

**ASSESSMENT OF STORM DRAIN SOURCES
OF CONTAMINANTS TO SANTA MONICA BAY**

**VOLUME V
TOXICITY OF DRY WEATHER URBAN RUNOFF**

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June 14, 1994

PREFACE AND ACKNOWLEDGMENTS

This report represents Volume V from a series of reports which form the basis of a pollution assessment and monitoring plan for Santa Monica Bay. Volume I describes land use statistics, catchment areas, existing water quality monitoring data, rainfall data, NPDES permit information for existing permits to storm drains, and contaminant mass emission estimates, based upon land use modeling. Volume II reviews sampling techniques, including sampling equipment, and other aspects associated with sampling such as a quality assurance plan. Volume III presents the proposed monitoring plan. Volume IV addresses best management practices as they apply to the Santa Monica Bay area. This volume describes dry weather flow water quality and chronic toxicity.

The contract was performed by UCLA under the direction of Professor Michael K. Stenstrom of the Civil and Environmental Engineering Department, and Professor I.H.(Mel) Suffet of the Environmental Health Sciences Department. There were several key individuals from both UCLA departments who assisted with the project; they include Kenneth Wong, Linda Schweitzer, Mario Capangpangan and Ed Ruth.

The project was conducted in parallel with a project sponsored by the American Oceans Campaign. Samples were collected, analyzed and toxicity testing was performed by the funding provided through this project. Special organic analysis were funded by the American Ocean Campaign.

The contractors are grateful for the assistance of many individuals. The Santa Monica Bay Project and LA Regional Water Quality Control Board staffs were most helpful. We extend our special thanks to Dr. Guang-yu Wang, Ms. Catherine Tyrrell, Dr. Rainer Hoeinke and Mr. Xavier Swamikannu. The Los Angeles County Department of Public Works and the City of Santa Monica were helpful in permitting the sampling. We are also indebted to the members of the Technical Advisory Committee of the Santa Monica Bay Project and others who reviewed and commented on our draft reports.

Five storm drains representing different types of land use and hydraulics were sampled over an extended dry weather season. Samples were taken for routine water quality analysis as well as short-term, chronic toxicity analysis. The five drains had water quality approximating secondary treated wastewater effluents for many parameters, and were somewhat higher for other parameters, such as COD, TSS and turbidity.

Four drains were tested with three marine species for toxicity and varying amounts were found in all four drains. The most toxic drain had the least flow rate, and it is suspected that the higher toxicities are associated with stagnant drain water and lack of dilution from flushing which occurred with the other drains.

One storm drain was analyzed in depth to ascertain the source of the toxicity. Inconclusive results were obtained in that different most likely causes were found from three different samplings. In one case the cause was consistent with the presence of organic chemicals. On another occasion the cause was consistent with the presence of toxic metals. On another occasion the toxicity disappeared after 24 hours, which is consistent with the presence of an oxidizing agent, such as residual chlorine from disinfection.

The toxicity was generally present in samples that contained more than 10% and less than 50% storm drain effluent. This suggests that a 10 fold dilution would reduce the toxicity below the detection limits used in this analysis. A brief review of the literature to determine ways of estimating the initial dilution of a storm drain found no reliable, proven methods for low flow conditions. For high flow conditions, jet nozzle methods might be applicable, but must be verified.

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This report presents the results of a one-year investigation of the toxicity of dry weather urban runoff to Santa Monica Bay. It is one of many projects sponsored by the Santa Monica Bay Restoration Project to ascertain the status of contaminant inputs to the Bay, with the eventual goal of developing a comprehensive action plan to restore and maintain the quality of Santa Monica Bay.

Dry weather runoff is a potential problem to Santa Monica Bay. Dry weather runoff is a somewhat confusing term, since "dry weather" suggests no rainfall and therefore no stormwater runoff. Storm drains in Los Angeles, with perhaps very minor exceptions, are separated from sanitary drains. The sanitary flow is conveyed to the various treatment plants through separate drains and sewers. One wonders why storm drains have flow when there is no rain and no wastewater discharge.

The answer is that certain wastewaters are discharged to the storm drains. There are also other inputs such as runoff from landscape irrigation, natural seeps and springs, uncontrolled and/or unregulated discharges, including illegal discharges, and treated secondary effluents. The discharges are sometimes referred to as "nuisance waters," although the magnitude of the discharges to the various storm drains in the Los Angeles Basin are much greater in magnitude than the traditional concept of nuisance waters.

Discharges entering storm drains include legal, NPDES permitted discharges. These might be cooling tower blow down, such as occurs with air conditioning systems, land dewatering, which is sometimes necessary when constructing new buildings, and discharges from facilities that use water without contaminating it, such as cooling towers. Cooling tower discharges should be free of most contaminants. They may be elevated in salt concentrations but should have a total organic carbon (TOC) concentration of 5 mg/L or less, and have no residual chlorine or corrosive inhibitors.

These permitted, normally harmless waters and wastewaters comprise the dry weather flow into Santa Monica Bay. Potential problems exist with these discharges. One potential problem is that the dry weather flow may hide or disguise an unpermitted, illegal, discharge. Several examples of sanitary sewer breaks have been documented in the course of the projects sponsored by Santa Monica Bay. Another problem is that the dry weather flow may scour pollutants from surfaces as they flow to the Bay. Emissions from vehicles maybe scoured and transported to the Bay through this mechanism. Also trash and other debris maybe washed into the Bay by dry weather flow.

The purpose of this investigation was to ascertain the potential aquatic toxicity and water quality of the dry weather flows just prior to their entering the Bay. Five storm drains were monitored for many water quality parameters, including conventional contaminants and analysis for a broad range of organics using gas chromatography/mass spectrometry (GC/MS). The drains were Pico-Kenter, Ashland Avenue, Ballona Creek (at the Inglewood overpass), Centinela Creek (at the Inglewood over pass), and the Sepulveda Channel as it enters Ballona Creek, just east of the Inglewood over pass.

Marine aquatic toxicity was assessed for four storm drains using three species (the Centinela Drain was not tested for toxicity). A screening assay was first performed to

determine which drains had the highest toxicity. An in-depth analysis was later performed to attempt to determine the type of contaminants causing the toxicity in the runoff.

The toxicity analysis were performed at the Southern California Coastal Water Research Project (SCCWRP) in their Long Beach laboratory. The other analysis were performed at UCLA, principally in the Department of Civil and Environmental Engineering and the Department of Environmental Health Sciences.

The bulk of the results are contained in appendices. Appendix B contains all the water quality data. Appendix D contains the toxicity data and the interpretation of the results. Appendix E contains the GC/MS data.

A parallel study was performed under partial sponsorship of the American Oceans Campaign (Suffet *et al*, 1993). This parallel study provided funding to perform the GC/MS analysis.

2.1 Sampling Location

The selection of storm drains as sampling locations of this project were based on the types of land-use, location and ease of sampling. Five storm drains in the Santa Monica Watershed were selected for sampling: Pico-Kenter; Ashland Avenue; Ballona Creek at Inglewood; Sepulveda Channel at Ballona Creek, and Centinela Creek at Inglewood (the first two storm drains were named with reference to their neighboring streets). Figure 1 shows the location of these five storm drains.

Originally only three storm drains were required in the request for proposals. A fourth storm drain was added in order to make a more complete evaluation of different land uses. Later, a cooperative sampling program was started with a project funded by the American Oceans Campaign (Suffet *et al.*, 1993), which required the addition of a fifth storm drain. Centinela Creek was selected as the fifth storm drain. Toxicity testing was never performed at this drain.

2.2 Sampling Procedures

Samples were bailed from the storm drains using a stainless steel bucket. Morning and afternoon grab samples were collected into a 2- or 4-L glass bottles, composited, and stored in ice chests with blue-ice packs while being transported to the laboratory. Samples were collected from the middle of the open channel from Ballona Creek, Centinela Creek (low flow channel) and the Sepulveda Channel. At Pico-Kenter, they were collected from the wet well installed to divert low flow to the sanitary sewer. At Ashland Avenue samples were withdrawn from an open access hole on Neilson Avenue in Santa Monica. All samples were stored in a refrigerator at 4°C until the time of analysis. The time between sample collection and analysis was within the holding times recommended by the US EPA (1983).

2.3 Materials

Chemicals. Analytical or better grade chemicals and HPLC grade solvents (e.g., methanol and methylene chloride) were used for the chemical analyses and solid phase extraction. All these materials were obtained from Fisher Scientific (Tustin, CA).

SPE columns. The 1000 mg C18 columns used were obtained from Burdick and Jackson (Muskegon, MI).

2.4 Conventional Chemical Analysis

Conventional water quality analyses were performed on the collected storm drains samples. The analyzed water quality parameters are listed in Table 1. All the parameters, except for UV absorbance, were analyzed according to the *Standard Methods* (1989) procedures. The

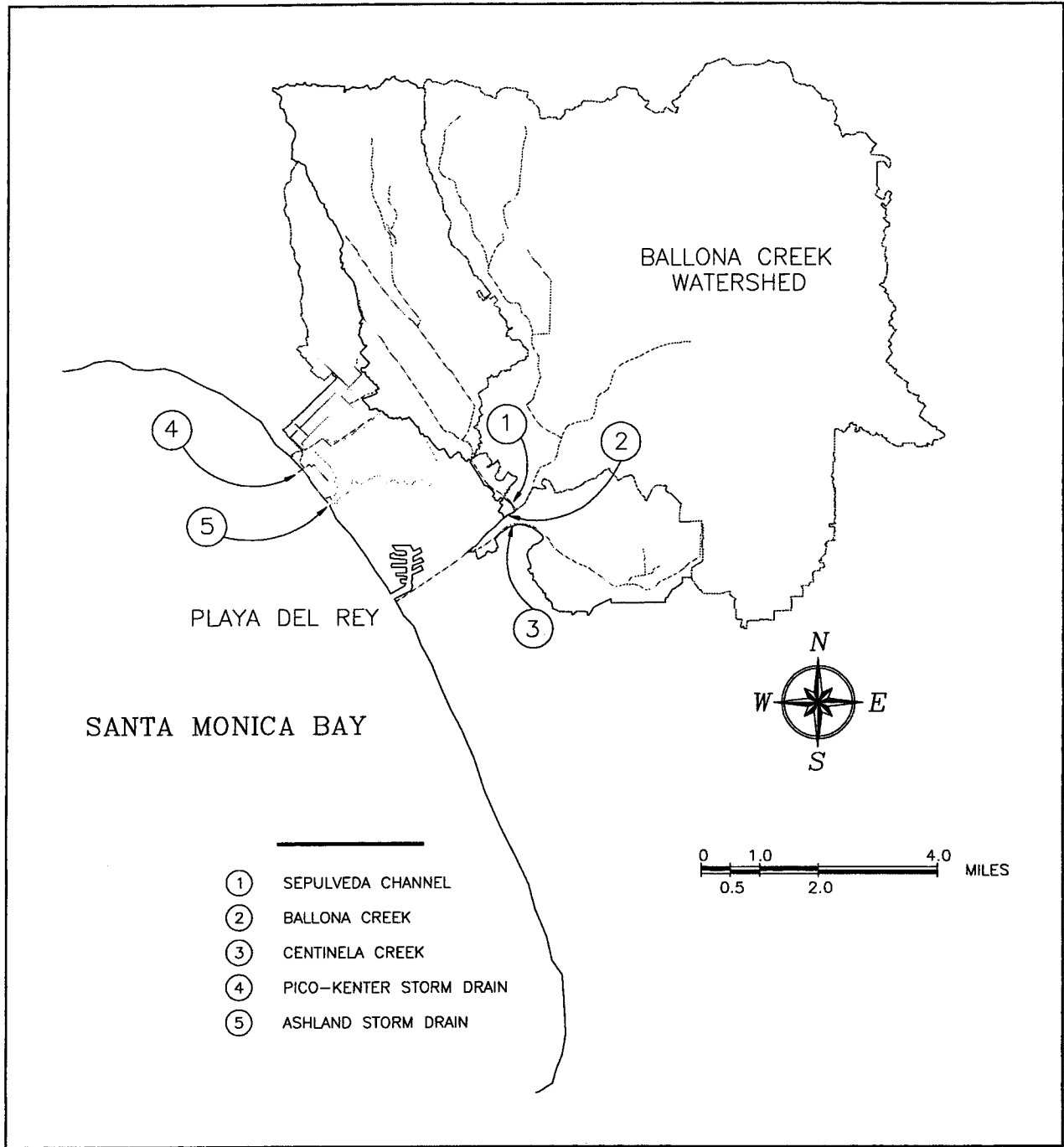


Figure 1. Sampling location of the five selected storm drains.

UV-absorbance of the collected storm drain samples (filtered) was measured at a wavelength of 254 nm, using Hewlett-Packard HP 8452A Diode Array Spectrophotometer. The measured UV-absorbance is a qualitative measure of the amount of organic carbon in the samples.

Table 1. Conventional Water Quality Parameters.

Water Quality Parameter (1)	Unit (2)	Method (3)
<i>Laboratory Analysis</i>		
Alkalinity	mg/L as CaCO ₃	Standard Method 2320.B
Hardness	mg/L as CaCO ₃	Standard Method 2340.C
Ammonia	mg/L as NH ₃ -N	Standard Method 4500-NH ₃ .F
Nitrite	mg/L as NO ₂ -N	Standard Method 4500-NO ₂ .B
Total Dissolved Solids (TDS) Dried at 180°C	mg/L	Standard Method 2540.C
Total Suspended Solids (TSS) Dried at 105°C	mg/L	Standard Method 2540.D
Volatile Suspended Solids (VSS)	mg/L	Standard Method 2540.E
Chemical Oxygen Demand (COD)	mg O ₂ /L	Standard Method 5220.B
Dissolved Organic Carbon (DOC)	mg C/L	Standard Method
UV absorbance (at $\lambda = 254\text{nm}$)		Hewlett-Packard HP8452A Diode Array Spectrophotometer
Conductivity	$\mu\text{mho/cm}$	Standard Method 2130.B
pH		
Turbidity	NTU	Standard Method 2130.B
<i>Field Analysis</i>		
Dissolved Oxygen - Probe (DO)	mg/L	Standard Method 4500-OG
Temperature	°C	Standard Method
% Salinity	%	

2.5 Velocity Measurement

The velocities of the flow across Ballona Creek, Sepulveda Channel and Centinela Creek were measured during each sampling period. The velocity at Ballona Creek and Sepulveda Channel were measured using a Marsh McBurney velocity meter at approximately five foot intervals across the channel. The water depth was also recorded at the same time and location. The velocity at the Centinela Creek was determined differently. Several small floating objects (bits of Styrofoam cup, etc.) were timed and the results were averaged. The depth of flow, which was too shallow to permit the use of the velocity meter, was also measured. The obtained data were used to calculate the average flow rate through the channel.

2.6 Solid Phase Extraction

The C18 SPE method described by Mount and Carnahan (1989) was the basis of our fractionation procedures to isolate non polar organic compounds from the collected storm drain samples. However, instead of using the proposed elution solvent system of methanol-water mixtures, a modified elution solvent system which involved mixtures of methanol-water and methanol-methylene chloride was used. A detailed description of the development of this modified elution system is given in the Appendix A and also described by Lau and Stenstrom (1993). The modified procedure was required because of the poor recoveries observed by the Mount and Carnahan procedure. The following procedures were used to fractionate non-polar organic compounds from the collected samples.

Filter blank. A 1 μm glass fiber filter (Whatman GF/B) was prepared by first acid washing with 10% HNO_3 and then rinsing thoroughly with deionized water. Next, approximately 200 ml of deionized water was passed through the filter, and the last 30-50 mls of filtrate were collected for the filter toxicity blank. The storm drain sample was then filtered.

Column blank. The 1000 mg C18 SPE columns were conditioned by pumping through 25 mls of HPLC grade methanol through the column at a flow rate of 5 mls/min. Before the sorbent dried, approximately 50 mls of deionized water were pumped through the column. The last 25-30 mls deionized water were collected for a column blank toxicity test. Pumping continued until no water emerged from the column.

Elution blank. Three elution blanks were collected from the prepared column by pumping 2 x 1.0 ml of each of the following solvents: 50% (v/v) methanol in water, 100% methanol, and 50% (v/v) methylene chloride in methanol, through the column and the eluates were collected in a clean glass vial as the SPE elution blanks. The column was allowed to dry between each elution.

SPE fractionation. The same C18 SPE column was again conditioned with 25 mls of methanol and 25 mls of deionized water. Before the sorbent dried, 1000 mls of filtered storm drain sample were pumped through the column at a rate of 5 mls/min. A 30 ml sample of the post C18 column effluent was collected after 500 mls of the sample passed through the column. The sorbent was dried by continuing the pumping after the entire 1000 mls sample passed through the column. Then 2 x 1.0 ml of 50% (v/v) methanol in water, 100% methanol, and 50% (v/v) methylene chloride in methanol were added sequentially into the column. Each fraction was collected into clean glass vials. The column was allowed to dry prior addition of each elution solvent mixture.

Toxicity testing was performed on the filtered sample, post C18 sample, the SPE eluates and all blanks (e.g., filter blank, column blank and elution blank).

2.7 Toxicity Procedures

Three marine test methods described in the California Ocean Plan (SWRCB, 1990) were used in this study: the echinoderm fertilization test, red abalone embryo development test, and giant kelp germination/germ tube growth test. Storm drain samples were stored under refrigeration in sealed 4-L glass bottles until the day of testing. Samples were thoroughly mixed before a 2.5-L subsample was removed and filtered through 1 μm glass fiber filter (Whatman GF/B).

The toxicity tests were conducted in two phases: Phase I - Relative Toxicity of Storm Drains and Phase II - Examination of Toxic Components. Toxicity testing was performed at the Southern California Coastal Water Research Project's (SCCWRP) laboratory in Long Beach. Seawater dilutions of each sample were prepared by adding appropriate amounts of seawater and brine solutions to create the desired dilutions and maintain a salinity of 32 - 35 mg/g. The dilution of the collected storm drain sample produced the required concentrations of storm drain sample for the toxicity tests, and test organisms were added to each sample within three hours of dilution. The concentrations of storm drain sample used in the toxicity testing were expressed in percentage of storm drain sample water used in the dilutions. For example, a concentration of 56% corresponds to a diluted sample consisting of 56% storm drain sample and 44% dilution water. The number of concentrations {expressed in % of storm drain sample (v/v)} and replicates of the samples used in the toxicity tests are shown in Table 2.

Table 2. Number of dilutions and replicates of each toxicity test.

Phase	No. locations	No. dilutions	Concentration (% v/v)	No. replicates
(1)	(2)	(3)	(4)	(5)
I	4	5	5.6, 10, 18, 32, 56	3
	3	4	5.6, 12, 25, 56	3
II	1	3 for blanks	12, 25, 56	2
		2 for SPE eluates	0.1, 0.2	2

Echinoderm fertilization test. The echinoderm fertilization test was conducted according to methods described by Dinnel *et al.* (1987). Purple sea urchins *Strongylocentrotus purpuratus* were collected from the intertidal in northern Santa Monica Bay and held at SCCWRP until used in the tests. Ten mls of each sample dilution were added to replicate glass test tubes and equilibrated to 15°C in a water bath. Sea urchins were then induced to spawn through injection of potassium chloride. The gametes were collected and diluted with seawater to produce stock solutions of the density recommended by the protocol. The test was conducted by adding sperm to each test tube. After 60 minutes of sperm

exposure, eggs were added to each tube for a 20 minute fertilization period. The sample was then preserved for microscopic examination. Toxic effects were indicated by a reduction in the percentage of fertilized eggs from that observed in a control sample (seawater).

Abalone development test. The abalone development test, using embryos of the red abalone *Haliotis rufescens*, was conducted according to methods described by Anderson *et al.* (1990). Sexually mature abalone were obtained from a commercial aquaculture facility and held at SCCWRP until used in the tests. Two hundred mls of each sample dilution were added to replicate 250 ml glass beakers and placed in a 15°C water bath. Abalone were induced to spawn by exposure to a hydrogen peroxide solution. The eggs were then fertilized, adjusted in density, and added to the exposure beakers. The developing embryos were exposed for 48 hours and preserved for microscopic examination. Toxic effects were indicated by an increased incidence of larvae with abnormally developed shells.

Giant kelp test. Tests with giant kelp were also conducted according to the procedures described by Anderson *et al.* (1990). Kelp blades containing reproductive spores (sporophyll) were obtained from offshore, uncontaminated kelp beds located near Santa Barbara and used within 24 hours. The toxicity test was conducted in 250 ml beakers containing 200 ml of the sample dilution. A glass microscope slide was placed on the bottom of each beaker to provide a surface for settlement of the kelp spores. Zoospore release from the sporophyll blades was induced by desiccation followed by immersion in seawater. The density of the released spores was adjusted and the appropriate number of spores was added to each beaker. The spores were exposed to the sample dilutions for 48 hours at 15°C and a controlled light level ($50\mu\text{Em}^{-2}\text{sec}^{-1}$). During this period of 48 hours, the spores germinated and formed gametophyte plants. The slides were then removed from each beaker and preserved for microscopic examination. Two endpoints were assessed: percentage spore germination and gametophyte length. Toxic effects were indicated by reductions in germination and gametophyte length, relative to a control group.

2.8 EDTA and Sodium Thiosulfate Addition Tests

EDTA and sodium thiosulfate addition tests described by Norberg-King *et al.* (1992) were conducted during the second phase of the toxicity test. The unfiltered storm drain samples with EDTA or sodium thiosulfate were analyzed for toxicity using the echinoderm fertilization test.

EDTA addition test. A stock solution of EDTA was prepared and added into 30 ml unfiltered storm drain samples. The final concentrations of EDTA in the samples were 3, 8, and 30 mg/L. Three different concentrations, 12%, 25% and 56% (v/v) of storm drain sample, were prepared from these EDTA-added samples and used for the toxicity test.

Sodium thiosulfate addition test. A stock solution of sodium thiosulfate was prepared and added into 30 mls of unfiltered storm drain samples. The final concentrations of sodium thiosulfate in the samples were 10 and 25 mg/L. Similar to the EDTA addition test, three concentrations, 12%, 25% and 56% (v/v) of storm drain sample, were prepared and used for the toxicity test.

2.9 GC and GC-MS

GC. The three SPE fractions were first analyzed using a Varian Vista 6000 gas chromatograph equipped with a splitless injector and flame ionization detector (FID). A 30 m x 0.25 mm i.d. DB5.625 capillary column (J & W Scientific) was used to analyze the non polar organic compounds (e.g., polyaromatic hydrocarbons) in the fractions. The GC temperature program was 40°C for 2 min., 40° - 140°C at 25°C/min., 140° - 290°C at 10°C/min., and 290°C for 20 min. The splitless injector and FID temperatures were 275°C and 300°C, respectively.

GC-MS. The SPE fraction(s) which show toxicity were analyzed by GC-MS to identify possible organic compounds present in that fraction. The GC-MS system used was a Finnigan 4000 Quadrapole mass-spectrometer with a Finnigan 9610 gas chromatograph. A Grob type splitless injector (at 290°C) was used for sample injection onto a 30 m x 0.25 mm i.d. DB-5MS capillary column (J & W Scientific). The GC temperature program was 30°C for 4 min., 40° - 300°C at 6°C/min. and 300°C for 30 min. Mass spectral data were collected by using a scan range of 35 - 500 amu and a scan rate of 1 scan/s.

3.1 Summary of Water Quality Data

Samplings were conducted from April 1992 to January 1993. The number of samples collected from each storm drain during this period are given in Table 3. The number of samples collected varied from location to location due to several factors. For example, no sample was collected from the storm drain at Ashland Avenue on several occasions due to seawater intrusion into the storm drain. More samples were taken from the Ballona Creek since it was the selected storm drain for the second phase of the toxicity testing.

As mentioned in the previous experimental sections, conventional water quality parameters (Table 1) of the collected samples were analyzed according to the *Standard Methods*. All the data collected between April 1992 and January 1993 for these five storm drains are tabulated in Appendix B. The mean and standard deviation of each analyzed water quality parameter are given in Table 3. From Table 3, it is observed that the water quality of the storm drain at Ashland Avenue is usually worse than the other four storm drains. Most of the analyzed water quality parameter concentrations from the Ashland Avenue storm drain are greater than the other storm drains. This poor water quality may be due to the storm drain condition. The Ashland Avenue storm drain is stagnant during low flow periods, due perhaps because of sand plugging its mouth (The Ashland Avenue drain, unlike the Pico-Kenter Drain, terminates at the surf line). During high tides, sea water may enter the drain, which was detected by high conductivity and total dissolved solids (TDS) concentration. Ashland Avenue is the only drain that has a tidal interaction (the sampling station on Ballona Creek is above the point of tidal interaction).

Table 3 also shows that samples from the Sepulveda Channel have high total dissolved solids (TDS) and hardness. The high TDS concentration results from ion exchange regeneration waters released by NPDES permit to this storm drain. The dissolved oxygen (DO) concentrations in Ballona Creek, Sepulveda Channel and Centinela Creek were often greater than the saturation concentration because of photosynthesis; both drains are open channels and had abundant algae during the sampling.

At various sampling times, the water quality of some of the storm drains was comparable or worse than typical secondary effluents. Table 4 shows the selected water quality comparison between the storm drain samples and typical secondary effluent. The secondary effluent parameters are typical of those plants which discharge into the storm drains in Los Angeles County. These discharges are regulated more strictly than other plants, due to the possibility of human contact in the open drain channels and infiltration into ground water basins. The results show that the chemical oxygen demand (COD) of water samples from Ashland Avenue is much greater than the value of typical secondary effluents prior discharge to the receiving waters. A similar observation was made on the total suspended solids (TSS) of the analyzed storm drain samples.

3.2 Hardness Interference

According to the *Standard Methods* (1989), the presence of certain metallic ions such as aluminum, cadmium, copper and lead may interfere the hardness test. Indistinct end-point

Table 3. Summary of water quality data (average and standard deviation) for the selected storm drains.

Parameters (1)	Pico-Kenter (2)	Ashland Avenue (3)	Ballona Creek (4)	Sepulveda Channel (5)	Centinela Creek (6)
No. of sampling	10	7	10	9	6
Alk (mg/L as CaCO ₃)*	266 ± 36	316 ± 64	233 ± 40	176 ± 49	152 ± 19
Hardness (mg/L as CaCO ₃)	287 ± 90	1290 ± 1122	675 ± 349	1513 ± 792	270 ± 44
Conductivity (µmho/cm)	1795 ± 927	7560 ± 6702	2052 ± 919	4852 ± 1411	1090 ± 252
TDS (mg/L)	1050 ± 510	4618 ± 4323	1445 ± 795	3346 ± 3346	684 ± 167
TSS (mg/L)	49 ± 55	365 ± 475	47 ± 65	24 ± 32	5 ± 3
VSS (mg/L)	21 ± 25	86 ± 101	9 ± 9	9 ± 6	4 ± 2
COD (mg/L)	66 ± 35	249 ± 61	41 ± 18	70 ± 16	54 ± 19
DOC (mg/L)	31 ± 32	46 ± 18	28 ± 33	29 ± 27	20 ± 11
Turbidity (NTU)	15.5 ± 13	145.4 ± 208.2	23.3 ± 43.9	7.3 ± 12.2	3.8 ± 0.9
DO (mg/L)**	7 ± 1.3	3.3 ± 2.6	13.7 ± 1.1	14.5 ± 0.5	13.0 ± 1.5
pH	8 ± 0	7.6 ± 0	8.6 ± 0.5	8.7 ± 0.3	9.2 ± 0.3
uv absorbance (at 254 nm)	0.407 ± 0.102	0.870 ± 0.339	0.172 ± 0.051	0.173 ± 0.053	0.296 ± 0.137
Ammonia (mg/L as NH ₃ -N)	0.18 ± 0.22	0.84 ± 0.96	0.28 ± 0.33	0.22 ± 0.49	0.05 ± 0.03
Nitrite (mg/L as NO ₂ -N)	0.10 ± 0.05	0.12 ± 0.18	0.10 ± 0.08	0.16 ± 0.15	0.02 ± 0.01

Note: * See section 3.2 for the interferences in the alkalinity test for some of the samples.
 ** Parameter measured in the field.

Table 4. Comparison of water quality of storm drain samples and secondary effluent.

Parameter (1)	Location					Secondary Effluent (7)
	Pico-Kenter (2)	Ashland (3)	Ballona Crk (4)	Sepulveda Ch. (5)	Centinela Crk (6)	
COD (mg/L)	72	249	41	70	54	~50-100
TSS (mg/L)	49	365	47	24	5	< 30
Turbidity (NTU)	15.5	145.5	23.3	7.3	3.8	< 2.2
DO (mg/L)	7	3.3	13.7	14.5	13.0	> 2
pH	8	7.6	8.6	8.7	9.2	~ 6-9
Ammonia (mg/L as NH ₃ -N)	0.18	0.84	0.28	0.22	0.05	< 2

or stoichiometric consumption of EDTA may occur. False, high indications of total hardness may be obtained. This type of interference can be eliminated by adding certain inhibitors (i.e., sodium sulfide nonahydrate or sodium cyanide) as suggested by *Standard Methods*. It was observed that the total hardness of some samples from the Ashland Avenue, Ballona Creek and Sepulveda Channel were lower after addition of sodium sulfide nonahydrate. For example, the afternoon grab sample from Ballona Creek which was collected on December 14, 1992 had a total hardness of 1750 mg/L as CaCO₃ without addition of sodium sulfite nonahydrate. The total hardness of the same sample decreased to 1180 mg/L as CaCO₃ (~ 33% decrease) after adding the inhibitor. This indicates the presence of interfering ions such as aluminum, cadmium, copper or lead in those samples. Appendix C describes the effect of these interfering ions on the total hardness of some samples.

