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LOS ANGELES COUNTY 1994-2000 INTEGRATED RECEIVING WATER IMPACTS REPORT

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Rod Kubomoto
Assistant Deputy Director/ Division Engineer

Terri Grant
Assistant Division Engineer

Dan Lafferty
Assistant Division Engineer

For information call
(626) 458-4300
or E-mail Carrie Inciong
cinciong@ladpw.org

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Acronyms and Abbreviations

ACOE	Army Corps of Engineers
ACWM	Department of Agricultural Commissioner/Weights and Measures
ADA	Americans with Disabilities Act
ANOVA	analysis of variance
BMPs	Best Management Practices
BOD_5	biochemical oxygen demand (five day)
COD	chemical oxygen demand
CV	coefficient of variation
DDT	dichlorodiphenyltrichloroethane
DF	degrees of freedom
DL	detection limit
EC_{50}	effective concentration for 50% reduction in fertilization
EMCs	Event Mean Concentrations
GIS	Geographical Information Systems
HDSFR	high density single family residential
ID	identification
LACDPW	Los Angeles County Department of Public Works
LAX	Los Angeles International Airport
mg/l	milligrams per liter
μg/l	micrograms per liter
NOEC	no observed effects concentration
NPDES	National Pollutant Discharge Elimination System
PAHs	polycyclic aromatic hydrocarbons
PCBs	polychlorinated biphenyls
pH	negative logarithm of hydrogen ion concentration
PQL	practical quantitation limit
QA/QC	quality assurance/quality control
ROWD	Report of Waste Discharge
RWQCB	Regional Water Quality Control Board
SCAG	Southern California Association of Governments
SCCWRP	Southern California Coastal Waters Research Project
SIC	Standard Industrial Classification
SID	statistically invalid data

TMDL	total maximum daily load
TKN	total Kjeldahl nitrogen
TPH	total petroleum hydrocarbons
TSS	total suspended solids
TU	toxicity units
UCLA	University of California, Los Angeles
USEPA	United States Environmental Protection Agency
WDR	waste discharge requirements
WMA	Watershed Management Area
WQC	water quality criteria

EXECUTIVE SUMMARY

Since the 1994-95 storm season, the County of Los Angeles Department of Public Works has endeavored to monitor and characterize stormwater water quality under the Los Angeles NPDES Municipal Stormwater Permits. The first two years of monitoring fell under the 1990 Permit, while the current monitoring program is defined in the 1996 Permit. The current monitoring program has consisted of four major elements: Santa Monica Bay receiving water impacts study, mass emission monitoring, land use runoff monitoring, and critical industry monitoring. Other peripheral and supportive studies were conducted since 1996. Those consisted of a study of sampling in wide channels (see Appendix E), a study of the feasibility of sampling storms down to 0.1" rainfall (see Appendix D), an El Niño season supplemental study (see Appendix F), and freshwater toxicity studies on the Los Angeles and San Gabriel Rivers (see Appendix G). In 1999, the County also voluntarily funded half of a study of impacts on stormwater quality from aerial deposition (see Appendix H for progress reports).

HYDROLOGIC CONDITIONS AND SAMPLING SUCCESS

The last six years have experienced a range of climatological events, ranging from the 1997-98 El Niño season (twice the normal annual rainfall) to the 1998-99 La Niña season (less than half the normal annual rainfall). Nevertheless, the County's resourcefulness allowed it to respond to many different and unexpected circumstances as they arose. Since January 1995, 212 mass emission and 396 land use monitoring station events have been sampled. The major objective of runoff characterization of mass emission, land use, and critical industry drainage areas was achieved.

OBJECTIVES ACHIEVED

The goal of the monitoring program has been to provide technical data and information to support effective watershed stormwater quality management programs in Los Angeles County. The monitoring program has been successful in meeting those goals, namely:

- Track Water Quality Status, Pollutant Trends and Pollutant Loads, and Identify Pollutants of Concern

  Water quality status, pollutant trends and loads were successfully addressed by all of the major monitoring program elements: the Santa Monica Bay receiving waters impact study, the mass emission monitoring element, the land use monitoring element, and the critical source monitoring element. The total cost incurred by the monitoring program to date has been more than $4.8 million.

