# TRACE METALS
# IN
# COASTAL POWER PLANT EFFLUENTS

By

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in
collaboration
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# TRACE METALS IN COASTAL POWER PLANT EFFLUENTS

## INTRODUCTION

Cooling water from coastal power plants constitutes the largest volume of discharge to the Southern California Bight. The average annual flow from fifteen major electrical generating stations in the Bight during 1970-71 was $7.7 \times 10^{12}$ liters/yr., approximately six times the corresponding rate for municipal wastewater discharged via submarine outfalls. In recent years, there has been growing concern that these very large thermal discharges could be elevating the levels of certain toxic trace metals, such as copper, in the nearshore waters. However, due to the extremely low concentrations of such metals in seawater and in the discharges, there has been almost no reliable information as to whether or not the effects of metals in these effluents are significant. Therefore, we have conducted an investigation into the levels of six trace metals of greatest potential concern in both seawater influent and effluent of eight major generating stations located along the Ventura, Los Angeles, and Orange County coastlines. Our findings to date indicate that, although increased levels of some metals are found in certain nearshore regions, (particularly harbors), the power plants studied do not appear to be an important source.

PROCEDURES

In February 1977, with the support and assistance of the Southern California Edison Company (SCE), we initiated a study of dissolved ($<0.4\ \mu$) and particulate ($>0.4\ \mu$) cadmium, chromium, copper, nickel, lead, and zinc in the influents and effluents of eight SCE coastal generating stations (Figure 1). During 1970-71, these plants had a total annual discharge of $5.3 \times 10^{12}$ liters/yr, which constituted approximately 70 percent of the total thermal discharge to the Bight; in 1976, the discharge rate for the plants was $6.8 \times 10^{12}$ liters/yr (4,900 MGD).

In view of the difficulty of establishing net differences of trace metals at levels below one part per billion, it was necessary to be extremely careful about the cleanliness of labware preparation, sampling, replication, and determination of procedural blank and recovery values. Because cooling water is generally taken into and released from a given power plant at a depth of about 10 meters and ports for obtaining representative samples of influent and effluent are not available, we developed an all-plastic subsurface seawater pumping system patterned after that of Prof. John Martin (Moss Landing Marine Station).

Before the day of sampling, arrangements were made with operators of each plant so that no retention basin water (consisting of acid-cleaning wastes, fireside boiler washwater, and floor drainings) was being discharged with the cooling effluent on the day of sampling. This procedure was adopted because the concentrations of metals in basin waters are highly variable, often ranging over four orders of magnitude, and thus, only the effect of cooling process itself was investigated in this study.

Early on the day of sampling, the intake structure(s) was located with a fathometer and the boat moored directly above the terminus. The sampling hose was lowered to generally within one meter of the intake opening, the pump engaged, and samples collected.

To sample the effluent, divers descended with the sampling hose and a length of polypropylene line. One end of this line was attached to an edge of the discharge structure. The line, with the sampling hose attached, was then pulled taught across the end of the pipe and tied off in such a way as to position the hose in the center of the effluent orifice. The divers then boarded the boat and sampling commenced.

Samples were collected at least in duplicate, and in triplicate whenever practical. To obtain a sample, a pre-cleaned, capped, 4-liter polyethylene bottle was removed from its double polyethylene bag packaging, the cap was removed, and the bottle was then rinsed with sample water and filled from the seawater stream. The sample bottles were then tightly recapped and placed in double polyethylene bags, and returned to the laboratory within a few hours of collection.

In the laboratory, the samples were filtered without delay through prewashed 0.4-micron Nuclepore membrane filters, and the filtrates were acidified with concentrated nitric acid to a pH of about 2. Aliquots of both influent and effluent filtrates were spiked with standard solutions of the six target metals to monitor recoveries. Two procedural blanks (prepared by filtering 1 liter of deionized-distilled water) were run with each sample set, which consisted of eight individual samples and two recovery aliquots.

Because levels of trace metals in seawater are usually very low, and the relatively large amounts of salts in seawater can cause serious analytical interferences, samples must be treated to concentrate the dissolved metals from a large sample volume and, at the same time, remove the bulk salts so that the target trace metals can be measured by atomic absorption spectroscopy. For this purpose, two techniques--organic solvent extraction and ion exchange--were employed in this study. To determine the dissolved chromium, copper, nickel, and lead, 200 ml of the sample was first treated with 2 ml of 1 percent ammonium pyrolidine dithiocarbamate at a pH of about 4 and then heated to incipient boiling. After the sample was cooled by water bath to room temperature, 5.5 ml of redistilled methyl isobutyl ketone were added to the mixture and then shaken for 25 minutes. The organic phase was then separated, and saved for trace metals measurement against a set of internal standards that were prepared following the same procedure. For the determination of dissolved cadmium and zinc, one liter of sample was adjusted to a pH of about 7.6 and passed through a 2-cm diameter pyrex glass column, which was fitted with a 4-cm-deep bed of ammonium-form chelex 100 resin. After rinsing the column and resin with 150 ml deionized-distilled water, the trace metals were eluted by passing 25 ml of 4N nitric acid solution through the column and concentrations measured against standards prepared in deionized-distilled water.

The fraction of a metal retained by the 0.4-micron filter, and thus defined as in the particulate state, was determined by digesting the filter pad with 10 ml of 4N nitric acid solution for 2 hours. After adding 10 ml of deionized-distilled water to the residue, the supernatant was removed by filtration, and the trace metals were measured against the standards prepared in dionized-distilled water.

## RESULTS

At three of the stations (Ormond Beach, Long Beach, and San Onofre), 3-4 replicate samples of both influent and effluent were collected and analyzed. This provided us an opportunity to determine the precision or repeatability of our measurements, as indicated by the overall percentage coefficient of variation, CV (standard deviation/mean x 100). The resulting CV values are listed in Table 1. These data show that, in general, the average coefficient of variation for a given metal and state is well below $\pm$ 50 percent, which is quite satisfactory when working at the sub-part-per-billion level.

In view of the large number of data obtained and the fact that replicate grab samples were collected only once from each site, we have grouped the data from the eight generating stations, to characterize the overall effect of SCE's use of nearshore seawater on the metals balance in the Bight. To accomplish this, for a given metal and state, each available mean effluent concentration was compared to the corresponding influent mean concentration, and the difference (positive or negative) was calculated. Because more than one effluent was sampled at several of the plants, ten to thirteen "delta" values generally were obtained for each of the twelve groups (six metals and two states); Table 2 lists the median value for each of these groups, and for comparison, the median influent concentration value for each group. To obtain estimates of the yearly input of the metals to the Bight by SCE from the cooling process, the median "delta" values were multiplied by the average total discharge from the eight plants ($6.8 \times 10^{12}$ liters/yr). The combined annual mass emission rate values (dissolved plus particulate) for each metal are presented in Table 3.

For comparsion, available estimates for three other types of inputs from this general area (Ventura, Los Angeles, and Orange Counties) are also listed in Table 3. These are (1) the 1976 values for municipal wastewater discharged by the Oxnard, Hyperion, JWPCP, and OCSD treatment plants (Schafer, 1977); (2) the estimated input to a 100 km by 100 km zone off Los Angeles and Orange Counties in 1975 (Young and Jan, 1977); and (3) the estimated input to the study area via storm runoff from a 1971 Project study (Young et al. 1973).

## DISCUSSION

The results of Table 2 show that, in 11 of the 12 available comparisons, the median difference between effluent and influent concentration was positive, suggesting a net addition of the metals to the seawater during its use for cooling. However, it should be noted that none of the increases exceeds 0.25 ppb, and ten of the twelve values are less than plus 0.1 ppb. Thus, althout some metals contamination of the influent seawater has been detected, in general it is occurring at exceeding low levels.

The data of Table 3 help to place these results in perspective. This comparison of estimated annual mass emission rates to the general study area for the six metals investigated indicates that the use of nearshore seawater by the SCE system contributes only 0.06 - 0.4 percent of the combined input measured from municipal wastewater, aerial fallout, storm runoff, and thermal discharge.

Sufficient data are not yet available to properly evaluate the periodic retention basin discharges to the effluent flow. Further study of this aspect of thermal discharges may be warranted, as well as the occassional elevated concentration of a particular metal in a particular effluent.