3.3 Mass Emissions

The velocity and depth of water in the Ballona Creek, Sepulveda Channel and Centinela Creek were measured during sampling. Figure 2 shows the cross-section of the Ballona Creek, Sepulveda Channel and Centinela Creek. The velocity and water depth measurements were used to calculate the flow rate of the water passed through the storm drain, using the following equation (1):

$$Flow\ rate\ \left(\frac{ft^3}{s}\right) = Area\ (ft^2) \times Velocity\ \left(\frac{ft}{s}\right) \quad (1)$$

The area of Sepulveda Channel and Ballona Creek (except the first and last 5 ft of Ballona Creek) was determined as follows:

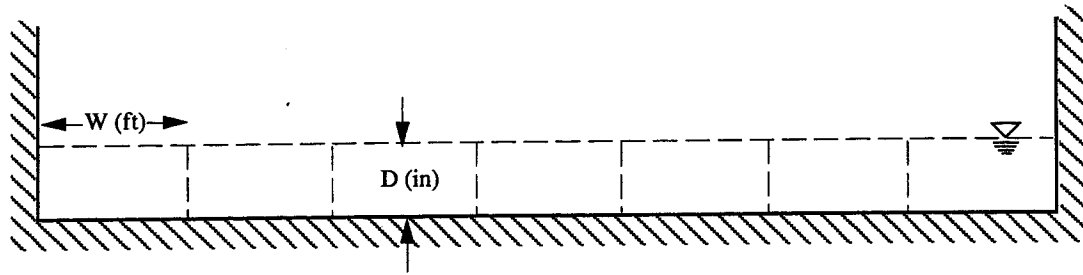
$$Area\ (ft^2) = width\ (ft) \times depth\ (ft) \quad (2)$$

For the Ballona Creek, the areas of the first and last 5 ft sections were determined as follows:

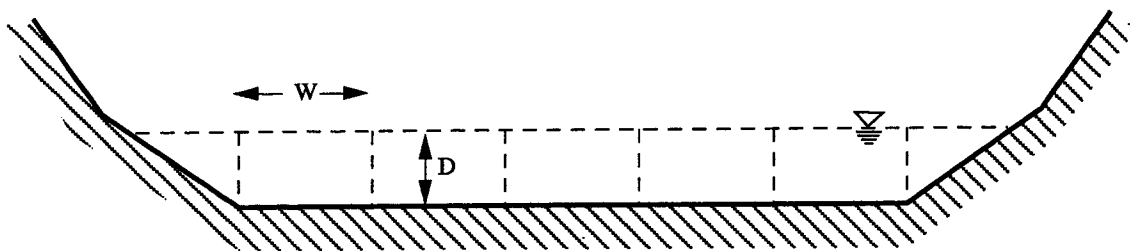
$$Area\ (ft^2) = \frac{1}{2} \times width\ (ft) \times depth\ (ft) \quad (3)$$

The flow rate at the Centinela Creek was measured differently than the above two storm drains. Unlike Ballona Creek and the Sepulveda Channel which were divided into several small areas, there was only one area determined in the Centinela Creek in which Eq. (2) was used. The width across the low-flow channel in Centinela Creek at the point of measurement is 85 in.

Table 5 shows the flow rate of the Ballona Creek, Sepulveda Channel and Centinela Creek. It is observed that Ballona Creek has greater flow rate than Sepulveda Channel and Centinela Creek. The average flow rate during the sampling of Ballona Creek, Sepulveda



Cross-section of Sepulveda Channel



Cross-section of Ballona Creek



Cross-section of Centinela Creek

Figure 2. Cross-section of Ballona Creek, Sepulveda Channel and Centinela Creek.

Table 5. Flow rate measured at various sampling periods for Ballona Creek, Sepulveda Channel and Centinela Creek.

Sampling date (1)	Flow rate (ft ³ /s)		
	Ballona Creek (2)	Sepulveda Channel (3)	Centinela Creek (4)
7/7/92 pm	2.80	0.92	1.00
7/27/92 am	3.04	2.14	0.71
7/27/92 pm	3.07	1.83	0.46
8/24/92 am	1.90	0.60	-
8/24/92 pm	2.52	0.58	-
9/8/92 am	3.29	0.61	1.21
9/8/92 pm	2.98	0.63	0.33
9/29/92 am	3.66	0.61	-
9/29/92 pm	2.50	0.84	-
10/12/92 am	2.55	0.81	-
10/12/92 pm	2.53	0.90	-
11/2/92 am	2.48	0.56	1.09
11/2/92 pm	2.83	0.65	5.21
11/23/92 am	2.66	-	-
11/23/92 pm	2.18	-	-
12/10/92 am	2.85	0.96	0.29
12/10/92 pm	3.35	0.59	0.34
12/14/92 am	2.86	-	-
12/14/92 pm	3.05	-	-
1/19/92 pm	14.33	-	-
Average	3.37	0.85	1.18

Note: - not measured/no samples were taken

Channel and Centinela Creek are 3.37 ft³/s, 0.85 ft³/s and 1.18 ft³/s, respectively (see Table 5). The calculated flow rate at Ballona Creek, Sepulveda Channel and Centinela Creek were then used to determine the annual mass emission of pollutants from dry weather flow into the Santa Monica Bay using the following equation:

$$\text{Mass emission } \left(\frac{\text{kg}}{\text{yr}} \right) = \text{Concentration } \left(\frac{\text{kg}}{\text{m}^3} \right) \times \text{Flow rate } \left(\frac{\text{m}^3}{\text{yr}} \right) \quad (4)$$

The calculated average dry weather mass emission of pollutants (i.e., TDS, TSS, COD, NH₃-N and NO₂-N) from Ballona Creek, Sepulveda Channel and Centinela Creek are given in Table 6. The obtained results show that the mass emission of those selected pollutants from Ballona Creek are greater than those from Sepulveda Channel and Centinela Creek. No estimates are given for Pico-Kenter and Ashland Avenue storm drains as the flow rates were not determined in these two drains. The flow at Ashland Avenue was mostly stagnant during the dry season, suggesting that few pollutants from this storm drain were discharged into the Bay on a routine basis. It is assumed that the stagnant water was "blown out" from the drain from time to time due to release of the sand plug at the surf line; however no blow outs were observed during testing. The dry weather flow from the Pico-Kenter storm drain during the period of the study was discharged to the Hyperion treatment plant.

The flow rates reported in Table 6 vary from those indicated by the gauging stations on Ballona Creek. A review of the procedure and the gauging station data found no error in reporting or calculating flow rates. One possible source of error is a difference in calibration - the gauging station might be calibrated for wet weather flow.

The appearance of the drain water varied from drain-to-drain. The open channel drains (Ballona, Sepulveda, and Centinela) were usually clear in appearance except for algae. Strings and rafts of algae were routinely observed in these drains. The color was usually green but occasionally they were "sandy" colored. Pico-Kenter frequently appeared highly colored from high turbidity. The color was often light orange or tan, which suggest the presence of clays in the suspended solids. Ashland Avenue always appeared black or dark gray and frequently had an odor.

3.4 Toxicity

The following section summarizes the toxicity results of four storm drains, i.e., Pico-Kenter, Ashland Avenue, Ballona Creek and Sepulveda Channel. The detailed reports and raw data of the toxicity tests are included in Appendix D.

3.4.1 Phase I - Relative Toxicity of Storm Drains

The objective of this phase of toxicity testing was to determine the most toxic storm drain among these four storm drains (Centinela Creek was excluded from toxicity analysis), and also to determine the most sensitive test organism among the three test species. Four sampling periods were performed in this phase, i.e., August 24, September 8, September 29 and October 12, 1992. Sampling was performed on two locations on the August 24 (i.e., Pico-Kenter and Ashland Avenue) and September 8, 1992 (i.e., Ballona Creek and Sepulveda Channel). It was necessary to sample drains in pairs because only two sets of storm drains could be analyzed by SCCWRP at a time. The storm drain with the least toxicity from this first sampling was excluded from the next following toxicity tests.

Samples collected from the selected storm drains were tested for toxicity according to the previously described procedures. For each toxicity test, except the kelp germ tube test, the percentage response of the organisms at each tested dilution/concentration of the collected storm drain samples was calculated; for the kelp germ tube test, the mean length of the kelp germ tube was measured instead. These dose-response results were then plotted versus the various concentration of the samples {expressed in % of storm drain sample (v/v)} used in the toxicity tests. Figures 3 - 6 show examples of dose-response plots for abalone, sea

Table 6. Average emission of selected pollutants from Ballona Creek, Sepulveda Channel and Centinela Creek.

Location (1)	Average flow rate (m ³ /hr) (2)	Mass emission (kg/yr)				
		TDS (3)	TSS (4)	COD (5)	NH ₃ -N (6)	NO ₂ -N (7)
Ballona Creek	391.52	4.44 x 10 ⁶	18.5 x 10 ⁴	13.4 x 10 ⁴	724	275
Sepulveda Channel	90.01	2.41 x 10 ⁶	1.97 x 10 ⁴	5.55 x 10 ⁴	158	104
Centinela Creek	118.66	0.583 x 10 ⁶	0.931 x 10 ⁴	3.98 x 10 ⁴	49	17

Table 7. NOEC and EC50 values for storm drains samples (Phase I).

Location (1)	Sampling Date (2)	NOEC				EC50			
		Abalone Development (3)	Kelp		Urchin Fertilization (6)	Abalone Development (7)	Kelp		Urchin Fertilization (10)
			Germ. (4)	Length (5)			Germ. (8)	Length (9)	
Pico-Kenter	Aug. 24 '92	18	>56	>56	>56	42	> 56	> 56	> 56
	Sept. 29 '92	nd	nd	nd	≥56	nd	nd	nd	> 56
	Oct. 12 '92	12	≥56	25	25	21	> 56	> 56	41
Ashland Avenue	Aug. 24 '92	<5.6	18	18	10	6.8	32	> 56	17
	Sept. 29 '92	nd	nd	nd	5.6	nd	nd	nd	14
	Oct. 12 '92	5.6	5.6	5.6	<5.6	10	22	50	< 5.6
Ballona Creek	Sept. 8 '92	>56	>56	>56	<5.6	> 56	> 56	> 56	14
	Sept. 29 '92	nd	nd	nd	12*	nd	nd	nd	> 56
	Oct. 12 '92	≥56	≥56	≥56	≥56	> 56	> 56	> 56	> 56
Sepulveda Channel	Sept. 8 '92	>56	>56	>56	10	> 56	> 56	> 56	nt

Note: All values are in % (v/v) of the storm drain samples. NOEC = the highest concentration not statistically different from controls; EC = effective concentration to cause 50% toxic effect; nd = not determined as technical difficulties prevented measurement of toxicity; nt = toxicity found but data not amenable to testing for EC50 (see Figure 2a); * = NOEC can also be stated as ≥56 since 56% concentration was not significantly different from respective brine control. A NOEC of 12 is felt to be more appropriate since 25% concentration was significantly toxic and 56% brine control was toxic, making accuracy of 56% effluent results questionable.

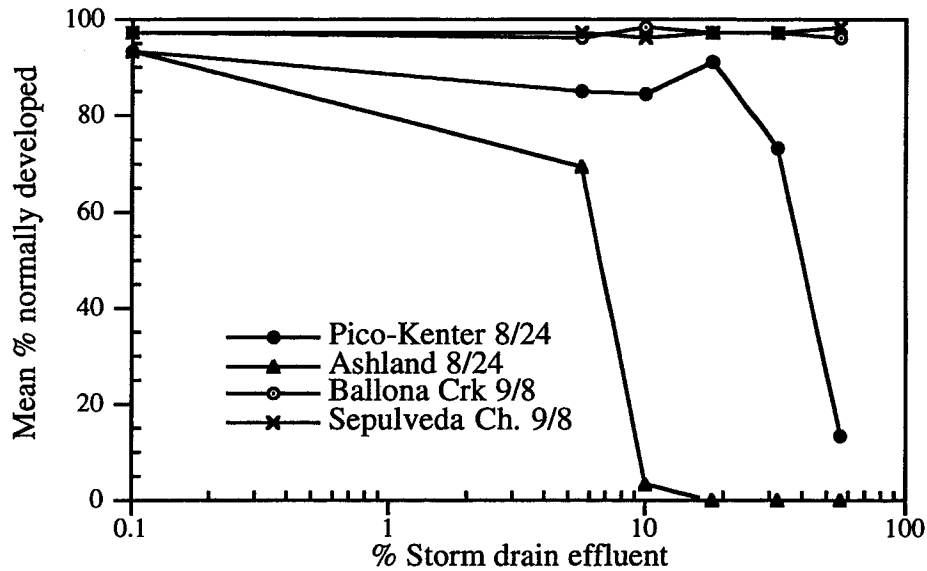


Figure 3. Example of dose-response plot for abalone development test (for samples collected on August 24, 1992 for Pico-Kenter and Ashland, and September 8, 1992 for Ballona Creek and Sepulveda Channel). Control values are those plotted at a concentration of 0.1%.

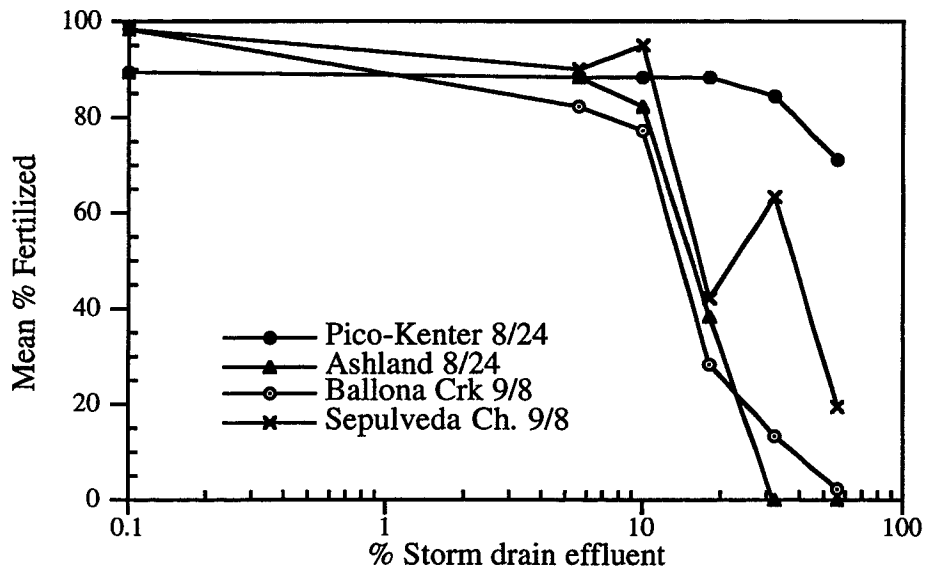


Figure 4. Example of dose-response plot for sea urchin fertilization test (for samples collected on August 24, 1992 for Pico-Kenter and Ashland, and September 8, 1992 for Ballona Creek and Sepulveda Channel). Control values are those plotted at a concentration of 0.1%.

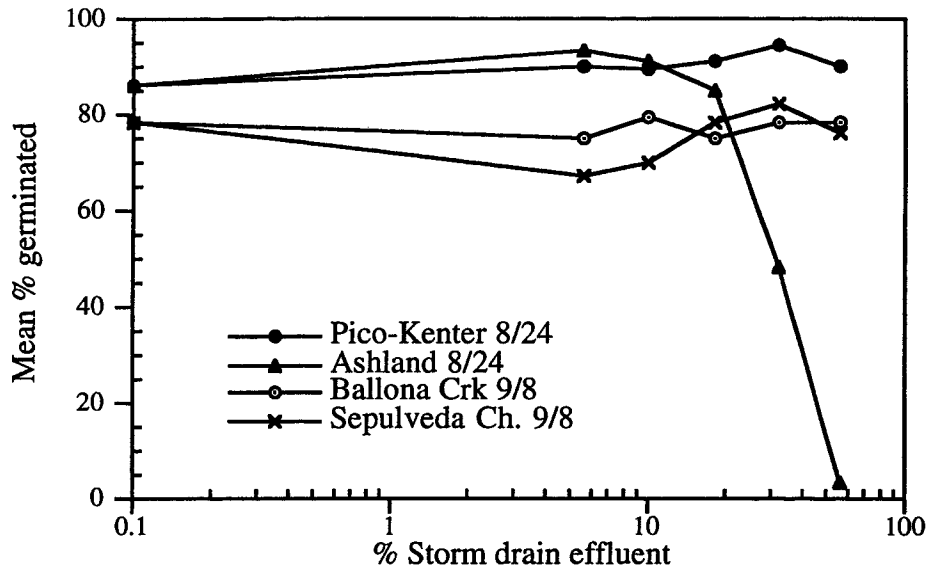


Figure 5. Example of dose-response plot for giant kelp germination test (for samples collected on August 24, 1992 for Pico-Kenter and Ashland, and September 8, 1992 for Ballona Creek and Sepulveda Channel). Control values are those plotted at a concentration of 0.1%.

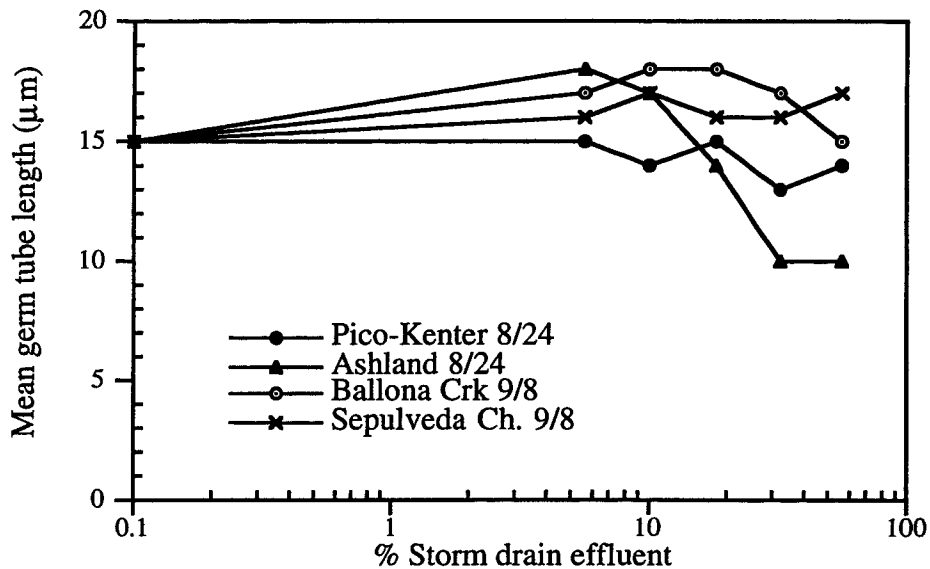


Figure 6. Example of dose-response plot for germ tube length test (for samples collected on August 24, 1992 for Pico-Kenter and Ashland, and September 8, 1992 for Ballona Creek and Sepulveda Channel). Control values are those plotted at a concentration of 0.1%.

3.4.2 Relative Toxicity

By using the obtained EC50 values from toxicity tests, the relative toxicity of Pico-Kenter, Ashland Avenue and Ballona Creek storm drains were assigned 3 for the most toxic to 1 for the least toxic storm drain for each toxicity test. For example, for samples collected on October 12, Ashland Avenue was the most toxic to the abalone test, followed by Pico-Kenter and Ballona Creek. Therefore, 3 was assigned to Ashland, 2 to Pico-Kenter and 1 to Ballona Creek. By using the same procedures, similar numbers were also assigned to all samples for all four toxicity tests and the results are shown in Tables 8 and 9. Table 8 shows the relative site toxicity ranks by species whereas Table 9 shows the relative rank test sensitivity to storm drain samples.

The Ashland Avenue storm drain was usually the most toxic to each test organism and consistently produced the greatest toxicity in all tests conducted. No clear distinction between the relative toxicity of the Ballona Creek and Pico-Kenter storm drains was observed. The abalone test was more sensitive to Pico-Kenter samples, with kelp test being the least sensitive. Ballona Creek samples produced the greatest toxic effects on sea urchin sperm while the abalone and kelp tests were unaffected by samples from this storm drain.

3.4.3 Phase II - Examination of Toxic Components

The objective of this phase of toxicity testing was to determine the type of compounds (e.g., organics or metals) that caused the toxicity in the selected storm drain. Based on the toxicity results from Phase I, the Ballona Creek storm drain and the sea urchin test were selected for this phase. Even though the relative toxicity of this location is not as great as Ashland Avenue, the annual input of runoff from Ballona Creek to Santa Monica Bay is much greater than the other storm drains, which means the mass emission from Ballona Creek will be much larger.

Three samplings were performed during this phase, i.e., on the November 23 and December 14, 1992, and January 19, 1993. The sampling procedures were slightly different than previous samplings. Grab samples from morning and afternoon were collected separately. Preliminary toxicity tests were performed on these two grab samples in order to determine which grab sample had a higher level of toxicity. Solid phase extraction (SPE) was then performed on the grab sample which exhibited greater toxicity. Samples collected from the extraction (e.g., SPE eluates, post C18, column blanks, etc.) were tested for toxicity. These tests were performed after the first rainfall of the 1992-93 water year, which occurred in late October. In order to insure that only dry weather flow was collected during sampling, the storm drain flow was monitored to insure that it returned to dry weather flow rates prior to sampling.

3.4.3.1 SPE Eluates

Currently, most of the methods used for toxicity-based (bioassay-directed) fractionations required the extraction of the sample with an organic solvent after some preliminary clean-up, and subsequent fractionation of the extract using normal-phase chromatography. The solvent systems used are extremely toxic to aquatic organisms (Burkhard *et al.*, 1991) and when these methods are used, solvent exchange and/or evaporation procedures are required before toxicity testing can be done. Losses of volatile toxicants can occur during these steps which may bias results

Table 8. Relative site toxicity ranks by species. Sample numbers refer to the three time periods studied (Sample 1 = 8/14 or 9/8/92). 3 = most toxic, 1 = least toxic.

Location (1)	Relative toxicity			Sum of ranks (5)
	Sample 1 (2)	Sample 2 (3)	Sample 3 (4)	
Abalone development				
Ashland	3	3	3	9
Ballona	1	1	1	3
Pico-Kenter	2	2	2	6
Kelp germination/growth				
Ashland	3	3	3	9
Ballona	1.5	1.5	1	4
Pico-Kenter	1.5	1.5	2	5
Sea urchin fertilization				
Ashland	2.5	3	3	8.5
Ballona	2.5	2	1	5.5
Pico-Kenter	1	1	2	4

Table 9. Relative rank test sensitivity to storm drain effluents. Rank assignments made on the basis of EC50 values (3 = most sensitive test).

Species (1)	Relative sensitivity		Sum of ranks (4)
	Sample 1 (2)	Sample 3 (3)	
Ashland			
Abalone	3	2	5
Kelp	1	1	2
Sea urchin	2	3	5
Pico-Kenter			
Abalone	3	3	6
Kelp	1.5	1	2.5
Sea urchin	1.5	2	3.5
Ballona Creek			
Abalone	1.5	2	3.5
Kelp	1.5	2	3.5
Sea urchin	3	2	5

The octadecyl (C18) solid phase extraction procedure used in this project was based on the method developed by Mount and Anderson-Carnahan (1989). This toxicity-based method has been successfully used to extract and fractionate non polar toxicants from the effluents for toxicity tests using cladocerans (water fleas) and fishes. In addition, low artifactual toxicity and excellent detection limits for gas chromatography/mass spectrometry (GC/MS) for toxicants identification can be obtained from this method. However, a preliminary recovery study showed that highly hydrophobic compounds such as chrysene and benzo(a)pyrene could not be eluted from the C18 sorbent by the elution solvents used by Mount and Anderson-Carnahan. Therefore a modified elution solvent system which consists of three fractions was developed for use on Phase II samples.

The first sampling of this phase was conducted on November 23, 1992. Preliminary toxicity results on the morning and afternoon grab samples showed that the afternoon sample produced toxic effects at concentrations $\geq 25\%$. Therefore, solid phase extraction procedures were used to concentrate the afternoon grab sample of Ballona Creek. In addition to the overall extraction procedures which were described in the experimental section, an additional sample manipulation was conducted. The pH of the sample was adjusted to pH 3 and pH 11 using 1N HCl acid and NaOH, respectively. Then samples with initial pH (pH_0), pH 3 and pH 11 were extracted using the C18 columns. The pH of deionized water used to prepare the filter and column blanks for the pH 3 and pH 11 samples was also adjusted prior to the extraction. During the solid phase extraction, two 30 ml samples of post C18 column effluents (i.e., after 25 mls and 950 mls of the sample passed through the column) were collected from each column. After the whole sample passed through the column and the column dried, 2 x 1.0 ml volume of six solvent mixtures were used to elute the sorbed organic from the C18 column. The solvent mixtures used for the elution of sorbed organics was 50%, 80%, 90% (v/v) of methanol in water, 100% of methanol, 10%, 20% and 50% (v/v) of methylene chloride in methanol.

Initially toxicity tests using the sea urchin were conducted on the filter blanks, column blanks and post C18 column effluents. Three concentrations were used, i.e., 12%, 25% and 56% (v/v) of storm drain sample. The results show that the pH_0 filter and column blanks were highly toxic. Filter blank toxicity was also found at pH 3 and less at pH 11. Post C18 column effluent at pH_0 was not toxic. In addition, a repeat of the baseline toxicity test with the Ballona Creek afternoon sample stored at SCCWRP showed a reduction of toxicity. Due to these bad results, it was suspected that toxicity may be introduced into the samples during the sample manipulations and extraction process. Therefore, it was decided that no further toxicity should be performed on the other samples, such as the SPE eluates, in order to save costs.

Two additional samples from Ballona Creek were collected on December 14, 1992 and January 12, 1993. The afternoon grab sample of December 14 and morning grab sample of January 12 were selected for the toxicity evaluation. Unlike the first sampling, the pH of the samples was not adjusted to either pH 3 or pH 11. Based on the earlier experience with the acute TIEs, it was found that major pH adjustment tests were not needed to characterize the toxicity of the sample (Norberg-King *et al*, 1992).

The solid phase extraction procedures used were as described in the experimental section. The three SPE eluates were then tested for toxicity using the urchin fertilization test. Two concentrations were used for the test, i.e., 0.1% and 0.2%, which corresponds to 50% and 100% (v/v) of storm drain sample, including the 500 fold increase obtained through the SPE procedures (the concentration factor of 500 times was obtained based on a sample volume of 1000 ml and elution volume of 2 ml). Table 10 shows the percentage fertilization of the SPE eluates (which has been normalized for blank response), post C18 effluents and the filtrates (pre-C18) of the Ballona Creek samples collected during this

Table 10. Toxicity results of C18 solid phase extraction (SPE) samples.

Sampling date and grab sample analyzed (1)	Filtrate (pre-C18)			SPE Eluates						Post C18		
				50% MeOH		100% MeOH		50% MeCl ₂				
	12%	25%	56%	0.1%	0.2%	0.1%	0.2%	0.1%	0.2%	12%	25%	56%
(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	
Dec. 14 '92 PM	86	66	15	100	100	94	7	100	63	-	92	76
Jan. 19 '93 AM	50	30	16	88	100	52	56	93	100	72	43	20

Note: All values are the mean % fertilization of sea urchin of two replicates.

phase. The results show that the 100% methanol fraction was the most toxic among the three eluates for both sampling periods. Little or no toxicity was present in the first and third eluate. The results suggest that most of the toxicants were present in the 100% methanol fraction for both sampling periods.

Table 10 also shows the toxicity results of pre- and post C18 samples at the concentrations tested. For the December 14 afternoon sample, a decrease in toxicity was observed after the passing the sample through the C18 column. At the concentration of 56%, the post C18 sample showed greater percentage fertilization (76%) than the untreated (pre-C18) sample (which only has 15% fertilization). This observation suggests that the C18 column removed toxicity and organic toxicants were most likely present in the sample. For the January 19 morning sample, no reduction of toxicity was observed in the post C18 sample and only moderate toxicity was observed in the 100% methanol fraction. Normally this result would suggest the presence of non-organics (e.g., metals), which are not removed by the C18 column; however, in this case it is not conclusive due to poor fertilization in the column blank. The presence of metals and other toxicants such as oxidative compounds in the samples can be confirmed by the EDTA and sodium thiosulfate addition tests.

3.4.3.2 EDTA and Sodium Thiosulfate Addition Tests

The objective of EDTA addition test is to detect toxicity caused by certain cationic metals. Non-toxic complexes will be formed after EDTA addition to the collected storm drain samples. Loss of toxicity with EDTA addition suggests that cationic metals are causing toxicity. The sodium thiosulfate addition test can detect toxicity caused by oxidative compounds (such as chlorine) and other compounds (such as copper and manganese). Toxicity from bromine, iodine, ozone, and chlorine dioxide is also reduced by the addition of sodium thiosulfate (Norberg-King *et al.*, 1992). The toxicity results of EDTA and sodium thiosulfate addition tests are shown in Table 11. For the sample collected on December 14, sodium thiosulfate reduced toxicity while EDTA only partially reduced the toxicity. This indicates that oxidative compounds may have caused toxicity in the December 14 sample. Reverse results were obtained for the sample collected on January 19, 1993. High percentage fertilization (Table 11) was observed in the samples with added EDTA while low percentage fertilization was observed in the thiosulfate addition test. These results show that EDTA completely removed the toxicity of the January 19 sample while thiosulfate had no effect on the sample toxicity. Therefore, cationic metals may be present in the January 19 sample and thus causing the toxicity.

Table 11. Toxicity results of the EDTA and sodium thiosulfate addition tests.

Sampling Date	EDTA Addition			Thiosulfate Addition	
	3 mg/L	8 mg/L	30 mg/L	10 mg/L	25 mg/L
(1)	(2)	(3)	(4)	(5)	(6)
Dec. 14 ' 92	44	12	-	99	98
Jan. 19 ' 93	92	96	92	10	12

Note: All values are the mean value of % fertilization of sea urchin at a concentration of 56% (v/v) storm drain sample.