- Monitor and Assess Pollutant Loads from Specific Land Uses and Watershed Areas

  Both the mass emission and land use monitoring elements were successful at assessing loading, and the County's GIS Loading Model has been recognized as an innovative solution to estimating loading in unmonitored watersheds.

- Identify, Monitor, and Assess Significant Water Quality Problems Related to Stormwater Discharges Within the Watershed

  The monitoring program was successful at identifying toxic levels of zinc and copper from Ballona Creek discharge, toxicity in the Los Angeles and San Gabriel Rivers, and the extent and severity of bacterial indicators in both dry and wet weather.

- Identify Sources of Pollutants in Stormwater Runoff

  In addition to the Bay receiving water impacts study's identifying Ballona Ck., and not Malibu Ck., as a contributor of stormwater toxicity, the mass emission monitoring identified the Los Angeles River as consistently contributing the most zinc, copper, and suspended solids. The land use monitoring identified light industrial, transportation, and retail/commercial land uses as developing the highest median concentrations for total and dissolved zinc. Light industrial and transportation land uses displayed the highest median concentrations for total and dissolved copper, and light industrial produced the highest concentrations of suspended solids. Finally, the critical source monitoring program identified fabricated metal businesses as producing the highest median concentrations for zinc, copper, and suspended solids.

- Identify and Eliminate Illicit Discharges

  Each Permittee has a program to identify and eliminate illicit connections to the storm drain system to the maximum extent practicable. The County has been successful in the inspection of open channels and underground storm drains to identify illicit connections.

  Most Permittees perform random area surveillance during dry and wet weather to inspect for potential illegal discharges. The Permittees also conduct educational site visits at businesses. During these visits, flyers with information on Best Management Practices (BMPs) applicable to that business are distributed.

  The Department has also been successful in developing and implementing a standard program for public reporting of illicit discharges and reporting hazardous substances via the 1-888-CleanLA hotline.

- Evaluate the Effectiveness of Management Programs, including Pollutant Reductions Achieved by Implementation of Best Management Practices (BMPs)

  The Critical Source element of the monitoring program was successful at examining the potential effectiveness of voluntary good housekeeping and preventive types of Best Management Practices at one critical source industry. There was no significant difference at other critical source industries at which BMPs were implemented. The inability to control the voluntary usage of good housekeeping BMPs at these critical industries may have compromized the study's effectiveness for those industries.

- Assess the Impacts of Stormwater Runoff on Receiving Waters

  The receiving waters impact study, one of the first in the nation to assess stormwater impacts on the marine environment, was very successful at assessing stormwater impacts on Santa Monica Bay. The study was able to discern the existence and extent of the stormwater plume in the Bay, identify two trace metals in Ballona Creek. stormwater discharge that are toxic to simple sea creatures, and conclude that sediments offshore of Ballona Creek generally had higher concentrations of urban contaminants. The findings related to toxicity and sediments, along with bacterial indicators, set the stage for the rest of this report.

WATER QUALITY CHEMICAL ANALYSES

Monitoring in Los Angeles county from 1994 to date has been performed in compliance with the Municipal Stormwater Permits of June, 1990, and July, 1996, which have required a broad suite of chemical analyses, including solids, minerals, bacteria, metals, organics, and nutrients. The Los Angeles county Department of Agricultural Commissioner/Weights and Measures, Environmental toxicology Laboratory, provided the water quality laboratory and related services to the Department of Public works. The laboratory implemented a Quality Assurance/Quality Control program to ensure that the analyses conducted were scientifically valid, defensible, and of known precision and accuracy.

WATER AND SEDIMENT QUALITY RESULTS

Conclusions on the status and trends of water quality over the past six years have been derived from the monitoring program's Santa Monica Bay receiving waters impact study, mass emissions monitoring element, land use runoff monitoring element, and critical industry monitoring element. Findings regarding sediment quality were derived from the Santa Monica Bay receiving waters impact study and the County's involvement with the California Sediment Task Force and the Corps of Engineers' Sediment Control Management Plan.

