C-11.0 WATER QUALITY MONITORING SUMMARY AND ANALYSES

C-11.1 Introduction

In response to the First Term Permits from the Santa Ana and San Diego Regional Boards, the Permittees developed and implemented a water quality monitoring program (1993 DAMP Appendix K) to aid in the detection and control of illicit connections and illegal discharges to the municipal storm drain systems and to meet other program performance objectives. The monitoring program focused on estimating pollutant loads in urban stormwater runoff, tracked compliance with water quality objectives, searched for sources of pollutants and addressed impacts on areas of special concern.

In response to the Second Term Permits, the Permittees conducted a two-year re-evaluation and revision of the water quality monitoring program in order to re-focus the efforts to determine the role, if any, of urban stormwater discharges to the impairment of beneficial uses and to provide technical information to support an effective urban stormwater management program to reduce the beneficial use impairments determined to be associated with urban stormwater (2000 DAMP Appendix K).

The Permittees also initiated several water quality planning efforts, conducted additional water quality evaluations in response to technical requests from the Regional Board and participated in various regional research and/or monitoring programs. The combination of these efforts will aid the Permittees in determining the extent and degree of the relationship between urban stormwater runoff and impairment of beneficial uses within the aquatic resources of Orange County.

This report presents the results of water quality monitoring, conducted between July 1, 2002 and June 30, 2003, in the portion of Orange County under the jurisdiction of the Santa Ana Regional Board.

C-11.2 Program Development

C-11.2.1 Pre-NPDES Water Quality Monitoring

From 1973 to 1990, the Principal Permittee conducted routine water quality monitoring on drainage facilities which are tributary to water bodies identified as waters of the state by the Regional Boards. The receiving waters were also monitored routinely to assess the chronic effects on established beneficial uses.

When the monitoring program was initiated in 1973, monthly nutrient and trace element sampling was performed at several locations. Sediment samples were collected semiannually to assess the impact of contaminant deposition and adsorption. Additional constituents such as mercury, selenium, DDT, PCBs and radioactivity were also evaluated on a semiannual basis to address public concerns regarding the pollution threat from these constituents.

C-11.2.2 First Term Permit Water Quality Monitoring

In order to bring the pre-NPDES water quality monitoring program into conformance with the 1990 federal NPDES regulations and the First Term Permit objectives (**Section 11.2**), field screening to detect gross contamination was added to the program and the number of sampling sites in the channels and receiving waters were increased in order to better assess the amount and type of contamination in the storm drain system.

The First Term Permit water quality monitoring program consisted of field screening (channels only); dry-weather and storm sampling and a receiving water program.

C-11.2.3 Second Term Permit Water Quality Monitoring

While the First Term Permit monitoring program produced useful information, the Permittees recognized (as has the rest of the nation) the high degree of uncertainty regarding the link between urban stormwater runoff and actual impairment of beneficial uses within the aquatic resources of Orange County.

Therefore, in response to the Second Term Permit objectives, the Permittees conducted a systematic re-evaluation of the water quality monitoring program which led to a re-statement of the monitoring program's primary goals. The primary and parallel goals of the monitoring program were re-stated as:

- To determine the role, if any, of urban stormwater discharges in the impairment of beneficial uses; and
- To provide technical information to support effective urban stormwater management program actions to reduce the beneficial use impairment determined to be associated with urban stormwater.

In order to organize the vast array of monitoring activities needed to carry out the objectives and goals, the Permittees identified three separate key elements within the Final Monitoring Program (May 1999).

These three key elements are:

- A focus on known sites (or Warm Spots) where constituents are substantially above system-wide averages;
- A parallel (and somewhat overlapping) focus on areas of critical aquatic concern (herein referred to as critical aquatic resources or CARs); and
- A countywide reconnaissance program to identify specific sources of contamination from sub-watershed areas as well as specific land use investigations in order to evaluate the effectiveness of a variety of BMPs.

The Final Monitoring Program includes an underlying rationale for each monitoring element, a discussion of how monitoring data will be used in decision-making, identification of potential links to other relevant monitoring programs being carried out by other agencies, a description of the basic monitoring design, identification of additional study design steps, and a description of anticipated monitoring activities.

These monitoring elements include many locations from the pre-NPDES and First Term Permit water quality monitoring programs that were of value because of the length of their historical record. Each key element of the Final Monitoring Program contains a description of the monitoring activities proposed to accomplish the objectives described above, as well as a description of the process for making decisions about how the monitoring program will respond to incoming data over time. This process can be used at any time throughout the life of the monitoring program to re-evaluate the direction of the program, or to reassess the appropriate allocation of resources within the program.

The Final Monitoring Program and subsequent elements utilize a five-year timeline (1998/99 - 2002/03) for addressing the goals/objectives associated with each task. This timeline is reflective of the dynamic nature of the monitoring program and the fact that many of the objectives will require a substantial investment of resources before they are finalized.

The data presented in this section are the result of the water quality monitoring conducted from July 1, 2002 to July 1, 2003 in the portion of Orange County under the jurisdiction of the Santa Ana Regional Board. A summary of the monitoring conducted in the San Diego Region will be submitted in a separate report to the San Diego Board. More detailed information specific to data from prior years can be found in each of the prior annual reports and the two prior Reports of Waste Discharge.

C-11.2.4 Additional Local Water Quality Monitoring

Any additional water quality monitoring conducted by the Permittees is described and summarized within the Performance Evaluation Assessment (PEA) of the respective Permittee.

C-11.3 Monitoring Approach

The Final Monitoring Program, described in Section 11.2.3 established three processes for selecting monitoring sites:

- A list of the Critical Aquatic Resources (CARs), including inland streams, bays, harbors, estuaries, and coastal waters, was compiled and ranked according to several criteria including 303(d) listing, community interest, and beneficial uses (**Table C- 11.1**). A summary of the priority rankings is found in **Table C- 11.2**. The CARs receiving the highest ranking were prioritized for study during the term of the Final Monitoring Program. The monitoring parameters that were proposed for the CARs investigations arose from mining information from several studies conducted by the Principal Permittee and others. The available information at the time that the program was designed can be found in **Table C- 11.3. Table C- 11.4** is a summary of the information found in the sources from **Table C- 11.3**. The CARs monitoring program is an adaptive process driven by the the on-going analysis of data gathered from this and other programs.

Figure C- 11.1 is the timeline that was developed for implementation of the studies of specific CARs. It should be noted that the Santa Ana Delhi and Costa Mesa Channels, although not CARs, are included in the timeline because information from these channels is an important component in the assessment of the impacts on the Upper Newport Bay.

The CARs in the Santa Ana Region that were selected for intensive study during this reporting year were the San Diego Creek Watershed, the Upper Newport Bay, and the Lower Newport Bay. A baseline monitoring program is being maintained for the other CARs until they are selected for focused studies in the future.

- The NPDES water and sediment quality data from 1991-97 was statistically evaluated to identify areas where the mean concentrations of constituents of concern were above countywide averages. These areas, designated as Warm Spots, were selected if their site mean concentration of a specific pollutant of concern was either (1) greater than two standard deviations above the systemwide mean (including all similar monitoring sites such as channels or harbor locations), or (2) three interquartile ranges above the third quartile. The database of each Warm Spot was further evaluated using power analyses to determine the frequency of annual monitoring that would be needed to detect statistically significant trends in the constituent of concern that led to the Warm Spot designation.

  The Warm Spots in the Santa Ana Region include Bonita Creek, Lane Channel, Agua Chinon Wash, Central Irvine Channel, Hicks Canyon Wash, Hines Channel, the Rhine Channel in the Lower Newport Bay, and Christiana Bay in Huntington Harbour. **Table C- 11.5** is a list of the Warm Spots and the frequencies of monitoring that were calculated to detect significant trends. **Figure C- 11.2** is a timeline that was developed for monitoring Warm Spots in order to identify the sources of constituents that resulted in their respective Warm Spot designations.

- The countywide Pollution, Notification, Investigation, and Response (PNIR) database maintained by Principal Permittee water pollution staff was interrogated to identify channels or drainage areas that had high incidences of water pollution activity during the period from 1991 through 1998. From these database evaluations was created a priority list for reconnaissance and source evaluation studies. The two high-priority areas in the Santa Ana Region, Construction Circle Drain which flows to Peters Canyon Wash, and Collins Channel which drains to the Santa Ana River, were investigated last year.

Figure C- 11.3 is a timeline showing the implementation schedule of all three elements of the Final Monitoring Program.

On January 18, 2002 and February 13, 2002, the Santa Ana and San Diego Regional Boards respectively, adopted Third Term NPDES permits for Orange County. The San

Diego Regional Board required development and implementation of new monitoring program elements during the 2002-03 monitoring year. The Santa Ana Regional Board requires submittal a new monitoring program for that region beginning in July 2003. As stated previously, the monitoring plan for the Third Term Permit was submitted to the Santa Ana Regional Board on July 1, 2003. Implemention of the new monitoring program in that region will begin once final approval of the plan is given by the Santa Ana Regional Board.

This monitoring year included a re-evaluation of monitoring locations from the First Term that were not evaluated during the Second Term. This monitoring was denoted as 5-Year Re-Evaluation on **Figure C- 11.2**. These sites included Anaheim Barber City, Bolsa Chica, Westminster, East Garden Grove Wintersburg, and Santa Isabella Channels.

C-11.3.1 Incorporation of the Nutrient Total Maximum Daily Load (TMDL) Regional Monitoring Program

At the direction of the Santa Ana Regional Board, a Regional Monitoring Program (RMP) for the San Diego Creek Nutrient TMDL was initiated in February of 2000. The chemical monitoring for this program includes many of the same sites in the Newport Bay and watershed as the Final Monitoring Program. Monitoring frequencies for some of the sites were increased as a result of the RMP and orthophosphate was been added to the suite of nutrient analyses. The Final Monitoring Program and the RMP are intended to complement each other. Therefore the chemical data from both programs will be included in this report.

Table C- 11.6 is compilation of the 5-Year Re-Evaluation sites, Warm Spots and CARs from the Final Monitoring Program and the RMP sites that were monitored during this reporting year. **Table C- 11.7** shows the monitoring frequencies of the Final Monitoring Program with the RMP additions in bold letters. If a monitoring location is within a designated "Water of the State", the beneficial uses for that waterbody can be found **Table C- 11.8**. **Exhibit C-11-I** contains the location maps of channels that were monitored with automatic samplers and continuously monitoring streamgauges.

C-11.4 Description of Monitoring Procedures

The following are brief descriptions of the procedures used during this reporting period.

C-11.4.1 Time-composite Sampling

Time-composite sampling is the primary method of monitoring the concentration and load of constituents in streams, creeks, and drainage channels. This type of sampling is conducted with automatic samplers that consist of programmable pumps (peristaltic) which transport water from the channel to a collection reservoir in the autosampler base. The collection reservoir can be a single large composite bottle or a series of up to 24 bottles. The autosampler program can be modified to vary sample volumes and frequency of collection. In the Final Monitoring Program, 24 discrete sample bottles are used in each autosampler base.

For dry weather discharge evaluations, the automatic samplers are programmed to collect a discrete sample once an hour for a 24-hour period. During storms, sampling is initiated when the water level in the channel rises above a triggering device hardwired to the autosampler. The frequency of collection during the first hour of the storm is set at 1 sample/15 minutes. After the fifth sample is collected at the one-hour mark, the collection frequency is decreased to once every 2 hours. A storm event sampling spans approximately 96 hours to allow comparison of the data to 96-hour guidance criteria for chronic aquatic toxicity from the California Toxics Rule (CTR). Autosampler maintenance is performed periodically to change bottles, icepacks, and power supplies.

The first five samples collected during a storm are composited and represent the first flush. The concentrations of dissolved heavy metals in this sample can be compared to acute toxicity criteria. The remaining bi-hourly storm samples are used to prepare composite samples that are representative of the subsequent parts of the storm. The discrete samples used to prepare each composite sample are selected using the stage hydrograph for the channel or by evaluating the electrical conductivities of the discrete samples. Using the hydrograph from the the Principal Permittee's Automated Local Evaluation in Real Time (ALERT) system, samples collected beyond the first flush and representing the storm peak and recession are composited into a single sample. Storms spanning multiple days may be broken up into two or more composite samples.

In the absence of a streamgauge hydrograph for the sampled channel, the conductivity of each discrete sample (in order of collection) is measured. Changes in conductivity usually denote the beginning or end of storm runoff. After the "first flush" of a storm, conductivities tend to immediately decrease during the rise of the storm hydrograph and slowly rise after the recession. Sample appearance (turbidity or fluvial sediment) can also be used in the compositing process. Storm samples tend to be more turbid and contain more fluvial sediment. Using these electroanalytical measurements and visual observations as a guide, composite samples can be prepared to evaluate various parts of a storm.

Composite samples are analyzed for pH, electrical conductivity, turbidity, nitrate, ammonia, total Kjehldahl Nitrogen (TKN), phosphate, total suspended and settleable solids, volatile suspended solids, and total recoverable and dissolved copper, chromium, lead, cadmium, zinc, silver and nickel (see **Exhibit C-11-II**). The frequency of time composite monitoring is dependent on whether the waterbody is designated as a "Water of the State". "Waters of the State" are monitored monthly and during storms. Other waterbodies are monitored during storms only.

Time composite monitoring is supported by the Principal Permittee's precipitation and streamgaging network which consists of recording and/or transmitting ALERT gages. Mechanical recording raingages are weighing bucket type. Accumulated rainfall is recorded in analog format on drum charts. The ALERT precipitation gages are tipping bucket type with dataloggers. Data are recorded and transmitted in digital format; sensitivity is 1 mm (0.04 inches) of accumulated rainfall.

The Principal Permittee uses several types of streamgauges to monitor changes in water level. The oldest design is the stilling well with water level float; the newer types are manometer gages or pressure transducers. Data (water level versus time) are recorded on stripcharts. The ALERT interface to these gages consists of a connection from the recorder chart drive to an ALERT shaft encoder. ALERT information is recorded on a datalogger and transmitted to the Principal Permittee's Katella yard base station in digital format. Sensitivity of the transmitted and recorded ALERT record is user-variable with the greatest sensitivity being a change in water level of 0.01 feet.

C-11.4.2 Harbor/Bay Monitoring

Harbor/bay monitoring is conducted semiannually and during storms (see **Exhibit C-11-III**). Monthly sampling in the Upper Newport Bay is also conducted to evaluate nutrient loading from the San Diego Creek. Monthly monitoring of nitrogen and phosphorus in the sediments of the Upper Newport Bay was added in 1999/2000 reporting period to assist with the CARs evaluation. The semiannual monitoring includes sampling for nutrients in the water column, and trace metals and organic contaminants in the sediments (See Section 11.4.3). Storm monitoring consists of surface water sampling for nutrient concentrations and depth-integrated sampling to evaluate the magnitude of heavy metal contamination in the water column.

C-11.4.3 Semiannual Sediment Sampling

On a semiannual schedule, sediment samples are collected from the channels and several locations in the harbors and bays (see **Table C- 11.7**) to evaluate concentrations of copper, chromium, cadmium, lead, zinc, silver, nickel, chlorinated hydrocarbon and organophosphate pesticides, herbicides, and PCBs. The data from these samplings is contained in **Exhibit C-11-IV**.

C-11.5 Methods of Data Analysis

Acute (CMC-Criteria Maximum Concentration) and chronic (CCC-Criteria Continuous Concentration) aquatic toxicity criteria from the CTR were used as guidance to evaluate dissolved metals data collected from storm channels and harbors. Water quality criteria from the CTR and other sources are presented in **Table C- 11.9.**

Sediment quality criteria from the National Oceanographic and Atmospheric Administration's (NOAA) Effects Range database were used as guidance to evaluate the toxicity of sediments in the harbors and bays. The Southern California Coastal Water Research Project's (SCCWRP) iron normalization procedure was also used evaluate harbor sediment quality relative to statistically predicted anthropogenic amounts of trace metals. A summary of the sediment guidance criteria is found in **Table C- 11.10.**

C-11.5.1 Comparison to Water Quality Guidance

California Water Code Section 13170 authorizes the State Water Resources Control Board (SWRCB) to adopt water quality control plans for waters where standards are required by the Federal Clean Water Act (CWA) and its 1987 amendments, the Water Quality Act (WQA). According to Section 303(c)(2)(B) of the CWA, these plans must contain water quality objectives for priority pollutants that could be reasonably expected to affect the beneficial uses of the waters of the State.

On March 2, 2000, the State adopted the United States Environmental Protection Agency's (USEPA) Rules establishing numeric water quality criteria for priority toxic pollutants (commonly referred to as the CTR) for the State of California. The CTR sets criteria for dissolved heavy metals in freshwater that are based on water hardness and separate criteria for saltwater. The dissolved metals data were compared to the acute (instantaneous maximum concentration) and chronic (4-day average concentration) criteria for guidance purposes. **Table C- 11.11** presents these guidance criteria for freshwater relative to water hardness.

According to the CTR, for waters with a hardness of 400 mg/l or less as calcium carbonate, the actual ambient hardness of the surface water shall be used in those equations. For waters with a hardness of over 400 mg/l as calcium carbonate, a hardness of 400 mg/l as calcium carbonate shall be used with a default Water-Effect Ratio (WER) of 1, or the actual hardness of the ambient surface water shall be used with a WER. For this reporting period the former method was used. The saltwater guidance criteria are found in **Table C- 11.9**.

In applying the CTR criteria to freshwater, if the time period to which the guidance applies is less than the length of the sampled period, a measured concentration greater than that guidance value will constitute an exceedance. For example, if the acute guidance for lead (at a hardness of 100 mg/L as $CaCO_3$) is 65 μg/L, a concentration of 68 μg/L during a 24-hour period will be considered an exceedance of the guidance criterion.

In computing the mean concentration during a sampled period with multiple composite samples, values below the detection limit were assumed to be zero. This assumption allows for a more consistent evaluation from year to year as detection limits are lowered with alternative methods of analysis or new technology. The assumption also gives greater confidence to a designation of an exceedance of a guidance criterion as it reduces the likelihood that the exceedance was caused by an erroneous estimation of a non-detected value. During this monitoring year the low detection limits achieved by the contract laboratory did not make this approach an issue except for a few instances where the calculated criterion for silver was lower than the detection limit of 2 μg/L.

With respect to the saltwater guidance from the CTR, the average concentrations of dissolved metals in depth-integrated samplings from each 4-day storm monitoring of the Harbors and Bays were compared to the 4-day guidance criteria. The dissolved metals concentrations in each grab sample were compared to the 1-hr acute toxicity guidance criteria. There is no chronic guidance criterion for silver so only the acute criterion was used. Since total chromium was analyzed only the criteria for trivalent chromium (Chromium III) were used.

C-11.5.2 Mass Load Calculations

Mass loads were calculated using chemical and hydrographic data. **Exhibit C-11-I** contains watershed maps for all of the channels monitored with automatic samplers. On each map, the watershed boundary upstream of the monitoring site, hydrographic (water level station) and representative precipitation station are shown. Water level records from streamgaging stations at or near the sampling site were processed using xStreamMeasures™ Software. Water levels from the station's continuous strip-chart recorder were digitized and converted to discharge rates using stage-discharge relationships (channel ratings). The digitized streamflow record was converted to ASCII format and imported to a Microsoft Excel file. Graphs of time vs. water level stage are contained in **Exhibit C-11-V**. The total discharge in acre-feet during each sampled period was computed. By multiplying the total water discharge per sampled period by the pollutant concentration of the composite sample from the period and applying the proper conversion factors (acre-feet to lbs. of water), a mass load in pounds or tons of contaminant was calculated. For data reported as ND (non-detected), one-half of reported laboratory detection limits were used in the calculations. **Table C- 11.12** is an annual summary.

C-11.5.3 Event Mean Concentrations (EMCs)

Event mean pollutant concentrations were calculated to produce a site mean EMC that could be used in the estimation of the mass loads from unsampled storms. To calculate the EMC of a monitored storm the sum of the mass load from each composite sampling during a storm was divided by the total sampled volume of water during the same period. After applying the appropriate conversion factors, an event mean concentration in mg/L or μg/L was calculated. The site mean EMCs were updated each year (**Exhibit C- C-11-VI**) with the EMC data from that year. **Table C- 11.13** contains the calculated EMCs of each monitored storm during the 2002-03 season.

C-11.5.4 Statistical Methods

Site mean EMCs were used to estimate mass loads from unsampled storms. To estimate these mass loads, the site mean EMC for a stormwater contaminant from a particular station was multiplied by the total annual volume of water discharged during unsampled storms and the appropriate conversion factors. The site mean EMC was calculated from the set of calculated EMCs from each sampled storm from the beginning of the NPDES program. Only EMCs in which the 75-120% of the total storm runoff volume was sampled were used in the calculation. Each year the site means were updated with the data from that year. **Exhibit C-11-VI** contains the statistics from monitoring through the end of 2001-2002 monitoring year. The database for each site in the Santa Ana Region has EMCs from over 15 separate storms.

To calculate the site-mean EMC for a specific constituent a monitoring location the following method was used.

The distribution of each EMC dataset was first evaluated for normality using the W Test developed by Shapiro and Wilk (1965). The W statistic was compared to a tabled value for a given value of α. To calculate W, the data from each station was first ordered from smallest to largest to obtain the sample order statistics $x_1 \leq x_2 \ldots \leq x_n$. k was then calculated from n where:

$$k = \frac{n}{2} \text{ if n is even or}$$

$$k = \frac{n-1}{2} \text{ if n is odd}$$

$$W = \frac{1}{d}\left[\sum_{i=1}^{k} a_i \left(x_{(n-i+1)} - x_i\right)\right]^2$$

where $$d = \sum_{i=1}^{n}(x_i - \bar{x})^2 = \sum_{i=1}^{n} x_i^2 - \frac{1}{n}\left(\sum_{i=1}^{n} x_i\right)^2$$

Values of a_i were found in Table A6[1]. If the calculated W was less than the tabled value at the α (0.05) significance level, the null hypothesis was rejected and the distribution was considered normal. If the distribution was not normal at the α significance level the data was log-transformed and the W test was repeated to test for log-normality. If the distribution was not lognormal, the dataset was inspected for possible outliers. The Dixon test (for n < 25) was used to determine if the suspected points were outliers to a normal distribution. The procedure was performed as follows:

The dataset was ordered from smallest to largest that is $X_1 < X_2 < X_3 < \ldots X_n$. The Dixon ratio r, which is a function of n was calculated.