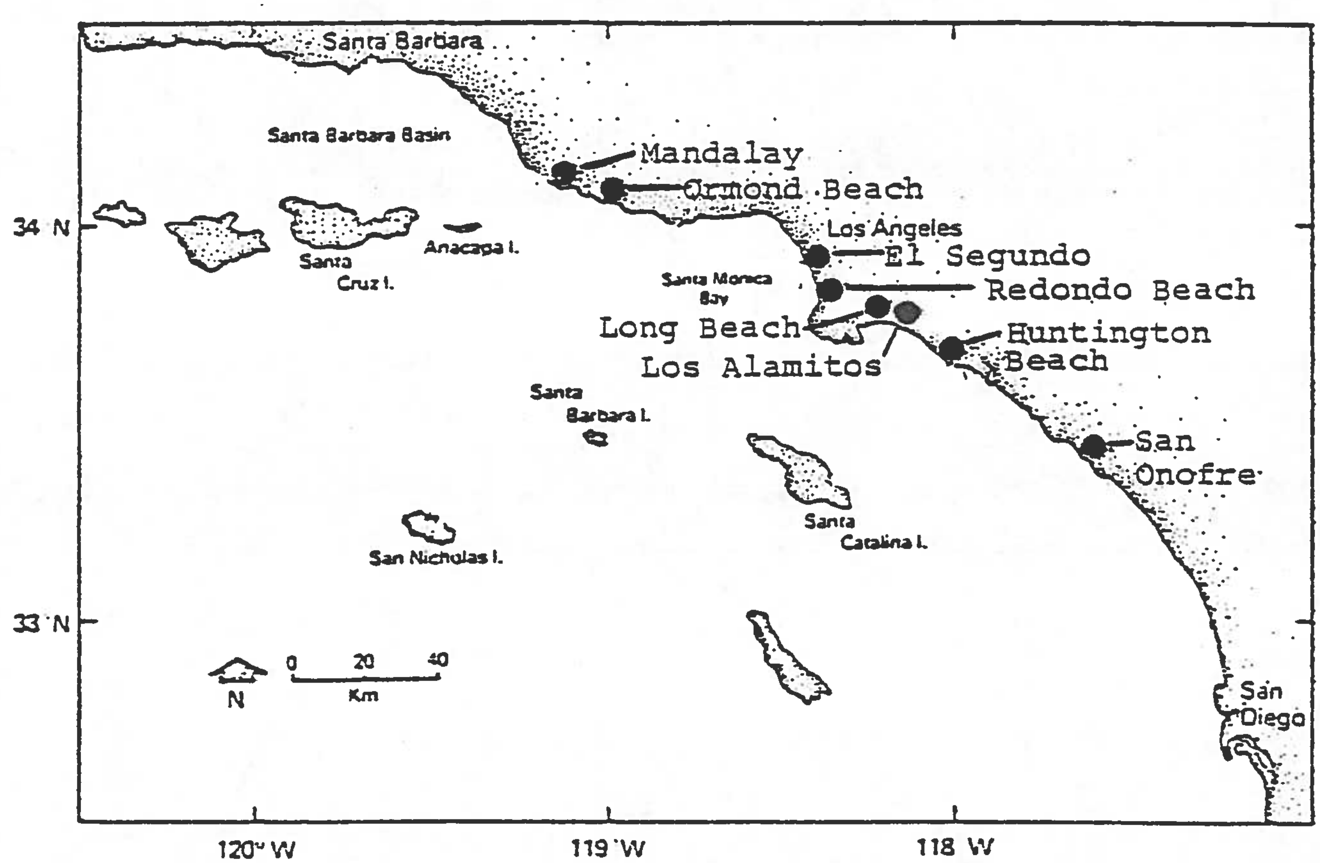


Figure 1. Locations of coastal Southern California Edison electrical generating stations.

Table 1. Coefficients of variation (%) for dissolved and particulate metal concentrations at three SCE stations where 3-4 replicate samples of both influent and effluent were analyzed.

| Metal | Phase | Ormond Beach Infl. | Ormond Beach Effl. | Long Beach Infl. | Long Beach Effl. | San Onofre Infl. | San Onofre Effl. |
|---|---|---|---|---|---|---|---|
| Cd | Diss | 48 | 17 | 6.2 | 62 | 102 | 61 |
| | Part | 52 | 39 | ND* | ND* | 82 | 79 |
| Cr | Diss | 40 | 17 | 5.9 | 5.4 | 22 | 5.7 |
| | Part | 12 | 28 | 2.2 | 7.1 | 18 | 31 |
| Cu | Diss | 37 | 26 | 9.9 | 14 | 22 | 14 |
| | Part | 17 | 2.5 | 3.6 | 1.4 | 13 | 23 |
| Ni | Diss | 37 | 27 | 12 | 5.0 | 15 | 7.1 |
| | Part | 17 | 18 | 13 | 5.2 | 64 | 27 |
| Pb | Diss | ND* | ND* | 3.3 | 27 | ND* | 83 |
| | Part | 1.3 | 45 | 36 | 5.0 | 119 | 19 |
| Zn | Diss | ND* | ND* | 31 | 21 | ND* | ND |
| | Part | 33 | 6.2 | 2.8 | 8.4 | 12 | 21 |

* Insufficient data

Table 2. Comparison of typical SCE influent metal concentrations (ppb) with median concentration increase (ppb) due to use of seawater for cooling.

| Metal | Median Influent Conc. | | Md. Conc. Increase | |
|---|---|---|---|---|
| | Diss. | Part. | Diss. | Part. |
| Cd | 0.06 | 0.006 | 0.034 | 0.005 |
| Cr | 0.16 | 0.200 | (0.010)* | 0.097 |
| Cu | 0.80 | 0.320 | 0.21 | 0.10 |
| Ni | 0.44 | 0.160 | 0.10 | 0.004 |
| Pb | 0.14 | 0.24 | 0.04 | 0.07 |
| Zn | 0.20 | 0.48 | 0.09 | 0.17 |

* Negative valve

Table 3. Comparison of estimated annual inputs of total metals (diss. and part.) to the Bight.
- m ton/yr -

| Total Metal | Muni. WW[1] | Dry Fallout[2] | Storm Runoff[3] | SCE Cooling | Sum | SCE Sum % |
|---|---|---|---|---|---|---|
| Cd | 66 | 0.8 | 1 | 0.3 | 68 | 0.4 |
| Cr | 930 | 6.6 | 25 | 0.6 | 962 | 0.06 |
| Cu | 881 | 31 | 18 | 2.1 | 933 | 0.2 |
| Ni | 398 | 12 | 17 | 0.7 | 428 | 0.2 |
| Pb | 205 | 240 | 90 | 0.8 | 536 | 0.2 |
| Zn | 1,660 | 150 | 100 | 1.8 | 1,910 | 0.1 |

1) Oxnard, Hyperion, JWPCP, OCSD - 1976.

2) 100 km x 100 km off LA-Orange Co. Basin - 1975.

3) Storm runoff from Ventura, L.A., and Orange Counties during 1971-72, an abnormally dry year.

## APPENDIX I: SAMPLING PROCEDURES

### Equipment:

1. Peristaltic pump (Little Giant, model LG-301) with Tygon tube
2. 30 meters of nylon reinforced Tygon hose
3. Plastic addaptors
4. One gallon Nalgene bottles
5. 2.5 kg P.V.C. weight
6. 50 meters of 1/4" polypropylene lowering and securing line
7. Portable Honda E-1500 generator
8. All plastic chest for sample transportation

### Bottle Filling:

Care was taken to avoid contamination while filling the precleaned sample bottles. A Nalgene one gallon container was removed from two plastic bags, the top removed and placed in a separate cleaned plastic bag. Another plastic bag was placed over the mouth of the bottle to prevent fallout contamination. The bottle was rinsed with sample water then filled by holding the Tygon discharge tube near the bottle orifice. The bottle was allowed to overflow, and the cap immediately placed back on the bottle. The bottle was labled , re-double bagged and placed in an all plastic container for transport back to the lab.

## INTAKE STRUCTURES

The intake structures were located by a fathometer and the boat was moored directly above. A PVC weight was used to submerge the nylon reinforced sampling hose. The plastic and parafilm end cover was removed from the hose below the water surface and the hose was lowered to within one meter of the actual intake structure. The parastaltic pump was engaged and allowed to pump for a minimum of five minutes before samples were collected. When two intake structures were side-by-side the samples were collected mid-way between the two at the appropriate depth.

Exceptions to this procedure are explained below:

### Los Alamitos:

There are three separate intakes for the six generating units, all receiving water from the Los Cerritos Channel. The influent was collected from near the center of this channel prior to the first intake structure.

### Long Beach:

There is a concrete dam around the intake structure located in the back channel of Long Beach Harbor. The sample (4-12-77) was collected by lowering the weighted sample hose in the channel near the outside of the dam.

Mandalay:

The intake water for this plant comes initially from the entrance of Channel Islands Marina. A channel from the Harbor runs for approximately two miles north to the generating plant. The sample hose was lowered to one foot below the surface approximately five feet from the intake grizzely screens. High and low tide samples were collected. at this plant.

DISCHARGE STRUCTURES

The discharge structures were generally easy to locate because of the distinct bubble on the sea surface. The dischage sampling procedures are discussed below:

Ormond Beach:

Divers descended with the sampling hose attached to a three meter section of P.V.C. pipe. One diver held the pipe in the flow while the second diver steadied the first. The topside personnel were notified that the hose was in place and samples were collected.

El Segundo, Huntington Beach, Redondo Beach and San Onofre:

Divers descended with the sampling hose and a 20 meter section of 1/4 inch polypropylene line. One diver attached one end of the line to the edge of the discharge pipe. He then swam around to the opposite side of the pipe and pulled the line taught across the orifice of the pipe with the sampling hose secured to the center of this line. The team of divers pulled themselelved along this taught line and ascended along the sampling hose making sure there were no constrictions. The team boarded the boat and sampling commenced.