- The nonprofit Center for Watershed Protection has linked overall watershed imperviousness to stormwater quality problems. The Dominguez Channel/L. A. Harbor Watershed Management Area has the highest overall imperviousness (62%) based on 1993 SCAG land use distribution, followed by the Ballona Creek (45%), Los Angeles River (35%), San Gabriel River (30%), Malibu Creek (6%), and Santa Clara River (5%) Watershed Management Areas.

- The monitoring program has identified the nearly ubiquitous existence of indicator bacteria in both dry and wet weather throughout the urbanized part of the coastal basin. Total coliforms, fecal coliforms, fecal streptococcus, and fecal enterococcus were detected in all stormwater samples tested since 1994 at densities (or most probable number, MPN) between several hundreds to several million cells per 100 ml., exceeding the public health criteria of AB411.

- The Malibu Creek station appears to have consistently lower indicator bacteria counts than other mass emission stations and is consistently lower for all four groups of bacteria.

- The 1995-96 season appears to have higher mean densities of indicator bacteria than other years. At 75% of normal, this was not a particularly rainy season.

- In a number of instances, peak fecal coliform counts occurred at different monitoring stations in different parts of the county during the same storm. Further, in 1995-96, the highest fecal coliform readings at five stations coincided with the largest storm of the season. Also, in 1996-97, the highest fecal coliform readings at two stations coincided with the first storm of the season greater than 0.1" rainfall. These observations suggest that peak fecal coliform levels may be related to regional hydrologic conditions.

- Except for somewhat lower bacteria densities at Malibu Creek, there was no seasonal or regional consistency in cell densities. There was a very wide range of densities for all stations.

- There was one storm event, January 9, 1998, that yielded extremely high counts in all stations for all bacterial strains. The available data do not provide an explanation, or suggest whether this could be a contamination artifact.

- The 1996-97 season had one event, November 21, 1996, that yielded runoff with high counts in all stations for all bacteria species.

- During the 1998-99 season, the event of March 15, 1999 was associated with high bacterial counts for most stations and the events of March 25, 1999 and April 4, 1999, were associated with unusually low counts for most stations.

- Virtually every sample of Ballona Creek stormwater tested in the Santa Monica Bay receiving water impacts study was toxic to sea urchin fertilization.

- The first storms of the year produced the most toxic stormwater in Santa Monica Bay during the receiving water impacts study.

- The toxic portions of the observed stormwater plume were variable in size, extending from 1/4 to 2 miles offshore of Ballona Creek.

- Surface water toxicity caused by unidentified sources was frequently encountered during dry weather in Santa Monica Bay during the receiving water impacts study.

- Zinc was the most important toxic constituent identified in stormwater in Santa Monica Bay, but zinc concentrations in the toxic portion of the discharge plume were usually below levels shown to cause toxicity in the laboratory.

- Copper and other unidentified constituents may also be responsible for some of the toxicity measured in Santa Monica Bay.

- The measured concentrations of zinc and copper in Ballona Creek stormwater were estimated to account for only 5% - 44% of the observed toxicity.

- The fate of most stormwater constituents discharged to Santa Monica Bay is unknown.

- For two years in a row, wet weather toxicity was significant in the Los Angeles River. Dry weather toxicity was significant the second year, but not the first.

- For the San Gabriel River, wet weather toxicity was significant the first year, but not the second. Dry weather toxicity was not significant either year.

- For both the Los Angeles and San Gabriel Rivers, wet weather toxicity was higher for the first storm tested, suggesting a seasonal "first flush" phenomenon for toxicity.

- The sea floor is where stormwater particles, and associated contaminants, eventually settle.

- The sediments on the sea floor can accumulate runoff inputs over an entire storm, over several storms, or over several seasons.

- Sediments offshore of Ballona Creek generally had higher concentrations of urban contaminants, including common stormwater constituents such as lead and zinc.

- Sediments offshore of Ballona Creek showed evidence of stormwater impacts over a large area.

- Sampled biological communities offshore of Ballona Creek were similar to those offshore of Malibu Creek. Both areas had comparable abundance and similar species composition.

- Sampled biological communities offshore of Ballona and Malibu Creeks were also similar to background reference conditions established in previous studies of southern California.