The toxicity results obtained from this phase were variable and not conclusive due to the small number of samples tested. For example, for December 14 sample, toxicity was found in the raw sample (pre-C18 sample), the 100% methanol eluate and EDTA addition test, whereas no toxicity was found in the thiosulfate addition test and post C18 sample. It is not clear what might cause this type of toxicity, but an organic oxidant is possible; it would be reduced by the thiosulfate and through adsorption onto the C18 column. Other possibilities also exist. More toxicity tests should be performed in order to determine these variabilities.

3.5 GC/MS Results

Tables 12 and 13 show the GC/MS results averaged over the period of the study. The results show many compounds that are potentially toxic to the marine organisms tested. Appendix E contains the GC/MS data for the separate samplings based on the parallel study performed by Suffet *et al* (1993). The absence of compounds does not assume that they were not present, but only that they were below detection limits.

No correlations were observed between the measured compounds and the observed toxicity.

Table 12. GC/MS results for volatile organic analysis (6/12 - 12/10/92).

CHEMICAL [1]	Ashland Pico-Kenter	Sepulveda	Ballona	Cent.	Grand	Grand	Number of Sample >MDL [9]	
	Avg Conc. ng/L [2]	Avg Conc. ng/L [3]	Avg Conc. ng/L [4]	Avg Conc. ng/L [5]	Avg Conc. ng/L [6]	Avg Conc. ng/L [7]		
Benzene	90	91	109	77	91	90	61	59
Bromochloromethane	454		309	519	164	401	310	7
Bromodichloromethane	1,683	160	772	293	420	554	1,307	32
Bromoform	10,555	390	401	179	337	1,351	7,179	49
2-Butanone = MEK	1,191	423	477	602	423	673	656	48
n-Butyl Benzene	60					60	0	1
Carbon Disulfide	1,102	299	227	299	213	442	775	58
Chloroform	4,066	366	568	636	779	1,152	2,647	67
Chloromethane	418	421	578	421	324	526	589	65
2-Chlorotoluene	89					89	0	1
4-Chlorotoluene	148					148	0	1
Dibromochloromethane	4,877	205	1,179	281	883	1,089	3,348	30
Dibromomethane	740	50	74	50		298	465	26
1,2-Dichlorobenzene	74					74	0	1
Dichlorodifluoromethane	267	210	200	210	221	221	39	12
1,1-Dichloroethane	187					187	0	1
1,2-Dichloroethane	53					53	0	1
Dichloromethane	6,298	2,177	525	2,163	1,905	2,325	8,422	63
1,1-Dichloropropene				102		102	0	1
Ethyl Benzene	57			50		54	5	2
2-Hexanone	225	213	127	213	135	193	84	14
p-isopropyltoluene	687	72		72		482	834	9
4-Methyl-2-Pentanone	573	295	232	295	9,478	1,422	6,935	43
Naphthalene	401		287	256	464	352	76	4
Styrene	54	46	47	46	47	49	9	19
Tetrachloroethene = PCE				242		242	90	16
Toluene	747	158	107	149	104	126	78	54
Trans 1,2-Dichloroethene			191	130		161	43	2
1,1,1-Trichloroethane			94	564		558	292	15
Trichloroethene = TCE	69			53		56	12	15
1,2,4-Trimethylbenzene	77	52		52		68	42	11
1,3,5-Trimethylbenzene	672					672	852	2
o-xylene	71		59			67	21	3

Dichloromethane = methylene chloride TCE = Trichloroethylene PCE = Perchloroethylene

Note: Only compounds that were found >MDL were averaged

Grand Average = Concentrations of compounds that are found >MDL/number of samples.

Table 13. GC/MS results for base neutral analysis (6/12 - 12/10/92).

CHEMICAL [1]	Ashland Pico-Kenter	Sepulveda	Ballona	Centenila	Grand	Grand	Number of Sample >MDL [9]	
	Avg Conc. ng/L [2]	Avg Conc. ng/L [3]	Avg Conc. ng/L [4]	Avg Conc. ng/L [5]	Avg Conc. ng/L [6]	Avg Conc. ng/L [7]		Std Dev. ng/L [8]
Acenaphthene*	6	4	30	3	5	10	16	9
Anthracene*	38	22	1,046	23	107	257	954	19
Azobenzene	34	25	21	17	14	21	14	23
Benz(a)anthracene*	32	32	14	22	22	27	19	15
Benzo(b)fluoranthene*	24	37	20	4	2	20	21	11
Benzo(k)fluoranthene*	25	14	39	5	2	18	18	7
Benzoic acid	472	920	501	543	584	523	393	21
Benzo(g,h,i)perylene*	71		58			66	55	3
Benzo(a)pyrene*	162	41	1,803	47	145	400	1,297	17
Benzyl alcohol	896			459		750	441	3
Bis(2-ethylhexyl)phthalate	14,765	6,800	4,349	4,518	6,240	6,627	7,013	42
Butyl benzyl phthalate	1,486	962	1,148	1,248	708	1,088	730	44
4-Chloro-3-methylphenol	9					9	0	1
2-Chloronaphthalene			1			1	0	1
4-Chlorophenyl phenyl ether	34	37	22	28	24	30	16	34
Chrysene*	126	69	2,016	61	181	513	1,828	19
Dibenzo(a,h) anthracene*	39		59			44	43	4
Dibenzofuran*	11	5	7	7	8	8	4	19
Di-n-butyl phthalate	3,050	1,046	1,223	1,337	816	1,421	1,967	44
1,4-Dichlorobenzene	68	66	58	75	44	63	31	40
Diethyl phthalate	463	187	201	214	216	247	209	43
2,4-Dimethylphenol	365					365	180	2
Dimethyl phthalate	31	14	26	27	20	22	28	16
Di-n-octyl phthalate	3,054	4,249	391	1,442	59	1,888	6,504	41
Fluoranthene*	49	59	19	9	9	31	58	34
Fluorene*	13	4	43	5	13	22	49	27
Indeno(1,2,3,4-c,d)pyrene*	40	7	71			39	41	5
Isophorone	42	1	17	33	52	35	26	9
2-Methylnaphthalene*	43	57	58	53	53	54	21	41
2-Methylphenol		8				8	0	1
4-Methylphenol	1,042	2,649		25		1,905	3,317	10
Naphthalene*	85	98	102	99	90	98	38	34
2-Nitroaniline	463					463	0	1
Nitrobenzene	230			24	29	51	70	7
2-Nitrophenol	38	455	27	42	30	147	624	30
4-Nitrophenol		3,903				3,903	0	1
N-Nitrosodiphenylamine		161				161	0	1
N-Nitrosodi-n-propylamine				3		3	0	1
Phenanthrene*	62	46	26	17	23	29	31	30
Phenol	162	1,204	100	166	83	465	1,145	22
Pyrene*	87	69	956	21	145	263	1,239	37

Grand Average = Concentrations of compounds that are found >MDL/number of samples.

Note: Only compounds that were found >MDL were averaged

* = Polycyclic Aromatic Hydrocarbon (PAH)

The toxicity analyses presented earlier in this report show that dilution of the dry weather urban runoff with uncontaminated seawater can reduce toxicity to below detection limits. It was also observed that in some cases the toxicity in the storm drain sample disappeared after 2 or 3 days. This disappearance could be due to a chemical or biochemical detoxification reaction. For example, if free or combined chlorine were present in the urban runoff, it would decompose after a finite period of time, perhaps hours to one or two days, depending upon the concentration and type of chlorine residual. It is therefore reasonable to consider mixing and dilution as a best management practice. The initial dilution would protect aquatic species near the mouth of the storm drain and allow the toxicity-producing contaminants to decompose. For long lasting toxicity-producing contaminants, or for contaminants that might bioaccumulate, dilution might mitigate the immediate impact but would probably not prevent longer term impacts. For biodegradable contaminants, dilution could have a large beneficial effect.

A literature review was conducted to determine if previous research had been performed to determine dilution and initial mixing of a low flow rate, buoyant plume of fresh water entering sea water at surface level. No previous experimentally based research was found. Previous researchers (Stenstrom *et al.*, 1982), have suggested dilution as a best management practice, and a low flow diffuser has been installed at Pico-Kenter storm drain; however no quantitative experimental validation of the amount of dilution or anticipated benefits has been made.

A large body of research exists on deeper water diffuser systems, such as those used for the City of Los Angeles Hyperion treatment plant in El Segundo, the Los Angeles County Joint Water Pollution Control Plant in Carson and the Orange County Treatment Plant. These studies however are not directly applicable to storm drains discharging across beaches or small creeks flowing into coastal waters. One of the authors of this report has submitted a proposal to the USC Sea Grant program in order to study the initial dilution that occurs at the mouth of a storm drain during wet and dry weather conditions. The results of this study, if funded, should provide experimental evidence of initial dilution of storm drains.

Woodward Clyde Consultants performed a "scoping" estimate of initial dilution of Ballona Creek as part of the Playa Vista Project. No experimental verification was performed, and they qualified their estimate for planning purposes only; however, their results and methodology provide the best estimate for dilution available at this time. They calculated a dilution based upon a dimensional analysis of the "near field" mixing and solved the diffusion equation to estimate "far field" dilution.

The near field effect is caused by the energy of the discharge (a jet or plume of fresh water entering saline water). They used a non-dimensional analysis using the Froude number, subject to the following assumptions:

- Steady-state conditions exist for the Bay as well as for the storm drain;
- The water depth of the Bay at the point of discharge is much deeper than the thickness of the plume of storm drain water;

- The shoreline is straight and storm drain and plume are perpendicular to the shoreline;
- The maximum concentration (minimum concentration) occurs along the shoreline;
- Mixing processes can be adequately characterized by a bulk dilution factor.

These assumptions are stringent and not fully applicable to the various storm drains that enter the Bay. For example, the Bay and the drains are in a constant state of flux. Tides and wind-induced currents are time-varying. The straight shoreline is not applicable to a situation where pockets or local stagnant zones are created by coastal structures or geometry of the shoreline.

WCC estimated the initial dilution factor from as follows:

$$S_s = F_o (b/h)^{0.25}$$

where,

S_s	=	Bulk dilution defined as the ratio of the local flow rate to the initial flow rate,
F_o	=	Froude number,
b	=	discharge half-width,
h	=	discharge depth.

Using this equation for Ballona Creek at a flow rate of 5,000 ft³/sec, which is significantly more than its flow rate during dry weather conditions, they estimated a initial near field dilution of 1.2 to 1.9, and concluded that 1.5 was a reasonable estimate.

The far field dilution was estimated by assuming steady state conditions and modeling the flows and currents as a two-dimensional diffusion problem. In this approach, tides and wind-induced waves are treated as diffusion or dispersion, which are random in direction. They solved the two dimensional equations and performed a sensitivity study over a range of dispersion coefficients (D) from 0.01 to 0.00001 ft²/sec. Over this range the far field dilution was estimated as 1 at D=0.00001 to 3 with D=0.01 at a distance of 5,000 feet from the Creek mouth. At 25,000 feet with D=0.01 the dilution increased to 9, but remained between 1 and 2 with D=0.00001.

The total dilution for a Ballona Creek, over the range of assumptions provided, ranges from 1 to perhaps as much as 20. These dilutions are far less than normally considered by the California Ocean Plan (e.g., 100 to 200), and far less than can be obtained with ocean outfall diffusers, such as those used at the large coastal wastewater treatment plants.

The dilution of dry weather flow, which is much less than the 5,000 ft³/sec. flow rate used in the above analysis, should be significantly less for the near field, since there is very little energy contained in discharge (the discharge is not like a "jet" entering the shoreline), but perhaps greater for the far field, since there is much less volume entering the Bay.

It is concluded that no reliable quantitative estimates of low flow dilution of storm drain discharges can be made. Best available information suggests that 1 to 10 is the probable dilution. Undoubtedly dilution of storm drains like Pico-Kenter can be enhanced by devices such as a low-flow diversion that conveys dry weather flow across the beach and well into the surf. Further research is needed to adequately characterized initial dilution and its potential benefits.

Water quality of five storm drains and relative toxicity of four storm drains in Santa Monica Bay Watershed were analyzed during low flow (dry weather) conditions. The water quality of the selected storm drains varied during the sampling periods, and was often comparable or worse than typical secondary effluents. This indicates that it is just as important to control dry weather urban runoff as it is to control secondary effluents.

Short-term chronic toxicity tests also show that significant toxicity was present in the selected storm drains. Probable sources of the toxicity ranged from non-organic (e.g., metals and oxidizing compounds) to organic contaminants. More samplings are needed to determine the variability of the toxicity. Toxicity testing should also be included in monitoring programs of urban runoff. Further work to identify the toxic components through quantitative chemical analysis (such as gas chromatography/mass spectrometry for organics) are also needed. Dilution of 10 fold or more was usually sufficient to reduce toxicity to below detection limits. A survey of the literature to determine dilution of storm drains that enter coastal waters found very little information. For Ballona Creek, during wet weather flow, the dilution might be as much as 10 fold. Further research is needed to determine the likely dilution at the mouth of storm drains.

A large amount of dry weather water quality data was collected. This data set is larger and more complete than any available previously for a single Santa Monica Bay storm drain at a single location. The new data have been added to the combined data set assembled from agency monitoring data in an earlier report (Stenstrom and Strecker, 1993).

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INTRODUCTION

Currently, most of the methods used for toxicity-based (bioassay-directed) fractionations require the sample extraction with an organic solvent after some preliminary clean-up, and subsequent fractionation of the extract using normal-phase chromatography. The solvent systems used are extremely toxic to aquatic organisms (Burkhard *et al.*, 1991) and solvent exchange and/or evaporation procedures are required before toxicity testing can be done. Losses of volatile toxicants can occur during these steps which may bias results.

After completing the development of the improved procedures, US EPA (Durhan *et al.*, 1993a, b) published an improved procedures which were nearly identical to the procedures we developed.

C18 SOLID PHASE EXTRACTION

The toxicity-directed method for fractionating non-polar organic toxicants using solid-phase extraction (SPE) described in phase II of EPA's "Methods for Aquatic Toxicity Identification Evaluations" (TIE) were used in this project. The proposed SPE method used octadecylsiloxane (C18) columns and an elution scheme with decreasing polarity. Prior to the extraction of actual storm drain samples, recovery studies using standard solutions of a combination of eight common polyaromatic hydrocarbons (PAHs) were performed. Modifications of the SPE procedures have been made based on the results of the recovery study in order to obtain good percentage recovery of PAHs from the C18 SPE columns. The following section described the rationale of the SPE procedures development which will be used for the actual storm drain samples.

EXPERIMENTAL PROCEDURES

Materials

SPE column. The 500 mg and 1000 mg octadecyl C18 columns used were obtained from Burdick and Jackson (Muskegon, MI)

Chemicals. Polyaromatic hydrocarbons (PAHs) mixed in the standard solutions, i.e., naphthalene, 2-methylnaphthalene, acenpathene, fluorene, anthracene, pyrene, chrysene and benzo(a)pyrene were obtained from Aldrich (Milwaukee, WI). The PAHs mixture in methanol was spiked into one liter deionized water.

Solvents. HPLC grade methanol, methylene chloride, hexane, carbon tetrachloride and isopropanol from Fisher Scientific (Tustin, CA) were used for SPE.

SPE procedures

The 1000 nmg C18 SPE column was conditioned with 25 ml of methanol and 25 ml of deionized water. Before the sorbent dried, 1000 ml standard water solution containing PAHs was then pumped through the column at a rate of 5 ml/min. The sorbent was dried by continuing the pumping for ~ 15 minutes after the whole 1000 ml sample passed through. Then 2 successive 1.0 ml volume of methanol/water, methanol and

methylene chloride/methanol were added sequentially into the column. Each fraction was collected separately into clean glass vials. The column was allowed to dry prior addition of each elution solvent mixture. The concentration of PAHs in each eluates were then analyzed using GC/FID. With the known initial concentration of each PAHs in the standard solution, the percentage recovery of each PAH was determined as follows:

$$\% \text{ Recovery} = \frac{\text{Concentration of PAH in eluate (GC determined)}}{\text{Expected concentration}} \times 100$$

Gas Chromatography Analysis

The SPE fractions were analyzed using a Varian Vista 6000 gas chromatograph equipped with a splitless injector and flame ionization detector (FID). A 30 m x 0.25 mm i.d. DB5.625 capillary column (J & W Scientific) was used to analyze the PAHs in the fractions. The GC temperature program was 40°C for 2 min, 40° - 140°C at 25°C/min, 140° - 290°C at 10°C/min, and 290°C for 20 min. The splitless injector and FID temperatures were 275°C and 300°C, respectively.

The above procedure is a general description of C18 SPE procedures used in our recovery study. Changes on the elution volume and elution solvents were made when the effect of these parameter on the percentage recovery of PAHs were studied.

RESULTS AND DISCUSSION

Methanol as the Elution Solvent

Our first recovery studies used only one fraction of 2 x 1.5 ml of methanol to elute the sorbed PAHs from the 500 mg C18 column. The final concentrations of PAHs in the eluates collected from the 100 mg size columns were used to determine the recovery of the each PAHs. Low recoveries were obtained for most of the PAHs (Table A-1). Anthracene, acenaphthene, fluorene and 2-methylnaphthalene were recovered the most, greater than 40%. Both naphthalene and benzo(a)pyrene have low recovery, less than 10%. It is suspected that the low recoveries might be caused by insufficient elution volume. Therefore, additional three successive 1.5 ml of methanol was used to elute the sorbed PAHs from the 500 mg and 1000 mg C18 columns. The obtained results only show slight improvement of the recoveries of PAHs (Table A-1). Therefore, it was suspected that maybe methanol might be too polar to be able to elute the strongly hydrophobic PAHs. Low recovery of naphthalene may also due to its loss through volatilization as naphthalene is considered semi-volatile ($H_c = 0.018$).

To determine the suitability of methanol as the elution solvent for PAHs, an addition of 200 µL of methylene chloride was used to elute the sorbed PAHs from the 100 mg C18 columns after the first 300 µL methanol. The results show that PAHs were only partially desorbed from the C18 sorbent by 100% methanol. Subsequent addition of methylene chloride helped to further elute some of the PAHs. The overall recovery (combination of methanol and methylene chloride eluates) of PAHs improved for most of the PAHs. However, the percentage recovery of chrysene and benzo(a)pyrene was still not good (Table A-1).

The improvement of the percentage recovery of most of PAHs helps to reconfirm our suspicions of the weakness of methanol as the elution solvent for PAHs. Therefore, the effect of other solvents, i.e., hexane, carbon tetrachloride, methylene chloride and 2-propanol, as the elution solvent for PAHs was studied. However, only 1000 mg size columns were used as hexane, methylene chloride and carbon tetrachloride were not miscible in water. The percentage recovery of most of the PAHs approached 100% in the hexane, carbon tetrachloride and methylene chloride cases (Table A-2). The percentage recovery of benzo(a)pyrene has improved from about 20% to almost 50%. No improvement of the recovery was obtained by using 2-propanol as the elution solvent.

Even though strong non-polar solvents such as hexane, carbon tetrachloride and methylene chloride improved the recovery of the PAHs, these solvents are not desirable as the elution solvent as (1) they are not miscible in water, and (2) they are toxic to the marine organisms used in the toxicity tests. A solvent exchange procedure is usually required before they can be used in toxicity assays. An alternative elution solvent system which meet these two criteria is needed as preliminary results had shown that the proposed elution solvent system by Mount and Carnahan cannot elute PAHs from the C18 sorbent efficiently. The modified elution solvent include methanol-methylene chloride mixtures so that those strongly sorbed PAHs such as chrysene and benzo(a)pyrene can be eluted from the C18 sorbent.

Composition Methanol-Water and Methanol-Methylene Chloride

Preliminary tolerance tests for marine organisms showed that methanol-water, methanol, and methanol-methylene chloride were acceptable elution mixtures. However, it was very desirable to limit the quantity of methylene chloride to less than 0.1% in the toxicity assay. Therefore, different composition of methanol-water and methanol-methylene chloride as elution solvents were studied.

A total of six fractions were used to fractionate the PAHs from the C18 columns. Two different compositions of methanol-water and methanol-methylene chloride were studied, i.e., a 10% and 25% gap between each fraction. The 10% gap in the first proposed elution solvent system consisted of 80% and 90% of methanol (v/v) in water, 100% methanol, 10%, 20% and 50% methylene chloride (v/v) in methanol. The second proposed solvent system, which has a 25% gap between each fraction, consisted of 50% and 75% of methanol (v/v) in water, 100% methanol, 25%, 50% and 75% of methylene chloride (v/v) in methanol. The percentage recovery of the eight PAHs were determined in each fractions and compared. The results of the first and second proposed elution solvent systems are shown in Tables A-3 and A-4.

Table A-3 shows that more fractionation occurs in the 10% gap solvent system than the 25% gap system. It is observed that at least 3 distinct fractions could be collected in the 10% gap system (Table A-3). For example, both naphthalene and 2-methylnaphthalene were fractionated into the 2nd fractions (i.e., 90% methanol), while most of the acenaphthene, fluorene, anthracene and pyrene were found in the 3rd fraction (i.e., 100% methanol). Both chrysene and benzo(a)pyrene were fractionated into the 4th fraction (i.e., 10% methylene chloride).

For the 25% gap elution solvent system, less fractionation of PAHs was observed (Table A-4). There were only two distinct fractions collected in this system. Most of naphthalene, 2-methylnaphthalene, acenaphthene, fluorene and anthracene were fractionated in the 3rd fraction (i.e., 100% methanol). Pyrene, chrysene and benzo(a)pyrene were found in the

4th fraction (i.e., 25% methylene chloride). There was no or insignificant PAHs found in the first and last two fractions.

Tables A-3 and A-4 also show that the overall percentage recovery of PAHs were greater in the 25% gap solvent system. However, as better fractionation of PAHs was obtained in the 10% gap system, it was decided that the composition of methanol-water and methylene chloride-methanol in the 2nd proposed elution solvent system will be used instead.

Elution Volume

The fractionation of PAHs caused by the volume of the elution solvent used was also studied. Two different elution volumes were compared, i.e., 2 x 1.0 ml and 2 x 1.5 ml of 80% and 90% of methanol (v/v) in water, 100% methanol, 10%, 20% and 50% of methylene chloride (v/v) in methanol. The results of the percentage recovery of PAHs using 2 x 1.0 ml and 2 x 1.5 ml of elution volume are shown in Tables A-3 and A-5. The total percentage of both volumes each PAH are quite similar, except for 2-methylnaphthalene in which a total of 76% was recovered when 2 x 1.5 ml elution volume was used and only 46% was recovered when 2 x 1.0 ml of elution volume was used.

Tables A-3 shows that for the 2 x 1.0 ml elution volume, greater recovery was observed with 100% methanol fraction than 90% methanol. For the 2 x 1.5 ml elution volume (Table A-5), the opposite was observed. Few PAHs were recovered in the 80% methanol and 50% methylene chloride fractions (for both 2 x 1.0 ml and 2 x 1.5 ml cases). No conclusion can be made here regarding which volume is better, except the volume of solvent and solvent make up can interact to effect recovery.

Based on the results of the above mentioned recoveries, it was decided to use the following elution scheme for the fractionation of PAHs from the C18 columns: 2 x 1.0 ml of 80% and 90% of methanol (v/v) in water, 100% methanol, 10%, 20% and 50% of methylene chloride (v/v) in methanol. The following section discussed the repeatability of this modified system based on a total of eight similar extractions.

Repeatability of the Modified Elution Solvent System

As mentioned in the above sections, the modified elution solvent system consists a total of 6 fractions, i.e., 2 x 1.0 ml volume of the following solvents: 80% and 90% methanol (v/v) in water, 100% methanol, 10%, 20% and 50% methylene chloride (v/v) in methanol. A total of 8 extractions were conducted to determine the variability SPE procedures using the modified elution solvent system. The extraction procedures of these extractions were identical except for the concentration of PAHs. For each extraction, the concentration of all PAHs, except benzo(a)pyrene were equal; the range of concentrations of each PAH (in the water solution) was varied from 10 µg/L to 40 µg/L. The concentration of benzo(a)pyrene ranged from 20 µg/L to 80 µg/L. The average percentage and standard deviation of each PAH recovery in each SPE fraction obtained from 8 extractions are shown in Table A-6. Repeatability of the extraction procedures, as measured by the standard deviation of the recovery, was generally within 5% for fluorene as the most repeatable, and 21% for 2-methylnaphthalene as the least repeatable.

From Table A-6 it is observed that the 80% methanol-water fraction (1st fraction) eluted no PAHs. Most of the naphthalene was recovered in the 90% methanol fraction (2nd fraction). Anthracene, fluorene and acenaphthene were eluted almost entirely in the 100% methanol fraction (3rd). 2-methylnaphthalene, pyrene, chrysene and benzo(a)pyrene were not well

separated. Table A-6 also shows that elution with methylene chloride (4th and 5th fractions) is required to recover those PAHs with high log K_{ow} value (such as chrysene and benzo(a)pyrene). Most were recovered with a maximum of 20% methylene chloride. The sequence of PAHs elution from the C18 column is also shown in Figure 1.

CONCLUSIONS

Based on the results of the recovery studies using eight commonly detected PAHs, a modified elution solvent system consists of six fractions of methanol-water, methanol and methylene chloride mixtures was developed, i.e., 2 x 1.0 ml of 80% and 90% of methanol (v/v) in water, 100% methanol, 10%, 20% and 50% of methylene chloride (v/v) in methanol. Three distinct groups of PAHs were obtained from the C18 column when this elution solvent system was used: naphthalene in the 90% methanol fraction; acenaphthene, fluorene and anthracene in the 100% methanol fraction, and chrysene and benzo(a)pyrene in either 10% or 20% methylene chloride fraction. The repeatability of the extraction was within the range of 5-21%.

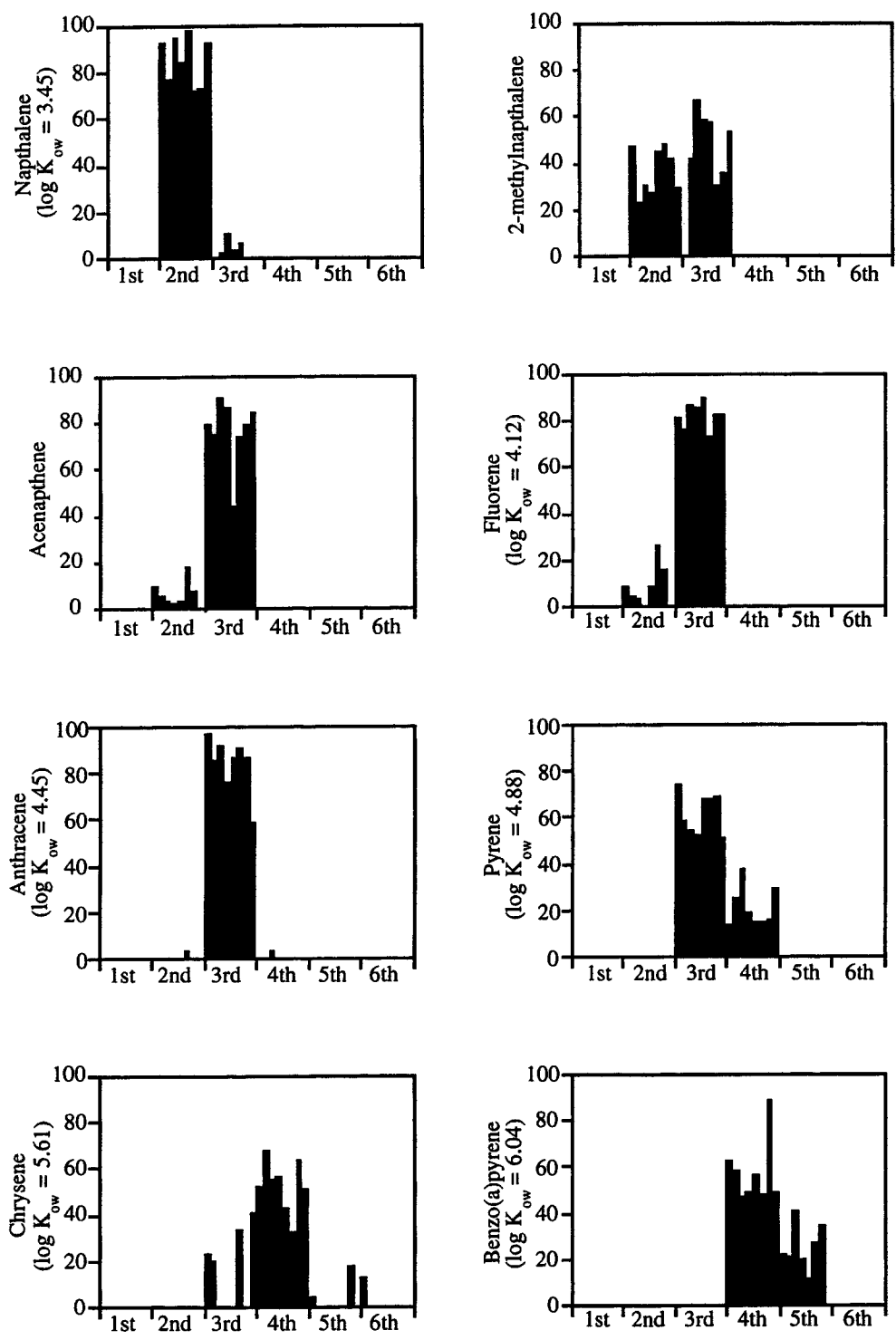


Figure A-1. C18 SPE modified elution scheme. The vertical axis represents the percent recovery of each PAH in each fraction. 1st: 80% methanol in water; 2nd: 90% methanol in water; 3rd: 100% methanol; 4th: 10% methylene chloride in methanol; 5th: 20% methylene chloride in methanol; 6th: 50% methylene chloride in methanol.

Table A-1. Total percentage recovery of PAHs from initial SPE recovery studies.