Los Alamitos:

There are three distinct discharges in the San Gabriel River, units 3 and 4 being farthest up stream, then 1 and 2, and 5 and 6 downstream. The sampling hose was attached to a three meter section of P.V.C. pipe which was held in the center of the bubble until sampling was completed. Each discharge at this plant was sampled in the same manner.

Long Beach:

The discharge structure at this plant is located in the Back Channel of Long Beach Harbor. The pipe is in 10 meters of water at the bottom of a concrete well that comes to the surface. On 4-12-77 the northern most of two side-by-side wells was sampled by lowering the weighted sampling hose to 9 meters below the surface of the water.

Mandalay:

The discharge water from this plant empties into a channel on the beach. The weighted sampling hose was lowered from a bridge to 0.3 meters below the surface of the water at both high and low tides.

APPENDIX II:

Net concentrations (µg/l of dissolved ( < 0.4 µ) and particulate ( > 0.4 µ) metals in influent and effluent seawater used for cooling by eight Southern California Edison Company generating stations. Total net concentrations (µg/l) were derived by combining dissolved plus particulate for each replicate. All concentrations corrected for procedural blanks (also presented) and ionic recoveries.

# MANDALAY

## MARCH 29, 1977

### PPB

| | | Cd | | Cr | | Cu | | Ni | | Pb | | Zn | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| * | | DIS | PART | DIS | PART | DIS | PART | DIS | PART | DIS | PART | DIS | PART |
| INFLUENT HIGH TIDE | 1 | 0.136 | 0.019 | 0.13 | 0.126 | 1.49 | 0.334 | 0.37 | 0.226 | 0.06 | 0.266 | 1.55 | 0.404 |
| | 2 | 0.123 | 0.057 | 0.19 | 0.149 | 1.48 | 0.699 | 0.36 | 0.386 | 0.10 | 0.919 | 1.97 | 0.541 |
| | $\bar{x}$ ± S.E. | 0.129 ± 0.006 | 0.038 ± 0.019 | 0.16 ± 0.03 | 0.138 ± 0.012 | 1.48 ± 0.005 | 0.516 ± 0.182 | 0.36 ± 0.005 | 0.306 ± 0.080 | 0.08 ± 0.02 | 0.592 ± 0.326 | 1.76 ± 0.21 | 0.472 0.068 |
| | TOTAL ± S.E. | 0.168 ± 0.012 | | 0.318 ± 0.020 | | 2.002 ± 0.178 | | 0.671 ± 0.075 | | 0.672 ± 0.346 | | 2.232 ± 0.278 | |

* TIDES: INFLUENT < HIGH: 3.9 FT. / LOW: 0.4 FT. EFFLUENT < HIGH: 3.5 FT. / LOW: 0.5 FT.

| | | Cd DIS | Cd PART | Cr DIS | Cr PART | Cu DIS | Cu PART | Ni DIS | Ni PART | Pb DIS | Pb PART | Zn DIS | Zn PART |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| INFLUENT LOW TIDE | 1 | 0.094 | 0.014 | 0.15 | 0.354 | 1.35 | 0.606 | 0.39 | 0.642 | 0.12 | 0.475 | 0.76 | 0.781 |
| | 2 | 0.144 | 0.015 | 0.16 | 0.318 | 1.35 | 0.597 | 0.39 | 0.693 | 0.05 | 0.428 | 1.19 | 0.806 |
| | $\bar{x}$ ± S.E. | 0.119 ± 0.025 | 0.014 ± 0.0005 | 0.16 ± 0.005 | 0.336 ± 0.016 | 1.35 — | 0.602 ± 0.004 | 0.39 — | 0.668 ± 0.025 | 0.08 ± 0.035 | 0.452 ± 0.023 | 0.98 ± 0.22 | 0.794 ± 0.012 |
| | TOTAL ± S.E. | 0.134 ± 0.025 | | 0.491 ± 0.013 | | 1.952 ± 0.004 | | 1.058 ± 0.025 | | 0.536 ± 0.058 | | 1.768 ± 0.227 | |

| | | Cd DIS | Cd PART | Cr DIS | Cr PART | Cu DIS | Cu PART | Ni DIS | Ni PART | Pb DIS | Pb PART | Zn DIS | Zn PART |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BLANK | 1 | 0.008 | 0.006 | 0.01 | <0.020 | 0.09 | <0.017 | 0.02 | <0.051 | 0.10 | 0.112 | 0.14 | 0.058 |
| | 2 | 0.004 | <0.004 | <0.01 | <0.025 | 0.15 | <0.021 | <0.02 | <0.062 | 0.11 | 0.030 | 0.14 | 0.058 |
| | $\bar{x}$ | 0.006 | <0.005 | <0.01 | <0.022 | 0.12 | <0.019 | <0.02 | <0.056 | 0.10 | 0.071 | 0.14 | 0.058 |
| | ± S.E. | ±0.002 | — | — | — | ±0.03 | — | — | | ±0.005 | ±0.041 | — | — |

# MANDALAY (CON'T)

## MARCH 29, 1977

### PPB

| | | Cd Dis | Cd Part | Cr Dis | Cr Part | Cu Dis | Cu Part | Ni Dis | Ni Part | Pb Dis | Pb Part | Zn Dis | Zn Part |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EFFLUENT HIGH TIDE | 1 | 0.116 | 0.005 | 0.16 | 0.129 | 1.94 | 0.400 | 0.44 | 0.171 | 0.17 | 0.281 | 0.74 | 0.503 |
| | 2 | 0.124 | <0.004 | 0.13 | 0.201 | 2.17 | 0.494 | 0.44 | 0.296 | 0.11 | 0.255 | 2.21 | 0.569 |
| | $\bar{x}$ ± S.E. | 0.120 ± 0.004 | <0.004 — | 0.14 ± 0.02 | 0.165 ± 0.036 | 2.06 ± 0.12 | 0.447 ± 0.047 | 0.44 — | 0.234 ± 0.062 | 0.14 ± 0.03 | 0.268 ± 0.013 | 1.47 ± 0.74 | 0.536 ± 0.033 |
| TOTAL ± S.E. | | <0.124 | | 0.310 ± 0.021 | | 2.502 ± 0.162 | | 0.674 ± 0.062 | | 0.408 ± 0.093 | | 2.011 ± 0.768 | |
| EFFLUENT LOW TIDE | 1 | 0.103 | 0.035 | 0.18 | 0.271 | 1.94 | 0.694 | 0.52 | 0.484 | 0.09 | 0.766 | 0.80 | 1.040 |
| | 2 | 0.098 | 0.005 | 0.12 | 0.300 | 1.95 | 0.727 | 0.37 | 0.375 | 0.13 | 0.363 | 1.34 | 0.882 |
| | $\bar{x}$ ± S.E. | 0.100 ± 0.002 | 0.020 ± 0.015 | 0.15 ± 0.03 | 0.286 ± 0.014 | 1.94 ± 0.005 | 0.710 ± 0.016 | 0.44 ± 0.08 | 0.430 ± 0.054 | 0.11 ± 0.02 | 0.564 ± 0.202 | 1.07 ± 0.27 | 0.961 ± 0.079 |
| TOTAL ± S.E. | | 0.120 ± 0.018 | | 0.436 ± 0.016 | | 2.656 ± 0.022 | | 0.874 ± 0.130 | | 0.674 ± 0.182 | | 2.031 ± 0.191 | |