- According to the Los Angeles Basin Contaminated Sediment Task Force, informal surveys of potential marina and harbor users and past dredging projects suggest that the major sources of contaminated dredge material will continue to be Marina del Rey, the ports of Los Angeles and Long Beach, and the mouth of the Los Angeles River.

- According to the Los Angeles Basin Contaminated Sediment Task Force, some of the sediments dredged from these harbors contain elevated levels of heavy metals, pesticides, and other contaminants. In most cases, the concentrations of these contaminants do not approach hazardous levels.

- According to the U. S. Army Corps of Engineers, four of 21 sites in the bottom of Ballona Creek and major tributaries were without any chemical concentration exceeding the National Oceanographic and Atmospheric Administration's "Effect Range-Low" (ERL) values: storm drain Bond Issue Project 9408, Project 425, Ballona Creek at Sawtelle Blvd., and Centinela Channel.

- According to the U. S. Army Corps of Engineers, sediments on the bottoms of storm drain Bond Issue Projects 648, 51, 494, and 503 ranked by dry weight most consistently as the most contaminated sites with respect to metals and polycyclic aromatic hydrocarbons (PAHs).

- According to the U. S. Army Corps of Engineers, the two areas of the main Ballona Ck. channel that ranked by dry weight as most contaminated and exceeding ERLs were just downstream of Madison Ave. and Fairfax Ave.

- According to the U. S. Army Corps of Engineers, with respect to the potential for contamination from PAHs, sites in Ballona Ck. at Pickford St. and Fairfax Ave., Higuera St. drain, Projects 51 and 3867, and Culver City Acquisition and Improvement District No. 4 drain appeared most contaminated.

- According to the U. S. Army Corps of Engineers, bed load sediment in the major tributary drains of Sepulveda and Centinela Channels were among the least contaminated samples.

- According to the U. S. Army Corps of Engineers, the area within the Ballona Ck. drainage area having expected highest stormwater loading of metals, oil, and grease extends from Hollywood to Culver City in a 1- to 2-mile wide, 5- to 6-mile long strip parallel and east of the San Diego (I-405) Freeway.

- Only two PAH compounds, phenanthrene and pyrene, exceeded the California Ocean Plan objective. This occurred at the Malibu Creek station. No other PAH compound exceedences appeared through the comparison of mass emission concentrations to the California Ocean Plan, although 1999-2000 was the first year of lower detection limits for PAHs.

- The Los Angeles River is the largest contributor of suspended solids of the five mass emission stations monitored.

- After exceedence of bacterial indicators, when compared to the California Ocean Plan, the Los Angeles Basin Plan, and the California Toxics Rule, the next most numerous "virtual" exceedences occurred with total and dissolved copper and bis(2-ethylhexyl)phthalate, followed by turbidity, total zinc, and total lead.

- The El Niño season, 1997-98, contributed the most virtual mass emission exceedences at all monitoring stations except Coyote Creek.

- The Los Angeles River produced the most virtual exceedences of any other mass emission monitoring station.

- Loading to the ocean was greatest during 1997-98, the El Niño season, during which the Los Angeles River delivered the highest loadings of total suspended solids (approx. 220,000 tons), dissolved copper (approx. 28 tons), total copper (approx. 40 tons), dissolved zinc (approx. 170 tons), and total zinc (approx. 230 tons).

- It appears that Los Angeles River loading for metals is disproportionate by drainage area to the other watersheds.

- According to the GIS Loading Model, the unmonitored Dominguez Channel/L. A. Harbor Watershed Management Area was estimated to contribute the highest loadings for dissolved zinc (approx. 2.3 tons) and dissolved copper (approx. 30 tons) and contribute the highest loadings of the unmonitored watersheds for each year since 1995. Comparison of loadings between monitored and unmonitored watersheds should not be made at this time because the model is not yet fully calibrated.

CONSTITUENTS OF CONCERN

- Sixteen chemical constituents were identified from the comparison of mass emission annual concentrations to the objectives of the California Ocean Plan, the Los Angeles Basin Plan, and the California Toxics Rule. Exceedence of these objectives, however, do not constitute noncompliance with the Permit.

- While Total Maximum Daily Loads (TMDLs) are not part of the Los Angeles Municipal Stormwater Permit, constituents identified by the 303d list that were not already identified through the comparison process, namely nutrients, are also constituents of concern. It should be noted, however, that a report by the Las Virgenes Municipal Water District found that beneficial use impairment due to algal growth is not a problem in Malibu Creek during storm season.