Number of Points	**Ratio Calculated**
n = 3 to 7	r_{10}
n = 8 to 10	r_{11}
n = 11 to 13	r_{21}
n = 14 to 25	r_{22}

Depending on which point was suspected of being the outlier, the ratio was calculated in the following manner:

[1]Gilbert, Richard O. Statistical Methods of Environmental Pollution Monitoring, 1987. Van Nostrand Reinhold, p259.

r	If X_n is Suspect	If X_1 is Suspect
r_{10}	$(X_n-X_{n-1})/(X_n-X_1)$	$(X_2-X_1)/(X_n-X_1)$
r_{11}	$(X_n-X_{n-1})/(X_n-X_2)$	$(X_2-X_1)/(X_{n-1}-X_1)$
r_{21}	$(X_n-X_{n-2})/(X_n-X_2)$	$(X_3-X_1)/(X_{n-1}-X_1)$
r_{22}	$(X_n-X_{n-2})/X_n-X_3)$	$(X3-X_1)/X_{n-2}-X_1)$

Using Table A.7[2], the calculated ratio was compared to the critical value at a confidence level of 95%. If the calculated value was greater than the tabled value the suspected point was rejected and the distribution was retested to confirm normality.

For normal distributions the mean is calculated as the arithmetic mean, that is

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

the confidence limits for the mean of a normal distribution with unknown variance is given by

$$\bar{x} - t_{(1-\alpha/2,n-1)}\frac{s}{\sqrt{n}} \le \mu \le \bar{x} + t_{(1-\alpha/2,n-1)}\frac{s}{\sqrt{n}}$$

where s is the standard deviation of the dataset and $t_{(1-\alpha/2,n-1)}$ is from table A2[3]. Using α = 0.05 the upper and lower limits are calculated. The true mean μ will occur outside of this range 5% of the time.

For lognormal distributions the arithmetic mean and standard deviation of the log-transformed data were first computed. The estimate of the mean is given by the minimum variance unbiased estimate μ_l which is defined as

$$\mu_1 = [\exp(\bar{x})]\Psi_n\left(\frac{s^2}{2}\right)$$

where $\Psi_n(t)$ is the infinite series defined by

$$\Psi_n(t) = 1 + \frac{(n+1)t}{n} + \frac{(n+1)^3 t^2}{2!n^2(n+1)} + \frac{(n-1)^5 t^3}{3!n^3(n+1)(n+3)} + \frac{(n-1)^7 t^4}{4!n^4(n+1)(n+3)(n+5)} + \bullet\bullet\bullet$$

[2]Taylor, John Keenan. Statistical Techniques for Data Analysis, 1990. Lewis Publishers, Inc., p168.
[3]Gilbert, Richard O. Statistical Methods of Environmental Pollution Monitoring, 1987. Van Nostrand Reinhold, p255.

$\frac{s^2}{2}$ is substituted for t and values for Ψ_n are calculated using formulas in a Microsoft EXCEL spreadsheet.

The lower confidence limit of the mean is given by

$$LL_{\alpha} = \exp\left(\bar{x} + 0.5s^2 + \frac{sH_{\alpha}}{\sqrt{n-1}}\right)$$

and the upper limit is given by

$$UL_{1-\alpha} = \exp\left(\bar{x} + 0.5s^2 + \frac{sH_{1-\alpha}}{\sqrt{n-1}}\right)$$

The values of H_{α} and $H_{1-\alpha}$ were found in Table A10 - A13[4]

The sample median of each normal distribution was calculated by first ordering the sample population from smallest to largest.

$$\text{sample median} = x_{(n-1)/2} \qquad \text{if n is odd}$$

$$= \frac{1}{2}\left(x_{(n/2)} + x_{(n+2)/2}\right) \quad \text{if n is even}$$

The true median of a lognormal distribution can be estimated by

$$M_2 = \exp(\bar{x})\Psi_n(t)$$

where $\Psi_n(t)$ is the infinite series described above. In this case the value of $t = -s^2/[2(n-1)]$.

C-11.5.5 Assessing Anthropogenic Influence in Harbor Sediments

The Southern California Coastal Water Research Project (SCCWRP) database for iron normalization[5] was used to determine the presence of anthropogenic enrichment in sediments collected from Orange County harbors. SCCWRP developed regression equations for the each relationship between a heavy metal and the percentage of iron in sediments collected from non-impacted sites in the Southern California Bight. 99% confidence limits (2 standard deviations) were calculated for each regression equation.

[4]Gilbert, Richard O. Statistical Methods of Environmental Pollution Monitoring, 1987. Van Nostrand Reinhold, pp264-265.
[5] Southern California Coastal Water Research Project. Annual Report,1996. Southern California Coastal Water Research Project Authority, pp68-76.

Concentrations of heavy metals greater than the upper confidence limits are considered to be the result of anthropogenic enrichment.

C-11.6 Analysis of Data

The Final Monitoring Program included a series of tables and figures outlining expected progress over the five-year term of the permit. These provide a framework for assessing the Program's current status and its progress toward completing the planned activities. The following sections briefly describe Program status with respect to each of the three major Program components, Warm Spots trend monitoring, CARs monitoring and assessment, and reconnaissance and source identification.

Figure C- 11.4 shows the accumulated daily rainfall recorded in Santa Ana during the monitoring year. **Figure C- 11.5** shows the season totals for the last nine seasons. This season's total of 14.57 inches was slightly above the 40-yr mean of 13.4 inches. The previous season total of 3.82 inches was the lowest in 40 years.

C-11.6.1 Warm Spot Monitoring

The Final Monitoring Program established long-term monitoring programs to evaluate trends in pollutant concentrations at Warm Spots. Sampling frequencies were established through statistical power analyses as part of the monitoring program design. The minimum periods for detecting statistically valid trends at these sites are on the order of 10-15 years. In addition to trend monitoring, source identification studies have also been conducted at some these locations. During the past four years the issues surrounding the designation of some of the Warm Spots have been resolved and the monitoring at those sites has been discontinued.

Monitoring at the remaining sites continued through this monitoring year but the future status of the Warm Spot monitoring element has not been decided. Although the monitoring program for the Third Permit did not specifically commit to continuation of Warm Spot monitoring, some stations (e.g. the Rhine Channel in Lower Newport Bay, and Christiana Bay in Huntington Harbor) will continue to be monitored during the next permit term. The proposed Reconnaissance Program will include dry-weather monitoring of "targeted" stormdrains identified by the Permittees as potential conduits of illegal discharges and illicit connections.

The following paragraphs provide additional detail on the specifics of trend monitoring and source identification efforts to date at the Warm Spots in the Santa Ana Region. Each site is listed followed by the constituent(s) of concern that caused it be listed as a Warm Spot.

Rattlesnake Canyon Wash – total suspended solids and metals in stormwater

Rattlesnake Canyon Wash was designated as a Warm Spot because of high concentrations of total suspended solids and total recoverable lead in stormwater samples. Subsequent to the development of the Final Monitoring Program Rattlesnake

Canyon Wash was rerouted to intersect with an underground section of Peters Canyon Channel upstream of the Peters Canyon / Hicks Canyon Wash confluence. The site on Bryan Avenue to which the Warm Spot designation was assigned does not receive runoff from this channel in its present configuration. With its new configuration sampling would be extremely difficult and trend analysis relative to its former configuration would not be meaningful. This Warm Spot is no longer monitored.

Lane Channel – total dissolved solids

Lane Channel was designated as a Warm Spot because of high electrical conductivity measurements (a surrogate measurement of total dissolved solids) in dry-weather discharges. The summary of the initial phase of the investigation for sources of high total dissolved solids in Lane Channel can be found in **Appendix Q** of the 2000-2001 Annual Status Report.

The results from the initial investigation suggest that the high dissolved solids concentrations found in Lane Channel are from multiple sources. Additional investigation would be required to isolate these sources. These source identifications may be incorporated into the Reconnaissance Program of the next permit term.

Bonita Canyon Channel – metals in stormwater

Bonita Canyon Channel was designated as a Warm Spot because of high levels of total recoverable nickel in its stormwater discharge. No source identification has been carried out, but this site has been added to the sediment TMDL program. A streamgauge has been installed and is currently being maintained by the USGS under contract to the Principal Permittee. The 2000-2001 Annual Status Report graphically showed that, aside from the El Niño season, the concentrations of metals have decreased from the high levels found in previous seasons. No stormwater samples were collected during this monitoring year.

Rhine Channel – copper in sediments

The Rhine Channel in Lower Newport Bay was designated as a Warm Spot because of high concentrations of copper in the bottom sediments. It is believed that these elevated levels of copper are the product of past activities of the boatyards in the immediate area. The boatyards carry out maintenance activities and have related discharge permits, but samples have not been collected to confirm this supposition. The data from the Rhine Channel are plotted in **Figure C- 11.6**. The concentration of copper in the sediments during the last five seasons is much lower than during the period from 1992 to 1998.

Agua Chinon and Hicks Canyon Wash – DDT in sediments

Agua Chinon Wash and Hicks Canyon Wash were designated as Warm Spots because of high concentrations of DDT metabolites in the bottom sediments of these creeks. The sources of these high concentrations have not been investigated. It is assumed that these legacy pesticides are in the soils of the agricultural areas in the watershed and enter the drainage system after large storms or development of these agricultural areas. From **Figure C- 11.7** it appears that the concentrations of these compounds in the sediments of Agua Chinon Wash have decreased since the mid-1990s with only a notable spike in the concentrations from the sample collected in November 2002. For Hicks Canyon Wash, the site at which the highest concentrations were found, has not been sampled since 2001, as the configuration of the channel at that point has been changed to a subsurface conduit. Samples from 2002 to present have been collected from the outlet of the drain upstream of the confluence with Peters Canyon Wash. **Figure C- 11.8** shows that concentrations of the DDT metabolites, although still slightly detectable are much lower than those measured in the mid-1990s.

Central Irvine and Hines Nursery Channels – nitrates

Central Irvine and Hines Nursery Channels have been investigated for high levels of nitrate in dry-weather samples. Efforts in the Central Irvine Channel are part of the last three intensive nutrient studies (1999, 2000, and 2001) in Peters Canyon Wash. The current emphasis has been on intensified monitoring, on a bi-weekly schedule, to better understand the temporal pattern of discharges. This information is intended, in part, to help focus subsequent source identification efforts on periods when discharge levels are highest. **Figure C- 11.9** shows the nitrate concentrations in Central Irvine Channel measured throughout the year.

In late May and early June of 2003 a short-term mass load study was conducted on the Central Irvine Channel. The monitoring consisted of 6-hour composite sampling and continuous flowrate measurement at Central Irvine and 24-hr composite sampling at Peters Canyon Wash at Barranca Parkway. **Figure C- 11.10** shows the flowrate at each site during the study. **Figure C- 11.11** shows the nitrate concentrations of each composite sample and **Figure C- 11.12** shows the computed nitrate-nitrogen loading rate in lbs/day from each composite sampling. The daily nitrate-nitrogen load from site was calculated and plotted in **Figure C- 11.13. Figure C- 11.13** shows that the Central Irvine Channel contributed a significant percentage of the nitrate load to Peters Canyon Wash during that week.

Christiana Bay – lead in sediment

Christiana Bay in Huntington Harbour was classified as a Warm Spot because of high levels of lead in the benthic sediments. **Figure C- 11.14** shows that the concentrations of lead in the sediment at this location have been significantly lower since 1998. This may be due to the effects of the El Niño season in 1997-98. Sediment scouring or deposition at the outlet of the Sunset channel may have altered the concentrations at the sampling point.

C-11.6.2 Critical Aquatic Resources (CARs) Monitoring

The CARs element is generally on track with the categories of activities and timelines listed in **Figure C- 11.3**. In Huntington Harbour, Bolsa Bay, and Newport Bay the effects of stormwater runoff from two storms were monitored during the year.

The Final Monitoring Program envisioned that the CARs would fulfill a broader impact assessment role that would involve filling important data gaps and collecting and integrating data from all sources to develop a more complete picture of impacts on aquatic resources.

The following are summaries of the activities conducted in the CARs (from **Figure C-11.1**) during the reporting period.

Upper Newport Bay tributaries

The Upper Newport Bay and its tributaries were assigned the top monitoring priority in the Final Monitoring Program for the Santa Ana Region. The monitoring of these areas included routine NPDES and TMDL sampling as described in **Table C- 11.7.**

Monitoring in the Upper Newport Bay and San Diego Creek also includes separate, but related studies to evaluate the trapping efficiency of the basins in the Upper Bay, assess toxicity in the Upper Bay, and evaluate the efficiency of the Irvine Ranch Water District's nutrient removal ponds.

The mass loads of nutrients and total recoverable metals were calculated for each storm monitored for which there was water quality and flowrate information. In the Upper Newport Bay, watershed loads were calculated for sampled stormwater runoff in Santa Ana-Delhi Channel, Peters Canyon Wash, San Diego Creek at Harvard Avenue, and San Diego Creek at Campus Drive. The mass load information for each sampled storm is contained in **Table C- 11.12**. The total annual stormwater discharge volumes from Santa Ana-Delhi Channel, Peters Canyon Wash, San Diego Creek at Harvard, and San Diego Creek at Campus Drive were calculated from Principal Permittee's streamgaging records. Using these volumes and the site mean EMCs from **Exhibit C-11-VI,** the unsampled stormwater loads from each of these channels were estimated. **Table C-11.14** includes a summary of the sampled and unsampled loads from each of the sites from **Exhibit C-11-VI** including those from the Newport Watershed.

Since monitoring thus far has only involved sampling of water chemistry, the impacts on the Bay can only be estimated by comparing the concentration concentrations of known toxicants in the freshwater discharges to saltwater toxicity criteria. Using this approach leads to a large margin of safety as mixing zone considerations are not taken into account. The results of this type of evaluation are only used to prioritize sites for further testing. The monitoring program for the Third Term Permit will include sampling for aqueous chemistry and aqueous toxicity in the channels and the harbors and bays. Harbor/Bay monitoring will include annual assessments of sediment chemistry, toxicity, and benthic infauna.

For channels discharging directly to the Newport Bay, dissolved metal concentrations were compared to the guidance criteria for saltwater from the CTR. Out of the 22 stormwater samples, all exceeded the acute toxicity guidance criterion for copper and six exceeded the acute toxicity guidance criterion for zinc. Of the two composite storm periods that were evaluated against the chronic toxicity guidance criteria for the protection of saltwater aquatic life, both exceeded the guidance criterion for copper and one exceeded the criterion for zinc. **Table C- 11.15** is a summary of exceedances relative to the CTR that were found in the storm channels during this monitoring year.

Santa Ana Delhi Channel

Figure C- 11.1 shows monitoring and assessment efforts at Santa Ana Delhi Channel extending throughout the permit period. Santa Ana Delhi was added to the sediment TMDL monitoring program, in order to help quantify the amount of sediment impacting Upper Newport Bay. It is also part of the nutrient TMDL program, and is therefore being monitored at levels above those proposed in the Final Monitoring Program.

Costa Mesa Channel

The Costa Mesa Channel was selected as a model urban runoff site because its watershed is approximately one square mile in area and has predominately urban land uses within it. It was sampled weekly for metals, nutrients, and bacteria and monthly for organophosphate pesticides. Monitoring at this site will be determined largely by requirements of the nutrient, pathogen, and toxics TMDLs.

With respect to the monitoring results from this reporting year and recognizing the discussion above, all eight of the stormwater samples and all 37 of dry weather samples from Costa Mesa Channel would exceed the CTR acute toxicity criteria for dissolved copper in saltwater at the interface of the channel and the Upper Newport Bay. Since the average dry-weather discharge rate of the Costa Mesa Channel is very low, the impact on the Bay due to copper is likely to be negligible.

Figure C- 11.15 is plot of the fecal coliform concentration in Costa Mesa Channel throughout the year. As in previous years the fecal coliform concentrations were extremely variable with a range of 120 to >160,000 MPN or CFU / 100 ml and a logmean of approximately 3,585 MPN / 100 ml.

Several samples were collected throughout the year for analyses of organophosphate pesticides (Diazinon, Chlorpyrifos, Dimethoate, and Malathion). Diazinon levels have declined from those seen in previous years. During the 2001-02 monitoring year this pesticide was found above the detection limit of the laboratory (0.05 μg/l) in nearly every sample collected. During this year the laboratory lowered its detection limit to 0.01 μg/L, and in 14 of the 37 samples collected, the diazinon concentration was reported as undetected. Only one sample had a detectable level (0.06 μg/L) of Chlorpyrifos. Dimethoate was found at a detectable level (0.058 μg/L) in only one sample. No Malathion was detected in any sample. During the first year of sampling (1999-2000) over one third of the samples had Diazinon concentrations greater than the LC_{50} for the freshwater toxicity testing organism *Ceriodaphnia dubia*[6]. In the second year about 10% were greater than the LC_{50}; about 13% were greater than the LC_{50} in the third

[6] Lee, G. Fred, Evaluation Monitoring Report for San Diego Creek, 1998, Table 6-3.

year; and about 8% were greater this year. **Figure C- 11.16** is a graphical summary of the Diazinon concentrations during this monitoring year.

Santa Isabella Channel

As part of the 5-year Re-Evaluation monitoring, the Santa Isabella Channel was monitored. Additional monitoring was also conducted to aid the City of Costa Mesa in its search for a potential site for a BMP. Several samples were collected near the stormdrain outlet at Irvine Avenue (SICG02) and at the base of the bluffs just upstream of the Upper Newport Bay (SIDG03). Monitored constituents included nutrients, metals, bacteria, and organophosphate pesticides.

The paired data from each sampling site suggest that the bluffs may aid in reducing levels of nitrate, total Kjeldahl Nitrogen (ammonia + organic nitrogen), total suspended solids, total recoverable (dissolved + particulate) copper, and total recoverable zinc. Statistical analyses (ANOVA, α=0.05) showed significant differences in the means of these constituents in the downstream monitoring locations relative to upstream. **Figure C- 11.17** and **Figure C- 11.18** graphically demonstrate this finding. There was no statistically significant difference between the two monitoring sites with respect to the fecal coliform or *Enterococcus* concentrations. Those data are shown graphically on **Figure C- 11.19**.

With the exception of two days, the concentrations of Diazinon in the samples collected at the two sites were either below or slightly above the detection limits of the laboratory (0.01 – 0.05 µg/L). On 3/5/03 and 5/8/03 the concentrations at SICG03 were 0.654 µg/L and 2.78 µg/L, respectively. The concentration at SIDG03 on 5/8/03 was 0.810 µg/L. These results suggest that that Diazinon was an acute problem in the discharge and public education may be the solution.

San Diego Creek and its tributaries

Sampling for diazinon in dry-weather discharges was also conducted in San Diego Creek at Campus Drive. **Figure C- 11.20** shows the concentration of diazinon in the samples collected this year. None of the samples had levels above the LC_{50} for *Ceriodaphnia*.

In order to gather more information for the toxics TMDL, samples for analyses of total recoverable selenium were collected from San Diego Creek at Campus Drive. The results of these analyses are shown in **Figure C- 11.21**.

Newport Bay

In addition to monthly dry-weather Nutrient TMDL monitoring and semiannual sediment sampling, the Bay was monitored during two storms this year. These storm assessments included sampling for fecal coliform during and subsequent to the storms.

Figure C- 11.22 and **Figure C- 11.23** show the fecal coliform concentrations at four Upper Bay stations during two separate storms. The data show that the peak flowrate into the Bay for both storms was about the same. The concentrations of bacteria during the storm appear to be a function of the time of sampling relative to the storm peak. The post-storm samplings however, suggest that the runoff from the April storm had longer residual effects than the February storm.

In February of 2000, the Regional Monitoring Program (RMP) for the Nutrient TMDL was initiated. Chemical sampling for nutrients during storms and dry weather was conducted according to the frequencies outlined in RMP report. The data from the 2002/03 reporting period are contained in **Exhibit C-12-I.**

Lower Newport Bay

Other than the additional sediment samples collected in the Rhine Channel there have been no efforts to date focused on Lower Newport Bay.

C-11.6.3 Reconnaissance

The Reconnaissance Program was developed to aid in source identification in areas of known water pollution problems. Stations were prioritized as part of the monitoring program design. Site-specific designs have been established and source identification conducted as each site is addressed. In prior years reconnaissance activities in the Santa Ana Region focused on the Construction Circle drain in Irvine and Collins Channel in Orange.

The monitoring program for the Third Term Permit will include a reconnaissance element that will focus on approximately 40 "targeted" stormdrains in the Santa Ana Region. These drains were identified by the Permittees as potential conduits for illegal discharges and illicit connections. Monitoring will involve five separate visits to each site during the dry season (May 1 – September 30). Each site visit will consist of a visual reconnaissance, in-situ measurements of physical characteristics (flowrate, specific conductance, pH, temperature, and dissolved oxygen), and field analysis of nitrate, ammonia, reactive phosphorus, total chlorine, phenols, surfactants, and water hardness. Samples will be collected and submitted for laboratory analysis of total suspended solids, dissolved metals, oil and grease, and organophosphate pesticides.

Unusual observations or measurements in the field will be reported immediately to the respective Permittee representative. The field and laboratory results will be entered into a statistical database, which will determine if those results require additional reconnaissance by the respective Permittee. The "average" condition will be determined from analysis of results from randomly selected stormdrains throughout the County. The trigger for watershed reconnaissance has been tentatively established as 3.9 standard deviations above the average (mean) value for any monitored parameter. If two consecutive measurements exceed the trigger level, reconnaissance will be initiated by the Permittee.

C-11.6.4 Semiannual Sediment Sampling

Samples of bottom sediment from several watershed and harbor/bay locations were collected in the fall/winter of 2002 and the spring/summer of 2003. These samples were analyzed for trace metals, iron, chlorinated hydrocarbon pesticides, selected herbicides, and particle size distribution.

The database for harbor and bay sediments was evaluated using NOAA's guidance criteria for sediment toxicity. These criteria are used by SCCWRP in assessing toxicity of sediments collected from the Southern California Bight. Concentrations of metals and organic compounds from Newport Bay, Huntington Harbor, and Bolsa Bay were compared to NOAA's Effects Range Median (ER-M). An ER-M is a predicted concentration at which half the test organisms in a toxicity test would show a toxic effect. Although none of the metals concentrations in the harbors exceeded ER-Ms, several samples collected had levels of Chlordane exceeding the ER-M.

SCCWRP's iron normalization procedure was again used to determine if concentrations of trace metals the sediments from the bays and harbors were the product of natural conditions or anthropogenic activities. Using the regression equations and prediction intervals (**Table C- 11.10**) it was determined that all samples were anthropogenically (caused by the actions of man) enriched with zinc, and all but one sample were enriched with copper. Every sample except those from Harbor Island Reach in the Lower Newport Bay (LNBHIR) and one of the two samples from Huntington Harbour at the mouth of Bolsa Chica Channel (HUNBCC) showed enrichment from lead.