# ORMOND BEACH

## FEB 15, 1977

## PPB

| | | Cd Dis | Cd Part | Cr Dis | Cr Part | Cu Dis | Cu Part | Ni Dis | Ni Part | Pb Dis | Pb Part | Zn Dis | Zn Part |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| INFLUENT | 1 | 0.043 | 0.002 | 0.21 | 0.100 | 0.52 | 0.016 | 1.32 | 0.069 | <0.05 | 0.037 | <0.3 | 0.168 |
| | 2 | 0.101 | 0.003 | 0.22 | 0.079 | 1.38 | 0.020 | 1.08 | 0.060 | <0.05 | 0.038 | <0.3 | 0.173 |
| | 3 | 0.047 | 0.001 | 0.18 | 0.083 | 1.14 | 0.023 | 0.53 | 0.085 | <0.05 | 0.038 | <0.3 | 0.294 |
| | 4 | 0.040 | — | 0.40 | -- | 0.94 | — | 1.47 | — | <0.05 | — | <0.3 | — |
| | $\bar{x}$ | 0.058 | 0.002 | 0.252 | 0.087 | 0.995 | 0.020 | 1.100 | 0.071 | <0.05 | 0.038 | <0.3 | 0.212 |
| | ± S.E. | ±0.014 | ±0.0006 | ±0.050 | ±0.006 | ±0.182 | ±0.002 | ±0.206 | ±0.007 | — | ±0.0003 | — | ±0.041 |
| TOTAL $\bar{x}$ ± S.E. | | 0.066 ±0.019 | | 0.291 ±0.014 | | 1.03 ±0.258 | | 1.05 ±0.228 | | <0.088 — | | <0.512 — | |
| EFFLUENT | 1 | 0.043 | 0.005 | 0.29 | 0.075 | 1.80 | 0.071 | 0.96 | 0.204 | <0.05 | 0.040 | <0.3 | 0.260 |
| | 2 | 0.046 | 0.002 | 0.24 | 0.119 | 1.00 | 0.068 | 0.53 | 0.197 | <0.05 | 0.087 | <0.3 | 0.286 |
| | 3 | 0.032 | 0.004 | 0.19 | 0.136 | 1.16 | 0.068 | 0.64 | 0.143 | <0.05 | 0.047 | <0.3 | 0.294 |
| | 4 | ND * | — | 0.24 | — | 1.27 | — | 0.62 | — | <0.05 | — | — | — |
| | $\bar{x}$ | 0.040 | 0.004 | 0.240 | 0.110 | 1.31 | 0.069 | 0.69 | 0.181 | <0.05 | 0.058 | <0.3 | 0.280 |
| | ± S.E. | ±0.004 | ±0.0009 | ±0.020 | ±0.018 | ±0.17 | ±0.001 | ±0.094 | ±0.019 | — | ±0.015 | — | ±0.010 |
| TOTAL $\bar{x}$ ± S.E. | | 0.044 ±0.004 | | 0.350 ±0.012 | | 1.39 ±0.245 | | 0.891 ±0.137 | | <0.108 — | | <0.580 — | |
| BLANK | 1 | 0.022 | <0.001 | <0.02 | 0.027 | 0.26 | 0.020 | 0.035 | <0.047 | 0.06 | 0.012 | 0.75 | <0.010 |
| | 2 | 0.033 | 0.003 | <0.02 | 0.033 | 0.09 | 0.023 | 0.035 | <0.053 | 0.05 | 0.014 | 1.00 | <0.010 |
| | $\bar{x}$ | 0.028 | <0.002 | <0.002 | 0.030 | 0.18 | 0.022 | 0.035 | <0.050 | 0.06 | 0.013 | 0.88 | <0.010 |
| | ± S.E. | ±0.006 | — | — | ±0.003 | ±0.08 | ±0.002 | — | — | ±0.005 | ±0.001 | ±0.12 | — |

* EXTREME VALUE DROPPED

EL SEGUNDO

MARCH 8, 1977

PPB

| | | Cd Dis | Cd Part | Cr Dis | Cr Part | Cu Dis | Cu Part | Ni Dis | Ni Part | Pb Dis | Pb Part | Zn Dis | Zn Part |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| INFLUENT | 1 | 0.036 | 0.010 | 0.14 | 0.426 | 0.42 | 0.064 | 0.36 | 0.095 | <0.04 | 0.240 | <0.2 | 0.358 |
| | 2 | 0.025 | 0.012 | 0.14 | 0.420 | 0.32 | 0.062 | 0.31 | 0.095 | 0.23 | 0.318 | <0.2 | 0.349 |
| | 3 | 0.021 | 0.011 | 0.16 | 0.456 | 0.27 | 0.103 | 0.29 | 0.082 | 0.25 | 0.260 | <0.2 | 0.300 |
| | $\bar{x}$ | 0.027 | 0.011 | 0.15 | 0.434 | 0.34 | 0.083 | 0.32 | 0.091 | <0.17 | 0.279 | <0.2 | 0.336 |
| | ± S.E. | ±0.004 | ±0.0006 | ±0.007 | ±0.011 | ±0.044 | ±0.011 | ±0.021 | ±0.004 | — | ±0.023 | — | ±0.018 |
| | TOTAL ± S.E. | 0.038 ± 0.004 | | 0.581 ± 0.018 | | 0.420 ± 0.033 | | 0.411 ± 0.024 | | <0.453 — | | <0.536 | |
| N. EFFLUENT | 1 | 0.078 | 0.019 | 0.22 | 1.32 | 0.56 | 0.328 | 0.46 | 0.235 | 0.09 | 0.656 | <0.2 | 0.830 |
| | 2 | 0.040 | 0.013 | 0.14 | 1.45 | 0.54 | 0.509 | 0.41 | 0.945 | 0.14 | 0.847 | <0.2 | 1.09 |
| | $\bar{x}$ | 0.059 | 0.016 | 0.18 | 1.38 | 0.55 | 0.42 | 0.44 | 0.590 | 0.11 | 0.752 | <0.2 | 0.960 |
| | ± S.E. | ±0.019 | ±0.003 | ±0.040 | ±0.065 | ±0.010 | ±0.09 | ±0.025 | ±0.355 | ±0.025 | ±0.096 | — | ±0.130 |
| | TOTAL ± S.E. | 0.075 ± 0.022 | | 1.565 ± 0.025 | | 0.968 ± 0.080 | | 1.025 ± 0.330 | | 0.866 ± 0.120 | | <1.160 — | |
| S. EFFLUENT | 1 | 0.036 | 0.014 | 0.17 | 0.635 | 0.52 | 0.170 | 0.48 | 0.055 | 0.10 | 0.331 | <0.2 | 0.568 |
| | 2 | 0.086 | 0.017 | 0.23 | 0.740 | 0.59 | 0.181 | 0.47 | 0.074 | 0.21 | 0.350 | <0.2 | 0.451 |
| | $\bar{x}$ | 0.061 | 0.016 | 0.20 | 0.688 | 0.56 | 0.18 | 0.48 | 0.064 | 0.16 | 0.340 | <0.2 | 0.510 |
| | ± S.E. | ±0.025 | ±0.002 | ±0.030 | ±0.052 | 0.035 | ±0.006 | ±0.005 | ±0.001 | ±0.055 | ±0.010 | — | ±0.058 |
| | TOTAL ± S.E. | 0.076 ± 0.026 | | 0.888 ± 0.082 | | 0.730 ± 0.040 | | 0.540 ± 0.004 | | 0.500 ± 0.064 | | <0.710 — | |
| BLANK | 1 | 0.014 | 0.006 | <0.01 | 0.035 | 0.16 | <0.022 | <0.03 | <0.044 | 0.13 | 0.056 | 0.19 | 0.083 |
| | 2 | 0.005 | <0.001 | <0.01 | 0.032 | ND* | <0.029 | <0.03 | <0.044 | 0.12 | <0.013 | 0.10 | 0.047 |
| | $\bar{x}$ | 0.010 | <0.004 | <0.01 | 0.034 | 0.16 | <0.026 | <0.03 | <0.044 | 0.12 | 0.034 | 0.14 | 0.065 |
| | ± S.E. | ±0.004 | ±0.002 | — | ±0.002 | — | — | — | — | 0.050 | ±0.022 | ±0.045 | ±0.018 |

* EXTREME VALUE DROPPED

# REDONDO BEACH

## MARCH 22, 1977

## PPB

| | | Cd Dis | Cd Part | Cr Dis | Cr Part | Cu Dis | Cu Part | Ni Dis | Ni Part | Pb Dis | Pb Part | Zn Dis | Zn Part |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| INFLUENT | 1 | 0.026 | 0.006 | 0.14 | 0.126 | 0.84 | 0.089 | 0.44 | 0.095 | 0.21 | 0.221 | <0.2 | 0.173 |
| | 2 | 0.023 | <0.002 | 0.15 | 0.111 | 0.87 | 0.078 | 0.38 | 0.056 | 0.20 | 0.148 | <0.2 | 0.157 |
| 1-6 | $\bar{x}$ ± S.E. | 0.018 ± 0.005 | <0.004 — | 0.14 ± 0.005 | 0.133 ± 0.007 | 0.86 ± 0.015 | 0.083 ± 0.006 | 0.41 ± 0.030 | 0.076 ± 0.020 | 0.20 ± 0.005 | 0.184 ± 0.036 | <0.2 — | 0.165 ± 0.008 |
| TOTAL ± S.E. | | <0.028 — | | 0.264 ± 0.002 | | 0.938 ± 0.010 | | 0.486 ± 0.049 | | 0.390 ± 0.042 | | <0.365 — | |
| INFLUENT | 1 | 0.026 | 0.007 | 0.11 | 0.204 | 0.42 | 0.074 | 0.31 | 0.077 | 0.12 | 0.247 | <0.2 | 0.281 |
| | 2 | 0.029 | <0.002 | 0.14 | 0.015 | 0.[illegible]4 | 0.041 | 0.35 | 0.050 | 0.11 | 0.050 | <0.2 | 0.026 |
| 7-8 | $\bar{x}$ ± S.E. | 0.028 ± 0.002 | <0.004 — | 0.12 ± 0.015 | 0.110 ± 0.094 | 0.38 ± 0.040 | 0.05[illegible] ± 0.016 | 0.33 ± 0.020 | 0.064 ± 0.014 | 0.12 ± 0.005 | 0.148 ± 0.098 | <0.2 — | 0.154 0.128 |
| TOTAL ± S.E. | | < 0.032 — | | 0.234 ± 0.080 | | 0.438 ± 0.056 | | 0.394 ± 0.006 | | 0.264 ± 0.104 | | <0.354 — | |
| BLANK | 1 | 0.006 | <0.001 | <0.01 | 0.021 | 0.14 | <0.024 | <0.03 | <0.048 | 0.05 | 0.010 | 0.10 | 0.027 |
| | 2 | 0.006 | <0.001 | <0.01 | <0.012 | 0.24 | <0.023 | <0.03 | <0.046 | 0.03 | 0.019 | 0.13 | 0.034 |
| | $\bar{x}$ ± S.E. | 0.006 — | <0.001 — | <0.01 — | <0.016 — | 0.19 ± 0.050 | <0.024 — | <0.03 — | <0.047 — | 0.04 ± 0.010 | 0.014 ± 0.004 | 0.12 0.02 | 0.030 ± 0.003 |