- Two organophosphate pesticides, diazinon and chlorpyrifos, are also among the constituents of concern due to their identification with stormwater toxicity in independent studies.

- Indicator bacteria (total coliform and fecal coliform, streptococcus, and enterococcus) are included as constituents of concern due their exceedence of AB411 (assembly bill).

IDENTIFICATION OF POSSIBLE SOURCES

- Light industrial, transportation, and retail/commercial land uses displayed the highest median values for total and dissolved zinc, with light industrial the highest at about 300 • g/l for dissolved zinc and about 360 • g/l for total zinc. Runoff concentrations for metals from the high density single family residential, education, multifamily residential, and mixed residential land uses were significantly less.

- Light industrial and transportation land uses displayed the highest median values for total and dissolved copper, with transportation the highest at about 28 • g/l for dissolved copper and about 40 • g/l for total copper.

- Median concentrations of total suspended solids were highest coming off of the light industrial land use category, at about 130 mg/l.

- Among all the critical industry monitoring sites, the highest median value for total zinc (approx. 450 • g/l), dissolved zinc (approx. 360 • g/l), total copper (approx. 240 • g/l), and dissolved copper (approx. 110 • g/l) were produced at the fabricated metal business sites.

- Levels for total and dissolved zinc did not appear to be significantly different between any of the industry types.

- Levels for total and dissolved copper did appear significantly higher for the fabricated metals sites over the other critical industry categories.

- The highest median level for suspended solids was also produced at the fabricated metals sites, but no industry was significantly higher or lower than another for suspended solids.

EVALUATION OF CRITICAL INDUSTRY BMP EFFECTIVENESS

- Limited success was achieved in evaluating BMPs for the auto dismantling and auto repair industries. The reasons for no discernable differences in concentrations before and after BMP implementation at the two industries are not obvious, but may include the voluntary nature of the BMP usage.

- For total and dissolved zinc, the median concentration lowered or stayed nearly the same with the implementation of BMPs at the auto dismantling, auto repair, and fabricated metals industries.

- For total and dissolved copper, where the fabricated metal industry had displayed the highest median concentrations, levels were significantly reduced with the implementation of BMPs.

- The auto dismantling and auto repair businesses showed no significant difference for copper pre- and post-BMP.

RECOMMENDATIONS

The following recommendations are made based on all the monitoring and studies to date, from within the Los Angeles County Department of Public Works and other sources. These recommendations include monitoring, research, and studies that should be considered or undertaken to advance the understanding of stormwater quality science and support future TMDL development. Because of their scope, such studies should be undertaken by various entities, such as the Regional Water Quality Control Board, NPDES permittees, or collaborative efforts between private and public organizations.

- Mass emission monitoring should continue at the five existing sites for up to five storm events per season.

- Those constituents that have been detected in less than 25% of ten consecutive sampling events (Table ES-1a) should be removed from the analytical suite for the associated mass emission monitoring stations. However, the constituents of concern should remain.

- As a result of the 25% Event (or Seasonal) Mean Concentration error rate (Table ES-1b), land use monitoring should only sample the following constituents:

LAND USE SITE	CONSTITUENTS
Retail/Commercial	Ammonia, total and dissolved copper, nitrate, total lead, TSS, PAH, diazinon, chlorpyrifos
Vacant	TKN, TSS, PAH, diazinon, chlorpyrifos
High Density Single Family Residential	Total lead, PAH, diazinon, chlorpyrifos
Transportation	PAH, diazinon, chlorpyrifos
Light Industrial	Total copper, PAH, diazinon, chlorpyrifos
Education	Total copper, total zinc, TSS, PAH, diazinon, chlorpyrifos
Multifamily Residential	Ammonia, ammonia nitrogen, nitrite nitrogen, TSS, PAH, diazinon, chlorpyrifos
Mixed Residential	Ammonia, nitrate, total zinc, PAH, diazinon, chlorpyrifos

- Receiving water impact studies should be performed on significant impaired water bodies to identify impacts due to stormwater. Such impact studies could include assessments of bioassessment.

