/027F	EPA/600/4-90/027F
Ceriodaphnia dubia	na	na	na	na	EPA/600/4-90/027F	EPA/600/R-95/136	EPA/600/4-90/027F	EPA/600/4-90/027F
Haliotis rufescens	EPA/600/R-95/136	EPA/600/R-95/136	na	na	EPA/600/R-95/136	EPA/600/4-90/027F	EPA/600/R-95/136	EPA/600/R-95/136
Holmesimysis costata	na	na	na	na	EPA/600/4-90/027F	EPA/600/4-85/013	na	na
Macrocystis pyrifera	na	na	EPA/600/4-91/003	EPA/600/4-91/003	na	EPA/600/R-95/136	EPA/600/R-95/136	EPA/600/R-95/136
Menidia beryllina	na	na	EPA/600/4-91/003	EPA/600/4-91/003	EPA/600/4-85/013	EPA/600/R-95/136	na	na
Mysidopsis bahia	na	na	EPA/600/4-91/003	EPA/600/4-91/003	na	na	EPA/600/4-90/027F	EPA/600/4-90/027F
Pimephales promelas	EPA/600/4-91/027	EPA/600/4-91/027	EPA/600/4-85/013	EPA/600/4-85/013	na	na	EPA/600/4-85/013	EPA/600/4-85/013
Strongylocentrotus purpuratus	na	na	na	na	EPA/600/R-95/136	EPA/600/R-95/136	na	na
Bacteria								
Enterococcus	SM 9230 C & 9020 B4	SM 9230 C & 9020 B8	na	na	na	na	na	na
Fecal Coliforms	SM 9222 B & 9020 B4	SM 9222 D & 9020 B8	na	na	na	na	na	na
Total Coliforms	SM 9222 B & 9020 B4	SM 9222 D & 9020 B8	na	na	na	na	nf	nf

na = not analyzed.
nf = method not found.
"SM" refers to protocols found in the Standard Methods for the Examination of Water and Wastewater (Clesceri 1992).
"EPA" refers to protocols found in the California Ocean Plan: Water Quality Control Plan, Ocean Water of California (SWRCB_Cal EPA).

Appendix II. Reporting levels (italics) and/or method detection limits used for constituent analyses by the large POTWs and/or their respective contract laboratories in 2003 and 2004.