# REDONDO BEACH (CON'T)

MARCH 22, 1977

PPB

| | | Cd | | Cr | | Cu | | Ni | | Pb | | Zn | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | DIS | PART | DIS | PART | DIS | PART | DIS | PART | DIS | PART | DIS | PART |
| EFFLUENT | 1 | 0.090 | 0.007 | 0.13 | 0.102 | 0.75 | 0.076 | 0.49 | 0.068 | 0.21 | 0.172 | <0.2 | 0.158 |
| | 2 | 0.048 | <0.002 | 0.11 | 0.100 | 0.70 | 0.077 | 0.58 | 0.047 | 0.23 | 0.154 | 0.2 | 0.225 |
| 1-6 | $\bar{x}$ ± S.E. | 0.069 ± 0.021 | <0.004 — | 0.12 ± 0.010 | 0.101 ± 0.001 | 0.72 ± 0.025 | 0.076 ± 0.0005 | 0.54 ± 0.045 | 0.058 ± 0.010 | 0.22 ± 0.010 | 0.163 ± 0.009 | <0.2 — | 0.192 0.033 |
| TOTAL ± S.E. | | <0.074 — | | 0.221 ± 0.011 | | 0.802 ± 0.024 | | 0.592 ± 0.034 | | 0.383 ± 0.001 | | <0.372 — | |

| | | Cd | | Cr | | Cu | | Ni | | Pb | | Zn | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EFFLUENT | 1 | 0.098 | 0.006 | 0.17 | 0.082 | 0.60 | 0.038 | 0.51 | 0.069 | 0.16 | 0.095 | 0.2 | 0.090 |
| | 2 | 0.082 | 0.002 | 0.17 | 0.088 | 0.43 | 0.054 | 0.48 | 0.078 | 0.16 | 0.100 | <0.2 | 0.088 |
| 7-8 | $\bar{x}$ ± S.E. | 0.090 ± 0.008 | 0.004 ± 0.002 | 0.17 — | 0.085 ± 0.003 | 0.52 ± 0.005 | 0.046 ± 0.008 | 0.50 ± 0.015 | 0.074 ± 0.004 | 0.16 — | 0.098 ± 0.002 | <0.2 — | 0.089 ± 0.001 |
| TOTAL ± S.E. | | <0.094 — | | 0.255 ± 0.003 | | 0.561 ± 0.077 | | 0.568 ± 0.010 | | 0.258 ± 0.002 | | <0.289 — | |

LONG BEACH

APRIL 12, 1977

PPB

| | | Cd | | Cr | | Cu | | Ni | | Pb | | Zn | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Dis | Part | Dis | Part | Dis | Part | Dis | Part | Dis | Part | Dis | Part |
| INFLUENT | 1 | 0.059 | 0.041 | 0.31 | 0.158 | 1.83 | 0.633 | 0.93 | 0.083 | 0.12 | 0.280 | 4.49 | 1.07 |
| | 2 | 0.066 | <0.005 | 0.34 | 0.158 | 1.56 | 0.594 | 0.71 | 0.091 | 0.13 | 0.140 | 5.32 | 1.13 |
| | 3 | 0.063 | <0.005 | 0.32 | 0.153 | 1.67 | 0.633 | 0.80 | 0.070 | 0.12 | 0.174 | 8.53 | 1.11 |
| | 4 | 0.067 | — | 0.31 | — | 1.43 | — | 0.75 | — | 0.12 | — | 8.27 | — |
| | $\bar{x}$ | 0.064 | <0.017 | 0.34 | 0.156 | 1.62 | 0.620 | 0.80 | 0.081 | 0.12 | 0.198 | 6.65 | 1.10 |
| | ± S.E. | ±0.002 | — | ±0.01 | ±0.002 | ±0.08 | ±0.013 | ±0.05 | ±0.006 | ±0.002 | ±0.042 | ±1.02 | ±0.018 |
| TOTAL $\bar{x}$ ± S.E. | | <0.080 — | | 0.500 ± 0.016 | | 2.307 ±0.089 | | 0.895 ± 0.062 | | 0.321 ± 0.040 | | 7.217 ± 1.239 | |
| EFFLUENT | 1 | 0.039 | 0.005 | 0.22 | 0.557 | 3.15 | 0.964 | 0.85 | 0.316 | 0.30 | 0.327 | 3.97 | 1.14 |
| | 2 | 0.039 | <0.005 | 0.20 | 0.555 | 3.69 | 0.972 | 0.77 | 0.338 | 0.21 | 0.344 | 4.20 | 1.04 |
| | 3 | 0.067 | 0.014 | 0.21 | 0.487 | 3.59 | 0.991 | 0.80 | 0.362 | 0.17 | 0.365 | 5.55 | 1.23 |
| | 4 | 0.126 | — | 0.23 | — | 4.39 | — | 0.77 | — | 0.20 | — | 6.15 | — |
| | $\bar{x}$ | 0.068 | <0.008 | 0.22 | 0.534 | 3.70 | 0.976 | 0.80 | 0.335 | 0.22 | 0.346 | 4.97 | 1.14 |
| | ± S.E. | ± 0.021 | — | ±0.006 | ±0.022 | ± 0.26 | ±0.008 | ± 0.02 | ±0.010 | ±0.03 | ±0.010 | ± 0.53 | ±0.055 |
| TOTAL $\bar{x}$ ± S.E. | | <0.056 — | | 0.750 ± 0.026 | | 4.452 ±0.171 | | 1.142 ± 0.017 | | 0.573 ± 0.029 | | 5.710 ±0.536 | |
| BLANK | 1 | 0.006 | 0.008 | <0.01 | <0.022 | 0.09 | <0.018 | <0.03 | <0.054 | 0.05 | 0.287 | 0.20 | 0.031 |
| | 2 | 0.013 | 0.009 | <0.01 | <0.028 | 0.15 | <0.023 | <0.03 | <0.070 | 0.05 | 0.228 | 0.19 | 0.037 |
| | $\bar{x}$ | 0.009 | 0.008 | <0.01 | <0.025 | 0.12 | <0.020 | <0.03 | <0.062 | 0.05 | 0.258 | 0.20 | 0.034 |
| | ± S.E. | ±0.003 | ±0.0005 | — | — | ±0.03 | — | — | — | — | ±0.029 | ± 0.005 | ±0.003 |

# ALAMITOS

## FEB 22, 1977

## PPB

| | | Cd Dis | Cd Part | Cr Dis | Cr Part | Cu Dis | Cu Part | Ni Dis | Ni Part | Pb Dis | Pb Part | Zn Dis | Zn Part |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| INFLUENT | 1 | 0.030 | 0.005 | 0.14 | 0.210 | 3.33 | 0.488 | 1.37 | 0.025 | 0.51 | 0.748 | 0.45 | 0.673 |
| | 2 | 0.045 | 0.003 | 0.18 | 0.314 | ND* | 0.619 | 1.32 | 0.132 | 0.70 | 0.874 | 1.18 | 0.753 |
| | $\bar{x}$ | 0.038 | 0.004 | 0.16 | 0.262 | 3.33 | 0.554 | 1.34 | 0.078 | 0.605 | 0.821 | 0.815 | 0.713 |
| | ± S.E. | ±0.008 | ±0.001 | ±0.02 | ±0.052 | — | ±0.065 | ±0.025 | ±0.054 | ±0.095 | ±0.073 | ±0.365 | ±0.040 |
| TOTAL ± S.E. | | 0.042 ± 0.006 | | 0.422 ± 0.072 | | 3.82 — | | 1.42 ± 0.028 | | 1.42 ± 0.168 | | 1.53 ± 0.405 | |
| EFFLUENT 1+2 | 1 | 0.110 | 0.025 | 0.05 | 2.16 | 3.94 | 1.93 | 26.8 | 1.07 | 0.33 | 1.91 | 0.37 | 4.29 |
| | 2 | 0.070 | 0.012 | 0.05 | 2.44 | 2.75 | 1.97 | 30.7 | 0.763 | 1.31 | 1.91 | 1.26 | 4.43 |
| | $\bar{x}$ | 0.090 | 0.018 | 0.05 | 2.30 | 3.34 | 1.95 | 28.7 | 0.916 | 0.820 | 1.91 | 0.815 | 4.36 |
| | ± S.E. | ±0.020 | ±0.006 | — | ±0.14 | ±0.595 | ±0.020 | ±1.95 | ±0.154 | ±0.490 | — | ±0.445 | 0.70 |
| TOTAL ± S.E. | | 0.108 ± 0.026 | | 2.35 ± 0.140 | | 5.30 ± 0.575 | | 29.7 ± 1.80 | | 2.73 ± 0.490 | | 5.18 ± 0.515 | |
| EFFLUENT 3+4 | 1 | 0.099 | 0.013 | 0.14 | 0.360 | 3.25 | 0.818 | 1.43 | 0.077 | 1.47 | 1.06 | 0.51 | 0.990 |
| | 2 | 0.153 | 0.015 | 0.15 | 0.395 | 3.21 | 0.943 | 1.65 | 0.145 | 0.48 | 1.16 | <0.30 | 0.935 |
| | $\bar{x}$ | 0.126 | 0.014 | 0.14 | 0.378 | 3.23 | 0.880 | 1.54 | 0.111 | 0.985 | 1.11 | <0.40 | 0.962 |
| | ± S.E. | ±0.027 | ±0.001 | ±0.005 | ±0.018 | ±0.010 | ±0.624 | ±0.110 | 0.034 | ±0.505 | ±0.050 | — | ±0.028 |
| TOTAL ± S.E. | | 0.140 ± 0.028 | | 0.522 ± 0.022 | | 4.11 ± 0.042 | | 1.65 ± 0.144 | | 2.10 ± 0.456 | | <1.37 — | |