Simazine, an aquatic herbicide used as a pre-emergent inhibitor of aquatic weeds and algae, was found at a concentration of 1020 μg/Kg in the sediment of the Christiana Bay in Huntington Harbour on May 30, 2003. In the other four samples collected at this site the concentration was below the detection limit of the laboratory (80 μg/Kg).

C-11.7 Quality Assurance / Quality Control

The quality of data produced by each of the three contractor laboratories was evaluated by submitting quality control samples with environmental samples. Most of the samples submitted were synthetic, comprised of aliquots of prepared standard solutions in nanopure water matrices. Quality Control sample conductivities were adjusted to levels similar to environmental samples with Ultrex grade sodium chloride. These synthetic samples were used to assess the accuracy of each laboratory. Replicate samples were also submitted to evaluate the precision of the laboratories.

The contractor laboratories conduct internal quality control programs utilizing certified reference materials (CRMs), spiked and replicate samples.

The results of the quality assurance program with the contract laboratory are summarized in **Exhibit C-11-VII.** The allowable range of percent recovery for synthetic and samples is set at 70 - 130 for concentrations above 5 times the detection limit. For replicate samples in which the highest reported value exceeded 5 times the detection limit, the allowable range was set at 75-125 percent. For blank sample analyses the allowable range was the detection limit (dl) to 3(dl). Those results outside these ranges are boxed in the exhibit.

Generally, the analytical performance of each laboratory was acceptable. Four of the 38 analyses for TKN in synthetic samples produced results outside acceptable range of recovery. For each of these samples outside the limit the laboratory reported a result below the actual value. For two samples the reported nitrate concentrations were two orders of magnitude above the true value. These errors may have been the result of sampling staff adding the wrong preservative (analytical grade nitric acid rather than sulfuric acid) to these samples. No environmental samples were affected by this apparent error.

Thirty-two quality assurance samples from a certified quality assurance vendor were submitted for analyses of total and fecal coliform. The results of the analyses of three of the samples were outside of the range of acceptability provided by the quality assurance vendor. In each case the value reported by the laboratory was outside the upper end of the range of acceptability.

Several samples were submitted for analysis of contamination that may be caused by equipment or methods used in collecting or processing samples. Nanopure water was used as the blank. Several pieces of equipment were evaluated including groundwater filtering capsules, ISCO sample bottles, a 50-liter Nanopure water storage carboy, ISCO peristaltic pump tubing, and ISCO strainer tubing. The rinse water (deionized water) from the laboratory bottle washer was analyzed for trace metals contamination. Nutrient analyses showed no detectable levels of contamination. The rinsate from the dishwasher had detectable levels of copper (5-7 μg/L) which were most likely from the deionized water system. The residue from the rinsate would not cause a detectable amount of contamination unless a full sample bottle of the rinsate was allowed to evaporate to dryness. Cleaned containers currently are drained and air dried in an inverted position.

C-11.8 Regional Research Monitoring Program

Stormwater runoff in southern California has become one of the largest environmental management issues in the region. While current runoff management has become an immensely successful system for flood control, it has not historically been designed to enhance water quality. Current estimates of pollutant loads from stormwater runoff rival those of traditional point sources for many constituents, and several examples of impacts from storm drains and channels have been observed in receiving waters. Examples include the contribution of bacteria that has resulted in posting of beaches for swimming, contributions of nutrients that have resulted in blooms of macroalgae, and contributions of toxics that has led to aquatic toxicity and degradation of aquatic habitats. This combination of emissions and impacts has led to an increasing regulatory focus on stormwater runoff, but much of the science needed to make effective and efficient management decisions is still lacking.

As a result of the increasing regulatory focus and the lack of scientific knowledge base, both stormwater regulators and municipal stormwater management agencies throughout southern California have developed a collaborative working relationship. The goal of this relationship is to develop the technical information necessary to better understand stormwater mechanisms and impacts, and then develop the tools that will effectively and efficiently improve stormwater decision-making. As individuals and agency representatives, there was early recognition that these issues are oftentimes not localized, but typically cross watershed and jurisdictional boundaries. This relationship culminated in a formal letter of agreement signed by all of the Phase I municipal stormwater NPDES lead permittees and the NPDES regulatory agencies in southern California to create the Stormwater Monitoring Coalition (SMC).

List of member agencies in the Stormwater Monitoring Coalition.

California Regional Water Quality Control Board, Los Angeles Region
California Regional Water Quality Control Board, San Diego Region
California Regional Water Quality Control Board, Santa Ana Region
City of Long Beach
County of Orange, Public Facilities and Resources Dept.
County of San Diego Stormwater Management Program
Los Angeles County Department of Public Works
Riverside County Flood Control and Water Conservation District
San Bernardino County Flood Control District
Southern California Coastal Water Research Project
Ventura County Flood Control District

The SMC member agencies have developed a clear vision of regional cooperation. The vision includes combining resources to cost effectively achieve their goal. The vision includes improved effectiveness of existing monitoring programs by promoting standardization, coordination, and reducing duplication of effort across individual programs. This will lead to improving the basic infrastructure for exchanging, combining, and analyzing data from across the region. The multi-agency collaboration hopes to trade off redundant or ineffective monitoring program elements in order to allocate resources to the research projects necessary for improving stormwater management. The findings from these applied research projects can then be easily and quickly integrated into the existing stormwater management programs.

This document outlines the activities that the SMC has accomplished over the last year. The initial project promoted by the SMC was the creation of a research agenda. The SMC has subsequently embraced three of the proposed projects in the research agenda and have begun work to accomplish the project objectives. The SMC meets on a quarterly basis to discuss these projects and ensure their success. Cumulatively, these activities demonstrate that the SMC is an active organization and is making great strides in achieving its stated goals. The common vision shared in by the initial founding members of the SMC has taken root and is being implemented to the benefit of both regulatory and regulated communities.

C-11.8.1 Project Status

See **Section C-3**.

Table C-11.1
Ranking of Critical Aquatic Resources

SITE	CRITERIA									
	303(d) listed	Community interest	Aquatic habitat	Wildlife habitat	Designated reserve	Contact recreation	Non-contact recreation	Utility resource	Urban impact	Total
Enclosed Bays and Estuaries										
Upper Newport Bay	XX	XX	X	X	X	X	X		X	10
Lower Newport Bay	XX	XX	X	X		X	X		X	9
Talbert Channel		XX	X	X	X	X	X		X	8
Bolsa Bay		XX	X	X	X	X	X		X	8
Sunset Aquatic/ Anaheim Bay / Huntington Harbour	XX	XX	X	X		X	X		X	9
Dana Point Harbor		XX	X	X		X	X		X	7
Coastal Resources										
Irvine Coast Marine Life Refuge		XX	X	X	X	X	X		X	8
Laguna Beach	XX	XX				X	X		X	7
Laguna Beach Marine Life Refuge		X	X		X	X	X		X	6
Newport Marine Life Refuge		X	X	X	X	X	X		X	7
Aliso Beach	XX	XX				X	X		X	7
Aliso Creek Mouth	XX	XX	X	X		X	X		X	9
Niguel Marine Life Refuge		X	X		X	X	X		X	6
Doheny Beach	XX	XX				X	X		X	7
Doheny Beach Marine Life Refuge		X	X		X	X	X		X	6
Inland Surface Waters										
Aliso Creek	XX	XX	X	X		X	X		X	9
Laguna Canyon Channel		XX		X		X	X	X	X	7
Oso Creek			X	X		X	X	X	X	6
Prima Desheca			X	X		X	X	X	X	6
San Diego Creek, Reach 1	XX	XX	X	X		X	X		X	9
San Diego Creek, Reach 2	XX	XX	X	X		X	X	X	X	10
San Juan Creek	XX	XX	X	X		X	X	X	X	10
San Juan Creek, Lower	XX	XX	X	X		X	X		X	9
Santa Ana River								X	X	2
Santiago Creek, Reach 4	XX		X	X		X	X	X		7
Segunda Desheca			X	X		X	X			4
Serrano Creek		XX	X	X		X	X		X	7
Silverado Creek	XX		X	X		X	X	X		7
Trabuco Creek			X	X		X	X	X	X	6

Scoring of candidate monitoring sites on each of several subjective criteria and Basin Plan beneficial uses that reflect habitat value and human us. Cells with more than one "X" indicate heavier weighting for that site on that criterion.

Table C-11.2
Summary of Ranking Critical Aquatic Resources

Number of "X"s	Candidate sites
	First priority
9 - 10	San Diego Creek, Reach 1& Reach 2
10	San Juan Creek
10	Upper Newport Bay
9	Aliso Creek
9	Aliso Creek Mouth
9	Lower Newport Bay
9	San Juan Creek, Lower
9	Sunset Aquatic/Anaheim Bay/Huntington Harbour
7	*Dana Point Harbor (DPH)
	Second priority
8	Bolsa Bay
8	Irvine Coast Marine Life Refuge
8	Talbert Channel
7	Aliso Beach
7	Doheny Beach
7	Laguna Beach
7	Laguna Canyon Channel
7	Newport Marine Life Reserve
7	Santiago Creek, Reach 4
7	Serrano Creek
7	Silverado Creek
	Third priority
6	Doheny Beach Marine Life Refuge
6	Laguna Beach Marine Life Refuge
6	Niguel Marine Life Reserve
6	Oso Creek
6	Prima Desheca
6	Trabuco Creek
4	Segunda Desheca
2	Santa Ana River, Reach 2

Results of the ranking exercise for candidate monitoring sites. Overall ranking was based simply on the number of "X"s in each row of Table 11.1. * Dana Point Harbor is included as a first priority site because of the extensive amount of human use and community interest.

Table C-11.3
Sources of Information Used for Critical Aquatic Resource Impact Assesment

	Study/Location	Agency	Funded by	Duration	Data
1	UNB Algal Studies	UCLA	IRWD	1996-	Salinity, nutrients, algal biomass
2	Newport Marine Life Reserve W'shed Studies	RiverTech	The Irvine Company		Nutrients
3	Newport Marine Life Reserve Offshore Studies	Dr. Ford, Cal State U. San Diego	The Irvine Company		Growth rate of kelp
4	Santa Ana River, Reach 1	SCCWRP	CSDOC	10/97-10/98	TSS, priority pollutants (organics, etc.)
5	Southern California Bight Pilot Project	SCCWRP	POTWs	1994, 1998	Chemical, biological, and toxicity samples
6	Basin Study, Santa Ana River (Imp. Hwy)	OC Water District & USGS	OCWD & USGS	10/95 - 9/99	Nitrates, organics
7	State Mussel Watch (UNB, DP, Huntington Harbor)	Ca. Dept. of Fish & Game	Reg'l Board	1977-	Toxics (trace metals, synthetic organics)
8	Toxic Substances Monitoring Program	Ca. Dept. of Fish & Game	Reg'l Board	1989	Toxics (trace metals, synthetic organics)
9	TMDL studies	Reg'l Board	Reg'l Board	1997	TMDLs on nutrients
10	TMDL studies	Reg'l Board	Reg'l Board		TMDLs on sediments
11	NB Plant Survey	Dr. Alex Horne, UC Berkeley	IRWD	1996	Plants
12	Coastal bacteria (coast)	County Environmental Health	County	1977-	Bacteria
13	Coastal bacteria (Aliso Creek, Laguna Beach)	Aliso Water Management Agency (AWMA)	AWMA	NPDES permit term	Bacteria
14	Coastal bacteria (San Juan Creek)	Southeast Regional Reclamation Authority (SERRA)	SERRA	NPDES permit term	Bacteria
15	Coastal bacteria (Santa Ana River)	County Sanitation Districts of Orange County (CSDOC)	CSDOC	NPDES permit term	Bacteria
16	Talbert Channel Conservancy	Cal State Long Beach			Polychaete taxonomy
17	Evaluation Monitoring Program (UNB w'shed)	Dr. Fred Lee, Transportation Corridor Agencies (TCA)		1997-2000	Toxicity
18	SD Creek Sediment Monitoring Program	Orange County Environmental Resources Section	County, Cities of Irvine, Tustin, & Newport Beach, Irvine Company	1987-	Transported sediment, channel profiling, bathymetric survey of NB
19	San Diego Creek/NB model	Resource Management Associates	County, City of Newport Beach, Army Corps of Engineers	1997-	Sediment transport model with potential for expansion into water quality model
20	Orange County Municipal NPDES Stormwater Program	Orange County Environmental Resources Section	County, Flood Control District, Cities	1991 -	Water and sediment quality data
21	Chemistry, Toxicity and Benthic Community Conditions in Sediments of Selected Southern California Bays and Estuaries	NOAA, SWRCB, USEPA, DFG, UCSC, CSUSJ	NOAA, SWRCB, USEPA, DFG	1997	Sediment quality data
22	Maintenance of trash/debris booms in Orange County flood control channels	Orange County PFRD/PW/OPS	County	Ongoing	Debris boom maintenance, debris disposal costs
23	Maintenance of Newport Dunes Aquatic Park	Newport Dunes Aquatic Park	Newport Dunes Aquatic Park	Ongoing	Algae removal costs
24	Debris removal in Huntington Harbour	G.H. Boston Company	City of Huntington Beach	Ongoing	Debris volumes
25	Debris removal in Newport Bay	City of Newport Beach Public Works	City of Newport Beach	Ongoing	Algae and debris volumes
26	Maintenance dredging in County facilites	Contractor administration by County Coastal Facilities	County	Ongoing	Sediment testing results, biological resources
27	Fish trawling in Newport Bay	Orange Coast College	Orange Coast College	Ongoing	Population distribution of fish
28	Army Corps of Engineers Reconnaissance Study - Aliso Creek	Army Corps of Engineers	Army Corps of Engineers, Cities, County, Water Districts	1998 - 2001	Create integrated watershed management plan.

Table C-11.4
Critical Aquatic Resources Preliminary Impact Assessment

Resource	Beneficial use(s)	Available Indicators of probable impact	Source of Indicator From Table 10	Constituents of concern	Possible Sources
San Diego Creek, Reach 1 & 2	Aquatic habitat	Elevated toxics in fish tissue	8	Toxaphene, Dacthal, Diazinon, Oxidizon, Total DDT, Group A, Cd, Se, Zn	Urban runoff, agriculture
		Bioaccumulation	7	Chlorpyrifos, Oxidizon, Toxaphene, Total Chlordane, Total DDT, Dieldrin, Total PCB, Total PAH, Cd	Urban runoff, agriculture
	Wildlife habitat	Water quality	17,20	Diazinon, Chlorpyrifos, nutrients	Urban runoff, agriculture
		Sedimentation	18,19,26	Sediment	Channel erosion, construction, agriculture
		Wildlife changes			Urbanization, urban runoff
		Vegetation changes			Urban runoff, channel erosion, flowrate
	Recreation/ aesthetics	Algal blooms	20	Nutrients	Urban runoff, agriculture
		Elevated levels of bacteria	12		Urban runoff, wildlife, sewer overflows / line breaks
San Juan Creek & Lower	Recreation/ aesthetics	Beach closures	12, 14	Bacteria	Urban runoff, wildlife, sewer overflows / line breaks
	Groundwater Recharge	Water quality	14,20	Total Dissolved Solids	Urban runoff
Upper Newport Bay	Aquatic habitat	Elevated toxics in fish tissue	8	Cu, Hg, Pb, Total DDT	Urban runoff, recreational boating
		Water quality	17,20	Diazinon, Chlorpyrifos, nutrients	Urban runoff, agriculture, open space
		Sediment contamination	5,20,21,26	Total DDT	Urban runoff, agriculture, boatyards
		Bioaccumulation	7	Chlorpyrifos, Toxaphene, Total Chlordane, Total DDT, Dichlorobenzophenone, Dicofol, Dieldrin, Total PCB, Total PAH, Cu, Hg	Urban runoff, agriculture
	Wildlife habitat	Sedimentation	18,19,26	Sediment	Channel erosion, construction, agriculture
		Loss/change of species diversity	26,27	Toxics, DO, nutrients, sediment, species composition	Urban runoff, agriculture, open space
		Sediment contamination	20,21,26	Total Chlordane, Total DDT, DDE	Urban runoff, agriculture, boatyards
	Recreation/ aesthetics	Algal blooms	11,23,25	Nutrients	Urban runoff, agriculture
		Trash and debris	22	Trash and debris	Urban, natural
		Beach closures	12	Bacteria	Urban runoff, POTW discharge/line breaks
Aliso Creek & Mouth	Aquatic/ riparian habitat	Bank erosion	28	Flowrate	Urban development
		Loss of riparian vegetation	28	Flowrate	Urban development
	Recreation/ aesthetics	Beach closures	12,13,33	Bacteria	Urban runoff, sewer overflows / line breaks
Lower Newport Bay	Aquatic habitat	Bioaccumulation	7	Chlorpyrifos, Dacthal, Heptachlor Epoxide, Toxaphene, Total Chlordane, Total DDT, Dieldrin, Total PCB, Total PAH, Al, As, Cd, Cu, Cr, Hg, Mn, Pb, Se, Zn	Urban runoff, agriculture,boatyards, recreational boating
		Sediment contamination	5,20,21,26	Total Chlordane, Total DDT, Cu, Hg	Urban runoff, agriculture
	Recreation/ aesthetics	Algal blooms	11,25	Nutrients	Urban runoff, agriculture
		Trash and debris	25	Trash and debris	Urban, natural
		Complaints	12,20,25	Trash and debris, nutrients, bacteria	Urban, natural, agriculture, open space
Sunset Aquatic/Anaheim Bay/Huntington Harbour	Aquatic habitat	Bioaccumulation	7	Chlorpyrifos, Dacthal, Heptachlor Epoxide,Oxidizon, Toxaphene, Total Chlordane, Total DDT, Dieldrin, Total PCB, Total PAH, Al, As, Cd, Cu, Cr, Mn, Pb, Se, Zn	Urban runoff, agriculture
		Elevated toxics in fish tissue	8	Total Chlordane, Total DDT, Total PCB, Total PAH	Urban runoff, agriculture
		Sedimentation	26	Sediment	Agricultural runoff
		Loss/change of species diversity	5,26	Sediment, disturbance	Agricultural runoff, dredging
		Sediment contamination	5,20,26	DDE	Urban runoff, agriculture
		Water quality	20	Metals, nutrients	Urban runoff, agriculture
	Recreation/ aesthetics	Trash and debris	22,24	Trash and debris	Urban runoff
		Beach closures	12	Bacteria	Urban runoff, wildlife, sewer overflows / line breaks
Dana Point Harbor	Recreation/ aesthetics	Beach closures	12	Bacteria	Urban runoff, wildlife, sewer overflows / line breaks
	Aquatic habitat	Bioaccumulation	7	Total Chlordane, Total PCB, Al, Cd, Cu, Zn	Urban runoff, recreational boating
		Sediment contamination	5,20,21,26	Total Chlordane, Cu	Urban runoff, recreational boating

Bioaccumulation - toxics found in filter feeding invertibrates such as mussels
bacteria - pathogenic indicator organisms
Group A chemicals - includes aldrin,dieldrin, endrin, heptachlor, heptachlor epoxide, chlordane (total), hexachlorocyclohexane (total), endosulfan, toxaphene

Table C-11.5
Warm Spot Constituents of Concern and Trend Monitoring Frequencies

Warm Spot	Location	STORET Code	Constituent(s) of Concern	from Power Analyses: Trend Detectable	Monitoring Frequency samples/yr	term (years)	min. reduction to show signifcant trend
Bonita Creek	u/s F05 conf.	BCF04	Ni Ni(s)	N N	(12) (2)		
Lane Channel	u/s Jamboree	LANF08	EC(d)	Y	10	5,10	28,13
Agua Chinon Wash	@ Irvine Ctr. Dr.	ACWF18	DDE(s), DDT(s)	N	(2)		
Central Irvine Channel	@ East Yale Loop	CICF25	NO_3(d)	?	20	20	78
Rattlesnake Canyon Wash	@ Bryan Ave.	RCWF26	TSS Pb	 Y	 20	 20	 70
Hicks Canyon Wash	@ Culver Dr.	HCWF27	DDE(s)	N	(2)		
Hines Channel	@ Bryan / Jeffrey	HINF28	NO_3(d)	Y	20	10,20	50,35
Sulphur Creek	d/s Sulphur Cr. Reservoir	SCDAM	Cd(s)	N	(2)		
Prima Deshecha Channel	@ Calle Vista Grande	PDCM01	EC(d) Cd Ni	Y Y Y	10 20 20	10,20 10,20 10,20	42,29 50,33 53,37
Segunda Deshecha Channel	@ El Camino Real	SDCM02	EC(d)	?	10	20	75
Lower Newport Bay	@ the Rhine Channel	LNBRIN	Cu(s)	?	5	20	85
Huntington Harbour	@ Christiana Bay	HUNCRB	Pb(s)	?	5	20	68

(s) sediment concentrations; (d) dry weather measurements; all others stormwater concentrations
(#) - frequency not based on power analyses

Table C-11.6
NPDES and Nutrient TMDL Monitoring Locations in the Santa Ana Region

	Warm Spot	CAR	TMDL	Waterbody	Location of Site	Station Code
			X	El Modena Irvine Ch.	at Michelle Dr.	MIRF07
			X	Lane Ch.	at Jamboree Blvd.	LANF08
	X		X	Agua Chinon Wash	at Pacifica	ACWF18
Upper Newport Bay	X			Central Irvine Ch.	at I-5 Fwy.	CICF25
Watershed	X			Hines Nursery Ch.	at Trabuco / Jefferey	HINF28
				Hicks Canyon Wash	at Culver Dr.	HCWF27
			X	Bonita Canyon Wash	u/s University Ave.	BCF04
		X	X	San Diego Creek	at Campus Dr.	SDMF05
		X	X	San Diego Creek	at Harvard Ave.	WYLSED
			X	Peters Canyon Wash	at Barranca Pkwy.	BARSED
			X	Costa Mesa Ch.	at Westcliff Dr.	CMCG02
			X	Santa Ana Delhi Ch.	u/s Irvine Ave.	SADF01
Upper Newport Bay		X	X		Unit I in-bay basin	UNBJAM
		X	X	Narrows	d/s Unit II In-bay basin	UNBSDC
		X	X	North Star Beach		UNBNSB
		X	X		at PCH bridge	UNBCHB
Lower Newport Bay		X		Turning Basin		LNBTUB
	X	X		Rhine Channel		LNBRIN
		X	X	Harbor Island Reach		LNBHIR
Huntington Harbour /				Anaheim Barber City Ch.	at Rancho Rd. / Naval RR X-ing	ABCC03
Bolsa Bay				Bolsa Chica Ch.	at Westminster Ave.	BCC02
Watershed				E. Garden Grove Wintersburg Ch.	at Gothard St.	EGWC05
				Westminster Ch.	at Beach Blvd.	WMCC04
Sunset Aquatic Park /		X		Sunset Aquatic Park	Near U.S. Navy bouys	HUNSUN
Anaheim Bay /		X		Huntington Harbour	approx. 1/4 mi. d/s Bolsa Chica Ch. Mouth	HUNBCC
Huntington Harbour		X		Huntington Harbour	d/s Warner Ave. near HH Yacht Club dock	HUNWAR
	X	X		Christiana Bay	near outlet of Sunset Channel	HUNCRB
		X		Anaheim Bay	between two breakwaters	HUNHAR
		X		Bolsa Bay	off pier	BBOLR