PAHs compounds (1)	1st Recovery	2nd Recovery		3rd Recovery*
	500 mg C18 (2)	500 mg C18 (3)	1000 mg C18 (4)	1000 mg C18 (5)
Anthracene	58	67	70	103
Acenaphthene	40	66	57	90
Fluorene	49	89	65	99
2-methylnapthalene	44	62	53	70
Pyrene	18	38	34	112
Chrysene	13	19	27	12
Benzo(a)pyrene	9	6	0	0
Napthalene	8	13	16	27

Note: * Combination of methanol and methylene chloride eluates.

Table A-2. Percentage recovery of PAHs using different solvents.

PAH Compound (1)	Total % Recovery			
	n-Hexane (2)	Carbon Tetrachloride (3)	Methylene chloride (4)	2-Propanol (5)
Napthalene	134	165	142	46
2-methylnapthalene	128	156	134	47
Acenaphthene	146	161	139	56
Fluorene	149	165	142	68
Anthracene	123	150	134	53
Pyrene	138	160	129	98
Chrysene	116	85	55	47
Benzo(a)pyrene	49	58	42	19

Note: The excessive recovery (i.e., > 100%) of several PAHs was due to negligence in volume measurements.

Table A-3. Percentage recovery of PAHs using the 10% gap elution solvent system.

PAH compounds (1)	Percentage recovery						Total Recovery (8)
	80% MeOH (2)	90% MeOH (3)	100% MeOH (4)	10% MeCl ₂ (5)	20% MeCl ₂ (6)	50% MeCl ₂ (7)	
Napthalene	5	93	0	0	0	0	98
2-methylnapthalene	0	47	0	0	0	0	47
Acenaphthene	0	10	79	0	0	0	89
Fluorene	0	9	81	0	0	0	90
Anthracene	0	0	97	0	0	0	97
Pyrene	0	0	74	14	0	0	88
Chrysene	0	0	24	53	5	13	95
Benzo(a)pyrene	0	0	0	63	23	0	86

Note: MeOH = methanol; MeCl₂ = methylene chloride. The elution solvent volume used was 2 x 1.0 ml.

Table A-4. Percentage recovery of PAHs using the 25% gap elution solvent system.

PAH Compounds (1)	Percentage recovery						Total Recovery (8)
	50% MeOH (2)	75% MeOH (3)	100% MeOH (4)	25% MeCl ₂ (5)	50% MeCl ₂ (6)	75% MeCl ₂ (7)	
Napthalene	0	0	84	33	0	0	117
2-methylnapthalene	0	0	84	5	0	0	89
Acenaphthene	0	0	73	19	0	0	92
Fluorene	0	9	76	16	0	0	101
Anthracene	0	0	53	35	0	0	88
Pyrene	0	0	13	74	0	0	87
Chrysene	0	0	0	124	0	0	124
Benzo(a)pyrene	0	0	0	98	18	0	116

Note: The elution solvent volume used was 2 x 1.0 ml.

Table A-5. Percentage recovery of PAHs using the elution volume of 2 x 1.5 ml.

PAH compounds (1)	Percentage recovery						Total Recovery (8)
	80% MeOH (2)	90% MeOH (3)	100% MeOH (4)	10% MeCl ₂ (5)	20% MeCl ₂ (6)	50% MeCl ₂ (7)	
Napthalene	5	83	0	0	0	0	88
2-methylnapthalene	0	76	0	0	0	0	76
Acenaphthene	0	61	19	0	0	0	80
Fluorene	0	63	17	0	0	0	80
Anthracene	0	33	55	0	0	0	88
Pyrene	0	0	104	0	0	0	104
Chrysene	0	0	85	11	0	3	99
Benzo(a)pyrene	0	0	16	78	0	0	94

Table A-6. Average percent recovery and standard deviation of each PAH from 8 different extractions using the modified elution scheme.

PAH compounds (1)	Log K _{ow} (2)	Average percentage recovery ± standard deviation					
		80% MeOH (3)	90% MeOH (4)	100% MeOH (5)	10% MeCl ₂ (6)	20% MeCl ₂ (7)	50% MeCl ₂ (8)
Napthalene	3.54	0	86 ± 11	3 ± 4	0	0	0
2-methylnapthalene	0	0	37 ± 10	43 ± 21	0	0	0
Acenaphthene	0	0	7 ± 6	77 ± 14	0	0	0
Fluorene	4.12	0	9 ± 9	82 ± 6	0	0	0
Anthracene	4.45	0	0.5 ± 1	84 ± 12	0.5 ± 1	0	0
Pyrene	4.88	0	0	62 ± 9	22 ± 9	0	0
Chrysene	5.61	0	0	15 ± 17	53 ± 11	3 ± 7	2 ± 5
Benzo(a)pyrene	6.04	0	0	0	57 ± 14	23 ± 13	0

APPENDIX B
WATER QUALITY DATA

Appendix B includes the results of water quality analyses of the samples from the five selected storm drains which were collected from April 1992 to January 1993.

Table B-1. Water quality data of Pico-Kenter storm drain (April '92 - December '92).

Parameter (1)	4/17/92 (2)	6/12/92 (3)	7/7/02 (4)	7/27/92 (5)	8/24/92 (6)	9/8/92 (7)	9/29/92 (8)	10/12/92 (9)	11/2/92 (10)	12/10/92 (11)
Sample Type	Grab	Grab	Composite	Composite	Composite	Composite	Composite	Composite	Composite	Composite
Alk (mg/L as CaCO ₃)	304	250	325	275	244	230	260	275	295	205
Hardness (mg/L as CaCO ₃)	298	234	256	242	536	234	284	239	272	270
pH*	8.5	8.4	8.4	7.9	7.6	7.6	7.7	7.65	7.9	8.4
Conductivity (µmho/cm)*	1477	1460	1902	1743	4350	1380	1620	1450	1540	1025
Ammonia (mg/L as NH ₃ -N)	-	-	0.28	0.0522	0.2154	0.6813	0.0801	0.0287	0.0377	0.0906
Nitrite (mg/L NO ₂ -N)	0.114	0.056	0.0686	0.1607	0.2021	0.099	0.0496	0.0695	0.1024	0.0419
TDS (mg/L)	886 [#]	791	1055	751	2456	876	1123	900	943	723
TSS (mg/L)	-	9	13	29	149	40	138	21	4	39
VSS (mg/L)	-	-	6	12	65	15	56	4	4	8
COD (as mg/L)	-	-	93	66	132	43	69	63	41	19
DOC (ppm)	-	-	18	15	14	7	16	15	89	74
Detergent (ppm as LAS)	-	-	-	-	0.75	0.5	0.5	1	-	9.7
uv absorbance (at λ = 254nm)	-	0.36	0.40	0.38	0.46	0.47	0.57	0.43	0.4	0.19
Turbidity (NTU)	2.05	7.3	3.67	22	45	17.4	16.9	24.8	4.8	11.3
% Salinity**	-	-	-	0.75	1.5	0.25	0.9	0.3	0.0375	0.625
DO (ppm)**	-	-	7.9	6.5	5.7	5.8	7.2	6.85	5.95	9.7

Note: # TDS = 0.6 x conductivity; * = measured in the lab; ** = measured in the field; - = no sample taken/no analysis done.

Table B-2. Water quality data of Ashland Avenue storm drain (April '92 - December '92).

Parameter (1)	4/17/92 (2)	6/12/92 (3)	7/7/92 (4)	7/27/92 (5)	8/24/92 (6)	9/8/92 (7)	9/29/92 (8)	10/12/92 (9)	11/2/92 (10)	12/10/92 (11)
Sample Type	Grab	-	Composite	Composite	Composite	-	Composite	Composite	Composite	-
Alk (mg/L as CaCO ₃)	198	-	310	370	355	-	370	345	265	-
Hardness (mg/L as CaCO ₃)	3310	-	224	388	274	-	1286	1680	1868	-
pH*	7.6	-	7	8	7.75	-	7.75	7.4	7.7	-
Conductivity (µmho/cm)*	1000	-	1753	3640	2680	-	13170	14620	16060	-
Ammonia (mg/L as NH ₃ -N)	-	-	0.052	2.578	1.2915	-	0.4711	0.5109	0.1215	-
Nitrite (mg/L NO ₂ -N)	0.079	-	0.0438	0.0371	0.5176	-	0.0308	0.0266	0.1195	-
TDS (mg/L)	587 [#]	-	910	2008	1615	-	7032	9527	10650	-
TSS (mg/L)	36	-	446	1169	849	-	28.55	19	10	-
VSS (mg/L)	21	-	80	237	221	-	23	13	8	-
COD (mg/L)	-	-	163	274	202	-	231	324	297	-
DOC (ppm)	-	-	46	50	27	-	51	25	75	55
Detergent (ppm as LAS)	-	-	-	-	3	-	4	3	-	-
uv absorbance (at λ = 254 nm)	-	-	0.71	1.19	1.23	-	0.73	1.02	0.34	-
Turbidity (NTU)	2.6	-	88	505	380	-	11.8	23.9	6.3	-
% Salinity**	-	-	-	1.50	1.10	-	2.25	3.25	3.25	-
DO (ppm)**	-	-	8.1	2.45	1.80	-	1.20	1.70	4.70	-

Note: # TDS = 0.587 x conductivity; * = measured in the lab; ** = measured in the field; - = no sample taken/no analysis done.

Table B-3. Water quality data of Ballona Creek @ Inglewood storm drain (June'92 - January'93).

Parameter (1)	6/12/92 (2)	7/7/92 (3)	7/27/92 (4)	8/24/92 (5)	9/8/92 (6)	9/29/92 (7)	10/12/92 (8)	11/2/92 (9)	11/23/92 pm (10)	12/10/92 (11)
Sample Type	Grab	Composite	Composite	Composite	Composite	Composite	Composite	Composite	Grab	Composite
Alk (mg/L as CaCO ₃)	220	250	165	185	205	215	215	275	175	275
Hardness (mg/L as CaCO ₃)	480	494	356	628	594	1082	492	720	388	808
pH*	8.9	8.7	9.5	9.15	8.6	8.8	9	8.5	9.6	8.2
Conductivity (µmho/cm)*	1900	1855	1439	2230	1975	3140	1630	2390	1126	2540
Ammonia (mg/L as NH ₃ -N)	-	0.11	0.0629	0.0821	0.1	0.0136	0.0287	0.0255	0.1	0.6486
Nitrite (mg/L NO ₂ -N)	0.072	0.0493	0.0153	0.0588	0.0371	0.0929	0.0509	0.1479	0.0296	0.1347
TDS (mg/L)	980	886	856	1362	1414	2328	1134	1526	837	1901
TSS (mg/L)	173	22	14	8	8	13	3	5	3	16
VSS (mg/L)	-	12	10	6	4	9	2	4	2.6	6
COD (mg/L)	-	35	33	48	17	65	70	34	13	45
DOC (ppm)	-	14	8	7	8	12	7	71	31	96
Detergent (ppm as LAS)	-	-	-	0.75	1.5	0.5	0.25	-	-	-
uv absorbance (at λ =254nm)	0.17	0.20	0.13	0.18	0.15	0.16	0.22	0.15	0.10	0.13
Turbidity (NTU)	9.5	1.78	3.8	2.6	3.4	3.08	2.4	1.8	2.3	2.8
% Salinity **	-	-	1.33	1.78	1.22	1.22	1.07	1.23	0.85	1.51
DO (ppm) **	-	13.6	> 15	> 15	> 15	14.7	> 15	> 15	> 15	14.2

Note: * = measured in the lab; ** = measured in the field; - = no sample taken/no analysis done.

Table B-3. Water quality data of Ballona Creek @ Inglewood storm drain (cont'd).

Parameter (1)	12/14/92 am (12)	12/14/92 pm (13)	1/12/93 am (14)	1/19/93 am (15)	1/19/93 pm (16)
Sample Type	Grab	Grab	Grab	Grab	Grab
Alk (mg/L as CaCO ₃)	285	285	235	254	255
Hardness (mg/L as CaCO ₃)	854	1725	500	530	480
pH*	8.4	8.15	8	8.1	8.1
Conductivity (µmho/cm)*	2180	4620	1644	1053	1054
Ammonia (mg/L as NH ₃ -N)	1.0636	0.705	0.5179	0.2795	0.1228
Nitrite (mg/L NO ₂ -N)	0.2593	0.1737	0.2453	0.0624	0.0795
TDS (mg/L)	1770	3810	1202	829	839
TSS (mg/L)	6	174	19	97	148
VSS (mg/L)	4	37	4	12	16
COD (mg/L)	28	70	37	37	46
DOC (ppm)	-	-	-	-	-
Detergent (ppm as LAS)	-	-	-	-	-
uv absorbance (at λ = 254nm)	0.12	0.27	0.11	0.25	0.23
Turbidity (NTU)	2.8	146	9.4	55.5	102
% Salinity **	0.92	-	-	-	-
DO (ppm)**	12.3	-	-	-	-

Note: * = measured in the lab; ** = measured in the field; - = no sample taken/no analysis done.

Table B-4. Water quality data of Sepulveda Channel @ Ballona Creek storm drain (June '92 - December '92).

Parameter (1)	6/12/92 (2)	7/7/92 (3)	7/27/92 (4)	8/24/92 (5)	9/8/92 (6)	9/29/92 (7)	10/12/92 (8)	11/2/92 (9)	12/10/92 (10)
Sample Type	Grab	Composite	Composite	Composite	Composite	Composite	Composite	Composite	Composite
Alk (mg/L as CaCO ₃)	85	212	160	145	145	170	215	205	245
Hardness (mg/L as CaCO ₃)	1364	1570	250	2100	1434	818	1524	3113	1444
pH*	9	8.5	9	8.8	8.7	9.1	8.6	8.5	8.1
Conductivity (µmho/cm) *	4000	5650	2870	7150	4720	3270	5530	6260	4220
Ammonia (mg/L as NH ₃ -N)	-	0.063	0.0629	0.0675	0.0681	0.0136	0.0162	0.0377	1.4251
Nitrite (mg/L NO ₂ -N)	0.095	0.0989	0.0248	0.2129	0.0605	0.0525	0.1296	0.5093	0.2185
TDS (mg/L)	3246	3548	1846	4657	4071	1931	3721	3827	3267
TSS (mg/L)	15	41	15	12	13	11	5	2	104
VSS (mg/L)	-	19	8	7	7	7	3	2	17
COD (mg/L)	-	62	73	88	73	40	90	63	71
DOC (ppm)	-	16	14	11	16	-	10	69	67
Detergent (ppm as LAS)	-	-	-	1	0.5	0.5	0.75	-	-
uv absorbance (at λ = 254nm)	0.10	0.24	0.10	0.20	0.18	0.18	0.16	0.14	0.25
Turbidity (NTU)	2.3	3.4	5.6	3.1	4.22	2.64	3.35	1.34	39.7
% Salinity **	-	-	1.18	3.17	2.12	2.02	1.85	2.12	1.57
DO (ppm) **	-	13.6	14.8	> 15	> 15	14.9	14.9	> 15	14.5

Note: * = measured in the lab; ** = measured in the field; - = no sample taken/no analysis done.

Table B-5. Water quality data of Centinela Creek @ Inglewood storm drain (July'92 - December'92).

Parameter (1)	7/7/92 (2)	7/27/92 (3)	8/24/92 (4)	9/8/92 (5)	9/29/92 (6)	10/12/92 (7)	11/2/92 (8)	12/10/92 (9)
Sample Type	Composite	Composite	Composite	Composite	-	-	Composite	Composite
Alk (mg/L as CaCO ₃)	184	145	155	155	-	-	145	125
Hardness (mg/L as CaCO ₃)	268	244	276	312	-	-	200	320
pH*	9.2	9.6	9.4	9.1	-	-	9	8.8
Conductivity (µmho/cm)*	1214	1090	1300	1338	-	-	683	915
Ammonia (mg/L as NH ₃ -N)	0.11	0.0434	0.0455	0.0562	-	-	0.0255	0.0412
Nitrite (mg/L NO ₂ -N)	0.0273	0.0221	0.0129	0.0454	-	-	0.0057	0.0149
TDS (mg/L)	743	660	728	900	-	-	390	680
TSS (mg/L)	7	2	7	8	-	-	2	4
VSS (mg/L)	4	-	5	5	-	-	2	2
COD (mg/L)	58	75	66	60	-	-	19	48
DOC (ppm)	17	19	15	12	-	-	-	39
Detergent (ppm as LAS)	-	-	1	1	-	-	-	-
uv absorbance (at λ = 254nm)	0.42	0.33	0.43	0.30	-	-	0.06	0.24
Turbidity (NTU)	4.07	3.9	4.2	4.27	-	-	1.96	4.6
% Salinity **	-	0.70	0.50	0.75	-	-	0.20	0.25
DO (ppm)**	13.6	14.7	> 15	> 15	-	-	12.5	11.3

Note: * = measured in the lab; ** = measured in the field; - = no sample taken/no analysis done.

INTRODUCTION

According to *Standard Methods*, the presence of some metal ions such as Al, Cd, Cu, and Pb can cause interference in the hardness analysis. Indistinct end-point or stoichiometric consumption of EDTA may happen. These interferences may be reduced by adding certain inhibitors. There are three types of Inhibitors suggested by *Standard Methods*, i.e.,

1. Inhibitor I: Sodium cyanide
2. Inhibitor II: Sodium sulfide nonahydrate (Na₂S.9H₂O) or Na₂S.5H₂O
3. Magnesium salt of 1,2-cyclohexanediaminetetraacetic acid (MgCDTA)

Due to the unavailability of MgCDTA, it was decided to test the effect of Inhibitors I and II on the hardness test.

EXPERIMENT I

Sample: Ballona Creek @ Inglewood (sampled on 12/14/92)

Inhibitor: Inhibitors I and II

Hardness Results:

Table C-1. Total hardness results from Experiment 1.

Sample	Without Inhibitors	Inhibitor I	Inhibitor II
(1)	(2)	(3)	(4)
Morning	860	832	619
Afternoon	1750	1700	1180

Note: All values are in mg/L as CaCO₃

Discussion

From Table C-1, total hardness of Ballona Creek samples collected in the morning and afternoon, without addition of either inhibitor, was 860 and 1750 mg/L as CaCO₃, respectively. When Inhibitor I (250 mg/ 50 ml diluted sample) was added into these samples, a slight decrease of the total hardness was observed (~ 3%). With Inhibitor I, the total hardness of the morning sample was 832 mg/L as CaCO₃ whereas the afternoon sample has total hardness of 1700 mg/L as CaCO₃. Different observations were made in the samples with the addition of Inhibitor II. When 1 ml of Inhibitor II solution was added into 50 ml of the diluted samples, a decrease of total hardness to 619 and 1180 mg/L as CaCO₃ was observed for morning and afternoon samples, respectively (~ 28 - 33% decrease). Therefore, it is concluded that significant interfering metal ions (such as Al, Pb, Cu, Cd and Zn) were presence in the Ballona Creek samples, causing false high value of total hardness.

EXPERIMENT 2

Sample: Standard solution of Ca and Mg (mixture)
(Concentration: 108 mg Ca/L and 82 mg Mg/L with a theoretical hardness of 606 mg/L as CaCO₃; 1000 ppm Ca and Mg reference solutions were used to prepare this standard solution)

Inhibitor: None

Hardness results:

Table C-2. Total hardness results from Experiments 2 and 3.

	Ca and Mg standard solution		
	Without interfering ions (1)	With interfering ions (2)	With interfering ions + Inhibitor II (3)
Total hardness (mg/L as CaCO ₃)	625	895	650

EXPERIMENT 3

Sample: Same concentrations of Ca and Mg except with addition of the following ions:
Al ~10 mg/L
Cd ~13 mg/L
Cu ~10 mg/L
Pb ~13 mg/L
Zn ~111 mg/L

Inhibitor: Inhibitor II

Hardness results: See Table C-2

Discussion

Table C-2 shows that total hardness of the standard solution with added interfering ions, without adding Inhibitor II, was 895 mg/L as CaCO₃. By comparing these total hardness results with those obtained from Experiment 2, we can conclude that the presence of these ions increased the consumption of EDTA and gave false high results of total hardness measurement. Another observation was noted during the titration. The sharp end-point of the indicator was absent. The presence of these interfering ions may also cause an indistinct end-point. By adding Inhibitor II before titration these interferences were reduced. Table C-2 shows that total hardness of the standard solution after addition of Inhibitor II decreased from 895 mg/L to 650 mg/L as CaCO₃. Thus it can be concluded that Inhibitor II reduces the interferences caused by the above mentioned metal ions.

Due to the above observation, analysis of total hardness of previous samples from Sepulveda Channel, Ballona Creek and Ashland (with suspected high content of total

hardness) were repeated. The total hardness results without the addition of Inhibitor II were compared with total hardness of those samples analyzed with Inhibitor II. The purpose of this comparison was to determine the presence of any interfering metal ions (such as Al, Cu, Cd, Zn, Pb, etc.). It is important to note that some of these samples may deteriorated due to the long storage period (~ 1-2 months).

EXPERIMENT 4

Sample: Ca and Mg standard solution (no interfering ions)

Inhibitor: Inhibitor II

Results:

Table C-3. Comparison of total Hardness of Ca and Mg standard solution with and without using Inhibitor II.

	Ca and Mg standard solution	
	Without Inhibitor II (1)	With Inhibitor II (2)
Total hardness (mg/L as CaCO ₃)	620	620

Discussion

Table C-3 shows that Inhibitor II does not affect the total hardness results if none of the interfering ions are present in the sample. The total hardness of Ca and Mg standard solution without addition of Inhibitor II is the same as the total hardness of standard solution which has added Inhibitor II.

EXPERIMENT 5

Sample: Previous samples from Sepulveda Channel @ Ballona Creek, Ballona Creek @ Inglewood and Ashland

Note: Almost all of the Sepulveda Channel samples were re-analyzed, except sample taken on 11/2/92 which was unavailable. Only a subset of the Ballona Creek samples (which had total hardness of > 500 mg/L as CaCO₃) were analyzed. Previous results show that three Ashland samples have a total hardness of > 1000 mg/L as CaCO₃. However, only two Ashland samples were analyzed as the sample from 11/2/92 was not stored.

Inhibitor: Inhibitor II

Results: See Tables C-4 (Sepulveda Channel), C-5 (Ballona Creek) and C-6 (Ashland)

Discussion

Tables C-4, C-5 and C-6 show that the total hardness of the stored samples (which were stored for more than 1-2 months) of Ballona Creek and Sepulveda Channel, without addition of the Inhibitor II, are quite similar to those results obtained previously. After addition of Inhibitor II, the total hardness of some samples was reduced, which indicates that some interfering metal ions were present. Almost all the Sepulveda Channel samples (except sample which was taken on 6/12/92) have reduced total hardness (about 20-30% reduction) (Table C-4). For Ballona Creek samples, only half of the samples analyzed were found to have reduced total hardness results with the addition of Inhibitor II (Table C-5). The percentage reduction of these samples is less than those in the Sepulveda Channel samples, i.e., about 10-15% only. This shows that the amount of interfering ions present in the Ballona Creek samples is less than those in the Sepulveda Channel samples.

Unlike Ballona Creek and Sepulveda Channel samples, the total hardness results for stored Ashland samples, without the addition of Inhibitor II, were quite different from those obtained previously. For example, the total hardness of Ashland sample dated 9/29/92 increased from 1286 mg/L to 1670 mg/L as CaCO₃ after the sample was stored for nearly 3 months. This dissimilarity may be due to deterioration of Ashland samples. However, the purpose of this experiment was to determine the presence of interfering ions in the sample that may cause the false results of total hardness test. The results show that interfering ions are present in two Ashland samples as the total hardness was reduced after addition of Inhibitor II (Table C-6).

Table C-4. Total hardness of Sepulveda Channel @ Ballona Creek samples.

Sampling date (1)	Previous analysis (2)	Total hardness (CaCO ₃)	
		Repeated analysis	
		Without Inhibitor II (3)	With Inhibitor II (4)
6/12/92	1364	1370	1350
7/7/92	1570	1440	1090
7/27/92	750	780	690
8/24/92	2100	2080	1390
9/8/92	1434	1340	1015
9/29/92	818	870	795
10/12/92	1524	1490	1150
11/2/92	3113	-	-
12/10/92	1444	1330	1085

Table C-5. Total hardness of Ballona Creek @ Inglewood samples.

Sampling date (1)	Previous analysis (2)	Total hardness (mg/L as CaCO ₃)	
		Repeated analysis	
		Without Inhibitor II (3)	With Inhibitor II (4)
8/24/92	628	600	600
9/8/92	594	650	580
9/29/92	1082	1000	870
11/2/92	720	560	560
12/10/92	808	920	800

Table C-6. Total hardness of Ashland Avenue samples.

Sampling date (1)	Previous analysis (2)	Total hardness (mg/L as CaCO ₃)	
		Repeated analysis	
		Without Inhibitor II (3)	With Inhibitor II (4)
9/29/92	1286	1670	1280
12/10/92	1680	1810	1215

CONCLUSION

It is suspected that interfering ions such as aluminum, cadmium, copper and lead were present in some of the samples collected from Ashland, Ballona Creek and Sepulveda Channel. The total hardness results obtained from samples in the absence of inhibitor sodium sulfide nonahydrate was found to be higher than those samples that had added the inhibitor.

APPENDIX D1
TOXICITY ANALYSIS OF
STORM DRAIN DRY WEATHER FLOW
SAMPLES COLLECTED 8/24 AND 9/28/92

INTRODUCTION

This report summarizes the results of marine toxicity tests conducted on samples of dry weather flow collected from four storm drains in Los Angeles (Ashland, Ballona Creek, Pico-Kenter, and Sepulveda). The intent of these experiments was to determine the concentration of effluent (diluted with seawater) that caused a 50% response in the test organisms (EC50) and also the highest concentration that did not cause a statistically significant level of toxicity (NOEC).

METHODS

Three species were used for toxicity testing. These were giant kelp (*Macrocystis pyrifera*), red abalone (*Haliotis rufescens*), and purple sea urchins (*Strongylocentrotus purpuratus*). Toxicity tests were conducted in accordance with the methods described in the State of California's Ocean Plan wherever possible. The principal deviation from these methods was the degree of replication used. Three instead of the recommended five replicates were tested for each effluent concentration. Replication was reduced in response to the EPA's (Region IX) request to increase the number of concentrations tested.

Storm drain samples were stored under refrigeration in sealed 4 L glass bottles until the day of testing. Tests were initiated within 48 hours of sample collection. Samples were thoroughly mixed before a 2.5 L subsample was removed and filtered through Whatman GF/B glass fiber filters. Samples from two locations (Ashland and Pico-Kenter) were centrifuged (3,200 x g for 10 min) prior to filtration to remove large particulates.

Seawater dilutions of each sample were prepared by adding appropriate amounts of seawater and brine solutions to create the desired concentrations and maintain a salinity of 32-35 mg/g. Concentrations containing 5.6, 10, 18, 32, and 56% storm drain effluent were prepared for each location. Toxicity test organisms were added to each sample within three hours of dilution. The pH of some dilutions of the Ballona and Sepulveda effluents was adjusted by addition of 0.2 N HCl in order to maintain a pH range of 7.9-8.3.

Several dilutions of unfiltered samples were also prepared to examine potential changes in toxicity related to filtration. Only one replicate was prepared for each of these samples. Brine controls (containing the same volumes of brine added to the three highest concentrations of storm drain effluent) were prepared to identify test effects related to the salinity adjustment method.

The dissolved oxygen, pH, and total ammonia content of a subsample of each effluent dilution was measured at the start of the toxicity tests. Measurements were made using electrodes that were calibrated daily. Oxygen and pH measurements were also made at the termination of each 48 hour test. Separate measurements were made on solutions obtained from kelp and abalone test beakers. Temperature within selected test chambers was measured daily with a mercury thermometer during the 48 hour tests. Water temperature

during the sea urchin fertilization test was measured in a test tube placed alongside the rack containing the test samples.

A concurrent reference toxicant test was run for each of the different toxicity tests. Seawater dilutions of copper chloride were used in the sea urchin and kelp reference toxicant tests. Zinc sulfate was the reference toxicant for the abalone test.

RESULTS AND DISCUSSION

Water Quality

Initial water quality measurements indicated that the undiluted samples were of low salinity (Table D1-1). Seawater brine was added during dilution preparation so that most of the diluted samples had a salinity of 34 mg/g (Appendix Tables D1.a-1 and a-4). Insufficient brine was available to fully adjust the Ashland 56% dilution to normal seawater salinity. The final salinity of this sample was 32 mg/l, a level still within the tolerance range of the test organisms.

Initial pH was elevated in the Ballona Creek and Sepulveda samples (Table D1-1). The 32 and 56% dilutions of these samples had unacceptably high pH values as a result. A small amount of HCl was added to these dilutions to reduce the pH and thus minimize toxicity artifacts during the tests.

Dissolved oxygen and ammonia concentrations were also measured on the sample dilutions (Tables D1.a-1 - a-6). Oxygen was within an acceptable range for all dilutions. Ammonia was elevated in dilutions of Ashland effluent only. These ammonia concentrations may have contributed to the toxicity of Ashland effluent to abalone. The measured concentrations of ammonia are not likely to have produced toxic effects on sea urchin sperm or kelp spores.

Kelp and abalone test chamber temperatures were generally within the desired range of 14-16°C (Tables D1.a-2, a-3, a-5, and a-6). Excessive temperatures were measured during the first day of the August 26-28 kelp test. Heat generated from the increased illumination required for this test was responsible for this situation. Temperatures were successfully reduced and stabilized after this situation was discovered. The control and reference toxicant results for this test are within the expected ranges, indicating that the temperature deviation did not seriously affect the test. Temperatures during the August and September sea urchin tests were 15.5 and 14.6°C, respectively.

Sea Urchin Toxicity

Results of sea urchin fertilization toxicity tests are summarized in Tables D1-2 and D1-3. Control fertilization was 89-98%, well within the desired range of 50-100%. Effluent from Ashland, Ballona, and Sepulveda storm drains were toxic to sea urchin sperm. Examination of the NOEC and EC50 statistics (Table D1-4) indicates the relative toxicity of each site. Fertilization was inhibited at concentrations $\geq 5.6\%$ for Ballona and $> 10\%$ for Ashland and Sepulveda.