- Support and cooperation should continue with the Southern California Coastal Waters Research Project in conducting current research and calibrating water quality models for the Santa Monica Bay and Los Angeles River.

- Similar water quality models should be initiated for other parts of the County where indicator bacteria impair beneficial uses.

- Support and cooperation should continue with the Corps of Engineers' Sediment Control Management Plan and the Coastal Commission Sediment Task Force.

- Studies of receiving water and stormwater impacts due to aerial deposition should be conducted on inland watersheds.

- Major tributaries to Ballona Creek should be surveyed to find possible contributing areas and sources of trace zinc and copper.

- Two dry weather and two wet weather Toxicity Identification Evaluations should be conducted for a full range of constituents on freshwater species for the L. A. River and Dominguez Channel.

- Two wet weather Toxicity Identification Evaluations should be conducted for a full range of constituents on freshwater species for the San Gabriel River.

- Follow-up studies should be conducted in Santa Monica Bay that address the persistence of stormwater plumes following storm events, the toxicity of stormwater on other representative species, and the fate of sediments in the Bay.

- A study should be conducted assessing the impacts due to stormwater on San Pedro Bay.

- Support and cooperation should continue toward local and regional monitoring programs, including but not limited to the Santa Monica Bay Restoration Project, the City of Long Beach, and the developing Southern California Regional Stormwater Monitoring Coalition.

- Best Management Practices and impacts should be formally evaluated in controlled cases. Current examples might include the City of Santa Clarita demonstration projects, catch basin inserts and deflectors, groundwater impacts due to stormwater infiltration, the Department of Public Works' parking lot retrofit, and storm drain low flow diversions.

- Continue the IC/ID model program as approved by the Regional Board on March 23, 1999.

- Calibrate the GIS Loading Model between monitored and unmonitored watersheds.

Table ES-1a. 1994-2000 Mass Emission Constituent Detection Rates

	Ballona Creek	Malibu Creek	Los Angeles River	Coyote Creek	San Gabriel River
Miscellaneous Constituents					
Cyanide*	X	X	X	&	X
TPH	X	X	-	&	X
Oil and Grease	X	X	-	&	X
Total Phenols	X	X	X	&	X
Indicator Bacteria*	-	-	-	&	-
General Minerals					
Ammonia	-	X	-	-	X
Calcium	-	-	-	-	-
Magnesium	-	-	-	-	-
Potassium	-	-	-	-	-
Sodium	-	-	-	-	-
Bicarbonate	-	-	-	-	-
Carbonate	X	X	X	X	X
Chloride	-	-	-	-	-
Flouride	-	-	-	-	-
Nitrate	-	-	-	-	-
Sulfate	-	-	-	-	-
Alkalinity	-	-	-	-	-
Hardness	-	-	-	-	-
COD	-	-	-	-	-
pH	-	-	-	-	-
Specific Conductance	-	-	-	-	-
Total Dissolved Solids*	-	-	-	-	-
Turbidity*	-	-	-	-	-
Total Suspended Solids*	-	-	-	-	-
Volatile Suspended Solids	-	-	-	-	-
MBAS	-	X	X	X	X
Total Organic Carbon	-	-	-	-	-
BOD	-	-	-	-	-
Nutrients					
Dissolved Phosphorus*	-	-	-	-	-
Total Phosphorus*	-	-	-	-	-
NH3-N*	-	X	X	-	X
Nitrate-N*	-	-	-	-	-
Nitrite-N*	-	X	-	-	-
TKN*	-	-	-	-	-
Metals					
Dissolved Aluminum	X	X	-	X	X
Total Aluminum*	-	-	-	-	-
Dissolved Antimony	X	X	X	X	X
Total Antimony	X	X	X	X	X
Dissolved Arsenic	X	X	X	X	X
Total Arsenic	X	X	X	X	X
Dissolved Barium	-	-	-	-	-
Total Barium	-	-	-	-	-
Dissolved Beryllium	X	X	X	X	X
Total Beryllium	X	X	X	X	X
Dissolved Boron	-	-	-	-	-
Total Boron	-	-	-	-	-
Dissolved Cadmium*	X	X	X	X	X
Total Cadmium	X	X	X	X	X
Dissolved Chromium	X	X	X	X	X
Total Chromium	X	X	X	X	X
Dissolved Chromium +6	X	X	X	X	X
Total Chromium +6	X	X	X	X	X
Dissolved Copper*	-	X	-	-	X