Constituent	2003				2004			
	HTP	JWPCP	OCSD	PLWTP	HTP	JWPCP	OCSD	PLWTP
Suspended Solids (mg/L)	np	np	np	np	np	np	np	0.6
Settleable Solids (mL/L)	0.1	np	*0.1*	np	0.1	np	*0.1*	0.1
BOD (mg/L)	np	np	np	np	np	np	np	2
Oil/Grease (mg/L)	np	5	np	np	np	5	np	1.4
Nitrate-N (mg/L)	0.2	0.05	na	0.03	10-20	0.05	na	0.03
Nitrite-N (mg/L)	na	0.01	na	np	np	0.01	na	np
Ammonia-N (mg/L)	0.1	0.3	np	0.2	0.1	0.3	np	0.2
Organic-N (mg/L)	0.1	0.1	na	na	0.1	0.1	na	na
(mg/L)	0.5	0.04	np	np	0.5	0.04	np	np
ortho-Phosphate (mg/L)	na	na	na	0.05	na	na	na	0.05
Cyanide (ug/L)	2-4	4	4.1	*2*	2-4	4	*2*	*2*
Arsenic (ug/L)	0.4	1	0.47	0.18	0.4	1	*0.47*	0.18
Cadmium (ug/L)	0.08	1	0.16	*1*	0.08	1	*0.16*	*1*
Chromium (ug/L)	0.7	12	0.17	*5*	0.7	12	*0.17*	*5*
Copper (ug/L)	1.5	6	0.47	4	1.5	6	*0.47*	4
Lead (ug/L)	2	8	0.31	18	2	8	*0.31*	*18*
Mercury (ug/L)	0.022	0.5	0.004	*0.27*	0.022	0.5	*0.02*	*0.09-0.27*
Nickel (ug/l)	0.24	25	0.69	*14*	0.24	25	*0.69*	*14*
Selenium (ug/L)	0.2	1	0.14	0.4	0.2	1	*0.14*	0.4
Silver (ug/L)	0.02	5	0.41	*6.6*	0.02	5	*0.41*	*6.6*
Zinc (ug/L)	2	25	5	4	2	25	*5*	4
Total Phenols (mg/L)	na	0.01	na	na	na	0.01	na	na
Chlorinated Phenols (ug/L)								
2,4,6-trichlorophenol	0.09	10-50	0.57	3.4	0.09	40-50	0.32-0.57	1.75
2,4-dichlorophenol	0.09	5-25	0.86	6.1	0.09	20-25	0.35-0.86	1.95
2-chlorophenol	0.09	5-25	1.3	3.6	0.09	20-25	0.11-1.3	1.76
4-chloro-3-methylphenol	0.18	5	2.6	3.6	0.18	4-5	0.23-2.6	1.34
Pentachlorophenol	0.4	5-25	2	5.87	0.4	20-25	1.5-2	5.87
Nonchlorinated Phenols (ug/L)								
Phenol	0.4	1	2	2.53	0.4	*5-50*	0.54-2	2.53
2,4-dimethylphenol	0.17	*1-30*	3.3	4.6	0.17	*5-50*	0.28-3.3	1.32
2,4-dinitrophenol	0.21	*6-100*	1.8	6.07	0.21	*20-200*	1-1.8	6.07
2-methyl-4,6-dinitrophenol	0.4	*1-50*	1.3-1.8	4.29	0.4	*10-100*	0.24-1.3	4.29
2-nitrophenol	0.09	*1-50*	1.1	4.5	0.09	*10-100*	0.25-1.1	1.88
4-nitrophenol	0.06	*1-50*	5	6.1	0.06	*10-100*	0.8-5	3.17
Total DDT (ug/L)								
o,p'-DDD	0.01	*0.02*	0.011	0.02	0.001-0.01	*0.01-0.02*	0.011	0.02
o,p'-DDE	0.002	*0.03*	0.01	0.03	0.001-0.002	*0.01-0.03*	0.01	0.03
o,p'-DDT	0.002	*0.02*	0.02	0.02	0.001-0.002	*0.01-0.02*	0.02	0.02
p,p'-DDD	0.002	*0.02*	0.009	0.03	0.001-0.002	*0.01-0.02*	0.009	*0.02*
p,p'-DDE	0.002	*0.01*	0.007	0.020	0.001-0.002	*0.01*	0.007	0.020
p,p'-DDT	0.002	*0.02*	0.019	0.020	0.001-0.002	*0.01-0.02*	0.019	0.050
Total PCB (ug/L)								
arochlor-1016	0.046	*0.5*	0.2	0.6	0.020-0.046	*0.1-0.5*	0.2	4
arochlor-1221	0.034	*0.8*	0.2	0.6	0.030-0.034	*0.1-0.8*	0.2	4
arochlor-1232	0.033	*0.5*	0.2	0.6	0.020-0.033	*0.1-0.5*	0.2	4
arochlor-1242	0.04	*0.9*	0.2	0.07	0.04	*0.1-0.9*	0.2	4
arochlor-1248	0.057	*0.08*	0.2	0.07	0.020-0.057	*0.08-0.1*	0.2	2
arochlor-1254	0.025	*0.4*	0.2	0.07	0.010-0.025	*0.05-0.4*	0.2	2
arochlor-1260	0.065	*0.1*	0.2	0.03	0.030-0.065	*0.1*	0.2	2
Total PAH (ug/L)								
Acenaphthene	1	*1-25*	0.85	2.2	1	*5-50*	0.85	2.2
Acenaphthylene	1	*1-25*	0.86	2.02	1	*5-50*	0.86	2.02
Anthracene	1	*0.24-10*	0.56	4.04	1	*0.24-25*	0.56	4.04
Benzo(a)anthracene	1	*0.016-10*	0.41	7.68	0.4-2	*0.016-25*	0.41	7.68
Benzo(a)pyrene	1	*0.013-20*	0.47	7.4	0.4-1	*0.013-25*	0.47	6.53
Benzo(b)fluoranthene	1	*0.017-10*	0.63	6.63	0.5-1	*0.017-25*	0.63	6.63
Benzo(g,h,i)perylene	1.5	*0.025-20*	0.5	7	0.5-1.5	*0.025-25*	0.5	7
Benzo(k)fluoranthene	1	*0.008-10*	0.71	7.36	1-2	*0.008-25*	0.71	7.36
Chrysene	1	*0.021-10*	0.44	7.49	1	*0.021-25*	0.44	7.49
Dibenzo(a,h)anthracene	1.5	*0.023-20*	0.55	7.8	0.3-1.5	*0.023-25*	0.55	6.19
Fluoranthene	1	*1-25*	0.7	6.9	1	*5-50*	0.7	6.9
Fluorene	1	*0.25-10*	0.69	2.43	1	*0.25-25*	0.69	2.43
Indeno[1,2,3-cd]pyrene	1.5	*0.017-20*	1.5	7.4	1-1.5	*0.017-25*	1.5	6.27
Naphthalene	2	*3-25*	1.6	1.6	1-2	*5-50*	1.6	1.52
Phenanthrene	1	*0.25-10*	0.46	4.15	1	*0.25-25*	0.46	4.15
Pyrene	1	*0.038-10*	0.76	5.19	1	*0.038-25*	0.76	5.19
Acute Toxicity (TUa)								
Atherinops affinis (survival)	na	na	na	*1.5*	na	na	na	np
Chronic Toxicity (TUc)								
Mysidopsis bahia (survival)	na	*1.5*	na	na	na	np	na	na

na = Not analyzed.

np = Not provided in monitoring report, all samples detected.