Table C-11.7
NPDES and Nutrient TMDL Monitoring Frequencies in the Santa Ana Region

Station Code	Nutrients (aq)	Nutrients (sed)	Trace (aq)	Trace (sed)	PHP (s)	PAH (s)	Other Interest
Huntington Watershed							
ABCC03	st		st				
EGWC05	m/st		st				
BCC02	m/st		st				
WMCC04	st		st				
Upper Newport Bay Watershed							
MIRF07	m/st						
LANF08	**m/st**						EC(m)
ACWF18	**m/st**				semi		
CICF25	biweekly						
HINF28	biweekly						
HCWF27					semi		
BCF04	**m/st**		st(12)	semi			
SDMF05	**w/st**		st	semi	semi		op pest (m)
WYLSED	**biweekly**/st		st	semi	semi		
BARSED	**biweekly/st**						
SICG03	st		st				
CMCG02	**w/st**		w/st				bacteria (w/st), op pest (m)
SADF01	**biweekly/st**		st				
Upper Newport Bay							
UNBJAM	m(s**,m,b**)/st	m	st	semi	semi		bacteria (m/st), debris (st)
UNBSDC	m(s**,m,b**)/st	m	st	semi	semi		bacteria (m/st), debris (st)
UNBNSB	m(s**,m,b**)/st	m	st				bacteria (m/st), debris (st)
UNBCHB	m(s**,m,b**)	m	st				bacteria (m/st), debris (st)
Lower Newport Bay							
LNBTUB	st		st	semi	semi		
LNBRIN	st		st	5	semi		
LNBHIR	**m(s,m,b**)/st		st	semi	semi		
Huntington Harbour/Bolsa Bay							
HUNSUN	semi/st		st				
HUNBCC	semi/st		st	semi	semi		
HUNWAR	semi/st		st	semi	semi		
HUNCRB	semi/st		st	5	semi		
HUNHAR	st		st				
BBOLR	semi/st		st	semi	semi		

(s,m,b) surface, middepth, bottom
s(12) storm sampling - 12 total composite samples per year
bold - nutrient TMDL additions including orthophosphate

Table C-11.8
Beneficial Uses of Monitored Waterbodies in the Santa Ana Region

Bay/Harbor	Station Codes		MUN	AGR	IND	PROC	GWR	NAV	POW	REC1	REC2	COMM	WARM	LWARM	COLD	BIOL	WILD	RARE	SPWN	MAR	SHEL	EST
Anaheim Bay - Outer	HUNHAR		+					X		X	X					X	X	X	X	X		
Anaheim Bay - Seal Beach Nat'l Wildlife Refuge	HUNSUN		+							X[1]	X					X	X	X	X	X		X
Sunset Bay - Huntington Harbor	HUNBCC, HUNCRB HUNWAR		+					X		X	X	X					X	X	X	X		
Bolsa Chica Ecological Reserve	BBOLR		+							X	X					X	X	X	X	X		X
Upper Newport Bay	UNBJAM, UNBSDC UNBBCW, UNBNSB UNBNDB, UNBCHB		+							X	X	X				X	X	X	X	X	X	X
Lower Newport Bay	LNBTUB, LNBTRI, LNBRIN, LNBHIR LNBHAR		+					X		X	X	X					X	X	X	X	X	

Channel	Station Code	Watershed	MUN	AGR	IND	PROC	GWR	NAV	POW	REC1	REC2	COMM	WARM	LWARM	COLD	BIOL	WILD	RARE	SPWN	MAR	SHEL	EST
Santa Ana Delhi	SADF01	Upper Newport Bay																				
Bonita Canyon Channel	BCF04	Upper Newport Bay	+				I			I	I		I									
San Diego Creek - Harvard	WYLSED	Upper Newport Bay	+				I			I	I		I				I					
San Diego Creek - Campus	SDMF05	Upper Newport Bay	+							X[2]	X		X				X					
Peters Canyon Wash	BARSED	Upper Newport Bay	+				I			I	I		I									
Sand Canyon Wash	SCCF15	Upper Newport Bay	+				I			I	I		I									
Bee Canyon Channel	BEEF17	Upper Newport Bay	+				I			I	I		I									
Agua Chinon Wash	ACWF18	Upper Newport Bay	+				I			I	I		I									
Serrano Creek	SERF19	Upper Newport Bay	+				I			I	I		I									
Rattlesnake Canyon Wash	RCWF26	Upper Newport Bay	+				I			I	I		I									
Hicks Canyon Wash	HCWF27	Upper Newport Bay	+				I			I	I		I									
E. Costa Mesa Channel	CMCG02	Upper Newport Bay																				
Santa Isabella Channel	SICG03	Upper Newport Bay																				
Big Canyon Wash	BCWG04	Upper Newport Bay																				
Santa Ana River - Imperial	SARIMP	Santa Ana River	+				X			X	X		X				X	X				
Santa Ana River - 5th Street	SARE01	Santa Ana River	+							X[2]	X		I				I					
Santiago Creek	SANE08	Santa Ana River	X				X			X[3]	X		X				X					
Silverado Creek	SILE17	Santa Ana River	X				X			I	I		I				I	I				

X - Present or Potential Beneficial Use
1 - No access per agency with jurisdiction (U.S. Navy)
2 - Access Prohibited in all or part by PFRD
I - Intermittent Beneficial Use
* - Excepted from MUN
o - Potential Beneficial Use
This information was taken from the 1994 update of the beneficial uses & water quality objectives for the San Diego Region and the 1995 Santa Ana River Basin Plan update.

Table C-11.9
Applicable Water Quality Guidance for the Protection of Aquatic Life

Water Quality Measurement	**California Toxics Rule (CTR) Freshwater dissolved metals** **H=ln(water hardness in mg/L as $CaCO_3$)**	**CTR Saltwater Dissolved metals**	**Ocean Plan Toxic Mat. Limits Total metals**	**Region 8 Basin Plan**
Lead ug/L H=ln Hardness	4 day =[1.462-0.146H][exp(1.273H-4.705)] 1 hour =[1.462-0.146H][exp(1.273H-1.460)]	4day = 8.1 1hr = 210	Daily max = 8 Inst. max = 20	
Cadmium ug/L	4 day = [1.107-0.042H][exp(0.7852H-2.715)] 1 hour = [1.137-0.042H][exp(1.128H-3.6867)]	4day = 9.3 1hr =42	Daily max = 4 Inst. max = 10	
Hexavalent Chromium ug/L		4day = 50 1hr = 1100	Daily max = 8 Inst. max = 20	
Nickel ug/L	4 day = 0.997[exp(0.846H+0.0584)] 1 hour = 0.998[exp(0.846H + 2.255)]	4day = 8.2 1hr = 74	Daily max = 60 Inst. max = 150	
Copper ug/L	4 day = 0.96[exp(0.8545H-1.702)] 1 hour = 0.96[exp(0.9422H-1.70)]	4day = 3.1 1hr = 4.8	Daily max = 12 Inst. max = 30	
Silver ug/L	1 hour = 0.85[exp(1.72H-6.52)]	1hr = 1.9	Daily max = 2.8 Inst. max = 7	
Zinc ug/L	4 day = 0.986[exp(0.8473H+0.884)] 1 hour = 0.978[exp(0.8473H+0.884)]	4 day = 81 1 hr = 90	Daily max = 80 Inst. max = 200	
Turbidity				Natural / Max. increase 0-50 NTU / 20% over natural 50-100 NTU / 10 NTU >100 NTU / 10% over natural
pH				6.5 - 8.5 freshwater 7.0 - 8.5 saltwater
Dissolved Oxygen				>5.0 mg/L MAR & WARM >6.0 mg/L COLD
Unionized Ammonia*				0.025 in receiving waters

$$\text{* [Unionized Ammonia]} = \frac{[NH3\text{-}N]}{10^{(pka-pH)} + 1}$$

$$\text{where } pka = 0.09018 + \frac{2729.92}{T}$$

NH3-N = Total Ammonia as N
T = water temperature in Kelvin (C + 273.16)
pH = water pH

For example : at 20 C and pH 8.0 divide the ammonia nitrogen value by 26.25 to obtain unionized ammonia.
at 25 C and pH 9.0 divide by 2.76.

Table C-11.10
Guidance Criteria for Harbor Sediment Evaluation

NOAA's Screening Concentrations

Metals (ppm)	**ER-L**	**ER-M**
Cadmium	1.2	9.6
Chromium	81	370
Copper	34	270
Lead	46.7	218
Nickel	20.9	51.6
Silver	1.0	3.7
Zinc	150	410
Organics (ppb)		
Acenaphthene	16	500
Acenaphthylene	44	640
Anthracene	85.3	1100
Fluorene	19	540
2-Methyl naphthalene	70	670
Naphthalene	160	2100
Phenanthrene	240	1500
Low molecular weight PAH	552	3160
Benzo(a)anthracene	261	1600
Benzo(a)pyrene	430	1600
Chrysene	384	2800
Dibenzo(a,h)anthracene	63.4	260
Fluoranthene	600	5100
Pyrene	665	2600
High molecular weight PAH	1700	9600
Total PAH	4022	44792
Chlordane	0.05	6
p,p' -DDD	2	20
p,p' -DDE	2.2	27
p,p' -DDT	1	7
Total DDT	1.58	46.1
Dieldrin	0.02	8.0
Total PCBs	22.7	180

ER-L - Effects Range Low

The ERL represents the concentration corresponding to the 10th percentile in toxicity testing. No effects are likely below the ER-L.

ER-M - Effects Range Median

The ERM represents the concentration corresponding to the 50th percentile or median value. Effects are likely above the ER-M.

SCCWRP Iron Normalization Regression Coefficients

Iron (% dry) versus	Sample Size	r^2	Slope (m)	Intercept (b)	± 99% Prediction Interval
Cadmium (μg/dry g)	83	0.734	0.0978	0.0055	0.1274
Chromium (μg/dry g)	88	0.882	16.50	-0.021	11.56
Copper (μg/dry g)	96	0.833	7.40	-2.01	6.50
Lead (μg/dry g)	103	0.738	4.350	0.0836	5.199
Nickel (μg/dry g)	110	0.533	9.850	-0.407	19.596
Silver (μg/dry g)	99	0.581	0.0795	-0.0183	0.1426
Zinc (μg/dry g)	88	0.967	31.50	-1.95	15.45

Table C-11.11
California Toxics Rule Criteria for Dissolved Metals in Freshwater

HARDNESS	ln	Lead		Cadmium		Chromium III		Nickel		Copper		Silver	Zinc	
		CMC	CCC	CMC	CCC	CMC	CCC	CMC	CCC	CMC	CCC	CMC	CMC	CCC
mg/L as CaCO3	Hardness	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L
10	2.30	4.91	0.19	0.35	0.41	83.25	27.00	67	7	1.54	1.25	0.07	17	17
20	3.00	10.79	0.42	0.74	0.68	146.86	47.64	120	13	2.95	2.26	0.22	30	30
30	3.40	17.04	0.66	1.16	0.92	204.70	66.40	169	19	4.32	3.20	0.43	42	43
40	3.69	23.51	0.92	1.58	1.14	259.09	84.05	216	24	5.67	4.09	0.71	54	54
50	3.91	30.14	1.17	2.01	1.34	311.04	100.90	260	29	6.99	4.95	1.05	65	66
60	4.09	36.88	1.44	2.45	1.53	361.14	117.15	304	34	8.31	5.79	1.43	76	77
70	4.25	43.71	1.70	2.90	1.72	409.73	132.91	346	38	9.60	6.60	1.87	87	87
80	4.38	50.61	1.97	3.35	1.90	457.08	148.27	388	43	10.89	7.40	2.35	97	98
90	4.50	57.57	2.24	3.80	2.07	503.37	163.29	428	48	12.17	8.18	2.88	107	108
100	4.61	64.58	2.52	4.26	2.24	548.74	178.00	468	52	13.44	8.96	3.45	117	118
110	4.70	71.63	2.79	4.73	2.40	593.29	192.46	508	56	14.70	9.72	4.06	127	128
120	4.79	78.72	3.07	5.20	2.56	637.11	206.67	546	61	15.96	10.47	4.72	137	138
130	4.87	85.83	3.34	5.67	2.72	680.28	220.67	585	65	17.21	11.21	5.42	146	148
140	4.94	92.97	3.62	6.14	2.87	722.84	234.48	622	69	18.45	11.94	6.15	156	157
150	5.01	100.13	3.90	6.62	3.02	764.86	248.11	660	73	19.69	12.66	6.93	165	167
160	5.08	107.31	4.18	7.10	3.17	806.38	261.58	697	77	20.93	13.38	7.74	175	176
170	5.14	114.50	4.46	7.58	3.31	847.43	274.90	734	81	22.16	14.09	8.59	184	185
180	5.19	121.70	4.74	8.06	3.45	888.04	288.07	770	86	23.38	14.80	9.48	193	194
190	5.25	128.92	5.02	8.55	3.60	928.25	301.11	806	90	24.60	15.50	10.41	202	204
200	5.30	136.14	5.31	9.03	3.73	968.07	314.03	842	93	25.82	16.19	11.37	211	213
210	5.35	143.37	5.59	9.52	3.87	1007.54	326.84	877	97	27.04	16.88	12.36	220	222
220	5.39	150.61	5.87	10.02	4.01	1046.67	339.53	912	101	28.25	17.57	13.39	229	230
230	5.44	157.85	6.15	10.51	4.14	1085.48	352.12	947	105	29.46	18.25	14.45	237	239
240	5.48	165.10	6.43	11.00	4.27	1123.98	364.61	982	109	30.66	18.92	15.55	246	248
250	5.52	172.34	6.72	11.50	4.40	1162.19	377.00	1017	113	31.86	19.59	16.68	255	257
260	5.56	179.59	7.00	12.00	4.53	1200.13	389.31	1051	117	33.06	20.26	17.85	263	265
270	5.60	186.84	7.28	12.50	4.66	1237.80	401.53	1085	121	34.26	20.93	19.04	272	274
280	5.63	194.09	7.56	13.00	4.78	1275.23	413.67	1119	124	35.46	21.59	20.27	280	283
290	5.67	201.34	7.85	13.50	4.91	1312.41	425.73	1153	128	36.65	22.24	21.53	289	291
300	5.70	208.58	8.13	14.01	5.03	1349.36	437.72	1186	132	37.84	22.90	22.83	297	300
310	5.74	215.83	8.41	14.51	5.16	1386.09	449.63	1219	135	39.02	23.55	24.15	306	308
320	5.77	223.07	8.69	15.02	5.28	1422.60	461.48	1253	139	40.21	24.20	25.51	314	317
330	5.80	230.31	8.97	15.53	5.40	1458.91	473.25	1286	143	41.39	24.84	26.89	322	325
340	5.83	237.54	9.26	16.04	5.52	1495.02	484.97	1319	146	42.57	25.48	28.31	331	333
350	5.86	244.77	9.54	16.55	5.64	1530.94	496.62	1351	150	43.75	26.12	29.76	339	341

Table C-11.11
California Toxics Rule Criteria for Dissolved Metals in Freshwater

		Lead		Cadmium		Chromium III		Nickel		Copper		Silver	Zinc	
HARDNESS	ln	CMC	CCC	CMC	CCC	CMC	CCC	CMC	CCC	CMC	CCC	CMC	CMC	CCC
mg/L as CaCO3	Hardness	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
360	5.89	252.00	9.82	17.06	5.76	1566.67	508.21	1384	154	44.93	26.76	31.24	347	350
370	5.91	259.22	10.10	17.57	5.88	1602.22	519.74	1416	157	46.10	27.39	32.74	355	358
380	5.94	266.43	10.38	18.09	5.99	1637.60	531.22	1449	161	47.28	28.02	34.28	363	366
390	5.97	273.64	10.66	18.60	6.11	1672.81	542.64	1481	164	48.45	28.65	35.85	371	374
400	5.99	280.85	10.94	19.12	6.22	1707.86	554.01	1513	168	49.62	29.28	37.44	379	382
410	6.02	288.04	11.22	19.64	6.34	1742.75	565.33	1545	172	50.79	29.90	39.07	387	390
420	6.04	295.24	11.50	20.15	6.45	1777.49	576.60	1577	175	51.95	30.53	40.72	395	399
430	6.06	302.42	11.78	20.67	6.56	1812.07	587.82	1608	179	53.12	31.15	42.40	403	407
440	6.09	309.60	12.06	21.19	6.67	1846.52	598.99	1640	182	54.28	31.76	44.11	411	415
450	6.11	316.77	12.34	21.71	6.79	1880.82	610.12	1671	186	55.44	32.38	45.85	419	423
460	6.13	323.93	12.62	22.23	6.90	1914.98	621.20	1703	189	56.60	32.99	47.62	427	430
470	6.15	331.09	12.90	22.76	7.01	1949.01	632.24	1734	193	57.76	33.61	49.41	435	438
480	6.17	338.24	13.18	23.28	7.12	1982.90	643.23	1765	196	58.92	34.22	51.23	443	446
490	6.19	345.38	13.46	23.81	7.22	2016.67	654.19	1796	200	60.07	34.82	53.08	450	454
500	6.21	352.51	13.74	24.33	7.33	2050.32	665.10	1827	203	61.23	35.43	54.96	458	462
510	6.23	359.64	14.01	24.86	7.44	2083.84	675.98	1858	206	62.38	36.03	56.86	466	470
520	6.25	366.75	14.29	25.38	7.55	2117.25	686.81	1889	210	63.53	36.64	58.80	474	478
530	6.27	373.86	14.57	25.91	7.65	2150.54	697.61	1920	213	64.68	37.24	60.75	481	485
540	6.29	380.96	14.85	26.44	7.76	2183.71	708.37	1950	217	65.83	37.84	62.74	489	493
550	6.31	388.05	15.12	26.97	7.87	2216.78	719.10	1981	220	66.98	38.44	64.75	497	501
560	6.33	395.14	15.40	27.50	7.97	2249.73	729.79	2011	223	68.13	39.03	66.79	504	509
570	6.35	402.21	15.67	28.03	8.07	2282.58	740.45	2041	227	69.27	39.63	68.85	512	516
580	6.36	409.27	15.95	28.56	8.18	2315.33	751.07	2072	230	70.42	40.22	70.94	520	524
590	6.38	416.33	16.22	29.09	8.28	2347.97	761.66	2102	233	71.56	40.81	73.06	527	532
600	6.40	423.38	16.50	29.63	8.38	2380.52	772.21	2132	237	72.70	41.40	75.20	535	539
610	6.41	430.41	16.77	30.16	8.49	2412.96	782.74	2162	240	73.84	41.99	77.37	542	547
620	6.43	437.44	17.05	30.69	8.59	2445.31	793.23	2192	243	74.98	42.58	79.57	550	554
630	6.45	444.46	17.32	31.23	8.69	2477.56	803.70	2222	247	76.12	43.17	81.79	557	562
640	6.46	451.47	17.59	31.76	8.79	2509.73	814.13	2252	250	77.26	43.75	84.03	565	569
650	6.48	458.47	17.87	32.30	8.89	2541.80	824.53	2281	253	78.40	44.33	86.30	572	577
660	6.49	465.46	18.14	32.84	8.99	2573.78	834.91	2311	257	79.53	44.92	88.60	580	585
670	6.51	472.45	18.41	33.38	9.09	2605.68	845.25	2341	260	80.67	45.50	90.92	587	592
680	6.52	479.42	18.68	33.91	9.19	2637.48	855.57	2370	263	81.80	46.08	93.27	595	599
690	6.54	486.38	18.95	34.45	9.29	2669.21	865.86	2400	267	82.93	46.66	95.64	602	607
700	6.55	493.33	19.22	34.99	9.39	2700.85	876.13	2429	270	84.07	47.23	98.04	609	614
710	6.57	500.28	19.50	35.53	9.49	2732.41	886.37	2458	273	85.20	47.81	100.46	617	622

Table C-11.11
California Toxics Rule Criteria for Dissolved Metals in Freshwater

		Lead		Cadmium		Chromium III		Nickel		Copper		Silver	Zinc	
HARDNESS mg/L as CaCO3	ln Hardness	CMC µg/L	CCC µg/L	CMC µg/L	CCC µg/L	CMC µg/L	CCC µg/L	CMC µg/L	CCC µg/L	CMC µg/L	CCC µg/L	CMC µg/L	CMC µg/L	CCC µg/L
720	6.58	507.21	19.77	36.07	9.59	2763.89	896.58	2488	276	86.33	48.38	102.90	624	629
730	6.59	514.13	20.04	36.61	9.68	2795.29	906.76	2517	280	87.46	48.96	105.37	631	637
740	6.61	521.05	20.30	37.15	9.78	2826.61	916.92	2546	283	88.59	49.53	107.87	639	644
750	6.62	527.95	20.57	37.70	9.88	2857.86	927.06	2575	286	89.71	50.10	110.39	646	651
760	6.63	534.85	20.84	38.24	9.97	2889.03	937.17	2604	289	90.84	50.67	112.93	653	659
770	6.65	541.73	21.11	38.78	10.07	2920.12	947.26	2633	292	91.96	51.24	115.50	661	666
780	6.66	548.60	21.38	39.33	10.17	2951.15	957.32	2662	296	93.09	51.81	118.09	668	673
790	6.67	555.47	21.65	39.87	10.26	2982.10	967.36	2691	299	94.21	52.38	120.71	675	681
800	6.68	562.32	21.91	40.42	10.36	3012.98	977.38	2719	302	95.34	52.94	123.35	682	688
810	6.70	569.17	22.18	40.96	10.45	3043.79	987.37	2748	305	96.46	53.51	126.01	690	695
820	6.71	576.00	22.45	41.51	10.55	3074.53	997.35	2777	308	97.58	54.07	128.70	697	703
830	6.72	582.82	22.71	42.05	10.64	3105.20	1007.30	2805	312	98.70	54.63	131.41	704	710
840	6.73	589.64	22.98	42.60	10.74	3135.81	1017.22	2834	315	99.82	55.19	134.15	711	717
850	6.75	596.44	23.24	43.15	10.83	3166.35	1027.13	2863	318	100.94	55.76	136.91	718	724
860	6.76	603.24	23.51	43.70	10.92	3196.83	1037.02	2891	321	102.06	56.32	139.69	726	731
870	6.77	610.02	23.77	44.24	11.02	3227.24	1046.88	2919	324	103.18	56.87	142.49	733	739
880	6.78	616.79	24.04	44.79	11.11	3257.59	1056.73	2948	327	104.29	57.43	145.32	740	746
890	6.79	623.56	24.30	45.34	11.20	3287.88	1066.55	2976	331	105.41	57.99	148.17	747	753
900	6.80	630.31	24.56	45.89	11.29	3318.10	1076.36	3004	334	106.53	58.55	151.05	754	760
910	6.81	637.05	24.83	46.44	11.39	3348.27	1086.14	3033	337	107.64	59.10	153.95	761	767
920	6.82	643.78	25.09	46.99	11.48	3378.37	1095.91	3061	340	108.76	59.66	156.87	768	774
930	6.84	650.51	25.35	47.55	11.57	3408.42	1105.66	3089	343	109.87	60.21	159.81	775	782
940	6.85	657.22	25.61	48.10	11.66	3438.40	1115.38	3117	346	110.98	60.76	162.78	782	789
950	6.86	663.92	25.87	48.65	11.75	3468.33	1125.09	3145	349	112.09	61.32	165.77	789	796
960	6.87	670.61	26.13	49.20	11.84	3498.21	1134.78	3173	352	113.21	61.87	168.78	796	803
970	6.88	677.30	26.39	49.76	11.93	3528.02	1144.45	3201	356	114.32	62.42	171.82	803	810
980	6.89	683.97	26.65	50.31	12.02	3557.78	1154.11	3229	359	115.43	62.97	174.88	810	817
990	6.90	690.63	26.91	50.86	12.11	3587.49	1163.74	3257	362	116.54	63.51	177.96	817	824
1000	6.91	697.28	27.17	51.42	12.20	3617.14	1173.36	3284	365	117.64	64.06	181.06	824	831

CMC : Contaminant Maximum Concentration - Highest concentration that aquatic life can be exposed to without deleterious effects.
CCC : Contaminant Continuous Concentration - Highest concentration that aquatic life can be exposed to for an extended period (4 days) without deleterious effects.
For Hardness greater than 400 mg/L multiply CMC or CCC by Water Effects Ratio (WER). Alternatively use criterion at for hardness=400 and WER=1.