* EXTREME VALUE DROPPED

# ALAMITOS (CONT)

## FEB 22, 1977

## PPB

| | | Cd | | Cr | | Cu | | Ni | | Pb | | Zn | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | DIS | PART | DIS | PART | DIS | PART | DIS | PART | DIS | PART | DIS | PART |
| EFFLUENT 5+6 | 1 | 0.149 | 0.010 | 0.13 | 0.476 | 2.83 | 0.823 | 1.83 | 0.113 | 0.85 | 1.09 | 1.85 | 1.17 |
| | 2 | 0.103 | 0.017 | 0.15 | 0.447 | 2.60 | 0.765 | 1.57 | 0.050 | 1.45 | 0.937 | 1.72 | 1.17 |
| | $\bar{x}$ | 0.126 | 0.014 | 0.14 | 0.462 | 2.72 | 0.799 | 1.71 | 0.082 | 1.15 | 1.01 | 1.78 | 1.17 |
| | ± S.E. | ± 0.023 | ± 0.003 | ± 0.010 | ± 0.014 | ± 0.115 | ± 0.034 | ± 0.120 | ± 0.032 | ± 0.300 | ± 0.076 | ± 0.065 | — |
| TOTAL ± S.E. | | 0.140 ± 0.020 | | 0.602 ± 0.004 | | 3.51 ± 0.149 | | 1.79 ± 0.152 | | 2.16 ± 0.224 | | 3.00 ± 0.065 | |
| BLANK | 1 | 0.030 | <0.001 | <0.01 | 0.031 | 0.16 | <0.024 | <0.025 | <0.040 | 0.27 | 0.015 | 0.75 | 0.049 |
| | 2 | 0.045 | 0.007 | 0.01 | 0.056 | 0.17 | 0.019 | 0.025 | <0.032 | 0.29 | 0.012 | 0.38 | 0.071 |
| | $\bar{x}$ | 0.038 | 0.004 | <0.01 | 0.044 | 0.16 | 0.022 | <0.025 | <0.036 | 0.28 | 0.014 | 0.565 | 0.060 |
| | ± S.E. | ± 0.008 | — | — | ± 0.012 | ± 0.005 | ± 0.002 | — | — | ± 0.010 | ± 0.002 | ± 0.185 | 0.011 |

# HUNTINGTON BEACH

## MARCH 15, 1977

## PPB

| | | Cd Dis | Cd Part | Cr Dis | Cr Part | Cu Dis | Cu Part | Ni Dis | Ni Part | Pb Dis | Pb Part | Zn Dis | Zn Part |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| INFLUENT | 1 | 0.048 | 0.006 | 0.18 | 1.31 | 0.41 | 0.661 | 0.50 | 0.617 | 0.39 | 0.712 | <0.20 | 2.13 |
| | 2 | 0.044 | 0.014 | 0.22 | 1.25 | 0.27 | 0.637 | 0.51 | 0.651 | 0.37 | 0.669 | 0.41 | 2.05 |
| | 3 | 0.048 | 0.008 | 0.14 | 1.29 | 0.48 | 0.603 | 0.48 | 0.412 | 0.31 | 0.683 | <0.20 | 2.03 |
| | $\bar{x}$ | 0.047 | 0.009 | 0.18 | 1.28 | 0.39 | 0.634 | 0.50 | 0.561 | 0.36 | 0.688 | <0.27 | 2.07 |
| | ± S.E. | ± 0.001 | ± 0.002 | ± 0.023 | ± 0.018 | ± 0.062 | ± 0.017 | ± 0.009 | ± 0.075 | ± 0.024 | ± 0.013 | — | ± 0.031 |
| TOTAL $\bar{x}$ ± S.E. | | 0.056 ± 0.001 | | 1.463 ± 0.018 | | 1.020 ± 0.057 | | 1.056 ± 0.084 | | 1.045 ± 0.032 | | <2.340 — | |
| EFFLUENT | 1 | 0.086 | <0.003 | 0.18 | 0.820 | 1.01 | 0.583 | 0.65 | 0.421 | 0.24 | 0.424 | <0.20 | 0.940 |
| | 2 | 0.079 | 0.004 | 0.16 | 0.865 | 1.15 | 0.550 | 0.54 | 0.377 | 0.20 | 1.12 | 0.30 | 1.28 |
| | 3 | 0.196 | 0.016 | 0.16 | 0.886 | 1.14 | 0.605 | 0.57 | 0.503 | 0.22 | 0.633 | 0.51 | 1.35 |
| | $\bar{x}$ | 0.120 | <0.008 | 0.17 | 0.857 | 1.10 | 0.579 | 0.59 | 0.434 | 0.22 | 0.726 | <0.30 | 1.190 |
| | ± S.E. | ± 0.039 | — | ± 0.007 | ± 0.019 | ± 0.045 | ± 0.016 | ± 0.033 | ± 0.037 | ± 0.012 | ± 0.206 | — | ± 0.127 |
| TOTAL $\bar{x}$ ± S.E. | | <0.128 — | | 1.022 ± 0.013 | | 1.679 ± 0.045 | | 1.020 ± 0.052 | | 0.946 ± 0.195 | | <1.527 — | |
| BLANK | 1 | 0.005 | 0.012 | <0.01 | 0.097 | 0.18 | <0.031 | <0.02 | <0.062 | 0.06 | 0.050 | 0.09 | 0.252 |
| | 2 | 0.004 | ND* | <0.01 | 0.051 | 0.31 | <0.025 | <0.02 | <0.050 | 0.08 | 0.062 | 0.12 | 0.048 |
| | $\bar{x}$ | 0.004 | 0.012 | <0.01 | 0.074 | 0.24 | <0.028 | <0.02 | <0.056 | 0.07 | 0.056 | 0.10 | 0.150 |
| | ± S.E. | ± 0.0005 | — | — | ± 0.023 | ± 0.215 | — | — | — | ± 0.005 | ± 0.006 | ± 0.015 | 0.102 |