Appendix III. Frequency of constituent analyses used by the large POTWs and/or their contract laboratories in 2003 and 2004.

	HTP		JWPCP		OCSD		PLWTP	
Constituent	2003	2004	2003	2004	2003	2004	2003	2004
Suspended Solids	daily	daily	daily	daily	daily	daily	daily	daily
Settleable Solids	daily	daily	daily	daily	daily	daily	daily	daily
Turbidity	daily	daily	daily	daily	daily	daily	daily	daily
Oil/grease	weekly	weekly	daily	daily	daily	daily	daily	daily
TOC	weekly	weekly	weekly	weekly	na	na	na	na
BOD	daily	daily	daily	daily	daily	daily	daily	daily
COD	na	na	daily	daily	na	na	weekly	weekly
Ammonia-N	monthly	monthly	monthly	monthly	daily	daily	weekly	weekly
Nitrate-N	monthly	monthly	monthly	monthly	na	na	weekly	weekly
Nitrite-N	na	na	monthly	monthly	na	na	na	na
Organic-N	monthly	monthly	monthly	monthly	na	na	na	na
Phosphate-P (Phosphorus)	monthly	monthly	monthly	monthly	na	na	na	na
ortho-Phosphate	na	na	na	na	na	na	weekly	weekly
Arsenic	monthly	monthly	monthly	monthly	monthly	monthly	weekly	monthly
Cadmium	monthly	monthly	monthly	monthly	monthly	monthly	weekly	monthly
Chromium	monthly	monthly	monthly	monthly	monthly	monthly	weekly	monthly
Copper	monthly	monthly	monthly	monthly	monthly	monthly	weekly	monthly
Cyanide	monthly	monthly	monthly	monthly	monthly	monthly	weekly	weekly
Lead	monthly	monthly	monthly	monthly	monthly	monthly	weekly	monthly
Mercury	monthly	monthly	monthly	monthly	monthly	monthly	weekly	monthly
Nickel	monthly	monthly	monthly	monthly	monthly	monthly	weekly	monthly
Selenium	monthly	monthly	monthly	monthly	monthly	monthly	weekly	monthly
Silver	monthly	monthly	monthly	monthly	monthly	monthly	weekly	monthly
Zinc	monthly	monthly	monthly	monthly	monthly	monthly	weekly	monthly
Phenols	na	na	monthly	monthly	na	na	na	na
Nonchlorinated Phenols	quarterly	quarterly	quarterly	quarterly	monthly	3/month	weekly	weekly
Chlorinated Phenols	quarterly	quarterly	monthly	monthly	monthly	3/month	weekly	weekly
Total DDT	quarterly	quarterly	monthly	monthly	monthly	3/month	weekly	weekly
Total PAH	quarterly	quarterly	quarterly	quarterly	monthly	3/month	monthly	monthly
Total PCB	quarterly	quarterly	monthly	monthly	monthly	3/month	weekly	weekly
Toxicity								
Atherinops affinis (growth)	na	na	na	na	na	na	monthly	na
Atherinops affinis (survival)	na	na	na	na	na	annually	monthly	annually
Ceriodaphnia dubia (survival)	na	na	na	na	monthly	monthly	na	na
Haliotis rufescens (development)	monthly	monthly	na	na	monthly	monthly	monthly	monthly
Macrocystis pyrifera (germination)	na	na	na	na	na	annually	monthly	monthly
Macrocystis pyrifera (germ tube length)	na	na	na	na	na	na	monthly	monthly
Menidia beryllina (biomass)	na	na	monthly	monthly	na	na	na	na
Menidia beryllina (survival)	na	na	monthly	monthly	quarterly	quarterly	na	na
Mysidopsis bahia (biomass)	na	na	na	monthly	na	na	na	na
Mysidopsis bahia (survival)	na	na	na	monthly	na	na	2/year	2/year
Pimephales promelas (survival)	monthly	monthly	monthly	monthly	na	na	na	na
Strongylocentrotus purpuratus (fertilization)	na	na	na	na	monthly	monthly	na	na
Bacteria								
Enterococcus	monthly	monthly	na	na	na	na	na	na
Fecal Coliforms	monthly	monthly	na	na	na	na	na	na
Total Coliforms	monthly	monthly	na	na	na	na	monthly	monthly

na = Not analyzed.
monthly = one sampling per month.
weekly = one sampling per week.
quarterly = one sampling per quarter.
annually = one sampling per year.