Table C-11.12
Mass Loads of Sampled Storms 2002-03

Site	Date	Volume Sampled	type	Nitrate as NO_3	NH_3 as N	TKN	Tot Phosphate as PO4	Ortho P as P	TSS	VSS	Cd	Cr	Cu	Pb	Ni	Ag	Zn	As	Se	Hardness as $CaCO_3$ as $CaCO_3$
		ac-ft		lbs																
ABCC03	Nov 07-12, 2002	665.2	ST	11625	1027	5324	2300	233	126145	45875	2.84	7.23	94.2	15.7	15.9	1.81	331	4.25	1.84	117598
		665.2	SF						dissolved		0.90	7.23	43.7	1.81	11.2	1.81	157	2.48	1.84	
	Feb 24-Mar 01, 2003	691.5	ST	6252	185	1545	665	138	26425	7813	0.95	7.52	36.3	9.44	3.76	1.88	127	1.55	1.55	174854
		691.5	SF						dissolved		0.94	7.52	27.3	1.88	3.76	1.88	66.0	1.55	1.55	
	Mar 15-19, 2003	2855.6	ST	71601	196	14744	5203	941	216794	39141	3.88	31.0	155	25.4	15.5	7.76	326			985229
		2850.3	SF						dissolved		3.87	31.0	116	7.75	15.5	7.75	124			
BCC02	Feb 24-25, 2003	279.0	ST	5269	171	988	500	82	43130	3791	0.38	3.03	17.1	4.30	1.52	0.76	44.5			67314
		279.0	SF						dissolved		0.38	3.03	10.6	0.76	1.52	0.76	14.1			
	Mar 15-19, 2003	36.9	ST	1258	12	160	94	25	1117	502	0.05	0.40	1.70	0.17	0.20	0.10	3.1			20020
		30.2	SF						dissolved		0.04	0.33	1.15	0.08	0.16	0.08	2.4			
WMCC04	Nov 08-12, 2002	194.0	ST	3308	314	1767	860	192	45831	13080	0.86	3.00	30.9	7.35	5.69	0.53	110.0	1.83	0.57	41814
		193.9	SF						dissolved		0.26	2.11	14.5	0.53	3.80	0.53	41.9	1.37	0.70	
	Feb 24-Mar 01, 2003	36.6	ST	67	1.8	23	10	1.5	892	200	0.01	0.08	0.42	0.15	0.05	0.02	1.49	0.05	0.02	17110
		36.6	SF						dissolved		0.05	0.40	1.42	0.33	0.20	0.10	5.06	0.00	0.00	16456
	Mar 15-19, 2003	469.2	ST	3224	168	1502	1168	161	92187	19478	0.64	5.24	33.5	14.1	2.85	1.27	102.8			53851
		469.2	SF						dissolved		0.64	5.10	10.2	1.27	2.64	1.27	21.2			
SADF01	Nov 08-12, 2002	424.4	ST	8367	458	4238	2006	294	131286	31474	0.73	5.36	83.3	20.6	13.1	1.15	218	3.46	1.53	143402
		424.4	SF						dissolved		0.58	4.61	21.6	2.84	7.81	1.15	85.0	2.41	1.45	
	Feb 11-15, 2003	792.6	ST	6533	524	2496	2071	343	170977	50266	1.08	8.62	80.9	31.47	12.39	2.15	260	4.44	2.22	172952
		792.6	SF						dissolved		1.08	8.62	39.0	2.15	4.31	2.15	71.1	2.18	2.21	
BARSED	Nov 08-12, 2002	947.7	ST	40013	780	11136	7021	1266	475808	82941	3.04	10.3	83.4	18.6	23.9	2.58	251	15.1	15.7	598193
		932.1	SF						dissolved		1.27	10.1	38.0	2.53	12.3	2.53	72.9	10.3	16.2	
	Feb 11-13, 2003	1106.4	ST	30063	496	5111	6704	1106	631332	96203	3.31	26.8	78.2	30.1	23.4	3.01	331	14.4	3.01	312660
		1106.4	SF						dissolved		1.50	12.0	26.2	3.01	6.01	3.01	36.1	7.52	3.01	
SDMF05	Nov 08-11, 2002	1972.5	ST	107391	281	29207	15856	2591	1593352	275792	5.89	53.40	212.15	38.2	63.9	10.72	530	38.05	23.89	974112
		1972.5	SF						dissolved		5.3598	42.88	51.16	10.72	27.78	10.72	111.7	23.2	21.79	
	Feb 11-15, 2003	4542.5	ST	159717	3321	29187	37132	5020	4954163	655770	13.8	125	425	108.1	111.4	12.34	1165	67.4	13.1	1941454
		4542.5	SF						dissolved		10.7	87.1	260	50.1	65.0	12.34	468	55.0	14.2	
WYLSED	Nov 08-09, 2002	235.5	ST	30718	218	4224	1760	248	191988	30718	1.15	7.04	26.2	5.18	8.96	0.64	96.0	5.06	3.39	203508
		235.5	SF						dissolved		0.32	2.56	9.60	0.64	3.97	0.64	25.60	3.52	3.14	
	Nov 10-11, 2002	6.4	ST	594	5.1	51	32	8.3	1293	245	0.02	0.07	0.26	0.02	0.10	0.02	0.63	0.13	0.10	5558
		6.4	SF						dissolved		0.01	0.07	0.31	0.02	0.08	0.02	0.40	0.12	0.09	
	Feb 11-13, 2003	1161.7	ST	53661	963	5997	8775	1209	662870	88383	4.10	37.9	78.9	29.7	31.6	3.16	297	29.7	3.16	984836
		1161.7	SF						dissolved		1.58	12.6	29.7	3.16	6.31	3.16	15.8	12.0	3.16	

Table C-11.13
Event Mean Concentrations of Sampled Storms - 2002-03

		Volume Sampled	type	Nitrate as NO_3	NH_3 as N	TKN	Tot Phosphate as PO4	Ortho P as P	TSS	VSS	Cd	Cr	Cu	Pb	Ni	Ag	Zn	As	Se	Hardness as $CaCO_3$
		ac-ft		mg/L							µg/L									mg/L
ABCC03	Nov 07-12, 2002	665.2	ST	6.43	0.57	2.95	1.27	0.20	69.8	25.4	1.6	<8.0	52.1	8.7	8.8	<2.0	183.1	2.4	<2.0	65
		665.2	SF						dissolved		<1.0	<8.0	24.2	<2.0	6.2	<2.0	86.8	1.4	<2.0	
	Feb 24-Mar 01, 2003	691.5	ST	4.01	0.12	0.99	0.43	0.09	17.0	5.0	<1.0	<8.0	19.3	5.0	<4.0	<2.0	67.4	<2.0	<2.0	93
		691.5	SF						dissolved		<1.0	<8.0	14.5	<2.0	<4.0	<2.0	35.1	<2.0	<2.0	
	Mar 15-19, 2003	2855.6	ST	9.23	0.03	1.90	0.67	0.12	27.9	5.0	<1.0	<8.0	20.0	3.3	<4.0	<2.0	42.0			127
		2850.3	SF						dissolved		<1.0	<8.0	15.0	<2.0	<4.0	<2.0	16.0			
BCC02	Feb 24-25, 2003	279.0	ST	6.95	0.23	1.30	0.66	0.11	56.9	5.0	<1.0	<8.0	22.6	5.7	<4.0	<2.0	58.7			89
		279.0	SF						dissolved		<1.0	<8.0	14.0	<2.0	<4.0	<2.0	18.6			
	Mar 15-19, 2003	36.9	ST	12.53	0.12	1.60	0.93	0.30	11.1	5.0	<1.0	<8.0	16.9	1.7	<4.0	<2.0	30.9			199
		30.2	SF						dissolved		<1.0	<8.0	14.1	<2.0	<4.0	<2.0	29.0			
WMCC04	Nov 08-12, 2002	194.0	ST	6.28	0.60	3.35	1.63	0.36	87.0	24.8	1.6	5.7	58.6	13.9	10.8	<2.0	208.8	3.5	1.1	79
		193.9	SF						dissolved		<1.0	<8.0	27.6	<2.0	7.2	<2.0	79.6	2.6	1.3	
	Feb 24-Mar 01, 2003	36.6	ST	3.54	0.10	1.22	0.54	0.08	47.4	10.6	<1.0	4.3	22.5	8.0	2.8	<2.0	79.4	2.5	<2.0	172
		36.6	SF						dissolved		<1.0	<8.0	14.3	3.3	<4.0	<2.0	50.8	<2.0	<2.0	204
	Mar 15-19, 2003	469.2	ST	2.53	0.13	1.18	0.92	0.13	72.3	15.3	<1.0	4.1	26.3	11.0	2.2	<2.0	80.7			42
		469.2	SF						dissolved		<1.0	<8.0	8.0	<2.0	2.1	<2.0	16.6			
SADF01	Nov 08-12, 2002	424.4	ST	7.26	0.40	3.68	1.74	0.26	114	27.3	0.6	4.7	72.2	17.9	11.3	<2.0	188.9	3.0	1.3	124
		424.4	SF						dissolved		<1.0	<8.0	18.7	2.5	6.8	<2.0	73.7	2.1	1.3	
	Feb 11-15, 2003	792.6	ST	3.03	0.24	1.16	0.96	0.16	79.4	23.3	<1.0	<8.0	37.5	14.6	5.8	<2.0	120.8	2.1	<2.0	80
		792.6	SF						dissolved		<1.0	<8.0	18.1	<2.0	<4.0	<2.0	33.0	<2.0	<2.0	
BARSED	Nov 08-12, 2002	947.7	ST	15.54	0.30	4.32	2.73	0.49	185	32.2	1.2	<8.0	32.4	7.2	9.3	<2.0	97.6	5.9	6.1	232
		932.1	SF						dissolved		<1.0	<8.0	15.0	<2.0	4.9	<2.0	28.8	4.1	6.4	
	Feb 11-13, 2003	1106.4	ST	10.00	0.17	1.70	2.23	0.37	210.0	32.0	1.1	8.9	26.0	10.0	7.8	<2.0	110.0	4.8	<2.0	104
		1106.4	SF						dissolved		<1.0	<8.0	8.7	<2.0	<4.0	<2.0	12.0	2.5	<2.0	
SDMF05	Nov 08-11, 2002	1972.5	ST	20.04	0.05	5.45	2.96	0.48	297	51.5	1.1	10.0	39.6	7.1	11.9	<2.0	98.9	7.1	4.5	182
		1972.5	SF						dissolved		<1.0	<8.0	9.5	<2.0	5.2	<2.0	20.8	4.3	4.1	
	Feb 11-15, 2003	4542.5	ST	12.94	0.27	2.36	3.01	0.41	401	53.1	1.1	10.1	34.4	8.8	9.0	<2.0	94.4	5.5	1.1	157
		4542.5	SF						dissolved		0.9	7.1	21.1	4.1	5.3	<2.0	37.9	4.5	1.1	
WYLSED	Nov 08-09, 2002	235.5	ST	48.00	0.34	6.60	2.75	0.39	300	48.0	1.8	11.0	41.0	8.1	14.0	<2.0	150.0	7.9	5.3	318
		235.5	SF						dissolved		<1.0	<8.0	15.0	<2.0	6.2	<2.0	40.0	5.5	4.9	
	Nov 10-11, 2002	6.4	ST	34.00	0.29	2.90	1.84	0.48	74.0	14.0	1.0	<8.0	15.0	<2.0	5.8	<2.0	36.0	7.2	5.5	318
		6.4	SF						dissolved		<1.0	<8.0	18.0	<2.0	4.5	<2.0	23.0	6.6	5.3	
	Feb 11-13, 2003	1161.7	ST	17.00	0.31	1.90	2.78	0.38	210.0	28.0	1.3	12.0	25.0	9.4	10.0	<2.0	94.0	9.4	<2.0	312
		1161.7	SF						dissolved		<1.0	<8.0	9.4	<2.0	<4.0	<2.0	<10.0	3.8	<2.0	

Table C-11.14
Total Stormwater Loads : 2002-2003

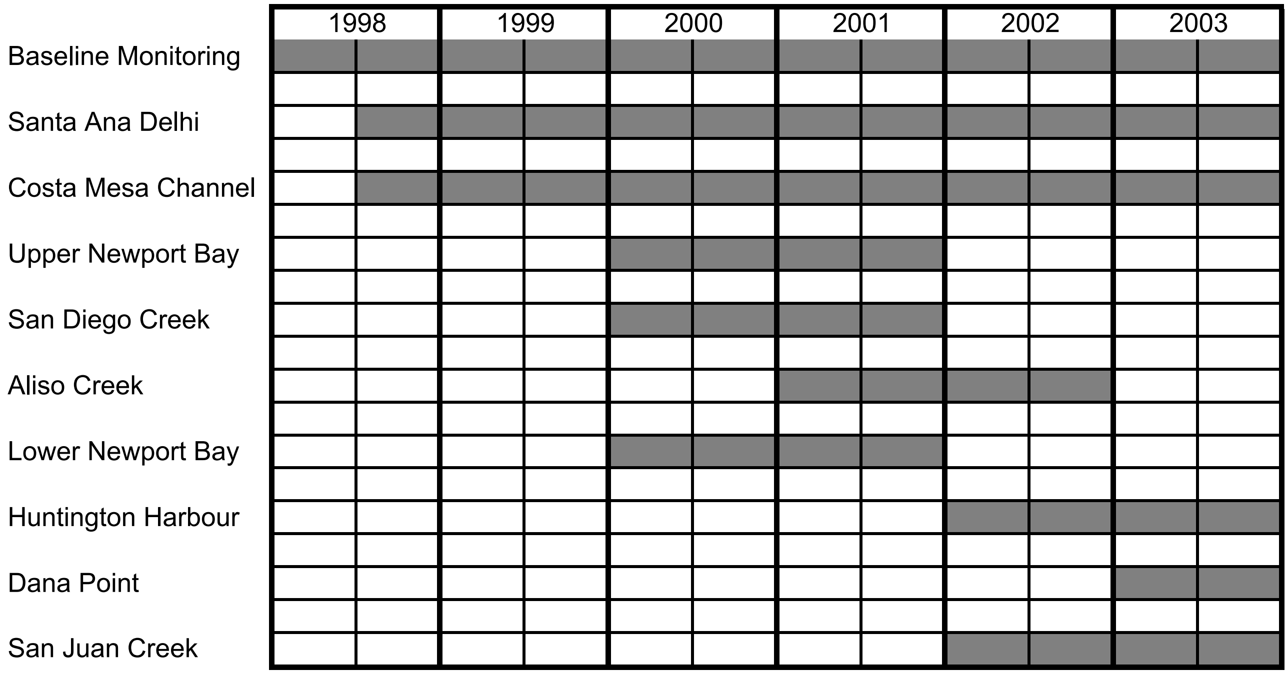
	Total Storm Volume ac-ft	Volume Sampled ac-ft	Nitrate as NO_3 tons	Total Nitrogen tons	Total Phos as PO_4 tons	TSS tons	Cu lbs	Pb lbs	Zn lbs
Peters Canyon Wash at Barranca Parkway									
Nov 08-12, 2002		948	20.01	10.09	3.51	237.90	83.44	18.59	251.29
Feb 11-13, 2003		1106	15.03	5.95	3.35	315.67	78.16	30.06	330.70
Total Sampled Load		2054	35.04	16.04	6.86	553.57	161.60	48.65	581.99
Annual Stormwater Volume	9,929	**Site Mean EMC**	**29.8**		**2.9**	**597.0**	**44.4**	**18.9**	**155.8**
Calc. Unsampled Load	7,875		318.7		31.3	6,389.4	950	404	3334
Sampled+Unsampled Load			353.7		38.2	6,943.0	1,112	453	3,916
Santa Ana Delhi Channel at Irvine Avenue									
Nov 08-12, 2002		424.4	4.18	3.06	1.00	65.64	83.27	20.63	217.8
Feb 11-15, 2003		792.6	3.27	1.99	1.04	85.49	80.86	31.47	260.1
Total Sampled Load		1217	7.45	5.05	2.04	151.13	164.14	52.10	477.87
Annual Stormwater Volume	5,040	**Site Mean EMC**	**7.5**		**2.1**	**220.2**	**41.4**	**33.2**	**185.1**
Calc. Unsampled Load	3,823		38.9		11.1	1,144.1	430	345	1924
Sampled+Unsampled Load			46.3		13.1	1,295.2	594	397	2,402
San Diego Creek at Campus Drive									
Nov 08-11, 2002		1973	53.70	26.73	7.93	796.68	212.15	38.18	530.1
Feb 11-15, 2003		4542	79.86	32.63	18.57	2,477.08	425.1	108.1	1,165.3
Total Sampled Load		6515	133.55	59.35	26.49	3273.76	637.29	146.32	1695.46
Annual Stormwater Volume	24,346	**Site Mean EMC**	**17.6**		**4.0**	**1,008.5**	**39.0**	**26.6**	**142.6**
Calc. Unsampled Load	17,831		426.4		97.8	24,438.7	1889	1290	6909
Sampled+Unsampled Load			560.0		124.3	27,712.4	2,526	1,436	8,605
San Diego Creek at Harvard Avenue									
Nov 08-09, 2002		235.5	15.36	5.58	0.88	95.99	26.24	5.18	96.0
Nov 10-11, 2002		6.43	0.30	0.09	0.02	0.65	0.26	0.02	0.6
Feb 11-13, 2003		1162	26.83	9.06	4.39	331.44	78.9	29.7	296.7
Total Sampled Load		1404	42.49	14.73	5.28	428.08	105.41	34.87	393.34
Annual Stormwater Volume	8,406	**Site Mean EMC**	**18.8**		**5.2**	**1,289.8**	**44.5**	**18.8**	**187.4**
Calc. Unsampled Load	7,002		178.7		49.2	12,274.5	848	359	3566
Sampled+Unsampled Load			221.2		54.4	12,702.5	953	393	3,959
Anaheim Barber City Channel at Rancho Road									
Nov 07-12, 2002		665.2	5.81	3.97	1.15	63.07	94.25	15.66	331.0
Feb 24-Mar 01, 2003		691.5	3.13	1.48	0.33	13.21	36.35	9.44	126.6
Mar 15-19, 2003		2856	35.80	15.46	2.60	108.40	155.3	25.4	326.1
Total Sampled Load		4212	44.74	20.91	4.08	184.68	285.93	50.54	783.65
Annual Stormwater Volume	7,944	**Site Mean EMC**	**6.7**		**1.3**	**74.7**	**41.0**	**18.9**	**179.1**
Calc. Unsampled Load	3,732		33.9		6.6	379.1	416	191	1817
Sampled+Unsampled Load			78.7		10.7	563.7	702	242	2,600
Bolsa Chica Channel at Westminster Avenue									
Feb 24-25, 2003		279.02	2.63	1.09	0.25	21.56	17.14	4.30	44.5
Mar 15-19, 2003		36.93	0.63	0.22	0.05	0.56	1.7	0.2	3.1
Total Sampled Load		315.96	3.26	1.31	0.30	22.12	18.84	4.47	47.63
Annual Stormwater Volume	7,265	**Site Mean EMC**	**8.6**		**2.1**	**247.7**	**33.4**	**25.0**	**171.7**
Calc. Unsampled Load	6,949		81.3		19.5	2,339.4	632	472	3243
Sampled+Unsampled Load			84.6		19.8	2,361.5	650	477	3,290
Westminster Channel at Beach Boulevard									
Nov 08-12, 2002		193.96	1.65	1.26	0.43	22.92	30.91	7.35	110.0
Feb 24-Mar 01, 2003		36.61	0.03	0.02	0.01	0.45	0.42	0.15	1.5
Mar 15-19, 2003		469.16	1.61	1.12	0.58	46.09	33.5	14.1	102.8
Total Sampled Load		699.73	3.30	2.39	1.02	69.46	64.87	21.58	214.36
Annual Stormwater Volume	1,684	**Site Mean EMC**	**7.1**		**1.6**	**176.7**	**47.9**	**28.3**	**170.0**
Calc. Unsampled Load	984		9.5		2.2	236.4	128	76	455
Sampled+Unsampled Load			12.8		3.2	305.9	193	97	669