Table ES-1a. 1994-2000 Mass Emission Constituent Detection Rates

	Ballona Creek	Malibu Creek	Los Angeles River	Coyote Creek	San Gabriel River
Total Copper*	-	-	-	-	-
Dissolved Iron	X	X	-	-	X
Total Iron	-	-	-	-	-
Dissolved Lead*	X	X	X	X	X
Total Lead*	X	X	-	X	X
Dissolved Manganese	X	X	X	X	X
Total Manganese	X	X	X	X	X
Dissolved Mercury	X	X	X	X	X
Total Mercury*	X	X	X	X	X
Dissolved Nickel*	X	X	-	X	X
Total Nickel*	-	-	-	-	X
Dissolved Selenium	X	X	X	X	X
Total Selenium	X	X	X	X	X
Dissolved Silver	X	X	X	X	X
Total Silver	X	X	X	X	X
Dissolved Thallium	X	X	X	X	X
Total Thallium	X	X	X	X	X
Dissolved Zinc*	X	X	X	X	X
Total Zinc*	-	X	-	X	X
SVOCs					
Bis(2-ethylhexyl)phthalate*	&	&	&	&	&
PAHs					
Phenanthrene*	&	&	&	&	&
Pyrene*	&	&	&	&	&
All other PAHs	&	&	&	&	&
All other SVOCs	X	X	X	X	X
Pesticides					
Organochlorine Pesticides & PCBs	X	X	X	X	X
Carbofuran	X	X	X	X	X
Glyphosate	X	X	X	X	X
Organo-Phosphate Pesticides					
Diazinon*	X	X	X	X	X
Chlorpyrifos*	X	X	X	X	X
N- and P-Containing Pesticides					
Thiobencarb	X	X	X	X	X
All other N- and P- Pesticieds	X	X	X	X	X
Phenoxyacetic Acid Herbicides					
2,4-D	X	X	X	X	X
2,4,5-TP	X	X	X	X	X
Bentazon	X	X	X	X	X

X = less than 25% detection in ten consecutive samples

- = more than 25% detection in ten consecutive samples

& = less than 10 samples tested

* Constituent of concern

Table ES-1b. 1994-2000 Land Use Constituent Detection Rates

	Commercial	Vacant	High Density Single Family Residential	Trans-portation	Light Industrial	Educational	Multi-Family Residential	Mixed Residential
Miscellaneous Constituents								
Cyanide*	&	X	&	&	&	&	&	&
TPH	&	X	&	&	&	&	&	&
Oil and Grease	&	X	&	&	&	&	&	&
Total Phenols	&	X	&	&	&	&	&	&
Indicator Bacteria*	&	-	&	&	&	&	&	&
General Minerals								
Ammonia	-	X	-	-	-	X	-	-
Calcium	-	-	-	-	-	-	-	-
Magnesium	-	-	-	-	-	-	-	-
Potassium	-	-	-	-	-	-	-	-
Sodium	-	-	-	-	-	-	-	-
Bicarbonate	-	-	-	-	-	-	-	-
Carbonate	X	X	X	X	X	X	X	X
Chloride	-	-	-	-	-	-	-	-
Flouride	X	-	X	X	X	X	X	X
Nitrate	-	-	-	-	-	-	-	-
Sulfate	-	-	-	-	-	-	-	-
Alkalinity	-	-	-	-	-	-	-	-
Hardness	-	-	-	-	-	-	-	-
COD	-	X	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-
Specific Conductance	-	-	-	-	-	-	-	-
Total Dissolved Solids*	-	-	-	-	-	-	-	-
Turbidity*	-	-	-	-	-	-	-	-
Total Suspended Solids*	-	-	-	-	-	-	-	-
Volatile Suspended Solids	-	-	-	-	-	-	-	-
MBAS	X	X	X	X	-	X	X	X
Total Organic Carbon	-	-	-	-	-	-	-	-
BOD	-	-	-	-	-	-	-	-
Nutrients								
Dissolved Phosphorus*	-	X	-	-	-	-	-	-
Total Phosphorus*	-	X	-	-	-	-	-	-
NH3-N*	-	X	-	-	-	X	-	-
Nitrate-N*	-	-	-	X	-	X	X	X
Nitrite-N*	-	X	-	-	-	X	-	-
TKN*	-	-	-	-	-	-	-	-
Metals								
Dissolved Aluminum	X	X	X	X	X	-	X	X
Total Aluminum*	X	X	-	X	-	-	-	-
Dissolved Antimony	X	X	X	X	X	X	X	X
Total Antimony	X	X	X	X	X	X	X	X
Dissolved Arsenic	X	X	X	X	X	X	X	X
Total Arsenic	X	X	X	X	X	X	X	X
Dissolved Barium	-	-	-	-	-	-	-	-
Total Barium	-	-	-	-	-	-	-	-
Dissolved Beryllium	X	X	X	X	X	X	X	X
Total Beryllium	X	X	X	X	X	X	X	X
Dissolved Boron	-	X	X	-	X	-	-	X
Total Boron	-	-	-	-	-	-	-	X
Dissolved Cadmium*	X	X	X	X	X	X	X	X
Total Cadmium	X	X	X	X	X	X	X	X
Dissolved Chromium	X	X	X	X	X	X	X	X
Total Chromium	X	X	X	X	X	X	X	X