* EXTREME VALUE DROPPED

# SAN ONOFRE

## APRIL 5, 1977
## PPB

| | | Cd | | Cr | | Cu | | Ni | | Pb | | Zn | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | DIS | PART | DIS | PART | DIS | PART | DIS | PART | DIS | PART | DIS | PART |
| INFLUENT | 1 | 0.045 | 0.016 | 0.13 | 0.192 | 0.55 | 0.061 | 0.30 | 0.411 | <0.05 | 0.049 | <0.2 | 0.300 |
| | 2 | 0.152 | 0.036 | 0.16 | 0.132 | 0.61 | 0.057 | 0.28 | 0.152 | 0.19 | 0.317 | <0.2 | 0.322 |
| | 3 | 0.017 | 0.005 | 0.11 | 0.158 | 0.43 | 0.047 | 0.22 | 0.146 | <0.05 | 0.068 | <0.2 | 0.374 |
| | 4 | 0.029 | — | 0.10 | — | 0.37 | — | 0.23 | — | <0.05 | — | <0.2 | — |
| | $\bar{x}$ | 0.061 | 0.019 | 0.12 | 0.161 | 0.49 | 0.055 | 0.26 | 0.236 | <0.08 | 0.145 | <0.2 | 0.332 |
| | ± S.E. | ±0.031 | ±0.009 | ±0.013 | ±0.017 | ±0.055 | ±0.004 | ±0.019 | ±0.087 | — | 0.086 | — | ±0.022 |
| TOTAL ± S.E. | | 0.090 ±0.050 | | 0.294 ±0.016 | | 0.585 ±0.056 | | 0.503 ±0.106 | | <0.241 — | | <0.532 — | |
| EFFLUENT | 1 | 0.042 | <0.005 | 0.14 | 0.458 | 0.36 | 0.158 | 0.28 | 0.376 | 0.25 | 0.165 | <0.2 | 0.551 |
| | 2 | 0.057 | 0.007 | 0.13 | 0.415 | 0.43 | 0.120 | 0.27 | 0.358 | 0.07 | 0.237 | <0.2 | 0.536 |
| | 3 | 0.124 | 0.021 | 0.15 | 0.717 | 0.51 | 0.193 | 0.30 | 0.573 | 0.09 | 0.230 | <0.2 | 0.765 |
| | 4 | 0.042 | — | 0.14 | — | 0.43 | — | 0.25 | — | 0.05 | — | <0.2 | — |
| | $\bar{x}$ | 0.066 | <0.011 | 0.14 | 0.530 | 0.43 | 0.157 | 0.28 | 0.436 | 0.12 | 0.211 | <0.2 | 0.617 |
| | ± S.E. | ±0.020 | ±0.005 | ±0.001 | ±0.094 | ±0.031 | ±0.021 | ±0.01 | ±0.069 | ±0.05 | ±0.023 | — | ±0.074 |
| TOTAL ± S.E. | | <0.085 — | | 0.670 ±0.010 | | 0.590 ±0.057 | | 0.720 ±0.077 | | 0.347 ±0.034 | | 0.817 ±0.074 | |
| BLANK | 1 | 0.024 | 0.011 | <0.003 | <0.022 | 0.14 | <0.018 | <0.02 | <0.054 | 0.13 | 0.070 | 0.31 | 0.034 |
| | 2 | 0.009 | 0.008 | <0.003 | <0.025 | 0.16 | <0.021 | <0.02 | <0.062 | 0.10 | 0.049 | 0.17 | 0.027 |
| | $\bar{x}$ | 0.016 | 0.010 | <0.003 | <0.024 | 0.15 | <0.020 | <0.02 | <0.058 | 0.12 | 0.060 | 0.24 | 0.030 |
| | ± S.E. | ±0.008 | ±0.002 | — | | 0.01 | — | — | — | ±0.02 | ±0.010 | ±0.07 | ±0.003 |

# Ormond Beach II

## June 26, 1977

## PPB

| | | Cd Dis | Cd Part | Cr Dis | Cr Part | Cu Dis | Cu Part | Ni Dis | Ni Part | Pb Dis | Pb Part | Zn Dis | Zn Part |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| INFLUENT | 1 | 0.026 | <0.001 | 0.30 | 0.062 | 0.16 | <0.014 | 0.23 | <0.030 | 0.05 | 0.119 | <0.20 | 0.076 |
| | 2 | 0.044 | 0.004 | 0.20 | 0.053 | 0.13 | <0.014 | 0.19 | <0.032 | <0.04 | 0.113 | <0.20 | 0.054 |
| | 3 | 0.072 | 0.003 | 0.15 | 0.035 | 0.10 | <0.013 | 0.21 | <0.027 | <0.04 | <0.010 | <0.20 | 0.060 |
| | 4 | 0.036 | — | 0.18 | — | 0.22 | — | 0.16 | — | <0.04 | — | <0.20 | — |
| | $\bar{x}$ | 0.044 | <0.003 | 0.21 | 0.050 | 0.152 | <0.014 | 0.20 | <0.030 | <0.04 | <0.081 | <0.20 | 0.063 |
| | ± S.E. | ± 0.010 | — | ± 0.032 | ± 0.008 | ± 0.026 | — | ± 0.015 | — | — | — | — | 0.007 |
| TOTAL $\bar{x}$ ± S.E. | | <0.050 | | 0.267 | | <0.144 | | <0.240 | | <0.372 | | <0.263 | |
| | | — | | ± 0.052 | | — | | — | | — | | — | |
| EFFLUENT | 1 | 0.144 | 0.023 | 0.23 | 0.106 | 0.38 | 0.034 | 0.28 | 0.075 | 0.06 | 0.108 | 0.58 | 0.168 |
| | 2 | 0.175 | <0.001 | 0.26 | 0.093 | 0.47 | 0.023 | 0.30 | 0.037 | 0.04 | 0.204 | <0.20 | 0.178 |
| | 3 | 0.198 | 0.013 | 0.20 | 0.110 | 0.38 | 0.014 | 0.30 | <0.033 | <0.04 | 0.054 | 0.20 | 0.161 |
| | 4 | 0.178 | — | 0.23 | — | 0.41 | — | 0.34 | — | 0.05 | — | <0.20 | — |
| | $\bar{x}$ | 0.174 | <0.012 | 0.230 | 0.103 | 0.41 | 0.024 | 0.30 | <0.048 | <0.05 | 0.122 | <0.30 | 0.169 |
| | ± S.E. | ± 0.011 | — | ± 0.012 | ± 0.005 | ± 0.021 | ± 0.006 | ± 0.013 | — | — | ± 0.044 | — | 0.005 |
| TOTAL $\bar{x}$ ± S.E. | | <0.185 | | 0.333 | | 0.434 | | <0.342 | | <0.169 | | <0.496 | |
| | | — | | ± 0.012 | | ± 0.030 | | — | | — | | — | |
| BLANK | 1 | 0.008 | 0.010 | ND* | 0.269 | 0.11 | <0.015 | <0.02 | <0.028 | 0.04 | 0.071 | 0.14 | 0.048 |
| | 2 | 0.011 | <0.001 | 0.01 | 0.244 | 0.06 | <0.014 | <0.02 | <0.029 | 0.05 | 0.041 | 0.17 | 0.043 |
| | $\bar{x}$ | 0.010 | <0.006 | 0.01 | 0.256 | 0.08 | <0.014 | <0.02 | <0.028 | 0.04 | 0.056 | 0.16 | 0.046 |
| | ± S.E. | ± 0.002 | — | — | ± 0.012 | ± 0.025 | — | — | — | ± 0.005 | ± 0.015 | ± 0.015 | ± 0.002 |

* EXTREME VALUE DROPPED

# REDONDO B[illegible]CH II

## JUNE 20, 1977

## PPB

| | | Cd Dis | Cd Part | Cr Dis | Cr Part | Cu Dis | Cu Part | Ni Dis | Ni Part | Pb Dis | Pb Part | Zn Dis | Zn Part |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| INFLUENT 1-6 | 1 | 0.037 | 0.002 | 0.33 | 0.431 | 0.86 | 0.323 | 0.42 | 0.182 | 0.06 | 0.290 | 0.32 | 0.418 |
| | 2 | 0.028 | 0.050 | 0.29 | 0.317 | 0.81 | 0.323 | 0.43 | 0.222 | 0.17 | 0.273 | 1.22 | 0.432 |
| | $\bar{x}$ ± S.E. | 0.032 ± 0.004 | 0.026 ± 0.024 | 0.31 ± 0.020 | 0.374 ± 0.057 | 0.84 ± 0.025 | 0.323 — | 0.42 ± 0.005 | 0.202 ± 0.020 | 0.12 ± 0.055 | 0.282 ± 0.008 | 0.77 ± 0.450 | 0.425 ± 0.007 |
| | TOTAL $\bar{x}$ ± S.E. | 0.058 ± 0.020 | | 0.684 ± 0.077 | | 1.158 ± 0.025 | | 0.627 0.025 | | 0.396 ± 0.046 | | 1.218 ± 0.434 | |
| INFLUENT 7-8 | 1 | 0.034 | 0.016 | 0.31 | 0.091 | 0.41 | 0.042 | 0.25 | 0.079 | 0.08 | 0.048 | 0.47 | 0.178 |
| | 2 | 0.031 | 0.001 | 0.26 | 0.124 | 0.42 | 0.030 | 0.25 | 0.048 | 0.09 | 0.041 | 0.32 | 0.190 |
| | $\bar{x}$ ± S.E. | 0.032 ± 0.002 | 0.008 ± 0.008 | 0.28 ± 0.025 | 0.108 ± 0.016 | 0.42 ± 0.005 | 0.036 ± 0.006 | 0.25 — | 0.064 ± 0.016 | 0.08 ± 0.005 | 0.044 ± 0.003 | 0.40 ± 0.075 | 0.184 ± 0.006 |
| | TOTAL $\bar{x}$ ± S.E. | 0.041 ± 0.009 | | 0.392 ± 0.008 | | 0.451 ± 0.001 | | 0.314 ± 0.016 | | 0.130 ± 0.002 | | 0.579 ± 0.069 | |
| BLANK | 1 | 0.013 | 0.008 | ND * | 0.313 | 0.04 | <0.015 | <0.02 | <0.032 | 0.04 | 0.119 | 0.18 | 0.034 |
| | 2 | 0.005 | 0.001 | <0.001 | 0.234 | 0.06 | <0.014 | <0.02 | <0.029 | 0.05 | 0.017 | 0.08 | 0.035 |
| | $\bar{x}$ | 0.009 | 0.004 | <0.001 | 0.274 | 0.05 | <0.014 | <0.02 | <0.030 | 0.04 | 0.068 | 0.13 | 0.039 |
| | ± S.E. | ± 0.004 | ± 0.003 | — | 0.039 | ± 0.010 | — | — | — | ± 0.005 | ± 0.051 | ± 0.050 | ± 0.0005 |