Table C-11.15
Evaluation of Dissolved Metal Concentrations in Channels Relative to the CTR (2002-03)

			Freshwater								Direct Discharges to Marine Waters > CTR Saltwater Criteria								Tributaries of San Diego Creek > Criteria*
			n		> Criteria						Acute				Chronic				
			Acute	Chronic	Acute			Chronic											
Station Code	**Channel**		**(CMC)**	**(CCC)**	**Cd**	**Cu**	**Zn**	**Cd**	**Cu**	**Zn**	**Cu**	**Ni**	**Ag**	**Zn**	**Cd**	**Cu**	**Ni**	**Zn**	**Acute or Chronic**
ABCC03	Anaheim Barber City	**S**	12	1		4	1		1										
BCC02	Bolsa Chica	**S**	5			1					5								
EGWC05	East Garden Grove Wintersburg	**S**	8	1		3					8					1			
WMCC04	Westminster	**S**	7			4				1									
BARSED	Peters Canyon Wash	**S**	4																None
CICF25	Central Irvine	**S**	1																None
	Central Irvine	**D**	1																None
CMCG02	Costa Mesa	**S**	8	1		5	3				8			3		1		1	
	Costa Mesa	**D**	37			2	1				37		2						
LANF08	Lane	**S**	5	1		3	1												None
SADF01	Santa Ana Delhi	**S**	8	1		5					8			2		1			
	Santa Ana Delhi	**D**	1			1					1								
SICG02	Santa Isabella	**S**	1			1					1								
	Santa Isabella	**D**	15								14								
SDMF05	San Diego Creek @ Campus	**S**	5			1					5			1					
	San Diego Creek @ Campus	**D**	39								23		1						
WYLSED	San Diego Creek @ Harvard	**S**	3																
	San Diego Creek @ Harvard	**D**	1																
	Totals	**S**	**67**	**5**	**0**	**27**	**5**	**0**	**1**	**1**	**35**	**0**	**0**	**6**	**0**	**3**	**0**	**1**	**0**
		D	**94**	**0**	**0**	**3**	**1**				**75**	**0**	**3**	**0**					

(shaded) Not Applicable
n = Number of observations
CMC = Criteria Maximum Concentration
CCC = Criteria Continuous Concentration
S = Stormwater sampling
D = Dry weather sampling
Freshwater evaluation included comparison to CTR criteria for Cd, Cu, Cr **III**, Pb, Ni, Ag, Zn
Evaluation of discharges to saltwater included comparison to CTR criteria for Cd, Cu, Pb, Ni, Ag, Zn
*Using freshwater criteria and average hardness of 400 mg/L for San Diego Creek

Figure C-11.1
Critical Aquatic Resources Monitoring Timeline



Monitoring year = July 1 of prior year - June 30 of reporting year

Figure C-11.2
Warm Spot Monitoring Timeline

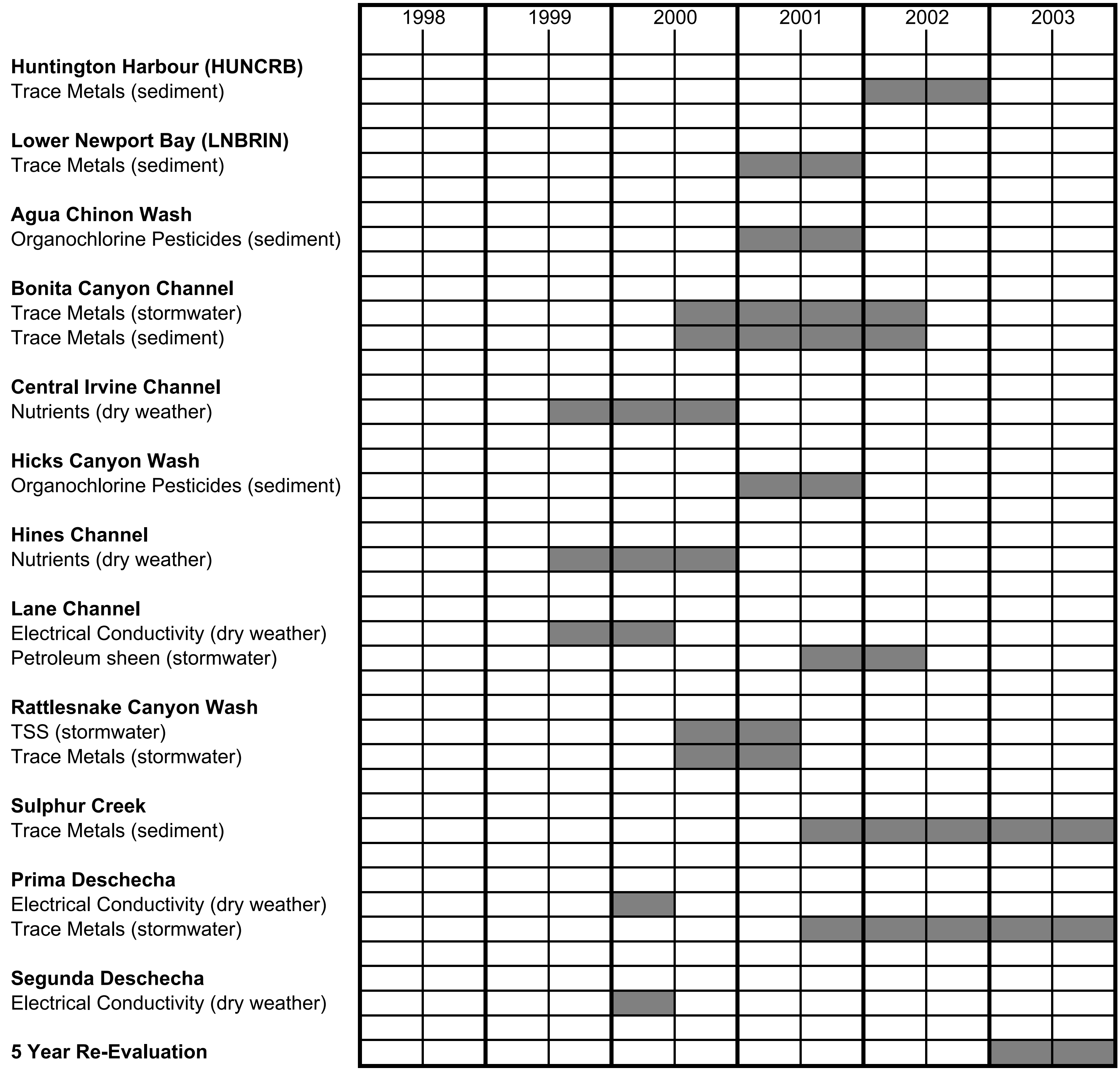
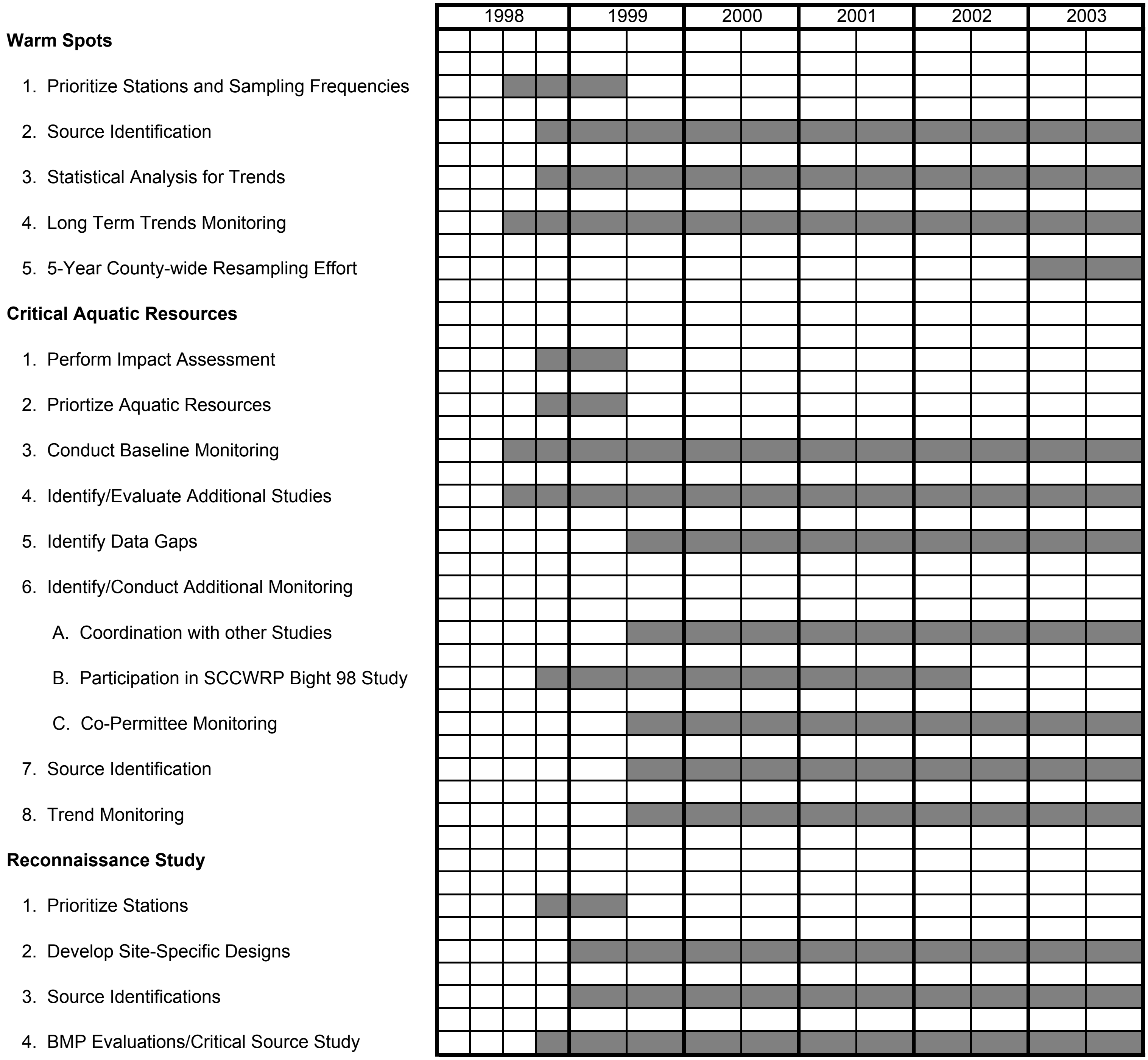


Figure C-11.3
Water Quality Monitoring Program Timeline



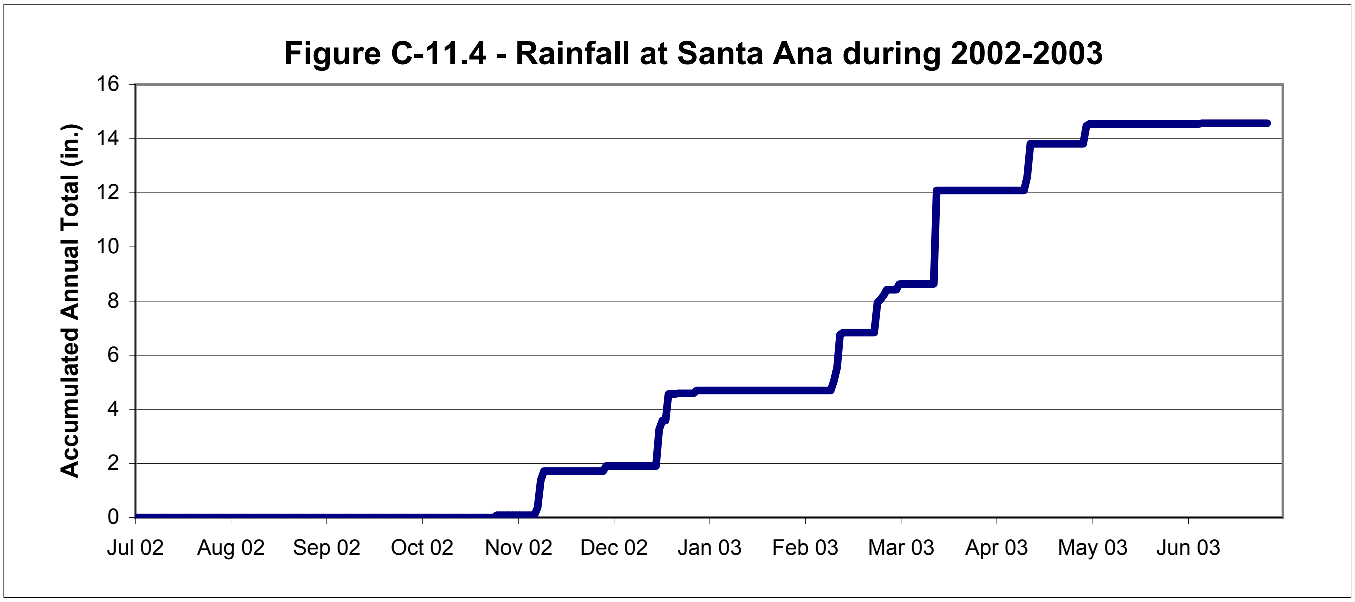


Figure C-11.4 - Rainfall at Santa Ana during 2002-2003
Accumulated Annual Total (in.)
16
14
12
10
8
6
4
2
0
Jul 02
Aug 02
Sep 02
Oct 02
Nov 02
Dec 02
Jan 03
Feb 03
Mar 03
Apr 03
May 03
Jun 03

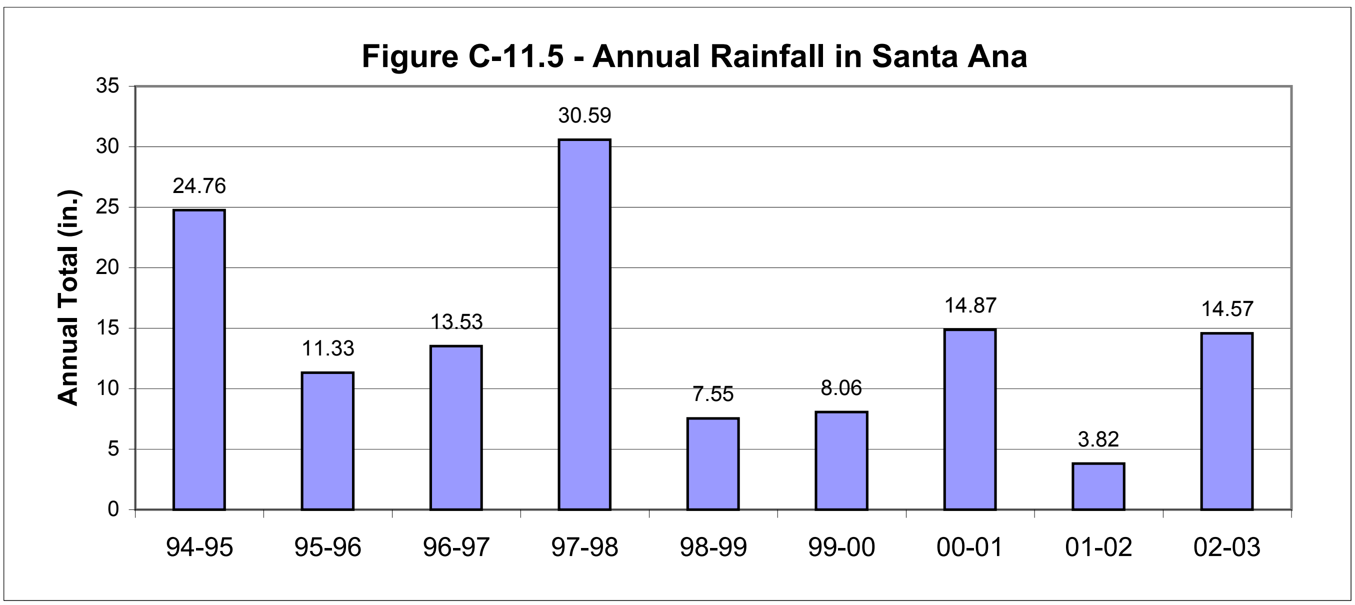


Figure C-11.5 - Annual Rainfall in Santa Ana
Annual Total (in.)
35
30
25
20
15
10
5
0
24.76
11.33
13.53
30.59
7.55
8.06
14.87
3.82
14.57
94-95
95-96
96-97
97-98
98-99
99-00
00-01
01-02
02-03

Figure C-11.6
Copper in Rhine Channel Sediments

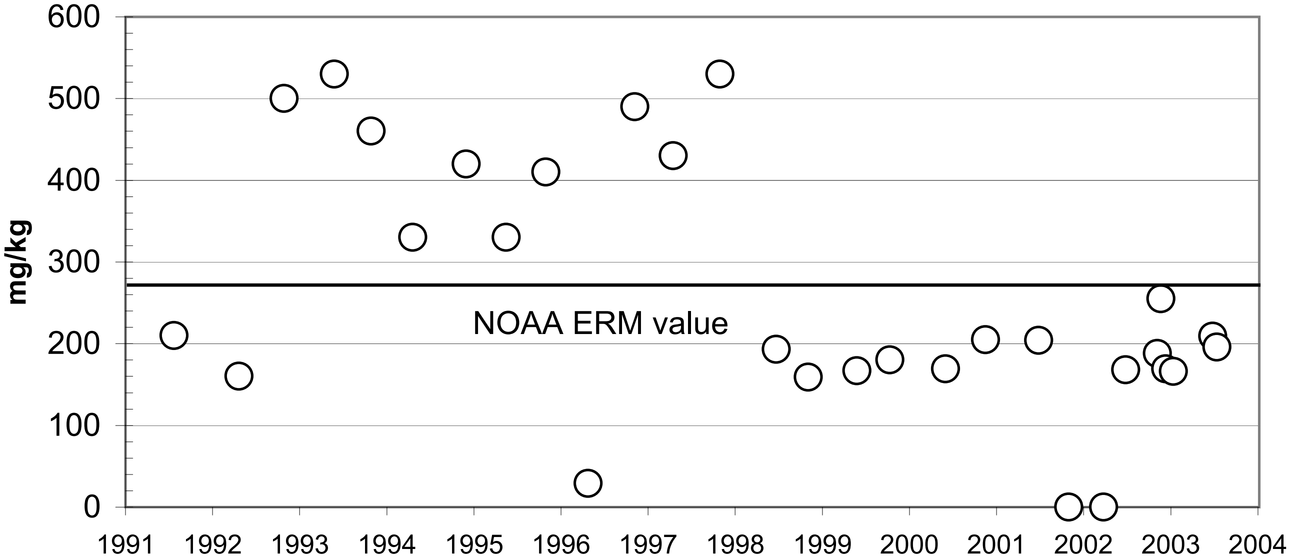


Figure C-11.7
DDT and DDE in Agua Chinon Wash Sediments

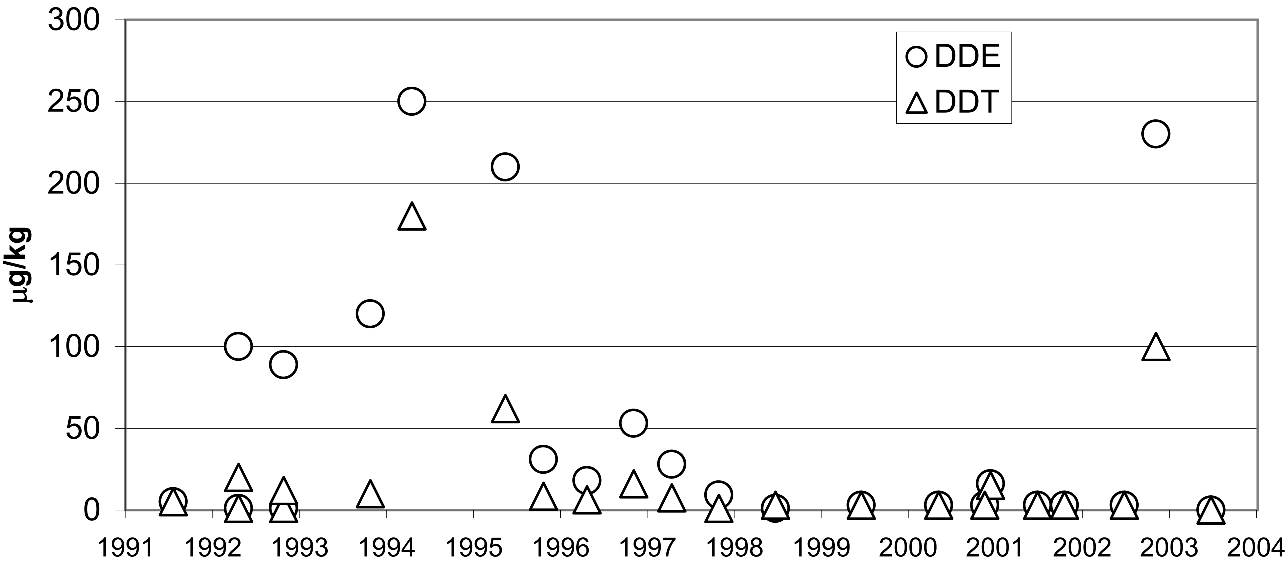
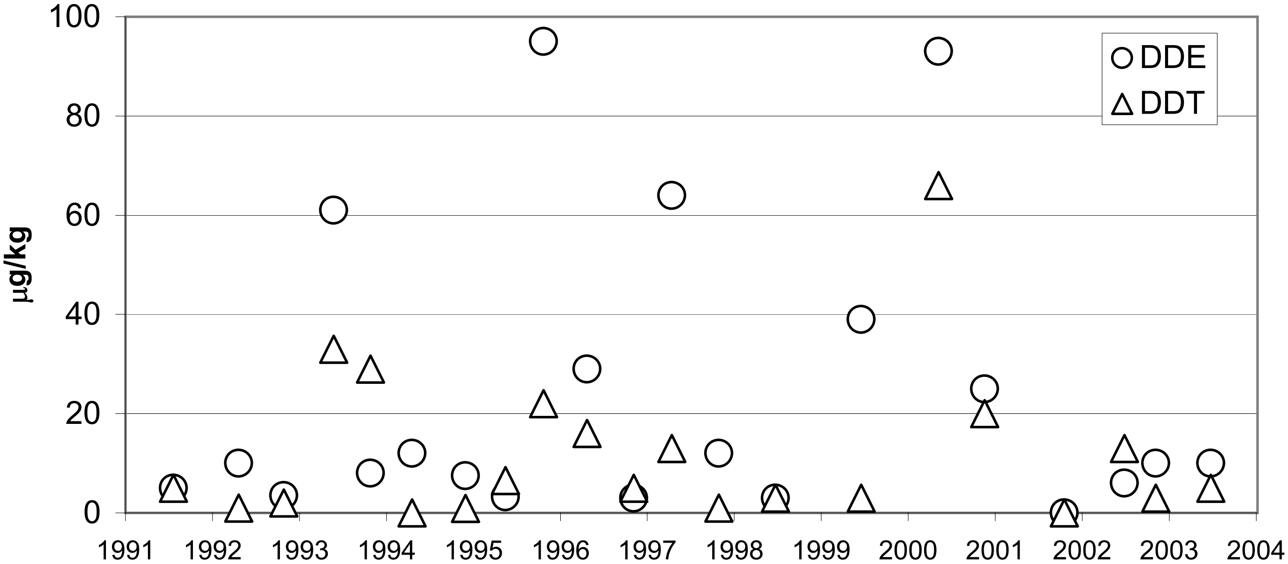