The EC50 (when available) is the best indicator of relative toxicity; lower EC50 values indicate greater toxicity. Ballona was the most toxic station, with an EC50 of 14%.

Ashland was slightly less toxic and Sepulveda had the lowest toxicity of the three stations producing an effect on sea urchin fertilization. An unusual dose-response pattern was found for the Sepulveda sample (Figure D1-1), an increase in fertilization relative to the value at 18% (instead of a decrease) was measured for the 32% concentration. Consequently, an EC50 could not be calculated for Sepulveda.

Additional treatments (brine controls, unfiltered samples, and egg controls) were tested to determine the impact of various aspects of the testing procedure. Brine controls at the 56% water concentration were toxic to sea urchin sperm. This result was not unexpected, as the sea urchin fertilization tests is very sensitive to most salinity adjustment procedures. Brine toxicity did not influence the results of the tests, however, since storm drain effluent toxicity was found at concentrations much lower than those containing toxic concentrations of brine.

Several dilutions of unfiltered effluent were tested to determine if the filtration step had a substantial effect on toxicity. The Ashland sample caused greater effects on fertilization in the unfiltered state. Results for the filtered and unfiltered samples from the other locations were similar.

Egg controls (no sperm added during test) were incorporated at EPA's request. Results for the egg controls indicate that there was no false fertilization caused by the storm drain samples or the handling of the egg solution.

Abalone Toxicity

Toxicity to red abalone embryos was caused by exposure to effluent from the Ashland and Pico-Kenter locations (Table D1-5). Effluent from Ballona Creek and the Sepulveda Channel did not produce toxicity at the concentrations tested (Table D1-6). Ashland effluent was more toxic than Pico-Kenter effluent, as can be seen from examination of the dose-response plots (Figure D1-1) and NOEC and EC50 statistics (Table D1-4). The lowest concentration of Ashland effluent tested (5.6%) caused significant toxicity to the abalone.

There was no toxicity associated with the use of brine in the abalone toxicity tests. Unfiltered effluent from Pico-Kenter appeared to produce greater toxicity than did similar concentrations of filtrate (Table D1-5). Toxicity results for unfiltered samples from the other locations were similar to those obtained for filtrates.

Kelp Toxicity

Two endpoints were assessed during the kelp spore toxicity tests. Both spore germination percentage and length of the germ tube were significantly reduced by exposure to Ashland effluent (Tables D1-7 and D1-8). The kelp test was the least sensitive of the three toxicity tests, as shown by the relatively high Ashland NOEC and EC50 values.

Exposure of kelp spores to effluent from Pico-Kenter, Ballona, and Sepulveda did not produce any toxicity at the dilutions tested (Tables D1-7 -10). Many of the test concentrations produced germ tube lengths greater than the corresponding reference groups (Figure D1-2). This situation is occasionally encountered in tests where growth is measured. Increased growth in a toxicity test is usually regarded as an overcompensation to a small stress. Another possibility is that germ tube growth was influenced by nutrients present in the storm drain effluents.

Table D1-2. Summary of Purple sea urchin fertilization test 184; conducted August 26, 1992. Abbreviation: % Ref = mean response expressed as a percentage of the appropriate reference group(s); NS = not significantly difference relative to reference; S = statistically significant difference; NT = not tested (no need or data not sufficient).

Group (1)	Description (2)	Reference group (3)	Percent Fertilized				
			Mean (4)	(SD) (5)	Sig. (6)	% Ref. (7)	Raw data (8)
1	Seawater control		89	(8)			98, 83, 87
2	Brine control 18%	1	86	(4)	NS	97	85, 80, 89, 90
3	Brine control 32%	1	81	(5)	NS	90	75, 78, 86, 84
4	Brine control 56%	1	42	(5)	S	47	42, 45, 35, 47
5	Pico-Kenter filtrate 5.6%	1-3	88	(3)	NS	104	91, 88, 86
6	Pico-Kenter filtrate 10%	1-3	88	(6)	NS	104	82, 90, 93
7	Pico-Kenter filtrate 18%	1-3	88	(5)	NS	104	88, 92, 83
8	Pico-Kenter filtrate 32%	1-3	84	(2)	NS	99	84, 82, 86
9	Pico-Kenter filtrate 56%	4	71	(1)	NT	170	71, 71, 72
10	Pico-Kenter 10% (unfilt.)	1-3	92		NT	108	92
11	Pico-Kenter 18% (unfilt.)	1-3	79		NT	93	79
12	Pico-Kenter 32% (unfilt.)	1-3	82		NT	97	82
13	Ashland filtrate 5.6%	1-3	88	(6)	NS	104	95, 83, 87
14	Ashland filtrate 10%	1-3	82	(4)	NS	97	80, 80, 87
15	Ashland filtrate 18%	1-3	38	(11)	S	45	28, 37, 50
16	Ashland filtrate 32%	1-3	0	(0)	S	0	0, 0, 0
17	Ashland filtrate 56%	4	0	(0)	NT	0	0, 0, 1
18	Ashland 10% (unfilt.)	1-3	1		NT	1	1
19	Ashland 18% (unfilt.)	1-3	0		NT	0	0
20	Egg control (Seawater)	1-3	0		NT	0	0
21	Egg control (brine 32%)	1-3	0		NT	0	0
22	Egg control (Pico 5.6%)	1-3	0		NT	0	0
23	Egg control (Pico 18%)	1-3	0		NT	0	0
24	Egg control (Pico 56%)	4	0		NT	0	0
25	Egg control (Ashland 5.6%)	1-3	0		NT	0	0
26	Egg control (Ashland 18%)	1-3	0		NT	0	0
27	Egg control (Ashland 56%)	4	0		NT	0	0

Table D1-3. Summary of Purple Sea Urchin fertilization test 186; Conducted September 9, 1992. Abbreviations as for Table D1-2.

Group (1)	Description (2)	Reference group (3)	Percent Fertilized				
			Mean (4)	(SD) (5)	Sig. (6)	% Ref. (7)	Raw data (8)
1	Seawater control		98	(1)			99, 98, 97
2	Brine control 18%	1	96	(2)	NS	98	94, 94, 96, 99
3	Brine control 32%	1	93	(6)	NS	95	96, 94, 86, 98
4	Brine control 56%	1	73	(6)	S	75	70, 72, 70, 82
5	Ballona filtrate 5.6%	1-3	82	(6)	S	86	83, 88, 76
6	Ballona filtrate 10%	1-3	77	(0)	S	80	76, 77, 76
7	Ballona filtrate 18%	1-3	28	(5)	S	29	25, 33, 25
8	Ballona filtrate 32%	1-3	13	(10)	S	14	6, 9, 24
9	Ballona filtrate 56%	4	2	(2)	NT	2	1, 0, 4
10	Ballona 10% (unfilt.)	1-3	96		NT	101	96
11	Ballona 18% (unfilt.)	1-3	38		NT	40	38
12	Ballona 32% (unfilt.)	1-3	58		NT	61	58
13	Sepulveda filtrate 5.6%	1-3	90	(4)	NS	94	94, 86, 87
14	Sepulveda filtrate 10%	1-3	95	(3)	NS	100	92, 97, 96
15	Sepulveda filtrate 18%	1-3	42	(15)	S	43	59, 32, 34
16	Sepulveda filtrate 32%	1-3	63	(7)	S	66	59, 72, 58
17	Sepulveda filtrate 56%	1-3	19	(8)	NT	26	10, 26, 21
18	Sepulveda 10% (unfilt.)	1-3	64		NT	65	64
19	Sepulveda 18% (unfilt.)	1-3	40		NT	41	40
20	Sepulveda 32% (unfilt.)	1-3	85		NT	87	85
21	Egg control (seawater)	1-3	0		NT	0	0
22	Egg control (brine 18%)	1-3	0		NT	0	0
23	Egg control (Ballona 18%)	1-3	0		NT	0	0
24	Egg control (Ballona 56%)	4	0		NT	0	0
25	Egg control (Sepulveda 5.6%)	1-3	0		NT	0	0
26	Egg control (Sepulveda 18%)	4	0		NT	0	0

Table D1-4. Summary of storm drain effluent NOEC and EC50 values for marine test species. Values are expressed in percent effluent.

Location (1)	Sampling Date (2)	NOEC				EC50			
		Abalone Develop. (3)	Kelp		Urchin Fert. (6)	Abalone Develop (7)	Kelp		Urchin Fert. (10)
			Germ. (4)	Length (5)			Germ. (8)	Length (9)	
Ashland	8-24-92	<5.6	18	18	10	6.8	32	> 56	17
Ballona	9-8-92	>56	>56	>56	<5.6	> 56	> 56	> 56	14
Pico-Kenter	8-24-92	18	>56	>56	>56	42	> 56	> 56	> 56
Sepulveda	9-8-92	>56	>56	>56	10	> 56	> 56	> 56	nt ^a

^aData not amenable to testing for EC50.

Table D1-5. Summary of 48 hour red abalone larval development test H-2; Conducted August 26, 1992. Abbreviations as for Table D1-2.

Group (1)	Description (2)	Reference group (3)	Percent normal development				
			Mean (4)	(SD) (5)	Sig. (6)	% Ref. (7)	Raw Data (8)
1	Seawater control	1	93	(6)			97, 89, 10 ^a
2	Brine control 18%	1	83	(6)	NS	98	91, 82, 79
3	Brine control 32%	1	84	(6)	NS	99	86, 89, 76
4	Brine control 56%	1	85	(8)	NS	99	75, 89, 90
5	Pico-Kenter filtrate 5.6%	1-4	85	(9)	NS	99	93, 75, 86
6	Pico-Kenter filtrate 10%	1-4	84	(5)	NS	98	79, 83, 86
7	Pico-Kenter filtrate 18%	1-4	91	(5)	NS	106	92, 94, 85
8	Pico-Kenter filtrate 32%	1-4	73	(9)	S	86	72, 65, 82
9	Pico-Kenter filtrate 56%	1-4	13	(8)	S	15	13, 5, 21
10	Pico-Kenter 10% (unfilt.)	1-4	79		NT	93	79
11	Pico-Kenter 18% (unfilt.)	1-4	77		NT	90	77
12	Pico-Kenter 32% (unfilt.)	1-4	29		NT	34	29
13	Ashland filtrate 5.6%	1-4	69	(2)	S	81	71, 68, 68
14	Ashland filtrate 10%	1-4	3	(2)	S	4	2, 6, 2
15	Ashland filtrate 18%	1-4	0	(0)	NT	0	0, 0, 0
16	Ashland filtrate 32%	1-4	0	(0)	NT	0	0, 0, 0
17	Ashland filtrate 56%	1-4	0	(0)	NT	0	0, 1, 0
18	Ashland 10% (unfilt.)	1-4	0		NT	0	0
19	Ashland 18% (unfilt.)	1-4	0		NT	0	0
20	Ashland 32% (unfilt.)	1-4	0		NT	0	0

^a Outlier value was not included in statistical calculations.

Table D1-6. Summary of 48 hour red abalone larval development test H-4; Conducted September 9, 1992. Abbreviations as for Table D1-2.

Group (1)	Description (2)	Reference group (3)	Percent normal development				
			Mean (4)	(SD) (5)	Sig. (6)	% Ref. (7)	Raw data (8)
1	Seawater control		97	(1)			97, 96, 98
2	Brine control 18%	1	98	(1)	NS	101	98, 99, 97, 98
3	Brine control 32%	1	96	(0)	NS	99	96, 96, 95, 96
4	Brine control 56%	1	97	(2)	NS	100	97, 96, 95, 100
5	Ballona filtrate 5.6%	1-4	96	(4)	NT	99	99, 96, 92
6	Ballona filtrate 10%	1-4	98	(1)	NT	101	98, 97, 98
7	Ballona filtrate 18%	1-4	97	(1)	NT	100	98, 97, 97
8	Ballona filtrate 32%	1-4	97	(1)	NT	100	96, 98, 97
9	Ballona filtrate 56%	1-4	96	(2)	NT	99	97, 94, 97
10	Ballona 10% (unfilt.)	1-4	96		NT	99	96
11	Ballona 18% (unfilt.)	1-4	99		NT	102	99
12	Ballona 32% (unfilt.)	1-4	98		NT	101	98
13	Sepulveda filtrate 5.6%	1-4	97	(1)	NT	100	96, 97, 97
14	Sepulveda filtrate 10%	1-4	96	(1)	NT	99	95, 96, 98
15	Sepulveda filtrate 18%	1-4	97	(2)	NT	100	95, 98, 97
16	Sepulveda filtrate 32%	1-4	97	(2)	NT	100	97, 95, 98
17	Sepulveda filtrate 56%	1-4	98	(1)	NT	101	98, 99, 98
18	Sepulveda 10% (unfilt.)	1-4	99		NT	102	99
19	Sepulveda 18% (unfilt.)	1-4	94		NT	97	94
20	Sepulveda 32% (unfilt.)	1-4	96		NT	99	96

Table D1-7. Summary of kelp spore germination endpoint for test M-3; Conducted August 26, 1992. Abbreviations as for Table D1-2.

Group (1)	Description (2)	Reference group (3)	Percent germinated				
			Mean (4)	(SD) (5)	Sig. (6)	% Ref. (7)	Raw data (8)
1	Seawater control		86	(1)			88, 85, 86
2	Brine control 18%	1	86	(4)	NT	100	86, 90, 88, 81
3	Brine control 32%	1	92	(4)	NT	106	94, 94, 93, 86
4	Brine control 56%	1	93	(2)	NT	108	92, 95, 93
5	Pico-Kenter filtrate 5.6%	1-4	90	(5)	NT	101	85, 95, 90
6	Pico-Kenter filtrate 10%	1-4	89	(4)	NT	100	87, 87, 93
7	Pico-Kenter filtrate 18%	1-4	91	(2)	NT	101	92, 91, 89
8	Pico-Kenter filtrate 32%	1-4	94	(4)	NT	105	94, 89, 97
9	Pico-Kenter filtrate 56%	1-4	90	(6)	NT	101	94, 84, 93
10	Pico-Kenter 10% (unfilt.)	1-4	91		NT	102	91
11	Pico-Kenter 18% (unfilt.)	1-4	85		NT	95	85
12	Pico-Kenter 32% (unfilt.)	1-4	76		NT	85	76
13	Ashland filtrate 5.6%	1-4	93	(2)	NS	104	91, 94, 93
14	Ashland filtrate 10%	1-4	91	(4)	NS	102	95, 89, 89
15	Ashland filtrate 18%	1-4	85	(1)	NS	95	85, 84, 86
16	Ashland filtrate 32%	1-4	48	(6)	S	53	49, 41, 52
17	Ashland filtrate 56%	1-4	3	(2)	S	3	4, 4, 0
18	Ashland 10% (unfilt.)	1-4	ND ^a				
19	Ashland 18% (unfilt.)	1-4	ND ^a				

^a Slide was unreadable due to particulates in sample.

Table D1-8. Summary of Kelp spore germ tube length endpoint for test M-3; Conducted August 26, 1992. Abbreviations as for Table D1-2.

Group (1)	Description (2)	Reference group (3)	Percent germinated				
			Mean (4)	(SD) (5)	Sig. (6)	% Ref. (7)	Raw data (8)
1	Seawater control		15	(2)			13, 17, 16
2	Brine control 18%	1	12	(0)	S	80	12, 12, 13, 12
3	Brine control 32%	1	13	(1)	NS	87	12, 14, 14, 12
4	Brine control 56%	1	14	(2)	NS	93	13, 12, 16
5	Pico-Kenter filtrate 5.6%	1,3,4	15	(1)	NT	107	14, 16, 14
6	Pico-Kenter filtrate 10%	1,3,4	14	(1)	NT	100	15, 13, 14
7	Pico-Kenter filtrate 18%	2	15	(3)	NT	125	17, 12, 15
8	Pico-Kenter filtrate 32%	1,3,4	13	(2)	NT	93	15, 13, 11
9	Pico-Kenter filtrate 56%	1,3,4	14	(2)	NT	100	13, 16, 14
10	Pico-Kenter 10% (unfilt.)	1,3,4	12		NT	86	12
11	Pico-Kenter 18% (unfilt.)	2	16		NT	133	16
12	Pico-Kenter 32% (unfilt.)	1,3,4	16		NT	114	16
13	Ashland filtrate 5.6%	1,3,4	18	(1)	NS	129	18, 17, 19
14	Ashland filtrate 10%	1,3,4	17	(1)	NS	121	17, 18, 16
15	Ashland filtrate 18%	2	14	(1)	NT	117	13, 16, 13
16	Ashland filtrate 32%	1,3,4	10	(2)	S	71	8, 11, 12
17	Ashland filtrate 56%	1,3,4	10	(1)	S	71	11, 8, 10
18	Ashland 10% (unfilt.)	1,3,4	ND ^a				
19	Ashland 18% (unfilt.)	2	ND ^a				

^a Slide was unreadable due to particulates in sample.

Table D1-9. Summary of Kelp spore germination endpoint for test M-5; Conducted September 9, 1992. Abbreviations as for Table D1-2.

Group (1)	Description (2)	Reference group (3)	Percent germinated				Raw data (8)
			Mean (4)	(SD) (5)	Sig. (6)	% Ref. (7)	
1	Seawater control		78	(5)			79, 82, 73
2	Brine control 18%	1	67	(9)	S	86	73, 58, 63, 75
3	Brine control 32%	1	75	(4)	NS	96	81, 74, 71, 76
4	Brine control 56%	1	78	(4)	NS	100	82, 77, 79, 73
5	Ballona filtrate 5.6%	1,3,4	75	(12)	NT	98	61, 85, 80
6	Ballona filtrate 10%	1,3,4	79	(7)	NT	103	85, 71, 81
7	Ballona filtrate 18%	2	75	(7)	NT	112	82, 76, 68
8	Ballona filtrate 32%	1,3,4	78	(1)	NT	101	78, 77, 80
9	Ballona filtrate 56%	1,3,4	78	(1)	NT	101	79, 77, 77
10	Ballona 10% (unfilt.)	1,3,4	78		NT	101	78
11	Ballona 18% (unfilt.)	2	79		NT	118	79
12	Ballona 32% (unfilt.)	1,3,4	74		NT	96	74
13	Sepulveda filtrate 5.6%	1,3,4	67	(7)	NT	86	66, 73, 60
14	Sepulveda filtrate 10%	1,3,4	70	(3)	NT	91	68, 73, 69
15	Sepulveda filtrate 18%	2	78	(8)	NT	116	78, 71, 86
16	Sepulveda filtrate 32%	1,3,4	82	(11)	NT	106	86, 91, 69
17	Sepulveda filtrate 56%	1,3,4	76	(5)	NT	99	72, 75, 83
18	Sepulveda 10% (unfilt.)	1,3,4	69		NT	90	69
19	Sepulveda 18% (unfilt.)	2	70		NT	91	70
20	Sepulveda 32% (unfilt.)	1,3,4	69		NT	90	69

Table D1-10. Summary of Kelp spore germ tube length endpoint for test M-5; Conducted September 9, 1992. Abbreviations as for Table D1-2.

Group (1)	Description (2)	Reference group (3)	Percent germinated				Raw data (8)
			Mean (4)	SD (5)	Sig. (6)	% Ref. (7)	
1	Seawater control		15	2			15, 17, 14
2	Brine control 18%	1	15	0	NT	100	15, 15, 14, 15
3	Brine control 32%	1	15	0	NT	100	15, 15, 14, 15
4	Brine control 56%	1	16	3	NT	107	19, 12, 15, 16
5	Ballona filtrate 5.6%	1,3,4	17	2	NT	113	16, 16, 19
6	Ballona filtrate 10%	1,3,4	18	1	NT	120	19, 17, 19
7	Ballona filtrate 18%	2	18	1	NT	120	18, 18, 19
8	Ballona filtrate 32%	1,3,4	17	1	NT	113	17, 17, 18
9	Ballona filtrate 56%	1,3,4	15	1	NT	100	14, 14, 16
10	Ballona 10% (unfilt.)	1,3,4	18		NT	120	18
11	Ballona 18% (unfilt.)	2	16		NT	107	16
12	Ballona 32% (unfilt.)	1,3,4	18		NT	120	18
13	Sepulveda filtrate 5.6%	1,3,4	16	1	NT	107	16, 17, 15
14	Sepulveda filtrate 10%	1,3,4	17	1	NT	113	16, 18, 16
15	Sepulveda filtrate 18%	2	16	2	NT	107	15, 15, 19
16	Sepulveda filtrate 32%	1,3,4	16	2	NT	107	19, 15, 15
17	Sepulveda filtrate 56%	1,3,4	17	2	NT	113	18, 18, 15
18	Sepulveda 10% (unfilt.)	1,3,4	17		NT	113	17
19	Sepulveda 18% (unfilt.)	2	15		NT	100	15
20	Sepulveda 32% (unfilt.)	1,3,4	17		NT	113	17

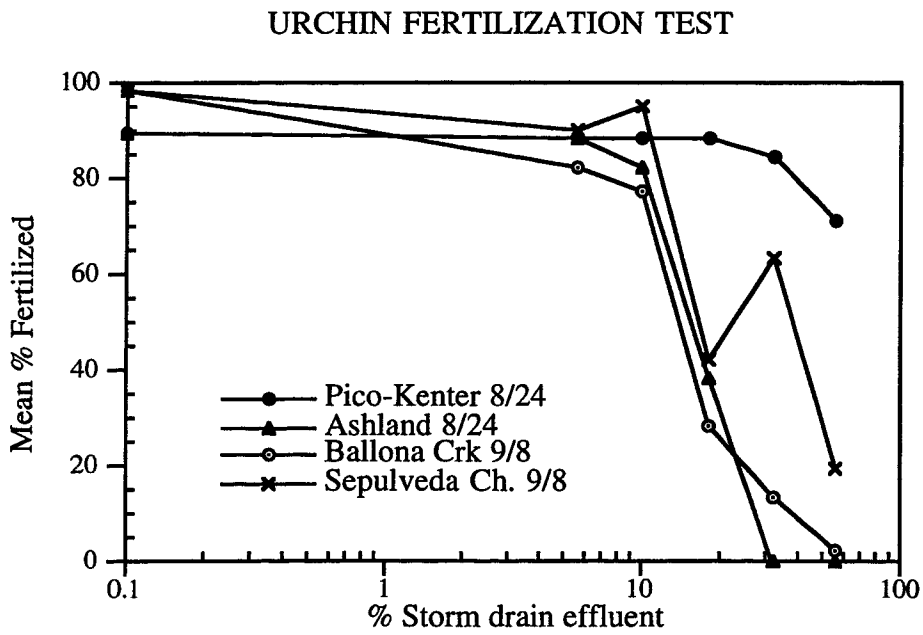
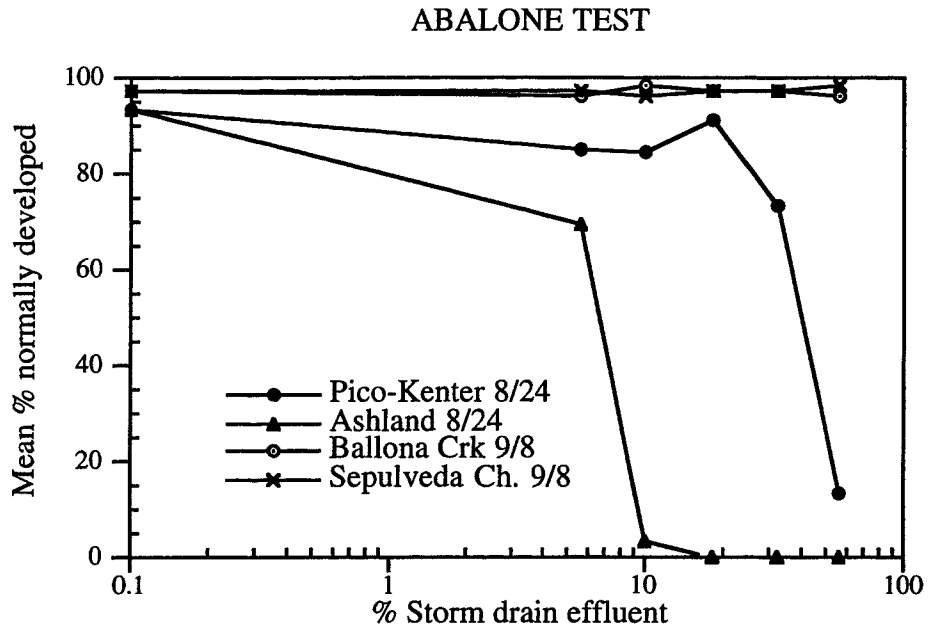


Figure D1-1. Dose-response plots for abalone embryo development and sea urchin fertilization tests. Control values are those plotted at a concentration of 0.1%.

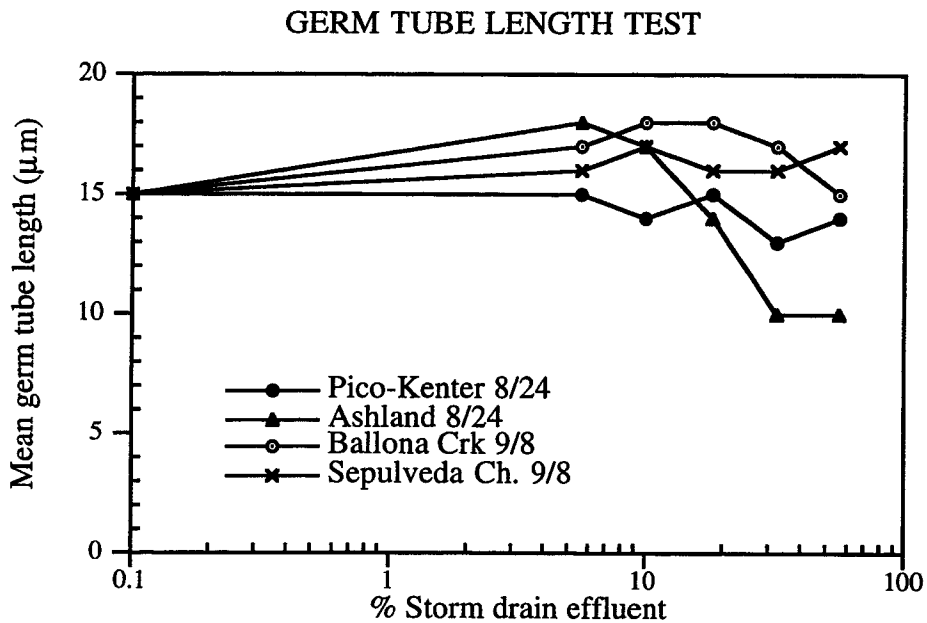
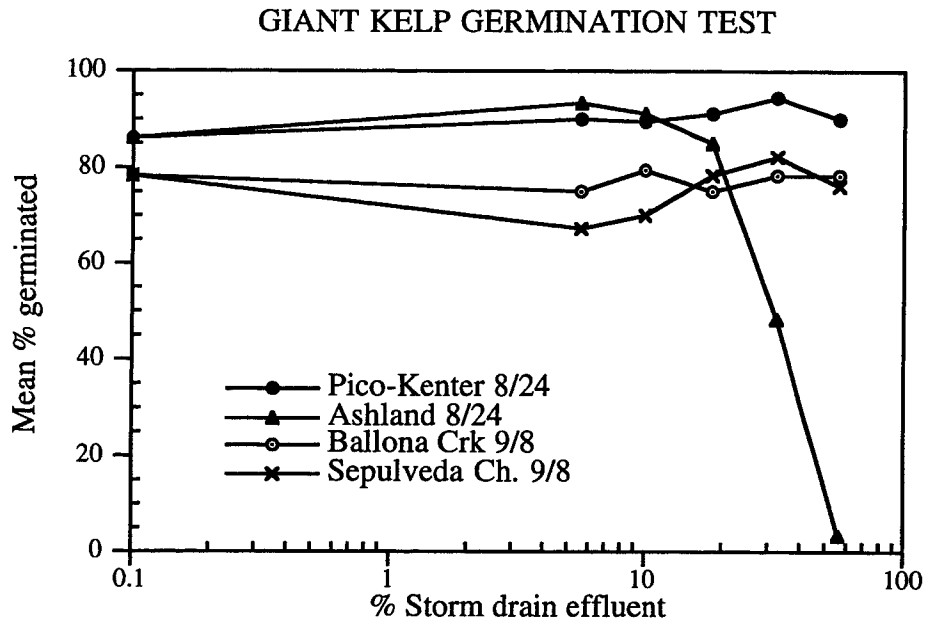


Figure D1-2. Dose-response plots for giant kelp germination and germ tube length tests. Control values are those plotted at a concentration of 0.1%.

APPENDIX D1.a
TOXICITY TEST WATER QUALITY DATA

Table D1.a-1. Summary of initial water quality data for toxicity tests conducted August 26-28, 1992 (tests S184, H2, M3). DO = dissolved oxygen.

Description	DO mg/L	Ammonia mg/L	pH	Salinity mg/g
(1)	(2)	(3)	(4)	(5)
Seawater control	7.8	0.04	7.90	34
Brine control 18%			8.26	34
Brine control 32%			8.26	34
Brine control 56%			8.22	34
Pico-Kenter filtrate 5.6%	8.4	0.03	8.23	34
Pico-Kenter filtrate 10%	8.4	0.03	8.22	34
Pico-Kenter filtrate 18%	8.4	0.03	8.18	34
Pico-Kenter filtrate 32%	8.4	0.04	8.14	34
Pico-Kenter filtrate 56%	8.0	0.05	8.11	35
Ashland filtrate 5.6%	7.8	0.10	8.23	34
Ashland filtrate 10%	7.6	0.13	8.21	34
Ashland filtrate 18%	7.8	0.25	8.17	34
Ashland filtrate 32%	7.8	0.46	8.11	34
Ashland filtrate 56%	7.9	0.91	8.06	32

Table D1.a-2. Summary of final water quality and temperature data for abalone toxicity test H2, conducted August 26-28, 1992. DO = dissolved oxygen.