* EXTREME VALUE DROPPED

# Redondo Beach II: (con't)

## June 20, 1977

## PPB

| Effluent | | Cd Dis | Cd Part | Cr Dis | Cr Part | Cu Dis | Cu Part | Ni Dis | Ni Part | Pb Dis | Pb Part | Zn Dis | Zn Part |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-6 | 1 | 0.056 | 0.016 | 0.32 | 0.351 | 0.75 | 0.175 | 0.52 | 0.432 | 0.08 | 0.220 | 0.29 | 0.575 |
| | 2 | 0.056 | 0.005 | 0.27 | 0.359 | 0.76 | 0.197 | 0.46 | 0.385 | 0.08 | 0.262 | 0.49 | 0.367 |
| | $\bar{x}$ ± S.E. | 0.056 — | 0.010 ± 0.006 | 0.30 ± 0.025 | 0.355 ± 0.004 | 0.76 ± 0.005 | 0.186 ± 0.011 | 0.49 ± 0.030 | 0.408 ± 0.023 | 0.08 — | 0.241 ± 0.021 | 0.39 ± 0.100 | 0.471 ± 0.104 |
| | Total $\bar{x}$ ± S.E. | 0.066 ± 0.006 | | 0.650 ± 0.021 | | 0.941 ± 0.016 | | 0.898 ± 0.054 | | 0.321 ± 0.021 | | 0.861 ± 0.004 | |
| 7-8 | 1 | 0.107 | 0.015 | 0.27 | 0.134 | 0.34 | 0.026 | 0.34 | 0.112 | 0.05 | 0.061 | <0.20 | 0.141 |
| | 2 | 0.042 | 0.036 | 0.28 | 0.100 | 0.32 | 0.029 | 0.26 | 0.093 | 0.04 | 0.057 | <0.20 | 0.140 |
| | $\bar{x}$ ± S.E. | 0.074 ± 0.032 | 0.026 ± 0.010 | 0.28 ± 0.005 | 0.117 ± 0.017 | 0.33 ± 0.010 | 0.028 ± 0.002 | 0.30 ± 0.040 | 0.102 ± 0.010 | 0.04 ± 0.005 | 0.060 ± 0.001 | <0.20 — | 0.140 ± 0.0005 |
| | Total $\bar{x}$ ± S.E. | 0.100 ± 0.022 | | 0.392 ± 0.012 | | 0.358 ± 0.008 | | 0.402 ± 0.049 | | 0.110 ± 0.001 | | <0.340 — | |

# HUNTINGTON BEACH II

## JUNE 15, 1977

### PPB

| | | Cd | | Cr | | Cu | | Ni | | Pb | | Zn | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Dis | Part | Dis | Part | Dis | Part | Dis | Part | Dis | Part | Dis | Part |
| INFLUENT | 1 | 0.055 | 0.004 | 0.15 | 0.668 | 0.57 | 0.194 | 0.47 | 0.451 | 0.09 | 0.295 | <0.20 | 0.500 |
| | 2 | 0.040 | 0.007 | 0.15 | 0.613 | 0.48 | 0.170 | 0.43 | 0.449 | 0.16 | 0.361 | <0.20 | 0.523 |
| | 3 | 0.032 | 0.009 | 0.19 | 0.541 | 0.44 | 0.186 | 0.47 | 0.376 | 0.21 | 0.287 | <0.20 | 0.522 |
| | 4 | 0.066 | — | — | — | — | — | — | — | — | — | 0.43 | — |
| | $\bar{x}$ | 0.048 | 0.005 | 0.16 | 0.607 | 0.50 | 0.183 | 0.46 | 0.425 | 0.15 | 0.314 | <0.26 | 0.515 |
| | ± S.E. | ± 0.008 | ± 0.001 | ± 0.013 | ± 0.037 | ± 0.038 | ± 0.007 | ± 0.013 | ± 0.025 | ± 0.035 | ± 0.023 | — | ± 0.008 |
| TOTAL $\bar{x}$ ± S.E. | | 0.047 ± 0.007 | | 0.771 ± 0.025 | | 0.680 ± 0.043 | | 0.882 ± 0.022 | | 0.468 ± 0.042 | | <0.715 — | |
| EFFLUENT | 1 | 0.121 | 0.011 | 0.20 | 0.799 | 0.60 | 0.321 | 0.49 | 0.644 | 0.08 | 0.428 | <0.20 | 0.913 |
| | 2 | 0.029 | 0.001 | 0.16 | 0.758 | 0.73 | 0.307 | 0.48 | 0.552 | 0.13 | 0.485 | <0.20 | 0.890 |
| | 3 | 0.112 | 0.004 | 0.20 | 0.958 | 1.13 | 0.350 | 0.61 | 0.405 | 0.10 | 0.460 | <0.20 | 1.00 |
| | 4 | 0.038 | — | 0.15 | — | 1.22 | — | 0.38 | — | 0.18 | — | <0.20 | — |
| | $\bar{x}$ | 0.075 | 0.005 | 0.18 | 0.838 | 0.92 | 0.326 | 0.49 | 0.533 | 0.12 | 0.458 | <0.20 | 0.934 |
| | ± S.E. | ± 0.024 | ± 0.003 | ± 0.013 | ± 0.061 | ± 0.151 | ± 0.013 | ± 0.047 | ± 0.070 | ± 0.022 | ± 0.016 | — | ± 0.033 |
| TOTAL $\bar{x}$ ± S.E. | | 0.093 ± 0.032 | | 1.025 ± 0.070 | | 1.146 ± 0.170 | | 1.060 ± 0.037 | | 0.561 ± 0.031 | | <1.134 — | |
| BLANK | 1 | 0.010 | 0.004 | <0.01 | 0.230 | 0.08 | <0.014 | <0.02 | <0.030 | 0.05 | 0.060 | 0.09 | 0.040 |
| | 2 | 0.018 | 0.007 | <0.01 | 0.292 | 0.12 | <0.014 | <0.02 | <0.031 | 0.08 | 0.054 | 0.18 | 0.041 |
| | $\bar{x}$ | 0.014 | 0.006 | <0.01 | 0.261 | 0.10 | <0.014 | <0.02 | <0.030 | 0.06 | 0.057 | 0.14 | 0.040 |
| | ± S.E. | ± 0.004 | ± 0.002 | — | 0.031 | ± 0.02 | — | — | — | ± 0.015 | ± 0.003 | ± 0.045 | ± 0.001 |

APPENDIX III

Mean net concentrations* ($\mu g/l$) of dissolved ($<0.4\mu$) and particulate ($>0.4\mu$) metals measured by the Project in nearshore waters of the Bight: 1974-1976.

| Location | Date | Form | Ag | Cd | Cr | Cu | Ni | Pb | Zn |
|---|---|---|---|---|---|---|---|---|---|
| Punta Banda, | May 2, | Diss. | <0.01 | 0.06 | 0.10 | 0.24 | 0.18 | <0.3 | 0.10 |
| N. Baja Calif. | 1976 | Part. | <0.002 | 0.01 | 0.17 | 0.01 | 0.05 | 0.12 | 0.06 |
| Palos Verdes Pen. | Feb 24, | Diss. | <0.01 | 0.06 | 0.23 | 0.11 | 0.30 | -** | - |
| (non-plume) | 1975 | Part. | <0.002 | 0.02 | 0.02 | 0.01 | 0.02 | - | - |
| Newport Harbor | Dec 7, | | | | | | | | |
| Outside | 1976 | Diss. | 0.01 | 0.02 | 0.10 | 0.59 | 0.16 | - | 0.21 |
| Entrance | | Diss. | 0.01 | 0.06 | 0.14 | 2.2 | 0.32 | - | 1.5 |
| Inner | | Diss. | 0.01 | 0.35 | 0.15 | 8.6 | 1.2 | - | 22 |
| Harbor Entrances | 1974 | | | | | | | | |
| Newport | Dec.10 | Diss. | 0.11 | - | 0.15 | 2.4 | 0.88 | - | 3.9 |
| | | Part. | 0.10 | 0.07 | 0.57 | 0.76 | 0.41 | 0.70 | 1.9 |
| San Diego | Nov.12 | Diss. | 0.13 | - | 0.63 | 1.8 | 1.8 | - | 5.7 |
| | | Part. | 0.10 | 0.01 | 0.53 | 0.45 | 0.16 | 0.34 | 1.2 |
| San Pedro | Oct.17 | Diss. | 0.02 | - | 0.17 | 0.90 | 2.0 | - | 3.8 |
| | | Part. | 0.02 | 0.02 | 0.45 | 0.57 | 0.11 | 0.04 | 1.8 |

*Corrected for procedural blanks and ionic recoveries
**No Data