Figure C-11.8
DDT and DDE in Hicks Canyon Wash Sediments



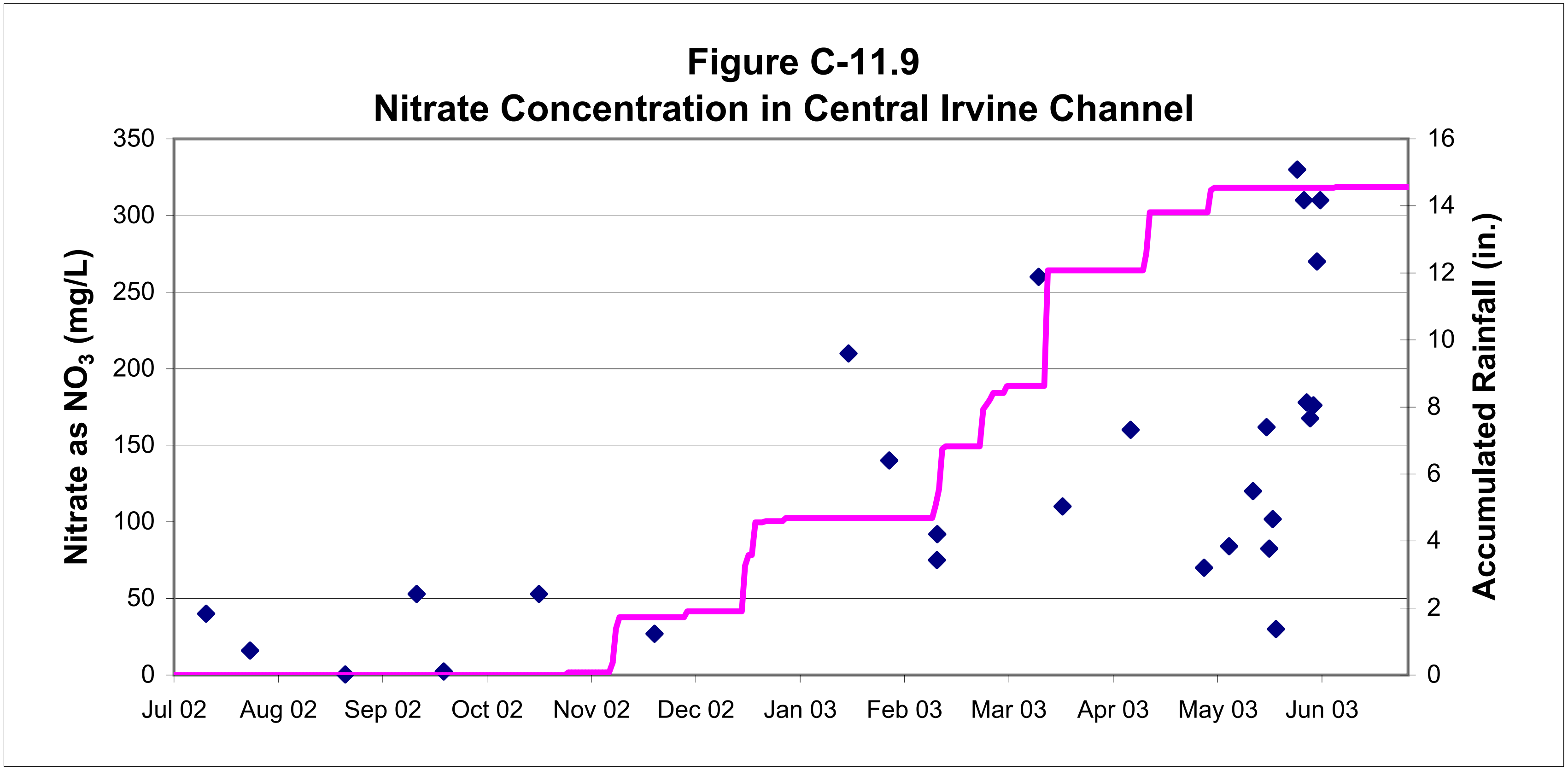


Figure C-11.9
Nitrate Concentration in Central Irvine Channel
Nitrate as NO_3 (mg/L)
Accumulated Rainfall (in.)
350
300
250
200
150
100
50
0
16
14
12
10
8
6
4
2
0
Jul 02
Aug 02
Sep 02
Oct 02
Nov 02
Dec 02
Jan 03
Feb 03
Mar 03
Apr 03
May 03
Jun 03

Figure C-11.10 - Flowrate in Peters Canyon Wash at Barranca and Central Irvine Channel
5/28 - 6/4/03

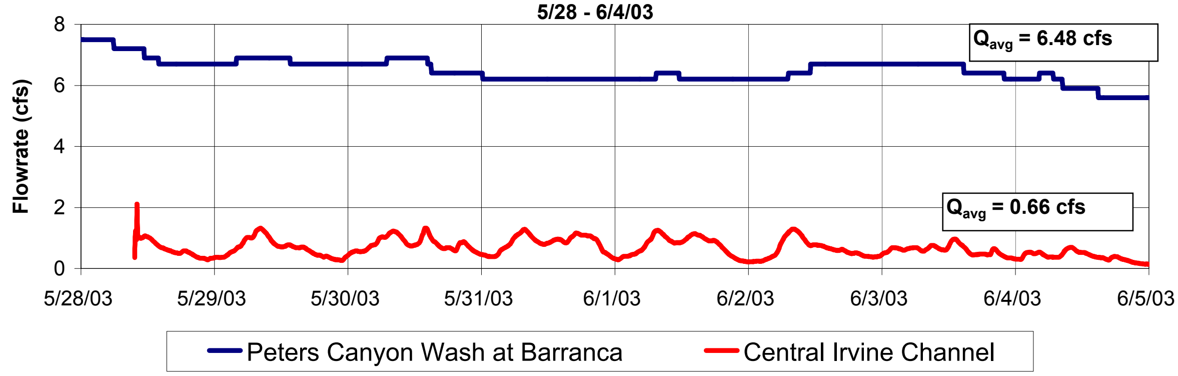


Figure C-11.11 - Nitrate Concentrations in Composite Samples from Peters Canyon Wash and Central Irvine Channel - 5/28 - 6/4/03

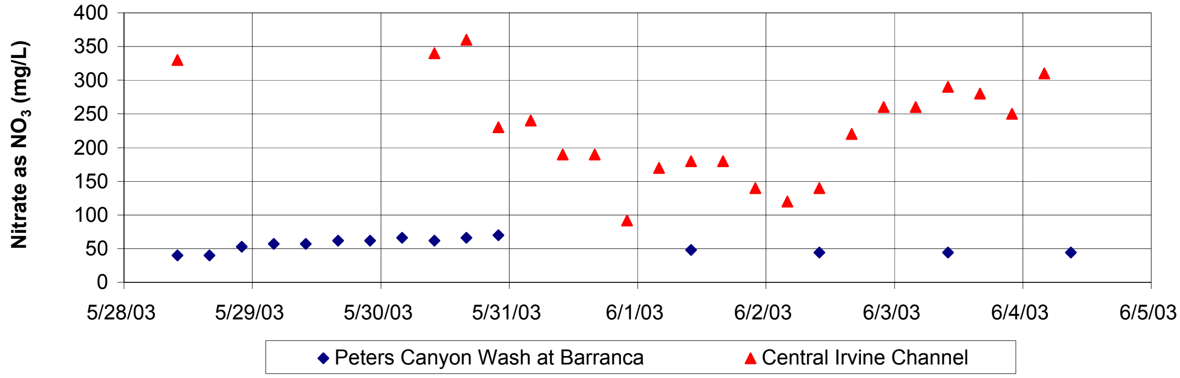


Figure C-11.12 - Nitrate Loading Rate in Composite Samples from Peters Canyon Wash and Central Irvine Channel- 5/28 - 6/4/03

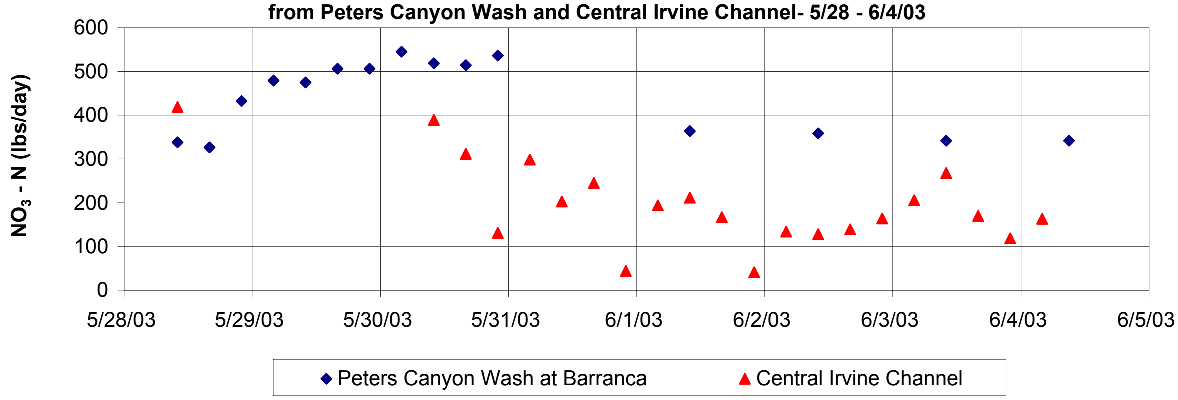
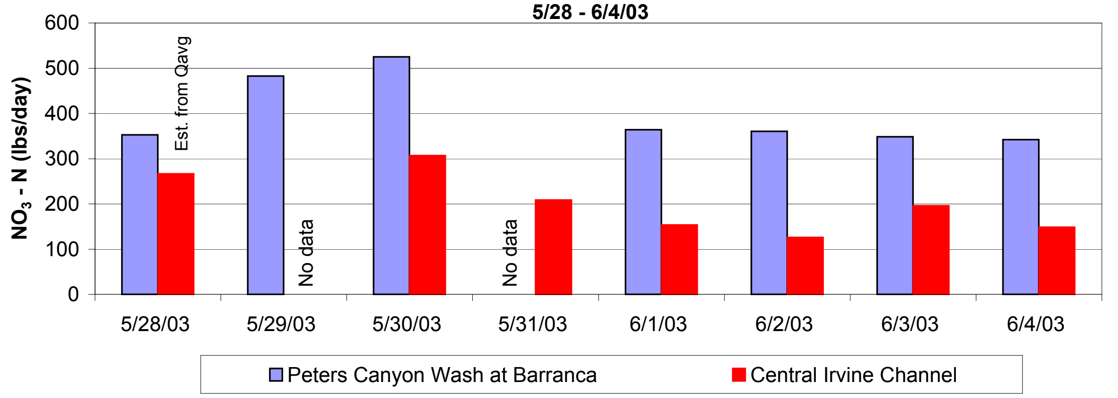


Figure C-11.13 - Daily Nitrate Load from Peters Canyon Wash and Central Irvine Channel
5/28 - 6/4/03



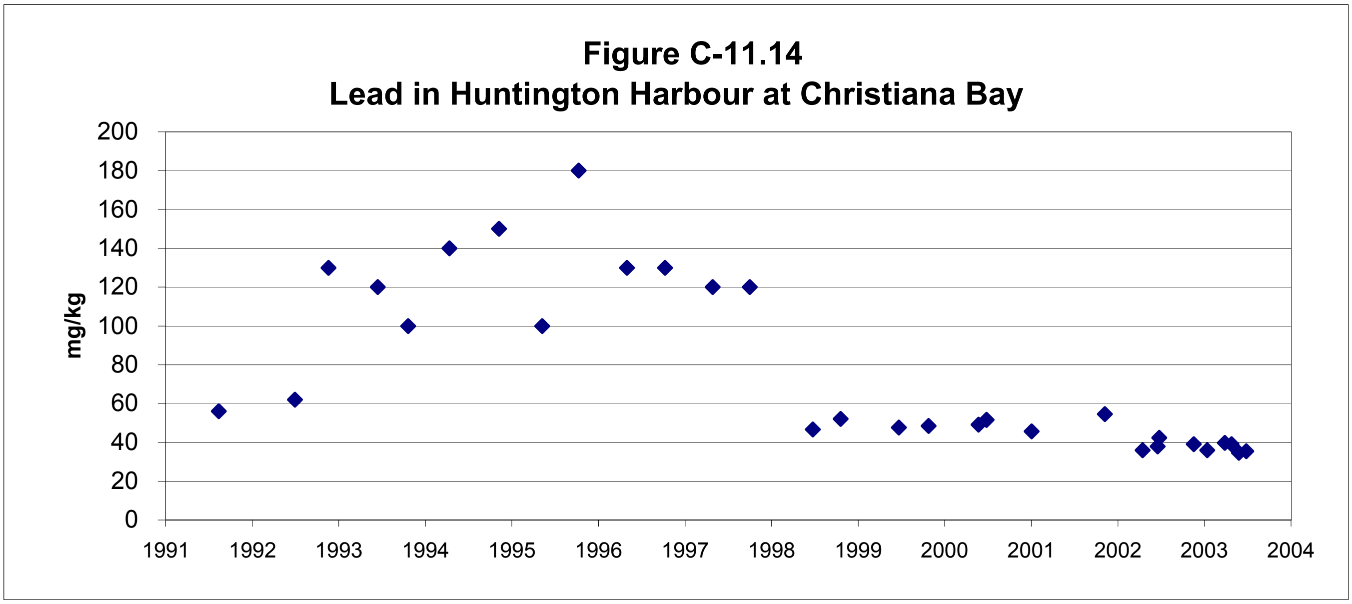


Figure C-11.14
Lead in Huntington Harbour at Christiana Bay
mg/kg
0
20
40
60
80
100
120
140
160
180
200
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004

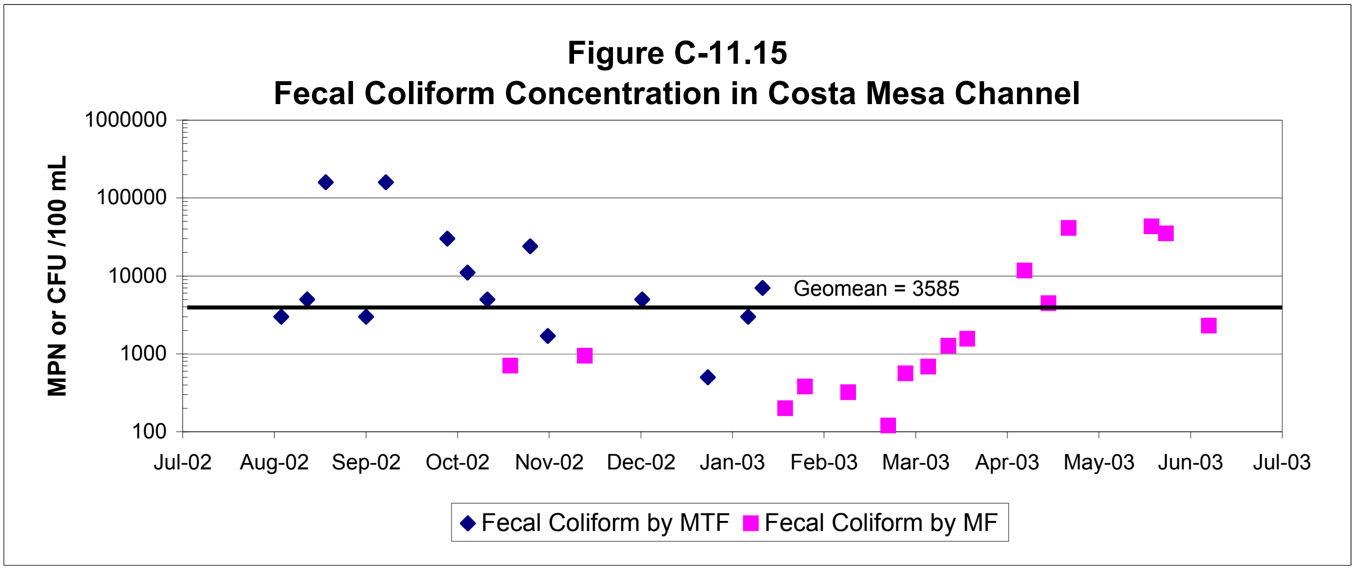


Figure C-11.15
Fecal Coliform Concentration in Costa Mesa Channel
MPN or CFU /100 mL
1000000
100000
10000
1000
100
Geomean = 3585
Jul-02
Aug-02
Sep-02
Oct-02
Nov-02
Dec-02
Jan-03
Feb-03
Mar-03
Apr-03
May-03
Jun-03
Jul-03
Fecal Coliform by MTF
Fecal Coliform by MF

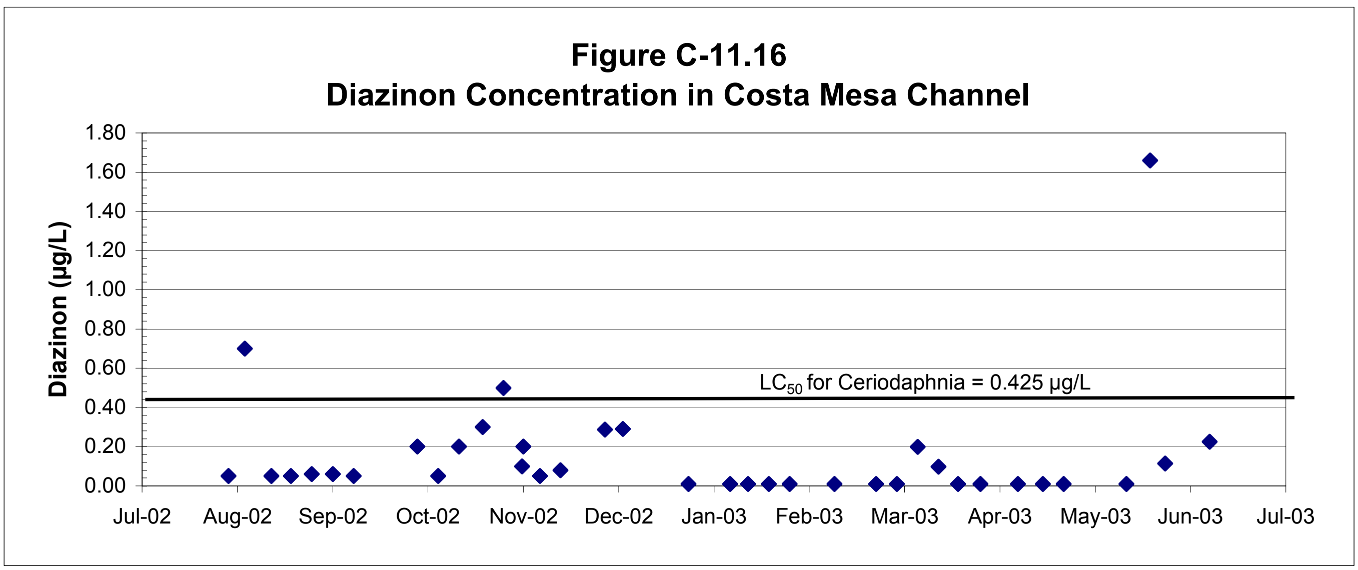
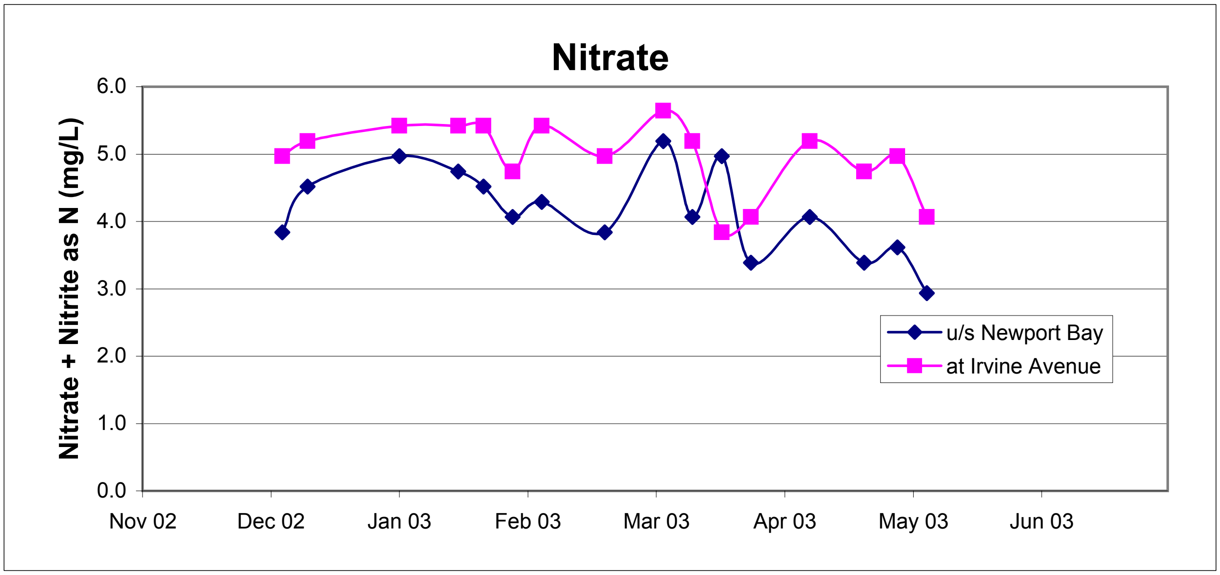