Description (1)	DO mg/L (2)	pH (3)	Salinity mg/g (4)	Temperature		
				Day 0 (5)	Day 1 (6)	Day 2 (7)
Seawater control	7.2	7.87	35	16.2	15.9	15.5
Brine control 18%	7.3	7.90	34	16.3	16.1	15.5
Brine control 32%	7.2	7.87	34	16.3	16.1	15.4
Brine control 56%	7.2	7.86	34	15.9	16.1	15.5
Pico-Kenter filtrate 5.6%	7.6	7.92	34	16.0	16.0	15.7
Pico-Kenter filtrate 10%	7.5	7.94	35	15.9	16.0	15.8
Pico-Kenter filtrate 18%	7.5	7.96	35	16.0	16.0	15.4
Pico-Kenter filtrate 32%	7.4	8.00	35	16.0	16.0	15.5
Pico-Kenter filtrate 56%	7.3	8.03	35	16.1	16.1	15.5
Ashland filtrate 5.6%	7.6	7.95	34	16.2	16.1	15.5
Ashland filtrate 10%	7.5	8.00	34	15.9	15.9	15.3
Ashland filtrate 18%	7.2	8.00	34	16.1	16.0	15.4
Ashland filtrate 32%	7.0	8.03	35	15.9	16.1	15.7
Ashland filtrate 56%	6.9	8.08	32	16.1	16.2	15.5

Table D1.a-3. Summary of final water quality and temperature data for kelp toxicity test M3, conducted August 26-28, 1992. DO = dissolved oxygen.

Description (1)	DO	pH (3)	Salinity	Temperature		
	mg/L (2)		mg/g (4)	Day 0 (5)	Day 1 (6)	Day 2 (7)
Seawater control	7.6	8.00	34	15.9	16.2	15.9
Brine control 18%	7.8	8.03	34	14.9	16.5	16.0
Brine control 32%	7.5	7.99	34	15.3	16.6	15.9
Brine control 56%	7.8	8.00	34	15.3	16.6	15.8
Pico-Kenter filtrate 5.6%	7.6	8.03	34	15.4	16.6	15.9
Pico-Kenter filtrate 10%	7.6	8.03	34	15.2	16.4	15.9
Pico-Kenter filtrate 18%	7.5	8.03	35	15.7	17.0	15.9
Pico-Kenter filtrate 32%	7.5	8.05	34	15.8	17.0	15.9
Pico-Kenter filtrate 56%	7.6	8.08	34	15.4	16.6	15.9
Ashland filtrate 5.6%	7.7	8.04	35	14.9	16.7	15.9
Ashland filtrate 10%	7.6	8.05	34	15.2	17.1	16.0
Ashland filtrate 18%	7.5	8.06	34	14.9	16.4	16.0
Ashland filtrate 32%	7.4	8.09	34	15.5	16.3	15.9
Ashland filtrate 56%	7.1	8.12	31	14.8	16.4	16.0

Table D1.a-4. Summary of initial water quality data for toxicity tests conducted September 9-11, 1992 (tests S186, H4, M5).

Description	DO mg/L	Ammonia mg/L	pH	Salinity mg/g
(1)	(2)	(3)	(4)	(5)
Seawater control	7.4	0.03	8.06	34
Brine control 18%	7.4		8.17	33
Brine control 32%	7.5		8.19	34
Brine control 56%	7.3		8.20	32
Ballona filtrate 5.6%	7.6	0.02	8.21	34
Ballona filtrate 10%	7.6	0.02	8.25	34
Ballona filtrate 18%	7.6	0.02	8.31	34
Ballona filtrate 32%	7.8	0.02	8.24 ^a	34
Ballona filtrate 56%	7.7	0.02	8.23 ^a	34
Sepulveda filtrate 5.6%	7.9	0.02	8.19	34
Sepulveda filtrate 10%	7.9	0.02	8.25	34
Sepulveda filtrate 18%	7.9	0.02	8.31	34
Sepulveda filtrate 32%	7.7	0.02	8.23 ^a	34
Sepulveda filtrate 56%	7.7	0.02	8.23 ^a	34

^a Value after pH adjustment.

Table D1.a-5. Summary of final water quality and temperature data for abalone toxicity test H4, conducted September 9-11, 1992. DO = dissolved oxygen.

Description (1)	DO mg/L (2)	pH (3)	Salinity mg/g (4)	Temperature		
				Day 0 (5)	Day 1 (6)	Day 2 (7)
Seawater control	6.8	8.07	34	14.9	14.8	14.7
Brine control 18%	6.8	8.06	34	14.8	14.9	14.6
Brine control 32%	6.8	8.06	34	14.8	14.9	14.5
Brine control 56%	6.8	8.08	33	14.8	14.9	14.5
Ballona filtrate 5.6%	6.8	8.11	34	15.0	15.0	14.5
Ballona filtrate 10%	6.8	8.14	34	14.7	14.8	14.7
Ballona filtrate 18%	6.6	8.19	34	14.8	14.9	14.5
Ballona filtrate 32%	6.6	8.20	34	14.9	14.9	14.7
Ballona filtrate 56%	6.5	8.24	34	14.8	14.8	14.5
Sepulveda filtrate 5.6%	6.8	8.09	34	14.8	14.9	14.6
Sepulveda filtrate 10%	6.9	8.12	34	14.8	15.0	14.8
Sepulveda filtrate 18%	6.7	8.16	34	14.9	14.8	14.5
Sepulveda filtrate 32%	6.8	8.15	34	14.7	15.0	14.0
Sepulveda filtrate 56%	6.6	8.19	34	14.8	14.9	14.6

Table D1.a-6. Summary of final water quality and temperature data for kelp toxicity test M5, conducted September 9-11, 1992. DO = dissolved oxygen.

Description (1)	DO mg/L (2)	pH (3)	Salinity mg/g (4)	Temperature		
				Day 0 (5)	Day 1 (6)	Day 2 (7)
Seawater control	7.2	8.15	34	16.0	16.0	15.6
Brine control 18%	7.3	8.13	34	16.3	15.9	15.5
Brine control 32%	7.4	8.14	34	16.1	16.1	15.7
Brine control 56%	7.3	8.14	33	15.9	16.0	15.4
Ballona filtrate 5.6%	7.2	8.18	35	16.0	16.0	15.6
Ballona filtrate 10%	7.3	8.20	34	16.1	16.0	15.5
Ballona filtrate 18%	7.2	8.25	34	16.0	16.0	15.5
Ballona filtrate 32%	7.2	8.26	34	16.1	16.0	15.5
Ballona filtrate 56%	7.2	8.30	34	16.2	16.0	15.5
Sepulveda filtrate 5.6%	7.2	8.16	34	15.9	15.9	15.6
Sepulveda filtrate 10%	7.2	8.20	34	15.9	16.0	15.5
Sepulveda filtrate 18%	7.4	8.23	35	15.8	16.0	15.5
Sepulveda filtrate 32%	7.3	8.22	34	16.3	15.9	15.5
Sepulveda filtrate 56%	7.1	8.24	34	16.1	16.1	15.5

**APPENDIX D2
TOXICITY ANALYSIS OF
STORM DRAIN DRY WEATHER FLOW
SAMPLES COLLECTED 9/29 AND 10/12/92**

INTRODUCTION

This report summarizes the results of marine toxicity tests conducted on two samples of dry weather flow collected from three storm drains in Los Angeles (Ashland, Ballona Creek, and Pico-Kenter). These tests were a continuation of work initiated in August, 1992. The objective of the tests described in this report was to collect additional toxicity data for use in determining the most toxic location and relative sensitivity of the test species used. Reference toxicant results for all tests conducted to date are also summarized in this report.

METHODS

Storm drain dry weather flow samples were collected on September 29 and October 12, 1992. Basic test methods were essentially the same as described in the previous report dated September 29, 1992. The number of dilutions tested was reduced to four (instead of five) and the concentrations used previously (5.6, 10, 18, 32, and 56%) were changed. Concentrations containing 5.6, 12, 25, and 56% storm drain effluent were prepared for each location.

Toxicity tests of samples collected September 29, 1992 were initiated on two successive days. Filtrate prepared on the first day (abalone and kelp tests) was stored at 5°C and used to prepare fresh effluent dilutions for the second day's work (sea urchin test). All three toxicity tests of the October 12, 1992 samples were initiated on the same day. Toxicity tests were initiated within 48 hours of sample collection in all cases.

Abalone and kelp toxicity tests of the September 29 sample were judged unacceptable because of poor control performance. Consequently, only limited water quality and microscopic analyses of these tests were performed. NOEC and EC50 values were not calculated for these data. An additional set of kelp and abalone toxicity tests was conducted on the October 12 sample in order to complete the initial phase of the project.

RESULTS AND DISCUSSION

Water Quality

The initial pH of undiluted Ballona Creek effluent was high (Table D2-1) and similar in value to the first sample tested. The pH values for the 56% Ballona test concentrations were unacceptably high (> 8.3) and were adjusted with dilute HCl before use (Appendix Tables D2.a-1 and a-2). The pH of samples from Ashland and Pico-Kenter were lower (Table 1) and did not produce unacceptable values once diluted with seawater.

Salinity of Ballona and Pico-Kenter effluents were low (Table D2-1) and similar to the values measured previously. The salinity of Ashland effluent was elevated on both

sampling occasions, probably because of tidal seawater intrusion. Adjustments made during the preparation of effluent dilutions eliminated salinity variations in the test solutions (Tables D2.a-1 and a-2).

All experiments except the October 1 sea urchin fertilization test were conducted at temperatures of 14-15°C. The exposure temperature for the October 1 sea urchin test was 11.8°C. Temperature during the October 13 sea urchin experiment was 14.5°C. Fluctuations in temperature were well within the tolerance range of the test species and were not likely to cause undesirable levels of stress. Concurrent reference toxicant test data indicate that the test sensitivity did not vary greatly as a result of this temperature difference. Other water quality measurements of test solutions at the beginning and end of the toxicity tests indicated that acceptable conditions were present during all of the tests (Tables D2.a-1 - a-4).

Relative Toxicity

Effluent from the Ashland storm drain had the greatest relative toxicity on both sampling occasions (Table D2-2). EC50s for this location ranged from 10% (abalone) to 22% (kelp). Ballona Creek effluent was least toxic of the three sites. No toxicity was found in the October sample and relatively minor toxicity was measured in the September 29 Ballona Creek sample. Pico-Kenter effluent from September 29 was not toxic to sea urchins (only test completed). The October sample produced intermediate toxic responses in all three test species, with EC50s ranging from 21% (abalone) to >56% (kelp).

Sea urchin toxicity

The sea urchin test was the only test conducted on the 9/29 sample that had acceptable control performance. A small reduction in fertilization was measured in one of the brine controls (56%, Table D2-3). Effluent from the Ashland drain was most toxic, producing reduced fertilization at concentrations of 12% and above. No toxicity was produced by exposure to Pico-Kenter effluent. An unusual dose-response pattern was obtained for the Ballona Creek sample. Significant toxicity was measured at a concentration of 25%, but not at 56%. The reason for this occurrence is not known, although it may be the result of an interaction between the effluent and the brine solution used to adjust salinity.

Fertilization test results for the 10/12 samples indicated toxicity for Ashland and Pico-Kenter only (Figure D2-1). Seawater and brine control results were within the desired range (Table D2-4). No fertilization was observed in any of the test samples exposed to Ashland effluent. Consequently, there was no need to conduct statistical tests on these data.

Abalone toxicity

Poor quality gametes were used in the abalone toxicity test of the 9/29 samples, resulting in poor control embryo development (Table D2-5). A few samples from this experiment were examined in order to estimate the relative toxicity of the samples. These data indicated that Ashland was toxic at 12%, some toxicity was present at Pico-Kenter, and no toxicity was evident at Ballona Creek (Figure D2-1). The accuracy of these results is uncertain because of the poor control results and limited number of samples examined.

Much better control results were obtained in the toxicity test of the 10/12 samples (Table D2-6). Control survival (68%) was still below the acceptable limit of 85% used for compliance monitoring purposes. Poor embryo development was also observed in the brine control for the 56% concentration. It was not felt that the low control survival would eliminate the usefulness of this test and all samples were therefore examined. This decision was supported by the reference toxicant test results, which indicated that the sensitivity of this test was within acceptable limits. Abalone embryo toxicity was produced by the Ashland and Pico-Kenter samples, but not Ballona Creek. This is similar to the pattern suggested by the aborted test of the 9/29 samples. Ashland was most toxic, with significant embryo deformities caused by exposure to 12% effluent.

Kelp toxicity

Spore germination in controls for the toxicity test of the 9/29 samples was very low and indicated that the test results could be unreliable. Control germ tube length measurements were within normal limits, however, and a limited number of samples were measured to estimate the relative toxicity of each site (Table D2-7). No indication of substantial toxic effects on germ tube length was found for any of the storm drain sites. Even Ashland, typically the most toxic site, produced only a slight reduction in length (Figure D2-2).

Control germination and tube length during the test of the 10/12 samples were higher and within acceptable limits. Germination was only reduced by Ashland effluent concentrations of 12% and above (Table D2-8). Reductions in germ tube length were produced by the brine, 12% and greater concentrations of Ashland effluent, and 56% Pico-Kenter effluent (Table D2-9). The dose response plots for these samples were typical in appearance (Figure D2-3).

Reference toxicant results

An important part of the QA/QC effort for this project was the testing of a concurrent reference toxicant dilution series for each species and sample investigated. The reference toxicant results are intended to document the relative sensitivity of the test species between experiments. Results for all of the reference toxicant tests are summarized in this report (raw data is available upon request). Corresponding storm drain effluent toxicity test data for the first sampling period (8/24 & 9/8) are described in the previous report dated 9/29/92.

Zinc was the reference toxicant used for the abalone toxicity tests. Reference toxicant results (NOEC) for experiments conducted on 8/26, 9/9, and 10/13 were all within limits stated in the test procedure .

Copper was used as the reference toxicant in the kelp toxicity tests. Experiments conducted on 9/9 and 10/13 were within the desired range, but the NOEC for the 8/26 test was above the acceptable limit. These results indicate that the 8/26 kelp test of Ashland and Pico-Kenter samples may have been less sensitive than subsequent experiments. It should be emphasized that there is no guarantee that the reference toxicant results bear any relation to variations in the actual sensitivity of kelp spores to storm drain effluents. The measured toxicity to kelp of Ashland and Pico-Kenter samples tested on 8/26 and 10/13 was very similar, suggesting that the 8/26 data are of acceptable accuracy.

Sea urchin fertilization reference toxicant tests also used copper. Results for this group of tests are presented as the EC50 and compared to SCCWRP data for the previous two years.

An acceptable range of response for the sea urchin test has not yet been developed. As a substitute, the data are plotted as quality control charts using ± 2 standard deviations of the cumulative mean as control limits. This approach is recommended by the EPA for toxicity data. All of the storm drain reference test data fell within control limits and were similar to prior results obtained at SCCWRP. The conclusion is that the sea urchin fertilization tests conducted during this project were of typical sensitivity.

CONCLUSIONS

The phase 1 toxicity test objectives for this project have been successfully completed. Tests with three marine species were conducted and have provided data that can be used to rank the relative toxicity of the sites and describe variability in toxicity.

The Ashland site was found to be most toxic to each of the three species of test organisms (Table D2-10). This location consistently produced the greatest toxicity in all tests conducted. No clear distinction between the relative toxicity of the Ballona Creek and Pico-Kenter sites can be made. Comparison of the EC50 values for the different samples shows that the test species responded differently to these sites, as shown in Table D2-11. The abalone test was more sensitive to Pico-Kenter effluent, with the kelp test being least sensitive. Ballona Creek effluent produced the greatest toxic effects on sea urchin sperm, however, while the abalone and kelp tests were unaffected by effluent from this site.

The differential sensitivity to each site shown by the tests also makes it difficult to generalize about which species is the most sensitive. The kelp test was always the least sensitive to each of the effluent types, however.

A moderate degree of temporal variability in effluent toxicity was found in this study. The magnitude of toxic effects produced by Ashland effluent was similar between sampling times. Pico-Kenter effluent was consistently toxic to abalone embryos, but produced toxic effects on sea urchin sperm in only one of three tests. Ballona Creek effluent produced a different level of toxicity to sea urchin sperm in each of the three tests conducted; toxic effects ranged from strong (EC50 = 14%) in the first sample to nontoxic in the last sample tested.

The temporal variability found in this study is not surprising, considering that each effluent represents a mixture of many separate inputs. It is interesting to note that the Ballona and Pico-Kenter samples having the greatest initial pH usually produced the greatest toxic effects. While pH itself was controlled during the test and not likely to produce toxicity directly, these pH changes may be related to variations in other effluent characteristics having an impact on relative toxicity.

Table D2-1. Summary of initial water quality data for undiluted storm drain effluent samples. Measurements were made on the day of toxicity test initiation. Salinity units are mg/g.

Location (1)	Collection Date (2)	pH (3)	Salinity (4)
Ashland	9-29-92	8.13	8
	10-12-92	8.03	9
Ballona	9-29-92	9.40	2
	10-12-92	9.16	3
Pico-Kenter	9-29-92	8.32	2
	10-12-92	8.58	2

Table D2-2. Storm drain effluent NOEC and EC50 values for storm drain samples collected September 29 and October 12, 1992. Values are expressed in percent effluent.

Location (1)	Sampling Date (2)	NOEC				EC50			
		Abalone Develop. (3)	Kelp		Urchin Fert. (6)	Abalone Develop (7)	Kelp		Urchin Fert. (10)
			Germ. (4)	Length (5)			Germ. (8)	Length (9)	
Ashland	9-29-92	nt ^a	nt	nt	5.6	nt	nt	nt	14
	10-12-92	5.6	5.6	5.6	<5.6	10	22	50	< 5.6
Ballona	9-29-92	nt	nt	nt	12 ^b	nt	nt	nt	> 56
	10-12-92	≥56	≥56	≥56	≥56	> 56	> 56	> 56	> 56
Pico-Kenter	9-29-92	nt	nt	nt	≥56	nt	nt	nt	> 56
	10-12-92	12	≥56	25	25	21	> 56	> 56	41

^aInsufficient data to calculate value.

^bNOEC could also be stated as ≥56% since 56% concentration was not significantly different from respective brine control. A NOEC of 12 is felt to be more appropriate since 25% concentration was significantly toxic and 56% brine control was toxic, making accuracy of 56% effluent results questionable.

Table D2-3. Summary of Purple sea urchin fertilization test; conducted October 1, 1992. Abbreviation: % Ref = mean response expressed as a percentage of the appropriate reference group(s); NS = not significantly difference relative to reference; S = statistically significant difference; NT = not tested (no need or data not sufficient).

Group (1)	Description (2)	Reference group (3)	Percent Fertilized				
			Mean (4)	(SD) (5)	Sig. (6)	% Ref. (7)	Raw data (8)
1	Seawater control		81	(2)			79, 81, 82
2	Brine control 25%	1	87	(3)	NS	107	87, 90, 84
3	Brine control 56%	1	75	(1)	S	93	75, 76, 74
4	Ballona filtrate 5.6%	1-2	86	(2)	NS	103	84, 88, 85
5	Ballona filtrate 12%	1-2	83	(6)	NS	99	76, 88, 85
6	Ballona filtrate 25%	1-2	64	(3)	S	76	61, 63, 68
7	Ballona filtrate 56%	3	69	(8)	NS	92	67, 77, 61
8	Ashland filtrate 5.6%	1-2	87	(5)	NS	104	87, 92, 82
9	Ashland filtrate 12%	1-2	62	(12)	S	74	49, 63, 73
10	Ashland filtrate 25%	1-2	0	(0)	S	0	1, 0, 0
11	Ashland filtrate 56%	3	0	(0)	NT	0	0, 0, 0
12	Pico-Kenter filtrate 5.6%	1-2	83	(6)	NS	99	90, 80, 78
13	Pico-Kenter filtrate 12%	1-2	77	(3)	NS	92	74, 79, 77
14	Pico-Kenter filtrate 25%	1-2	82	(3)	NS	98	82, 85, 78
15	Pico-Kenter filtrate 56%	3	77	(4)	NS	103	75, 82, 75
16	Egg control (Seawater)	1-2	0		NT	0	0
17	Egg control (Ballona 25%)	1-2	0		NT	0	0
18	Egg control (Ashland 25%)	1-2	0		NT	0	0
19	Egg control (Pico-Kenter 25%)	1-2	0		NT	0	0

Table D2-4. Summary of Purple Sea Urchin fertilization test 190; Conducted October 13, 1992. Abbreviations as for Table D2-3.

Group (1)	Description (2)	Reference group (3)	Percent Fertilized				Raw data (8)
			Mean (4)	(SD) (5)	Sig. (6)	% Ref. (7)	
1	Seawater control		84	(10)			87, 91, 72
2	Brine control 25%	1	92	(2)	NS	110	90, 91, 94
3	Brine control 56%	1	78	(10)	NS	94	70, 90, 75
4	Ballona filtrate 5.6%	1-3	96	(2)	NT	114	93, 96, 98
5	Ballona filtrate 12%	1-3	97	(2)	NT	115	99, 96, 96
6	Ballona filtrate 25%	1-3	86	(7)	NT	102	80, 94, 83
7	Ballona filtrate 56%	1-3	88	(5)	NT	104	92, 91, 82
8	Ashland filtrate 5.6%	1-3	0	(1)	NT	0	0, 1, 0
9	Ashland filtrate 12%	1-3	0	(0)	NT	0	0, 0, 0
10	Ashland filtrate 25%	1-3	0	(1)	NT	0	0, 0, 1
11	Ashland filtrate 56%	1-3	0	(0)	NT	0	0, 0, 0
12	Pico-Kenter filtrate 5.6%	1-3	97	(2)	NS	115	95, 99, 97
13	Pico-Kenter filtrate 12%	1-3	94	(6)	NS	111	86, 98, 96
14	Pico-Kenter filtrate 25%	1-3	90	(2)	NS	107	88, 90, 92
15	Pico-Kenter filtrate 56%	1-3	9	(3)	S	11	10, 12, 6
16	Egg control (Seawater)	1-3	0		NT	0	0
17	Egg control (Ballona 25%)	1-3	0		NT	0	0
18	Egg control (Ashland 25%)	1-3	0		NT	0	0
19	Egg control (Pico-Kenter 25%)	1-3	0		NT	0	0

Table D2-5. Summary of 48 hour red abalone larval development test H-6; Conducted September 30, 1992. Abbreviations as for Table D2-3.

Group (1)	Description (2)	Reference group (3)	Percent normal development				Raw Data (8)
			Mean (4)	(SD) (5)	Sig. (6)	% Ref. (7)	
1	Seawater control	1	7				7
2	Brine control 25%	1	7	(1)	NT	100	8, 6, 6
3	Brine control 56%	1	6	(1)	NT	86	7, 6, 6
4	Ballona filtrate 56%	1-3	9	(1)	NT	128	9, 10, 9
5	Pico-Kenter filtrate 56%	1-3	2	(2)	NT	29	1, 4, 1
6	Ashland filtrate 5.6%	1-3	5	(2)	NT	71	4, 4, 7
7	Ashland filtrate 12%	1-3	1	(1)	NT	14	0, 1
8	Ashland filtrate 25%	1-3	0	(0)	NT	0	0, 0
9	Ashland filtrate 56%	1-3	0		NT	0	0

Table D2-6. Summary of 48 hour red abalone larval development test H-8; Conducted October 13, 1992. Abbreviations as for Table D2-3.

Group (1)	Description (2)	Reference group (3)	Percent normal development				
			Mean (4)	(SD) (5)	Sig. (6)	% Ref. (7)	Raw data (8)
1	Seawater control	1	68	(12)			59, 82, 63
2	Brine control 25%	1	67	(1)	NS	99	66, 67
3	Brine control 56%	1	17	(2)	NT	25	18, 17, 15
4	Ballona filtrate 5.6%	1-2	70	(3)	NS	103	73, 68, 68
5	Ballona filtrate 12%	1-2	67	(8)	NS	100	66, 60, 76
6	Ballona filtrate 25%	1-2	66	(8)	NS	98	69, 57, 71
7	Ballona filtrate 56%	3	60	(4)	NT	89	58, 57, 71
8	Pico-Kenter filtrate 5.6%	1-2	61	(4)	NS	91	57, 63, 64
9	Pico-Kenter filtrate 12%	1-2	62	(8)	NS	92	71, 57, 59
10	Pico-Kenter filtrate 25%	1-2	24	(4)	S	35	28, 24, 20
11	Pico-Kenter filtrate 56%	3	0		NT	0	0
12	Ashland filtrate 5.6%	1-2	61	(2)	NS	90	62, 62, 58
13	Ashland filtrate 12%	1-2	25	(8)	S	37	23, 35, 18
14	Ashland filtrate 25%	1-2	0	(0)	NT	0	0, 0, 0
15	Ashland filtrate 56%	3	0		NT	0	0

Table D2-7. Summary of Kelp spore germ tube length endpoint for test M-7; Conducted September 30, 1992. Abbreviations as for Table D2-3.

Group (1)	Description (2)	Reference group (3)	Germ Tube Length (mm)				Raw data (8)
			Mean (4)	(SD) (5)	Sig. (6)	% Ref. (7)	
1	Seawater control		15	(2)			17, 15, 14
2	Brine control 25%	1	13	(1)	NT	87	14, 12, 14
3	Brine control 56%	1	15	(2)	NT	100	15, 13, 16
4	Ballona filtrate 56%	1-3	16	(1)	NT	107	17, 17, 15
5	Ashland filtrate 5.6%	1-3	14	(1)	NT	93	14, 15, 14
6	Ashland filtrate 12%	1-3	14	(2)	NT	93	14, 16, 13
7	Ashland filtrate 25%	1-3	13	(1)	NT	87	14, 13, 12
8	Ashland filtrate 56%	1-3	13	(1)	NT	87	14, 14, 12
9	Pico-Kenter filtrate 25%	1-3	13	(1)	NT	87	13, 14, 13
10	Pico-Kenter filtrate 56%	1-3	16	(2)	NT	107	15, 18, 16

Table D2-8. Summary of Kelp spore germination endpoint for test M-9; Conducted October 13, 1992. Abbreviations as for Table D2-3.

Group (1)	Description (2)	Reference group (3)	Percent germinated				
			Mean (4)	(SD) (5)	Sig. (6)	% Ref. (7)	Raw data (8)
1	Seawater control		87	(5)			91, 88, 81
2	Brine control 25%	1	95	(1)	NS	109	95, 95, 94
3	Brine control 56%	1	92	(2)	NS	106	90, 92, 94
4	Ballona filtrate 5.6%	1-3	88	(3)	NT	96	87, 91, 85
5	Ballona filtrate 12%	1-3	87	(4)	NT	95	90, 88, 83
6	Ballona filtrate 25%	1-3	93	(2)	NT	102	95, 91, 92
7	Ballona filtrate 56%	1-3	94	(1)	NT	103	93, 93, 95
8	Ashland filtrate 5.6%	1-3	94	(4)	NS	103	96, 95, 89
9	Ashland filtrate 12%	1-3	79	(8)	S	87	87, 71, 79
10	Ashland filtrate 25%	1-3	38	(27)	S	42	66, 13, 37
11	Ashland filtrate 56%	1-3	2	(2)	S	2	1, 0, 4
12	Pico-Kenter filtrate 5.6%	1-3	93	(2)	NT	102	92, 93, 95
13	Pico-Kenter filtrate 12%	1-3	91	(4)	NT	100	96, 89, 88
14	Pico-Kenter filtrate 25%	1-3	90	(3)	NT	99	87, 94, 91
15	Pico-Kenter filtrate 56%	1-3	89	(4)	NT	98	92, 92, 84

Table D2-9. Summary of Kelp spore germ tube length endpoint for test M-9; Conducted October 13, 1992. Abbreviations as for Table D2-3.

Group (1)	Description (2)	Reference group (3)	Germ Tube Length (mm)				Raw data (8)
			Mean (4)	(SD) (5)	Sig. (6)	% Ref. (7)	
1	Seawater control		17	(1)			17, 18, 17
2	Brine control 25%	1	14	(1)	S	82	15, 13, 14
3	Brine control 56%	1	14	(2)	S	82	15, 14, 12
4	Ballona filtrate 5.6%	2,3	19	(1)	NS	136	18, 19, 19
5	Ballona filtrate 12%	2,3	19	(1)	NS	136	19, 19, 18
6	Ballona filtrate 25%	2,3	18	(1)	NS	129	19, 17, 17
7	Ballona filtrate 56%	2,3	17	(1)	NS	121	18, 16, 18
8	Ashland filtrate 5.6%	2,3	14	(2)	NS	100	12, 17, 14
9	Ashland filtrate 12%	2,3	12	(1)	S	86	13, 11, 11
10	Ashland filtrate 25%	2,3	9	(1)	S	64	10, 9, 8
11	Ashland filtrate 56%	2,3	6	(1)	S	43	7, 6
12	Pico-Kenter filtrate 5.6%	2,3	18	(1)	NS	129	17, 18, 18
13	Pico-Kenter filtrate 12%	2,3	17	(1)	NS	121	17, 16, 17
14	Pico-Kenter filtrate 25%	2,3	15	(1)	NS	107	14, 15, 16
15	Pico-Kenter filtrate 56%	2,3	12	(1)	S	86	12, 12, 11

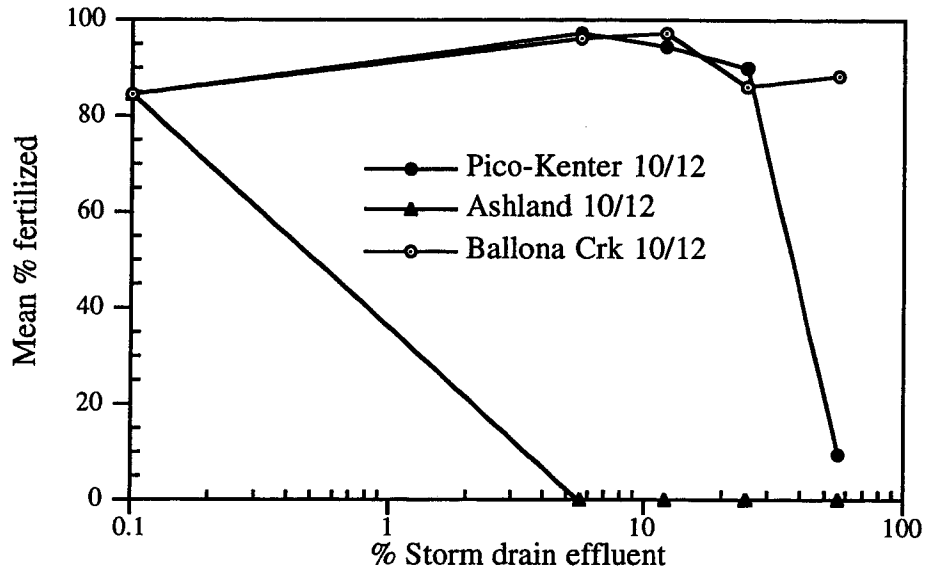
Table D2-10. Relative site toxicity ranks by species. Sample numbers refers to the three time periods studied (Sample 1 = 8/24 or 9/8/92). 3 = most toxic, 1 = least toxic.