Figure C-11.16
Diazinon Concentration in Costa Mesa Channel
Diazinon (µg/L)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
LC50 for Ceriodaphnia = 0.425 µg/L
Jul-02
Aug-02
Sep-02
Oct-02
Nov-02
Dec-02
Jan-03
Feb-03
Mar-03
Apr-03
May-03
Jun-03
Jul-03

Figure C-11.17
Nutrient Concentrations in Santa Isabella Channel



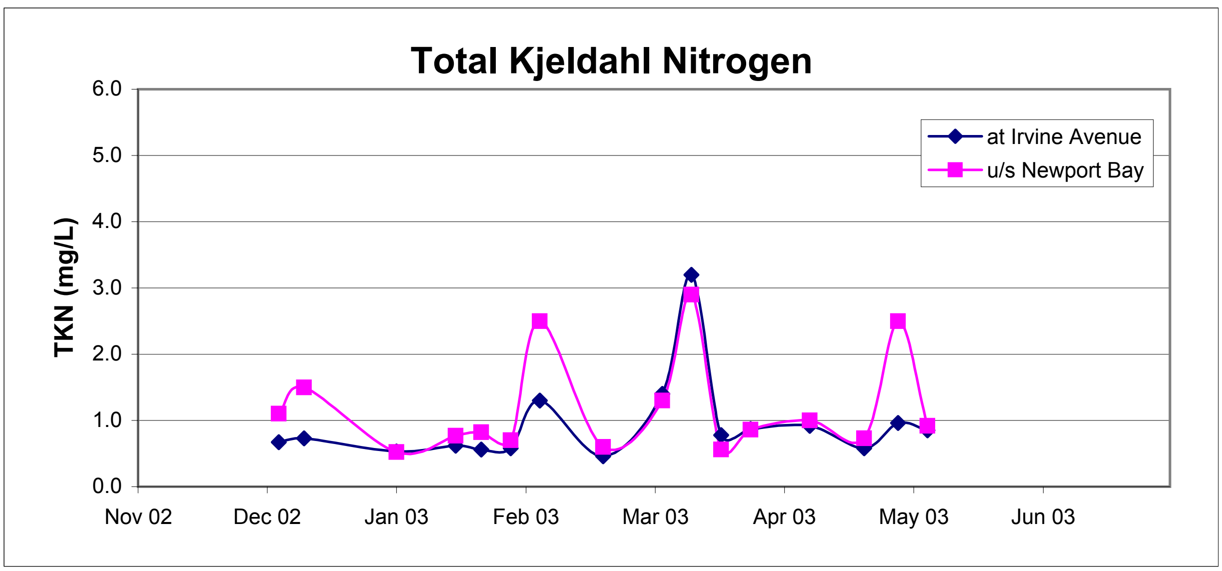
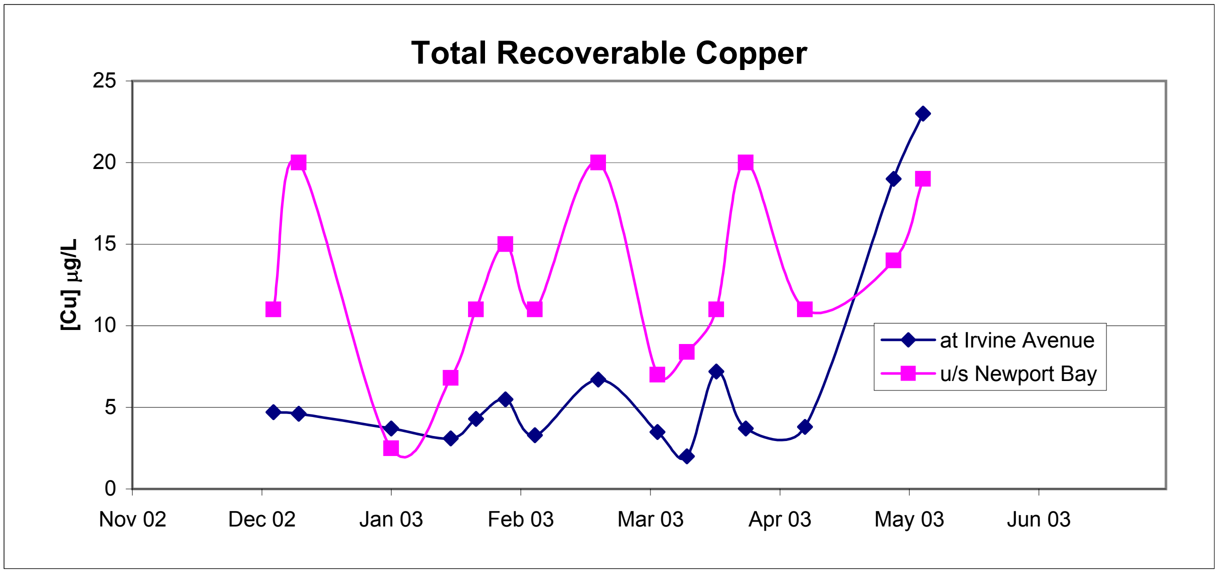
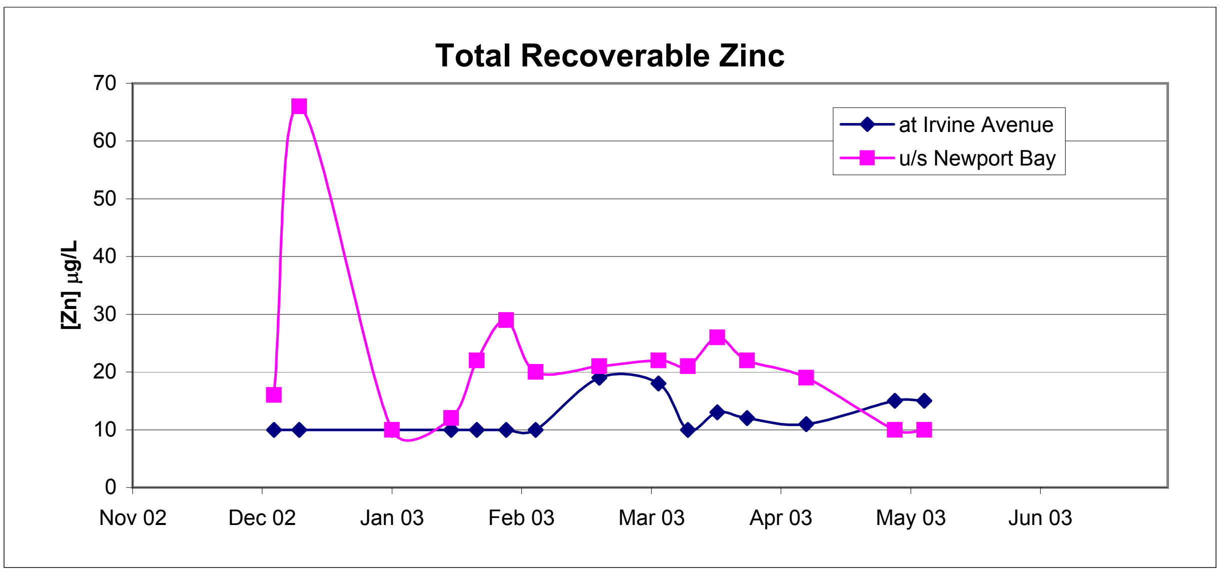


Figure C-11.18
Concentrations of Copper, Zinc, and Total Suspended Solids in Santa Isabella Channel





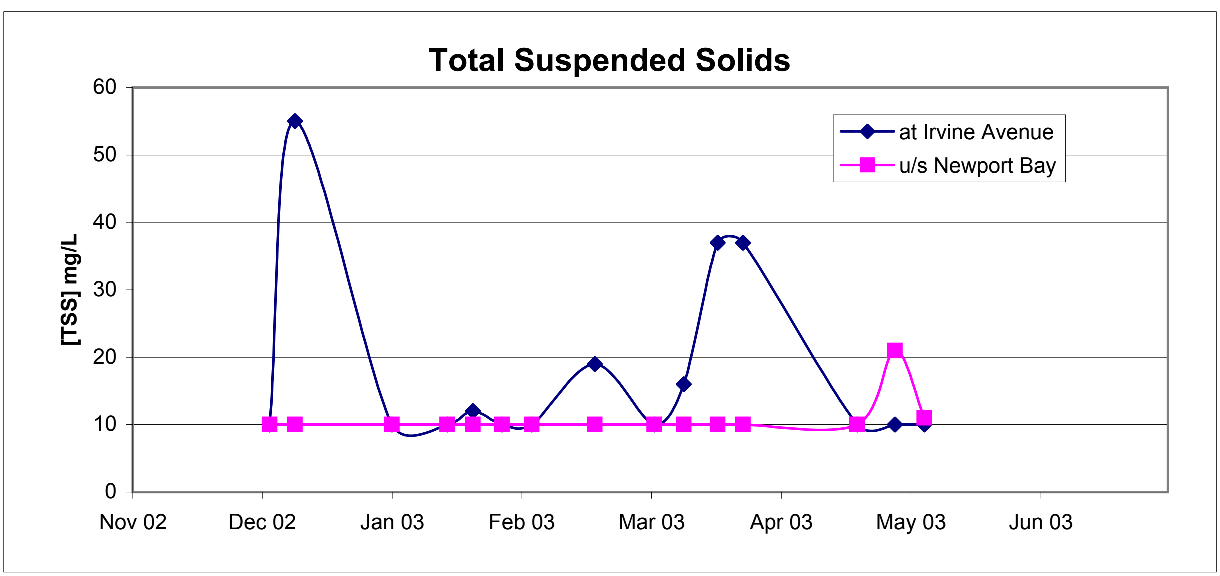
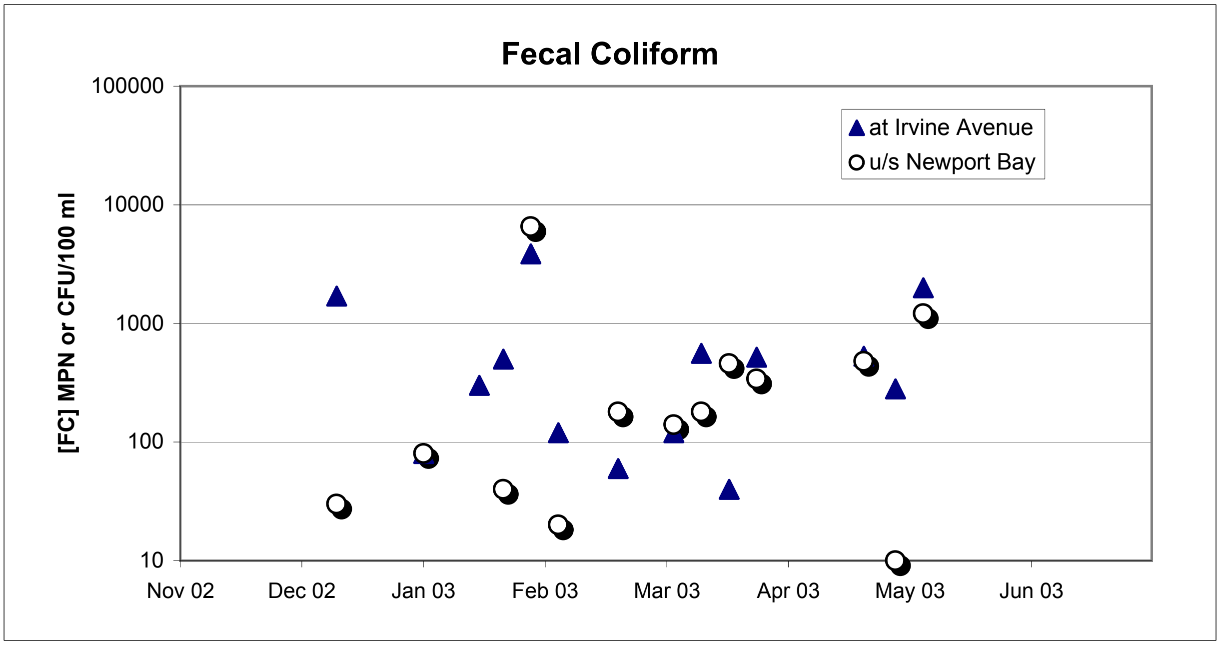


Figure C-11.19
Bacteria in Dry-weather Runoff from Santa Isabella Channel



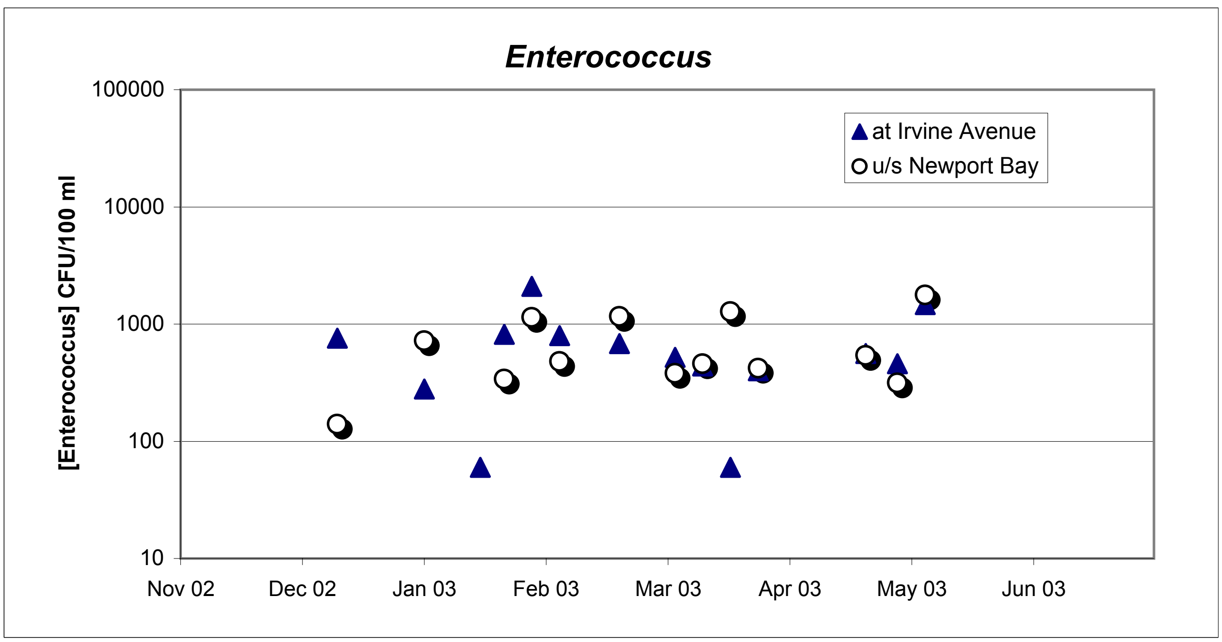


Figure C-11.20
Diazinon Concentration in San Diego Creek at Campus Drive

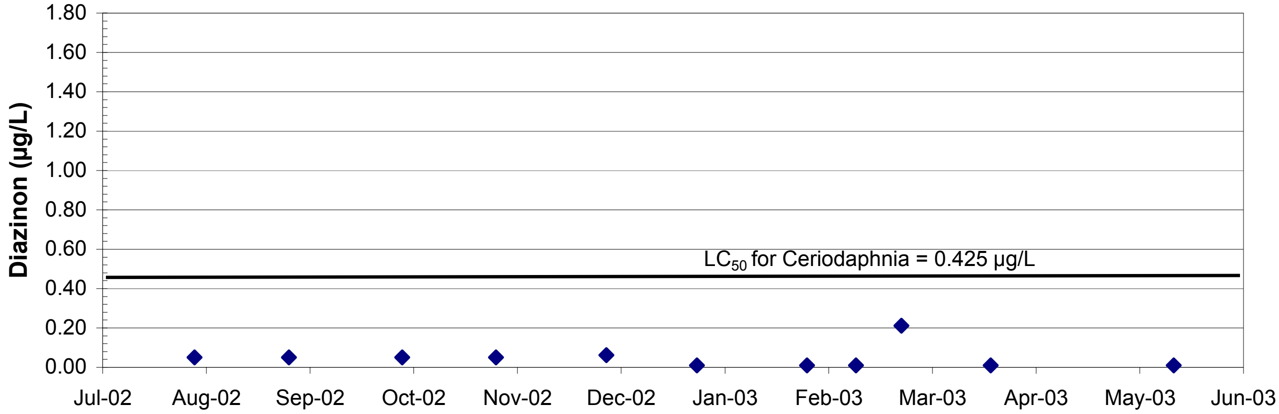
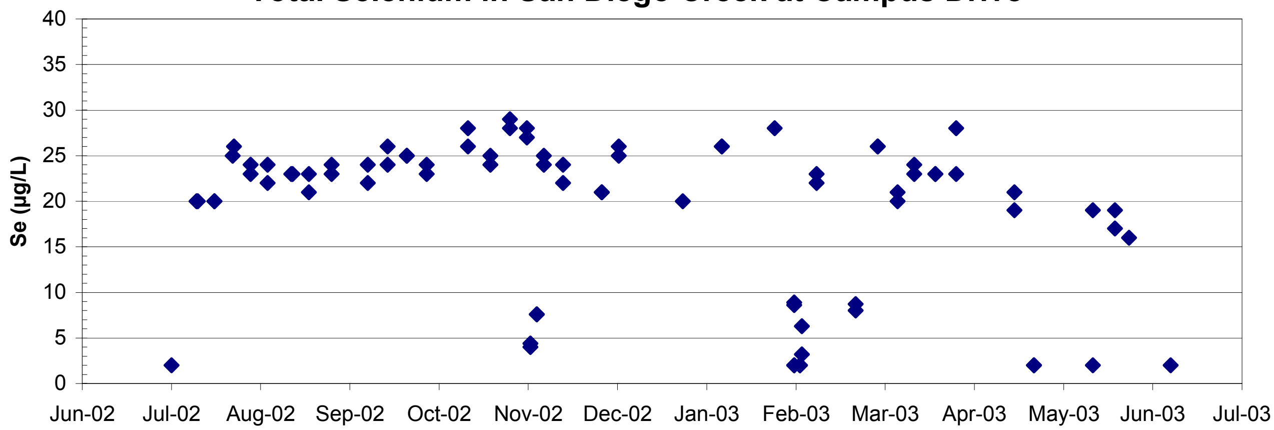


Figure C-11.21
Total Selenium in San Diego Creek at Campus Drive



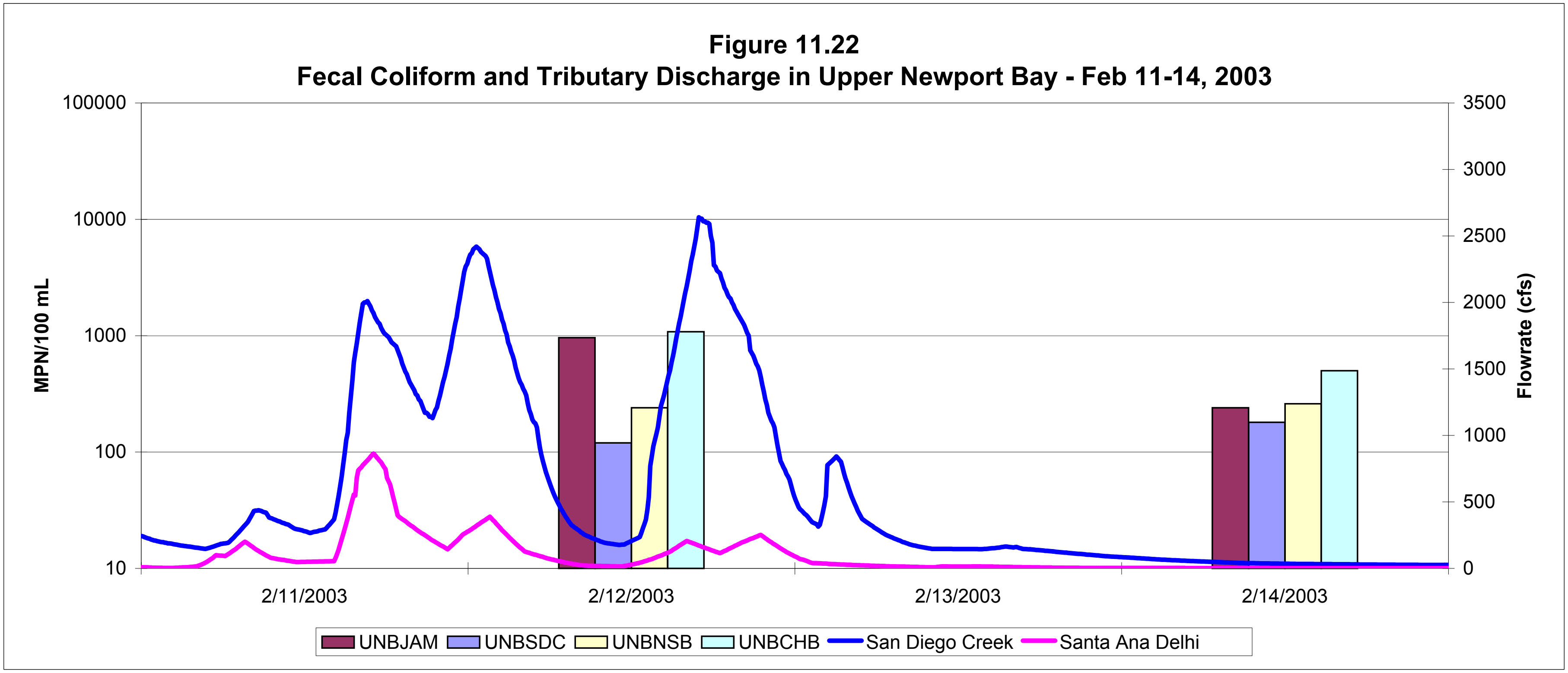


Figure 11.22
Fecal Coliform and Tributary Discharge in Upper Newport Bay - Feb 11-14, 2003
MPN/100 mL
100000
10000
1000
100
10
Flowrate (cfs)
3500
3000
2500
2000
1500
1000
500
0
2/11/2003
2/12/2003
2/13/2003
2/14/2003
UNBJAM
UNBSDC
UNBNSB
UNBCHB
San Diego Creek
Santa Ana Delhi

Figure 11.23
Fecal Coliform and Tributary Discharge in Upper Newport Bay - Apr 14-17, 2003