Location (1)	Relative toxicity			Sum of ranks (5)
	Sample 1 (2)	Sample 2 (3)	Sample 3 (4)	
Abalone development				
Ashland	3	3	3	9
Ballona	1	1	1	3
Pico-Kenter	2	2	2	6
Kelp germination/growth				
Ashland	3	3	3	9
Ballona	1.5	1.5	1	4
Pico-Kenter	1.5	1.5	2	5
Sea urchin fertilization				
Ashland	2.5	3	3	8.5
Ballona	2.5	2	1	5.5
Pico-Kenter	1	1	2	4

Table D2-11. Relative rank test sensitivity to storm drain effluents. Rank assignments made on the basis of EC50 values (3 = most sensitive test).

Species (1)	Relative toxicity		Sum of ranks (4)
	Sample 1 (2)	Sample 3 (3)	
Ashland			
Abalone	3	2	5
Kelp	1	1	2
Sea urchin	2	3	5
Pico-Kenter			
Abalone	3	3	6
Kelp	1.5	1	2.5
Sea urchin	1.5	2	3.5
Ballona Creek			
Abalone	1.5	2	3.5
Kelp	1.5	2	3.5
Sea urchin	3	2	5

URCHIN FERTILIZATION TEST



ABALONE TEST

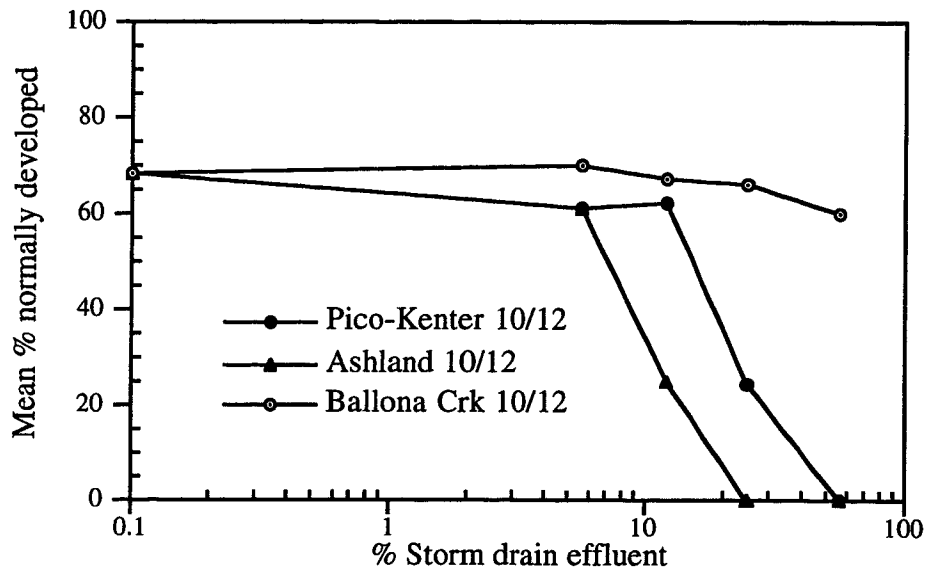


Figure D2-1. Dose-response plots for sea urchin fertilization and abalone embryo development tests of storm drain samples collected on October 12, 1992. Control values are those plotted at a concentration of 0.1%.

GERM TUBE LENGTH TEST

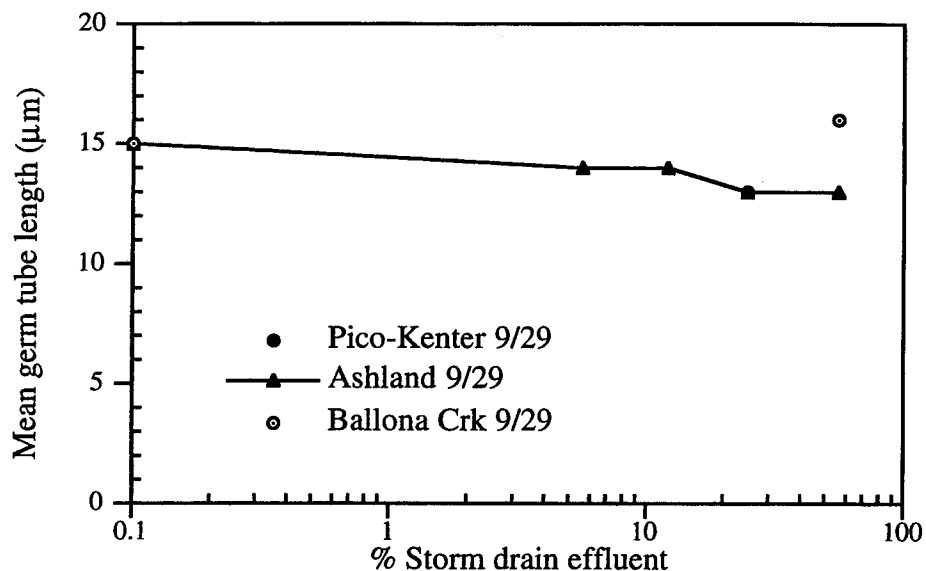


Figure D2-2. Dose-response plots for giant kelp germ tube length test of storm drain samples collected on September 29, 1992. Percent germination was not assessed because of poor control performance. Control values are those plotted at a concentration of 0.1%.

GIANT KELP GERMINATION TEST

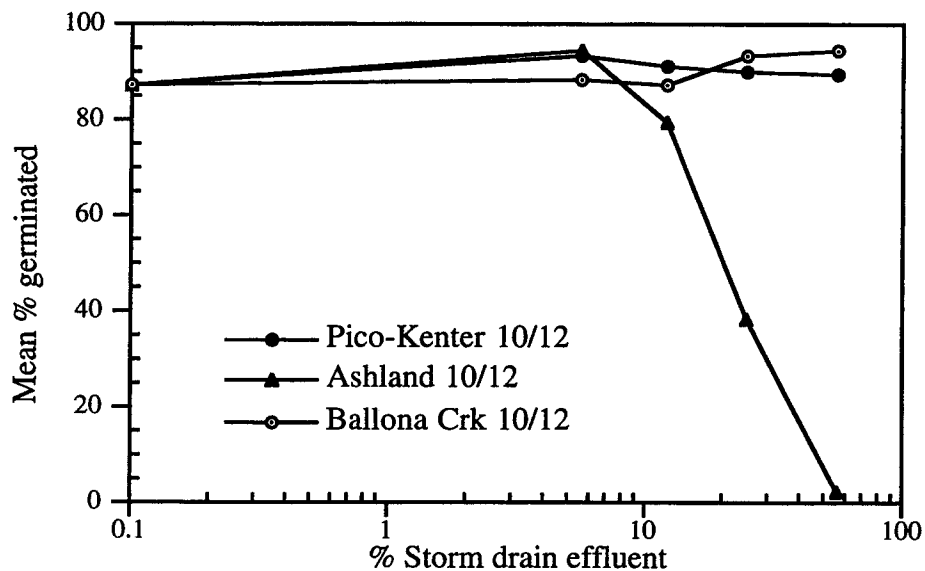


Figure D2-3. Dose-response plots for giant kelp germination of storm drain samples collected on October 12, 1992. Control values are those plotted at a concentration of 0.1%.

APPENDIX D2.a
TOXICITY TEST WATER QUALITY DATA

Table D2.a-1. Summary of initial water quality data for toxicity test conducted October 1, 1992 (test S188).

Description (1)	pH (2)	Salinity mg/g (3)
Seawater control	8.04	34
Brine control 25%	8.06	34
Brine control 56%	8.10	32
Ballona filtrate 5.6%	8.15	34
Ballona filtrate 12%	8.17	34
Ballona filtrate 25%	8.21	34
Ballona filtrate 56%	8.19	32
Ashland filtrate 5.6%	8.12	34
Ashland filtrate 12%	8.10	34
Ashland filtrate 25%	8.06	34
Ashland filtrate 56%	7.99	34
Pico-Kenter filtrate 5.6%	8.11	34
Pico-Kenter filtrate 12%	8.08	34
Pico-Kenter filtrate 25%	8.03	34
Pico-Kenter filtrate 56%	7.96	32
Ballona raw filtrate	9.30	

Table D2.a-2. Summary of initial water quality data for toxicity tests conducted October 13-15, 1992 (tests S190, M9, H8). DO = dissolved oxygen.

Description (1)	DO mg/L (2)	Ammonia mg/L (3)	pH (4)	Salinity mg/g (5)
Seawater control	7.8	0.02	8.18	34
Brine control 25%	8.4		8.16	34
Brine control 56%	8.2		8.18	34
Ballona filtrate 5.6%	8.6	0.01	8.19	34
Ballona filtrate 12%	8.4	0.01	8.25	33
Ballona filtrate 25%	8.5	0.02	8.30	34
Ballona filtrate 56%	8.7	0.02	8.26	34
Ashland filtrate 5.6%	8.3	0.01	8.13	34
Ashland filtrate 12%	8.6	0.21	8.09	33
Ashland filtrate 25%	8.3	0.44	8.03	34
Ashland filtrate 56%	7.5	1.06	7.94	33
Pico-Kenter filtrate 5.6%	8.6	0.03	8.15	34
Pico-Kenter filtrate 12%	8.6	0.02	8.13	34
Pico-Kenter filtrate 25%	8.6	0.03	8.09	34
Pico-Kenter filtrate 56%	8.5	0.07	8.01	34

Table D2.a-3. Summary of final water quality and temperature data for abalone toxicity test H8, conducted October 13-15, 1992. DO, dissolved oxygen.

Description (1)	DO	pH (3)	Salinity	Temperature		
	mg/L (2)		mg/g (4)	Day 0 (5)	Day 1 (6)	Day 2 (7)
Seawater control	7.8	8.09	34	14.3	14.5	14.1
Brine control 25%	7.8	8.10	34	14.3	14.5	14.1
Brine control 56%	7.9	8.11	34	14.3	14.5	14.2
Ballona filtrate 5.6%	7.9	8.13	34	14.2	14.6	14.1
Ballona filtrate 12%	7.7	8.17	34	14.2	14.5	14.2
Ballona filtrate 25%	7.8	8.24	34	14.2	14.6	14.2
Ballona filtrate 56%	7.7	8.29	34	14.2	14.5	14.1
Ashland filtrate 5.6%	7.8	8.10	34	14.1	14.5	14.1
Ashland filtrate 12%	7.7	8.12	33	14.2	14.5	14.1
Ashland filtrate 25%	7.3	8.13	33	14.1	14.5	14.1
Ashland filtrate 56%	6.8	8.15	33	14.1	14.5	14.2
Pico-Kenter filtrate 5.6%	7.8	8.11	34	14.0	14.5	14.1
Pico-Kenter filtrate 12%	7.8	8.13	33	14.2	14.6	14.1
Pico-Kenter filtrate 25%	7.8	8.16	33	14.1	14.6	14.1
Pico-Kenter filtrate 56%	7.8	8.20	33	14.1	14.5	14.1

Table D2.a-4. Summary of final water quality and temperature data for kelp toxicity test M9, conducted October 13-15, 1992. DO, dissolved oxygen.

Description (1)	DO	pH (3)	Salinity	Temperature		
	mg/L (2)		mg/g (4)	Day 0 (5)	Day 1 (6)	Day 2 (7)
Seawater control	8.2	8.08	34	14.9	14.9	14.8
Brine control 25%	8.1	8.10	34	15.1	15.0	15.0
Brine control 56%	8.0	8.11	34	14.8	14.9	15.0
Ballona filtrate 5.6%	8.1	8.11	34	14.9	14.9	14.8
Ballona filtrate 12%	8.1	8.18	33	14.9	15.0	14.9
Ballona filtrate 25%	8.1	8.24	34	14.9	15.0	14.9
Ballona filtrate 56%	8.1	8.28	33	14.9	15.0	15.0
Ashland filtrate 5.6%	8.0	8.11	34	14.9	15.0	14.8
Ashland filtrate 12%	7.7	8.10	33	15.0	15.0	14.9
Ashland filtrate 25%	7.7	8.14	33	14.9	15.1	14.8
Ashland filtrate 56%	7.4	8.16	34	14.9	15.1	14.8
Pico-Kenter filtrate 5.6%	8.1	8.12	34	14.9	15.0	14.9
Pico-Kenter filtrate 12%	8.1	8.13	33	15.0	15.0	14.9
Pico-Kenter filtrate 25%	8.1	8.14	34	14.9	14.9	14.8
Pico-Kenter filtrate 56%	7.9	8.16	34	15.1	15.0	14.9

**APPENDIX D3
TOXICITY RESULTS OF
BALLONA CREEK SAMPLE
COLLECTED 12/10/92**

The following are data reports for the two toxicity tests conducted on samples of Ballona Creek dry weather flow collected December 14, 1992.

Experiment 194

The first experiment was conducted on December 14, immediately after sample collection to characterize the initial toxicity of the samples. Samples were tested at concentrations of 12, 25, and 56%. Control fertilization was 68% which is within the range considered acceptable for this test. Samples containing 56% runoff were not examined for fertilization because the 56% brine control was strongly toxic (Table D3-1). Results for the 12 and 25% concentrations indicated that the afternoon sample was about twice as toxic as the sample collected in the morning.

The pH of the runoff samples ranged from 8.45 (a.m.) to 8.26 (p.m.) which is considerably lower than the pH of samples collected previously.

Samples of deionized water from UCLA and filter blanks prepared with either UCLA or SCCWRP water were also tested for toxicity in the first experiment. No toxicity was detected in a sample of 25% UCLA water. Egg fertilization in the filter blank prepared from UCLA water was 79% of the unfiltered sample, indicating that some toxicity was introduced by the filtration process. The filter blank using SCCWRP water was more toxic; fertilization in these samples was only 38% of the unfiltered water (25% brine control).

Experiment 195

The second experiment was conducted on December 16, following laboratory manipulation of the Ballona p.m. sample to characterize toxicity. Control fertilization and brine control results were satisfactory for this test (Table D3-2). A baseline toxicity test was conducted on a sample of effluent that had been stored at SCCWRP (unfiltered, 5°C). Baseline toxicity was substantially less than measured on December 14, but still sufficient to permit evaluation of the TIE samples.

Strong toxicity was found in the 56% filter blank solution. Filter blank results (corrected for control response) at 25% were similar for the 12/14 and 12/16 experiments, indicating the same level of toxicity was probably present in both blanks. Toxicity was also found in the column blank samples, reflecting the toxicity of the filter blank solution passed through the column.

Toxicity was reduced by the C18, EDTA, and thiosulfate treatments. Examination of the results for the 56% samples indicate that toxicity was partially removed by the C18 column and completely removed by thiosulfate treatment. Toxicity was found in the thiosulfate blank, as was the case in the previous TIE experiment.

The EDTA treatment results had an unusual pattern. Fertilization at 25% sample concentration was high (no toxicity) for both the 3 and 8 mg/l EDTA solutions. Reduced fertilization was measured at the 56% sample concentrations, with the lowest fertilization occurring in the 8 mg/l solution. There are two interpretations of this pattern. First it could be an indication of partial toxicity removal, as was found for C18 column treatment. An alternate explanation would be toxicity produced by the EDTA treatment. Toxicity due to the EDTA compound is unlikely since the results of previous experiments indicate that solutions of 250 mg/l EDTA were nontoxic. One possibility is that the 56% EDTA solutions may have had an altered pH which adversely affected fertilization rate (pH of the EDTA solutions was not checked or adjusted in this experiment, but was adjusted in the previous TIE experiment). We are investigating this situation and should have more information in a few days.

Analysis of the column elutriate blanks indicated no toxicity for methanol solutions and slight toxicity for the 50% methylene chloride/50% methanol blank. Elution of the C18 column with 100% methanol was successful in recovering a portion of the toxicity in the aqueous sample.

Solvent extracts of two different Ballona Creek samples (11/23 and 12/14 collections) were also tested for toxicity. Strong toxicity was found in solutions containing 0.1% of the extract while 0.01% solutions were nontoxic. It is questionable whether the extract toxicity corresponds to the whole effluent toxicity since the toxic reconstituted solutions were much more concentrated than the original aqueous sample. Even the nontoxic 0.01% extract solutions were more concentrated (equivalent to 80% undiluted effluent) than the highest concentration of aqueous sample tested (56%).

Table D3-1. Summary of Experiment 194 (Conducted Dec. 14, 1992).

Sample (1)	% Fertilized (2)	Mean (3)
Seawater control	67, 68	68
Brine control 25% DIW	73	
Brine control 56% DIW	3, 1	2
Ballona A.M. filtrate 12%	63, 58	60
Ballona A.M. filtrate 25%	44, 45	44
Ballona A.M. filtrate 56%		
Ballona P.M. filtrate 12%	49, 33	41
Ballona P.M. filtrate 25%	16, 19	18
Ballona P.M. filtrate 56%		
UCLA DIW 25%	72, 72	72
UCLA DIW 56%		
Filter Blank #1 (UCLA water) 12%		
Filter Blank #1 (UCLA water) 25%	56, 58	57
Filter Blank #1 (UCLA water) 56%		
Filter Blank #2 (SCCWRP water) 12%		
Filter Blank #2 (SCCWRP water) 25%	24, 31	28
Filter Blank #2 (SCCWRP water) 56%		

Table D3-2. Summary of Experiment 195 (Conducted Dec. 16, 1992).

Sample (1)	% Fertilized (2)	Mean (3)
Seawater control	96, 98	97
Brine control 25% DIW	100, 98	99
Brine control 56% DIW	69, 78	74
Ballona P.M. filtrate 12%	82, 91	86
Ballona P.M. filtrate 25%	67, 65	66
Ballona P.M. filtrate 56%	18, 12	15
Filter Blank 12%	94, 97	96
Filter Blank 25%	82, 75	78
Filter Blank 56%	5, 5	5
Column Blank 12 %		
Column Blank 25%	52, 51	52
Column Blank 56%	21, 23	22
Post Column filtrate 12%		
Post Column filtrate 25%	89, 94	92
Post Column filtrate 56%	69, 82	76
EDTA 3 mg/l 12%		
EDTA 3 mg/l 25%	90, 90	90
EDTA 3 mg/l 56%	39, 50	44
EDTA 8 mg/l 12%		
EDTA 8 mg/l 25%	91, 98	94
EDTA 8 mg/l 56%	11, 13	12
Thiosulfate blank 12%		
Thiosulfate blank 25%	13, 35	24
Thiosulfate blank 56%	2, 0	1
Thiosulfate 10 mg/l 12%		
Thiosulfate 10 mg/l 25%	86, 91	88
Thiosulfate 10 mg/l 56%	99, 99	99
Thiosulfate 25 mg/l 12%		
Thiosulfate 25 mg/l 25%	98, 100	99
Thiosulfate 25 mg/l 56%	96, 99	98
50% Methanol elutriate blank 0.1%		
50% Methanol elutriate blank 0.2%	99, 100	100
100% Methanol blank 0.1%		
100% Methanol blank 0.2%	97, 96	96
50% MeCl ₂ Blank 0.1%	98, 98	98
50% MeCl ₂ Blank 0.2%	73, 78	76

Table D3-2 (continued).

Sample (1)	%Fertilized (2)	Mean (3)
50% Methanol eluate 0.1%	100, 99	100
50% Methanol eluate 0.2%	100, 99	100
100% Methanol eluate 0.1%	92, 88	90
100% Methanol eluate 0.2%	8, 6	7
50% MeCl ₂ eluate 0.1%	97, 99	98
50% MeCl ₂ eluate 0.2%	50, 47	48
MeCl ₂ extract 11/23 0.01%	97, 96	96
MeCl ₂ extract 11/23 0.1%	0	
MeCl ₂ extract 12/14 0.01%	80, 86	83
MeCl ₂ extract 12/14 0.1%	0	
MeCl ₂ extract blank 0.01%	99, 97	98
MeCl ₂ extract blank 0.1%	77, 75	76

**APPENDIX D4
TOXICITY RESULTS OF
BALLONA CREEK SAMPLE
COLLECTED 1/19/93**

The following are data reports for the two toxicity tests conducted on samples of Ballona Creek effluent collected January 19, 1993.

Experiment 196

The first experiment was conducted on January 19, immediately after sample collection to characterize the initial toxicity of the samples. Samples were tested at concentrations of 12, 25, and 56%. The initial pH values of the two effluent samples were 8.26 and 8.33, similar to the pH of the December 14 samples.

Control fertilization was 100% (Table D4-1), indicating the test organisms were of acceptable health. No toxicity was present in the brine controls. Both the morning and afternoon samples were toxic, with less than 10% fertilization at a concentration of 56% effluent. The results for the 25% concentration indicated that the morning (a.m.) sample was slightly more toxic; this sample was selected for the TIE procedure.

Experiment 197

The second experiment was conducted on January 21, following laboratory manipulation of the Ballona a.m. sample to characterize toxicity. The pH of the effluent sample declined slightly to 7.87 after two days of storage. The pH of the EDTA- and Thiosulfate-treated effluent samples was 7.40-7.93 after dilution with laboratory seawater which had a pH of 7.99. A small amount of HCl was added to samples having a pH less than 7.9 to adjust them to pH 7.93-8.09.

Control fertilization and brine control results were satisfactory for this test (Table D4-2). A baseline toxicity test was conducted on a sample of effluent that had been stored at SCCWRP (unfiltered, 5°C). Baseline toxicity was similar to that measured two days earlier. Slightly greater toxicity was measured at 12 and 25%, which is a pattern not seen in previous tests of stored Ballona Creek samples.

Some toxicity was found in the filter blank samples, although it was much less than measured in previous experiments. This result may indicate a beneficial effect of using distilled water from SCCWRP. Increased toxicity (relative to the filter blank) was measured in the column blank samples. This is an indication of toxic materials being leached from the column. Evidence of column toxicity could not be detected in previous experiments because of the high toxicity of the filter blanks.

Only a slight reduction in toxicity was measured following treatment of the Ballona Creek sample with the C18 column.

Toxicity was completely removed by a 3 mg/L EDTA addition. The additional EDTA treatments were also nontoxic, indicating that no adverse effects were produced by this chemical.

Toxicity was absent in the thiosulfate blank. This result was somewhat unexpected, as strong blank toxicity was measured in both previous TIE experiments. Thiosulfate treatment had no effect on Ballona Creek effluent toxicity.

The solvent elution fractions of the C18 column were tested for toxicity even though column treatment was relatively ineffective. The solvent blank results were generally acceptable; only the 50% MeCl₂ blank showed moderate toxicity at a concentration of 0.2%. A small amount of toxicity was recovered from the column by elution with 100% methanol. The amount of toxicity recovered was too small to significantly contribute to the baseline toxicity of the effluent sample. Elutions with 50% methanol or methylene chloride were ineffective.

Table E-6 (cont'd)

CHEMICAL NAME [1]	Number Found Above MDL & Blank (11 Samples) [2]	Average (ng/L) [3]	Range (ng/L) [4]	Drinking Water Standards (a) (ng/L) [5]	Ocean Standards (b) (ng/L) [6]
Di-n-butyl phthalate(*)	10	1,046	445 - 1,905		
Fluoranthene	8	59	5 - 327		
Pyrene	8	69	6 - 211		8.8 (c,f)
Butyl benzyl phthalate(*)	11	962	265 - 1,006		
Benz(a)anthracene	4	32	10 - 75		
Chrysene(*)	4	69	1 - 185		8.8 (c,f)
Bis(2-ethylhexyl) phthalate(*)	11	6,800	1,241 - 28,173	6,000	3,500 (c)
Di-n-octyl phthalate(*)	10	4,249	11 - 39,206		
Benzo(b)fluoranthene	2	37	10 - 64		
Benzo(k)fluoranthene	3	14	2 - 30		8.8 (c,f)
Benzo(a)pyrene	4	41	4 - 128	200	8.8 (c,f)
Indeno(1,2,3,4-c,d)pyrene	1	7	-		8.8 (c,f)
Dibenzo(a,h)anthracene	0	<MDL	-		8.8 (c,f)
Benzo(g,h,i)perylene	0	<MDL	-		

(a)USEPA Drinking Water Standards reported by the AWWA Journal, Feb. 1993, p. 48.

(b)California Ocean Plan, 1990, State of California, State Water Resources Control Board, Resolution No. 90-27, Adopted and effective March 22, 1990.

(c)California Ocean Plan, Carcinogen

(d)California Ocean Plan, Non-Carcinogen

(e)Sum of 1,2 and 1,3-dichlorobenzenes

(f)Sum of polynuclear aromatic hydrocarbons (PAHs) including all PAHs listed and 1,2 benzanthracene and 3,4-benzofluoranthene = 8.8 ng/L

(*)Values are compared versus blank instead of the MDL.

Table D4-1. Summary of Experiment 196 (Conducted Jan. 19, 1993).

Sample (1)	% Fertilized (2)	Mean (3)
Seawater control	100, 100	100
Brine control 25% DIW	100, 99	100
Brine control 56% DIW	100, 98	99
Ballona A.M. filtrate 12%	98, 94	96
Ballona A.M. filtrate 25%	56, 44	50
Ballona A.M. filtrate 56%	7, 5	6
Ballona P.M. filtrate 12%	96, 98	97
Ballona P.M. filtrate 25%	68, 64	66
Ballona P.M. filtrate 56%	1, 2	2

Table D4-2. Summary of Experiment 197 (Conducted Jan. 21, 1993).

Sample (1)	% Fertilized (2)	Mean (3)
Seawater control	87, 94	90
Brine control 25% DIW	80, 71	76
Brine control 56% DIW	89, 81	85
Ballona A.M. filtrate 12%	57, 43	50
Ballona A.M. filtrate 25%	31, 28	30
Ballona A.M. filtrate 56%	14, 17	16
Filter blank 12%	68, 69	68
Filter blank 25%	63, 70	66
Filter blank 56%	58, 66	62
Column blank 12 %	76, 71	74
Column blank 25%	23, 19	21
Column blank 56%	7, 15	11
Post column effluent 12%	75, 69	72
Post column effluent 25%	44, 42	43
Post column effluent 56%	20, 19	20
EDTA 3 mg/l 12%	90, 87	88
EDTA 3 mg/l 25%	92, 94	93
EDTA 3 mg/l 56%	95, 90	92
EDTA 8 mg/l 12%	91, 95	93
EDTA 8 mg/l 25%	93, 95	94
EDTA 8 mg/l 56%	96, 95	96
EDTA 30 mg/l 12%	95, 97	96
EDTA 30 mg/l 25%	95, 97	96
EDTA 30 mg/l 56%	95, 90	92
Thiosulfate blank 12%	89, 88	88
Thiosulfate blank 25%	100, 89	94
Thiosulfate blank 56%	97, 96	96
Thiosulfate 10 mg/l 12%	25, 30	28
Thiosulfate 10 mg/l 25%	4, 5	4
Thiosulfate 10 mg/l 56%	9, 12	10
Thiosulfate 25 mg/l 12%	27, 28	28
Thiosulfate 25 mg/l 25%	23, 14	18
Thiosulfate 25 mg/l 56%	10, 14	12
50% Methanol elut. blank 0.1%	77, 85	81
50% Methanol elut. blank 0.2%	82, 81	82
100% Methanol elut. blank 0.1%	79, 86	82

Table D4-2 (cont'd).

Sample (1)	% Fertilized (2)	Mean (3)
100% Methanol elut. blank 0.2%	69, 78	74
50% MeCl ₂ elut. blank 0.1%	83, 82	82
50% MeCl ₂ elut. blank 0.2%	61, 55	58
50% Methanol eluate 0.1%	80, 65	72
50% Methanol eluate 0.2%	89, 85	87
100% Methanol eluate 0.1%	46, 40	43
100% Methanol eluate 0.2%	46, 39	42
50% MeCl ₂ eluate 0.1%	86, 67	76
50% MeCl ₂ eluate 0.2%	77, 77	77

APPENDIX E
GC/MS RESULTS

Tables E-1 to E-10 show the GC/MS results of the volatile organic and base neutral analyses of samples collected from Pico-Kenter, Ashland Avenue, Ballona Creek, Sepulveda Channel and Centinela Creek storm drains. These GC/MS results were obtained from the parallel study performed under the partial sponsorship of the American Ocean Campaign (Suffet *et al*, 1993).

Table E-1. GC/MS results of volatile organic analysis for Pico-Kenter samples (6/12 - 12/10/92).

CHEMICAL NAME	MDL ug/l	FIELD & LAB BLANK ug/l	NUMBER FOUND ABOVE MDL & BL'K	AVERAGE ug/l	RANGE ug/l - ug/l	DRINKING WATER MCLs ug/l
[1]	[2]	[3]	[4]	[5]	[6]	[7]
Dichlorodifluoromethane	0.18	0.15 - 0.20	4	0.22	0.20 - 0.25	
Chloromethane	0.14	0.14 - 0.17	13	0.42	0.29 - 0.94	
Carbon Disulfide	0.11	0.11 - 0.14	11	0.30	0.15 - 0.71	
Methylene Chloride(1)	0.07	0.11 - 0.14	14	2.18	0.18 - 12.82	5*
2-Butanone	?	0.24 - 0.33	8	0.61	0.33 - 1.24	
Chloroform	0.11		15	0.35	0.11 - 0.98	100 THMs
Benzene	0.04		12	0.09	0.04 - 0.25	5
Dibromomethane	0.03		5	0.05	0.03 - 0.07	
Bromodichloromethane	0.06		2	0.16	0.11 - 0.22	100 THMs
4-Methyl-2-Pentanone	0.12		11	0.30	0.13 - 1.30	
Toluene	0.05		12	0.16	0.06 - 0.35	1000
2-Hexanone	0.09		4	0.21	0.12 - 0.30	
Dibromochloromethane	0.09		2	0.21	0.19 - 0.23	100 THMs
Styrene	0.04		5	0.05	0.04 - 0.05	100
Bromoform	0.06		6	0.39	0.07 - 1.49	100 THMs
1,2,4-Trimethylbenzene	0.04		1	0.05	-	
p-Isopropyltoluene	0.06		3	0.07	0.06 - 0.08	

15 Samples - 6/12 to 12/10/9 (Dry Weather Flow)

MDL - Minimum Detectable Limit

No. & Average are above MDL and Blank Values

Average = Values above MDL and Blank / No. Found

* Proposed MDL only

THMs - Trihalomethanes

(1) Note- Methylene chloride in the 6/12 sample (33.448 ug/l) is considered an artifact and is not included in the data. Fourteen samples were completed for methylene chloride.

Table E-2. GC/MS results of volatile organic analysis for Ashland samples (6/12 - 12/10/92).

CHEMICAL NAME [1]	MDL ug/l [2]	FIELD & LAB BLANK ug/l [3]	NUMBER FOUND ABOVE MDL & BL'K [4]	AVERAGE ug/l [5]	RANGE ug/l - ug/l [6]	DRINKING WATER MCLs ug/l [7]
Dichlorodifluoromethane	0.18	0.15-0.20	2	0.27	0.20 - 0.33	
Chloromethane	0.14	0.14-0.17	14	0.42	0.22 - 0.91	
1,1-Dichloroethane	0.17		1	0.19	-	
Carbon Disulfide	0.11	0.11-0.14	14	1.10	0.16 - 5.80	
Methylene Chloride (1)	0.07	0.11-0.14	13	6.30	0.24 - 65.74	5*
2-Butanone	?	0.24-0.33	9	1.09	0.29 - 3.73	
Bromochloromethane	0.16		4	0.45	0.17 - 1.05	
Chloroform	0.11		11	4.07	0.13 - 19.11	100 THMs
Benzene	0.04		13	0.09	0.05 - 0.22	5
1,2-Dichloroethane	0.04		1	0.05	-	5
Trichloroethene	0.04		3	0.07	0.06 - 0.08	5
Dibromomethane	0.03		9	0.74	0.11 - 2.00	
Bromodichloromethane	0.06		5	1.68	0.10 - 7.42	100 THMs
4-Methyl-2-Pentanone	0.12		11	0.57	0.16 - 1.40	
Toluene	0.05		11	0.75	0.09 - 6.63	1000
2-Hexanone	0.09		5	0.23	0.15 - 0.41	
Dibromochloromethane	0.09		4	4.88	0.11 - 18.54	100 THMs
Ethyl Benzene	0.05		1	0.06	-	700
o-Xylene	0.04		2	0.15	0.05 - 0.09	10000 (Total)
Styrene	0.04		5	0.05	0.04 - 0.08	1000
Bromoform	0.06		5	10.56	0.04 - 50.52	100 THMs
1,3,5-Trimethylbenzene	0.05		2	0.67	0.07 - 1.27	
1,2,4-Trimethylbenzene	0.04		8	0.08	0.04 - 0.17	
p-Isopropyltoluene	0.06		6	0.69	0.06 - 2.51	
n-Butylbenzene	0.06		1	0.06	-	
Naphthalene	0.25		1	0.40	-	
1,2-Dichlorobenzene	0.04		1	0.07	-	600

14 Samples - 6/12 to 12/10/9 (Dry Weather Flow)

No. & Average are above MDL and Blank Values

* Proposed MDL only

(1) Note- Methylene chloride in the 9/8 AM sample (11.862 ug/l) is considered an artifact and is not included in the data. Thirteen samples were completed for methylene chloride.

MDL - Minimum Detectable Limit

Average = Values above MDL and Blank/No. Found

THMs - Trihalomethanes

Table E-3. GC/MS results of volatile organic analysis for Ballona Creek samples (6/12 - 12/10/92).

CHEMICAL NAME [1]	MDL ug/l [2]	FIELD & LAB BLANK ug/l [3]	NUMBER FOUND ABOVE MDL & BL'K [4]	AVERAGE ug/l [5]	RANGE ug/l - ug/l [6]	DRINKING WATER MCLs ug/l [7]
Dichlorodifluoromethane	0.18	0.15-0.20	1	-	0.21	
Chloromethane	0.14	0.14-0.17	12	0.51	0.26 - 2.17	
Carbon Disulfide	0.11	0.11-0.14	15	0.20	0.14 - 0.29	
Methylene Chloride (1)	0.07	0.11-0.14	13	?	0.19 - 2.12	5*
Trans-1,2-Dichloroethene	0.12		1	-	0.13	100
2-Butanone	?	0.24-0.33	11	0.60	0.34 - 1.58	
Bromochloromethane	0.16		1	-	0.52	
Chloroform	0.11		17	0.63	0.21 - 2.16	100 THMs
1,1,1-Trichloroethane	0.06		15	0.55	0.11 - 0.96	200
Benzene	0.04		13	0.08	0.04 - 0.22	5
Trichloroethene	0.04		11	0.05	0.05 - 0.08	5
Dibromomethane	0.3		3	0.06	0.04 - 0.26	
Bromodichloromethane	0.06		16	0.23	0.11 - 0.57	100 THMs
4-Methyl-2-Pentanone	0.12		10	0.27	0.15 - 0.59	
Toluene	0.05		13	0.10	0.05 - 0.17	1000
Tetrachloroethene	0.05		16	0.24	0.07 - 0.41	5
2-Hexanone	0.09		2	0.14	0.07 - 0.20	
Dibromochloromethane	0.09		16	0.28	0.11 - 0.82	100 THMs
Styrene	0.04		3	0.05	0.04 - 0.07	1000
Bromoform	0.06		18	0.18	0.07 - 0.42	100 THMs
1,2,4-Trimethylbenzene	0.04		2	0.04	0.04	
Napthalene	0.25		1	-	0.26	
1,1-Dichloropropene	0.06		1	-	0.10	

17 Samples - 6/12 to 12/10/92 (Dry Weather Flow)

No. & Average are above MDL and Blank Values

* Proposed only

MDL - Minimum Detectable Limit

Average = Values above MDL and Blank / No. Found

THMs - Trihalomethanes

(1) Note- Methylene chloride in the 6/12 and 9/8 AM samples of 129.41 and 154.22 ug/l, respectively are considered artifacts and are not included in the data. Fifteen samples were completed for methylene chloride.

Table E-4. GC/MS results of volatile organic analysis for Sepulveda Channel samples (6/12 -2/10/92).

CHEMICAL NAME [1]	MDL ug/l [2]	FIELD & LAB BLANK ug/l [3]	NUMBER FOUND ABOVE MDL & BL'K [4]	AVERAGE ug/l [5]	RANGE ug/l [6]	DRINKING WATER MCLs ug/l [7]
Dichlorodifluoromethane	0.18	0.15 - 0.20	1	0.20	0.20	
Chloromethane	0.14	0.14 - 0.17	14	0.58	0.20 - 2.90	
Carbon Disulfide	0.11	0.11 - 0.14	8	0.23	0.14 - 0.34	
Methylene Chloride (1)	0.07	0.11 - 0.14	12	0.52	0.14 - 1.75	5*
Trans-1,2-Dichloroethene	0.12		1	0.19	0.19	100
2-Butanone	?	0.24 - 0.33	9	0.77	0.36 - 3.15	
Bromochloromethane	0.16		1	0.31	0.31	
Chloroform	0.11		14	0.57	0.14 - 2.13	100 THMs
1,1,1-Trichloroethane	0.06		1	0.09	0.09	200
Benzene	0.04		13	0.10	0.04 - 0.25	5
Dibromomethane	0.03		9	0.07	0.03 - 1.29	
Bromodichloromethane	0.06		4	0.82	0.06 - 1.54	100 THMs
4-Methyl-2-Pentanone	0.12		5	0.25	0.15 - 0.62	
Toluene	0.05		11	0.10	0.06 - 0.37	1000
2-Hexanone	0.09		2	0.13	0.11 - 0.14	
Dibromochloromethane	0.09		4	1.18	0.18 - 2.14	100 THMs
(m+p)-Xylene	0.1		1	0.15	0.15	100,000 /
o-Xylene	0.04		1	0.06	0.06	TOTAL
Styrene	0.04		3	0.05	0.05	1000
Bromoform	0.06		15	0.40	0.13 - 1.09	100 THMs
Naphthalene	0.25		1	0.29	0.29	

15 Samples - 6/12 to 12/10/92 (Dry Weather Flow)

No. & Average are above MDL and Blank Values

* Proposed only

(1) Note- Methylene chloride in the 6/12 and 9/8 AM samples of 75.115 and 4.696 ug/l, respectively are considered artifacts and are not included in the data. Twelve samples were completed for methylene chloride

MDL - Minimum Detectable Limit

Average = Values above MDL and Blank / No. Found

THMs - Trihalomethanes

Table E-5. GC/MS results of volatile organic analysis for Centinela Creek samples (7/12 - 12/10/92).

CHEMICAL NAME [1]	MDL ug/l [2]	FIELD & LAB BLANK ug/l [3]	NUMBER FOUND ABOVE MDL & BL'K [4]	AVERAGE ug/l [5]	RANGE ug/l - ug/l [6]	DRINKING WATER MCLs ug/l [7]
Dichlorodifluoromethane	0.18	0.15 - 0.20	2	0.22	0.21 - 0.23	
Chloromethane	0.14	0.14 - 0.17	11	0.32	0.19 - 0.47	
Carbon Disulfide	0.11	0.11 - 0.14	10	0.21	0.16 - 0.29	
Methylene Chloride	0.07	0.11 - 0.14	11	1.90	0.20 - 8.19	5*
2-Butanone	?	0.24 - 0.33	4	0.57	0.34 - 1.28	
Bromochloromethane	0.16		1	0.16	-	
Chloroform	0.11		11	0.78	0.23 - 2.01	100 THMs
Benzene	0.04		8	0.09	0.04 - 0.19	5
Bromodichloromethane	0.06		5	0.42	0.07 - 1.24	100 THMs
4-Methyl-2-Pentanone	0.12		5	9.48	0.16 - 45.79	
Toluene	0.05		8	0.10	0.06 - 0.17	1000
2-Hexanone	0.09		8	0.03	0.09 - 0.18	
Dibromochloromethane	0.09		4	0.88	0.11 - 2.24	100 THMs
Styrene	0.04		3	0.05	0.04 - 0.05	1000
Bromoform	0.06		5	0.34	1.12	100 THMs
Napthalene	0.25		1	0.46		

11 Samples - 7/12 to 12/10/92 (Dry Weather Flow)
 No. & Average are above MDL and Blank Values
 * Proposed only

MDL -Minimum Detectable Limit
 Average = Values above MDL and Blank / No. Found
 THMs- Trihalomethanes

Table E-6. GC/MS results of base neutral analysis for Pico-Kenter Samples (7/7 - 12/10/92).

CHEMICAL NAME [1]	Number Found Above MDL & Blank (11 Samples) [2]	Average (ng/L) [3]	Range (ng/L) [4]	Drinking Water Standards (a) (ng/L) [5]	Ocean Standards (b) (ng/L) [6]
Phenol	7	1,204	30 - 4,073		
2-Methylphenol	1	8	-		
4-Methylphenol	6	2,649	38 - 9,749		
2-Nitrophenol	8	455	9 - 3451		
Benzoic Acid	6	920	196 - 1,707		
4-Chloro-3-methylphenol	0	<MDL	-		
4-Nitrophenol	1	3,903	-		
1,4-Dichlorobenzene(*)	10	66	33 - 127	75,000	18,000 (c)
N-Nitrosodi-n-propylamine	0	<MDL	-		
Nitrobenzene	2	30	15 - 46		4,900 (d)
Isophorone	1	1	-		150,000,000 (d)
Naphthalene(*)	10	98	37 - 160		
2-Methylnaphthalene	10	57	23 - 105		
Acenaphthylene	0	<MDL	-		8.8 (c,f)
Dimethyl phthalate	3	14	2 - 28		820,000,000 (d)
Acenaphthene	1	4	-		
Dibenzofuran	4	5	4 - 7		
Fluorene	7	4	2 - 8		8.8 (c,f)
Diethyl phthalate(*)	10	187	76 - 236		33,000,000 (d)
4-Chlorophenyl phenyl ether	8	37	14 - 82		
N-Nitrosodiphenylamine	1	161	-		2,500 (c)
Azobenzene	9	25	12 - 47		
Phenanthrene	9	46	6 - 165		8.8 (c,f)
Anthracene	5	22	1 - 33		8.8 (c,f)

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Table E-6 (cont'd)

CHEMICAL NAME [1]	Number Found Above MDL & Blank (11 Samples) [2]	Average (ng/L) [3]	Range (ng/L) [4]	Drinking Water Standards (a) (ng/L) [5]	Ocean Standards (b) (ng/L) [6]
Di-n-butyl phthalate(*)	10	1,046	445 - 1,905		
Fluoranthene	8	59	5 - 327		
Pyrene	8	69	6 - 211		8.8 (c,f)
Butyl benzyl phthalate(*)	11	962	265 - 1,006		
Benz(a)anthracene	4	32	10 - 75		
Chrysene(*)	4	69	1 - 185		8.8 (c,f)
Bis(2-ethylhexyl) phthalate(*)	11	6,800	1,241 - 28,173	6,000	3,500 (c)
Di-n-octyl phthalate(*)	10	4,249	11 - 39,206		
Benzo(b)fluoranthene	2	37	10 - 64		
Benzo(k)fluoranthene	3	14	2 - 30		8.8 (c,f)
Benzo(a)pyrene	4	41	4 - 128	200	8.8 (c,f)
Indeno(1,2,3,4-c,d)pyrene	1	7	-		8.8 (c,f)
Dibenzo(a,h)anthracene	0	<MDL	-		8.8 (c,f)
Benzo(g,h,i)perylene	0	<MDL	-		

(a)USEPA Drinking Water Standards reported by the AWWA Journal, Feb. 1993, p. 48.

(b)California Ocean Plan, 1990, State of California, State Water Resources Control Board, Resolution No. 90-27, Adopted and effective March 22, 1990.

(c)California Ocean Plan, Carcinogen

(d)California Ocean Plan, Non-Carcinogen

(e)Sum of 1,2 and 1,3-dichlorobenzenes

(f)Sum of polynuclear aromatic hydrocarbons (PAHs) including all PAHs listed and 1,2 benzanthracene and 3,4-benzofluoranthene = 8.8 ng/L

(*)Values are compared versus blank instead of the MDL.

Table E-7. GC/MS results of base neutral analysis of Ashland samples (7/7 - 12/10/92).

CHEMICAL NAME [1]	Number Found Above MDL & Blank (8 Samples) [2]	Average (ng/L) [3]	Range (ng/L) [4]	Drinking Water Standards (a) (ng/L) [5]	Ocean Standards (b) (ng/L) [6]
Phenol	5	162	65 - 375		
2-Methylphenol	0	<MDL	-		
4-Methylphenol	3	1,042	20 - 2,764		
2-Nitrophenol	5	38	21 - 74		
2,4-Dimethylphenol	2	365	238 - 492		
Benzoic Acid	6	472	60 - 1,518		
4-Chloro-3-methylphenol	1	9	-		
2,4,6-Trichlorophenol	0	<MDL	-		290 (c)
2,4,5-Trichlorophenol	0	<MDL	-		
1,4-Dichlorobenzene(*)	6	68	32 - 107	75,000	18,000 (c)
1,2-Dichlorobenzene	0	<MDL	-	600,000	5,100,000 (e)
Benzyl alcohol	2	896	533 - 1,258		
Nitrobenzene	2	230	204 - 257		4,900 (d)
Isophorone	3	42	10 - 75		150,000,000 (d)
Naphthalene(*)	7	85	48 - 126		
2-Methylnaphthalene	7	43	30 - 57		
2-Nitroaniline	1	463	-		
Dimethyl phthalate	4	31	2 - 102		820,000,000 (d)
Acenaphthene	2	6	5 - 6		
Dibenzofuran	4	11	5 - 16		
Fluorene	3	13	6 - 18		8.8 (c,f)
Diethyl phthalate(*)	7	463	124 - 1,110		33,000,000 (d)
4-Chlorophenyl phenyl ether	7	34	19 - 44		
Azobenzene	6	34	11 - 63		
Phenanthrene	7	62	20 - 152		8.8 (c,f)

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Table E-7 (cont'd)

CHEMICAL NAME [1]	Number Found Above MDL & Blank (8 Samples) [2]	Average (ng/L) [3]	Range (ng/L) [4]	Drinking Water Standards (a) (ng/L) [5]	Ocean Standards (b) (ng/L) [6]
Anthracene	4	38	4 - 125		8.8 (c,f)
Di-n-butyl phthalate(*)	7	3,050	637 - 13,667		3,500,000 (d)
Fluoranthene	7	49	10 - 94		15,000 (d)
Pyrene(*)	7	87	14 - 295		8.8 (c,f)
Butyl benzyl phthalate(*)	7	1,486	631 - 2,500		
Benz(a)anthracene	3	32	21 - 51		
3,3'-Dichlorobenzidine	0	<MDL	-		
Chrysene(*)	4	126	11 - 391		8.8 (c,f)
Bis(2-ethylhexyl) phthalate(*)	5	14,765	8,445 - 24,668	6,000	3,500 (c)
Di-n-octyl phthalate(*)	6	3,054	406 - 15,488		
Benzo(b)fluoranthene	4	24	8 - 49		
Benzo(k)fluoranthene	3	25	10 - 46		8.8 (c,f)
Benzo(a)pyrene	3	162	19 - 393	200	8.8 (c,f)
Indeno(1,2,3,4-c,d)pyrene	3	40	5 - 95		8.8 (c,f)
Dibenzo(a,h)anthracene	3	39	8 - 97		8.8 (c,f)
Benzo(g,h,i)perylene	2	71	16 - 125		

(a)USEPA Drinking Water Standards reported by the AWWA Journal, Feb. 1993, p. 48.

(b)California Ocean Plan, 1990, State of California, State Water Resources Control Board, Resolution No. 90-27, Adopted and effective March 22, 1990.

(c)California Ocean Plan, Carcinogen

(d)California Ocean Plan, Non-Carcinogen

(e)Sum of 1,2 and 1,3-dichlorobenzenes

(f)Sum of polynuclear aromatic hydrocarbons (PAHs) including all PAHs listed and 1,2 benzanthracene and 3,4-benzofluoranthene = 8.8 ng/L

(*) Values are compared versus blank instead of the MDL.

Table E-8. GC/MS results of base neutral analysis of Ballona Creek samples (7/7 - 12/10/92)

CHEMICAL NAME [1]	Number Found Above MDL & Blank (10 Samples) [2]	Average (ng/L) [3]	Range (ng/L) [4]	Drinking Water Standards (a) (ng/L) [5]	Ocean Standards (b) (ng/L) [6]
	Phenol	7	166	29 - 749	
2-Methylphenol	0	<MDL	-		
4-Methylphenol	0	25	-		
2-Nitrophenol	7	42	27 - 72		
Benzoic Acid	5	543	111 - 961		
1,4-Dichlorobenzene(*)	9	75	38 - 146	75,000	18,000 (c)
Benzyl alcohol	1	459	-		
N-Nitrosodi-n-propylamine	1	3	-		
Nitrobenzene	2	24	7 - 40		4,900 (d)
Isophorone	2	33	19 - 47		150,000,000 (d)
Naphthalene(*)	9	99	61 - 138		
2-Methylnaphthalene	9	53	33 - 60		
Acenaphthylene	0	<MDL	-		8.8(c,f)
Dimethyl phthalate	4	27	4 - 70		820,000,000(d)
Acenaphthene	1	3	-		
Dibenzofuran	3	7	6 - 10		
Fluorene	4	5	3 - 6		8.8 (c,f)
Diethyl phthalate(*)	10	214	99 - 378		33,000,000 (d)
4-Chlorophenyl phenyl ether	7	28	7 - 53		
Azobenzene	7	17	5 - 26		
Phenanthrene	9	17	5 - 39		8.8 (c,f)
Anthracene	2	23	6 - 39		8.8 (c,f)
Di-n-butyl phthalate(*)	10	1,337	679 - 1,947		3,500,000 (d)
Fluoranthene	8	9	3 - 21		15,000 (d)

E-11

Table E-8 (cont'd)

CHEMICAL NAME [1]	Number Found Above MDL & Blank (10 Samples) [2]	Average (ng/L) [3]	Range (ng/L) [4]	Drinking Water Standards (a) (ng/L) [5]	Ocean Standards (b) (ng/L) [6]
Pyrene(*)	9	21	2 - 126		8.8 (c,f)
Butyl benzyl phthalate(*)	10	1,248	217 - 2,245		
Benzo(a)anthracene	5	22	9 - 46		
Chrysene(*)	3	61	13 - 145		8.8 (c,f)
Bis(2-ethylhexyl) phthalate(*)	9	4,518	2,248 - 7,120	6,000	3,500
Di-n-octyl phthalate(*)	9	1,442	17 - 3,655		
Benzo(b)fluoranthene	1	4	-		
Benzo(k)fluoranthene	1	5	-		8.8 (c,f)
Benzo(a)pyrene	4	47	18 - 106	200	8.8 (c,f)
Indeno(1,2,3,4-c,d)pyrene	0	<MDL	-		8.8 (c,f)
Dibenzo(a,h)anthracene	0	<MDL	-		8.8 (c,f)
Benzo(g,h,i)perylene	0	<MDL	-		

(a)USEPA Drinking Water Standards reported by the AWWA Journal, Feb. 1993, p. 48.

(b)California Ocean Plan, 1990, State of California, State Water Resources Control Board, Resolution No. 90-27, Adopted and effective March 22, 1990.

(c)California Ocean Plan, Carcinogen

(d)California Ocean Plan, Non-Carcinogen

(e)Sum of 1,2 and 1,3-dichlorobenzenes

(f)Sum of polynuclear aromatic hydrocarbons (PAHs) including all PAHs listed and 1,2 benzanthracene and 3,4-benzofluoranthene = 8.8 ng/L

(*) Values are compared versus blank instead of the MDL.

Table E-9 (cont'd)

CHEMICAL NAME [1]	Number Found Above MDL & Blank (9 Samples) [2]	Average (ng/L) [3]	Range (ng/L) [4]	Drinking Water Standards (a) (ng/L) [5]	Ocean Standards (b) (ng/L) [6]
Chrysene(*)	4	2,016	3 - 8,032		8.8 (c,f)
Bis(2-ethylhexyl) phthalate(*)	9	4,349	2,783 - 5,400	6,000	3500 (c)
Di-n-octyl phthalate(*)	8	391	2 - 1,902		
Benzo(b)fluoranthene	2	20	1 - 38		
Benzo(k)fluoranthene	1	39	-		8.8 (c,f)
Benzo(a)pyrene	3	1,803	3 - 5,398	200	8.8 (c,f)
Indeno(1,2,3,4-c,d)pyrene	1	71	-		8.8 (c,f)
Dibenzo(a,h)anthracene	1	59	-		8.8 (c,f)
Benzo(g,h,i)perylene	1	58	-		

(a)USEPA Drinking Water Standards reported by the AWWA Journal, Feb. 1993, p. 48.

(b)California Ocean Plan, 1990, State of California, State Water Resources Control Board, Resolution No. 90-27, Adopted and effective March 22, 1990.

(c)California Ocean Plan, Carcinogen

(d)California Ocean Plan, Non-Carcinogen

(e)Sum of 1,2 and 1,3-dichlorobenzenes

(f)Sum of polynuclear aromatic hydrocarbons (PAHs) including all PAHs listed and 1,2 benzanthracene and 3,4-benzofluoranthene = 8.8 ng/L

(*)Values are compared versus blank instead of the MDL.

Table E-9. GC/MS results of base neutral analysis of Sepulveda Channel samples (7/7 - 12/10/92).

CHEMICAL NAME [1]	Number Found Above MDL & Blank (9 Samples) [2]	Average (ng/L) [3]	Range (ng/L) [4]	Drinking Water Standards (a) (ng/L) [5]	Ocean Standards (b) (ng/L) [6]
	Phenol	5	100	33 - 290	
2-Nitrophenol	5	27	13 - 49		
Benzoic Acid	5	501	226 - 810		
1,4-Dichlorobenzene(*)	8	58	34 - 117	75,000	18,000 (c)
Isophorone	1	17	-		150,000,000 (d)
Naphthalene(*)	8	102	38 - 153		
2-Methylnaphthalene	8	58	26 - 100		
2-Chloronaphthalene	1	1	-		
2-Nitroaniline	0	<MDL	-		
Dimethyl phthalate	2	26	23 - 30		820,000,000 (d)
Acenaphthene	2	30	8 - 53		
Dibenzofuran	4	7	2 - 12		
Fluorene	5	43	2 - 190		8.8 (c,f)
Diethyl phthalate(*)	8	201	88 - 420		33,000,000 (d)
4-Chlorophenyl phenyl ether	7	22	15 - 34		
Azobenzene	4	21	9 - 29		
Phenanthrene	7	26	8 - 43		8.8 (c,f)
Anthracene	4	1,046	2 - 4,177		8.8 (c,f)
Di-n-butyl phthalate(*)	8	1,223	570 - 2,782		
Fluoranthene	6	19	5 - 33		15,000 (d)
Pyrene(*)	8	956	4 - 7,560		8.8 (c,f)
Butyl benzyl phthalate(*)	9	1,148	408 - 3,271		
Benz(a)anthracene	4	14	9 - 17		

Table E-10. GC/MS results of base neutral analysis of Centinela Creek samples (7/7 - 12/10/92).

CHEMICAL NAME [1]	Number Found Above MDL & Blank (8 Samples) [2]	Average (ng/L) [3]	Range (ng/L) [4]	Drinking Water Standards (a) (ng/L) [5]	Ocean Standards (b) (ng/L) [6]
Phenol	3	83	6 - 125		
2-Nitrophenol	5	30	7 - 49		
Benzoic Acid	5	584	38 - 1,194		
4-Chloro-3-methylphenol	0	<MDL	-		
1,4-Dichlorobenzene(*)	7	44	2 - 77	75,000	18,000 (c)
Nitrobenzene	1	29	-		
Isophorone	2	52	37 - 68		
Bis(2-chloroethoxy)methane	0	<MDL	-		4,400 (d)
Naphthalene(*)	7	90	6 - 130		
2-Methylnaphthalene	7	53	3 - 73		
2-Chloronaphthalene	0	<MDL	-		
Dimethyl phthalate	3	20	3 - 31		820,000,000 (d)
Acenaphthene	3	5	3 - 7		
Dibenzofuran	4	8	2 - 16		
Fluorene	3	13	4 - 24		8.8 (c,f)
Diethyl phthalate(*)	8	216	6 - 730		33,000,000 (d)
4-Chlorophenyl phenyl ether	6	24	1 - 37		
Azobenzene	6	14	1 - 20		
Phenanthrene	5	23	1 - 65		8.8 (c,f)
Anthracene	4	107	1 - 406		8.8 (c,f)
Di-n-butyl phthalate(*)	8	816	70 - 1,931		3,500,000 (d)
Fluoranthene	5	9	1 - 17		15,000 (d)
Pyrene(*)	5	145	1 - 665		8.8 (c,f)

Table E-10 (cont'd)

CHEMICAL NAME [1]	Number Found Above MDL & Blank (8 Samples) [2]	Average (ng/L) [3]	Range (ng/L) [4]	Drinking Water Standards (a) (ng/L) [5]	Ocean Standards (b) (ng/L) [6]
Butyl benzyl phthalate(*)	8	708	62 - 1,606		
Benz(a)anthracene	3	22	10 - 38		
Chrysene(*)	4	181	11 - 654		8.8 (c,f)
Bis(2-ethylhexyl) phthalate(*)	8	6,240	807 - 32,055	6,000	3,500 (c)
Di-n-octyl phthalate(*)	8	59	4 - 147		
Benzo(b)fluoranthene	2	2	2 - 3		
Benzo(k)fluoranthene	2	2	1 - 3		8.8 (c,f)
Benzo(a)pyrene	4	145	4 - 546	200	8.8 (c,f)

(a)USEPA Drinking Water Standards reported by the AWWA Journal, Feb. 1993, p. 48.

(b)California Ocean Plan, 1990, State of California, State Water Resources Control Board, Resolution No. 90-27, Adopted and effective March 22, 1990.

(c)California Ocean Plan, Carcinogen

(d)California Ocean Plan, Non-Carcinogen

(e)Sum of 1,2 and 1,3-dichlorobenzenes

(f)Sum of polynuclear aromatic hydrocarbons (PAHs) including all PAHs listed and 1,2 benzanthracene and 3,4-benzofluoranthene = 8.8 ng/L

(*)Values are compared versus blank instead of the MDL.