Table ES-1b. 1994-2000 Land Use Constituent Detection Rates

	Commercial	Vacant	High Density Single Family Residential	Trans-portation	Light Industrial	Educational	Multi-Family Residential	Mixed Residential
Dissolved Chromium +6	X	X	X	X	X	X	X	X
Total Chromium +6	X	X	X	X	X	X	X	X
Dissolved Copper*	-	X	-	-	-	-	-	-
Total Copper*	-	-	-	-	-	-	-	-
Dissolved Iron	-	X	X	X	-	-	X	X
Total Iron	-	-	-	-	-	-	-	-
Dissolved Lead*	X	X	X	X	X	X	X	X
Total Lead*	X	X	-	X	X	X	X	X
Dissolved Manganese	X	X	X	X	X	X	X	X
Total Manganese	X	X	X	X	X	X	X	X
Dissolved Mercury	X	X	X	X	X	X	X	X
Total Mercury*	X	X	X	X	X	X	X	X
Dissolved Nickel*	X	X	X	X	X	X	X	X
Total Nickel*	-	X	X	X	-	X	X	X
Dissolved Selenium	X	X	X	X	X	X	X	X
Total Selenium	X	X	X	X	X	X	X	X
Dissolved Silver	X	X	X	X	X	X	X	X
Total Silver	X	X	X	X	X	X	X	X
Dissolved Thallium	X	X	X	X	X	X	X	X
Total Thallium	X	X	X	X	X	X	X	X
Dissolved Zinc*	-	X	X	-	-	-	-	-
Total Zinc*	-	X	X	-	-	-	-	-
SVOCs								
Bis(2-ethylhexyl)phthalate*	&	&	&	&	&	&	&	&
PAHs								
Phenanthrene*	&	&	&	&	&	&	&	&
Pyrene*	&	&	&	&	&	&	&	&
All other PAHs	&	&	&	&	&	&	&	&
All other SVOCs	X	X	X	X	X	X	X	X
Pesticides								
Organochlorine Pesticides & PCBs	X	X	X	X	X	X	X	X
Carbofuran	X	X	X	X	X	X	X	X
Glyphosate	X	X	X	X	X	X	X	X
Organo-Phosphate Pesticides								
Diazinon*	X	X	X	X	X	X	X	X
Chlorpyrifos*	X	X	X	X	X	X	X	X
N- and P-Containing Pesticides								
Thiobencarb	X	X	X	X	X	X	X	X
All other N- and P- Pesticieds	X	X	X	X	X	X	X	X
Phenoxyacetic Acid Herbicides								
2,4-D	X	X	X	X	X	X	X	X
2,4,5-TP	X	X	X	X	X	X	X	X
Bentazon	X	X	X	X	X	X	X	X

X = less than 25% detection in ten consecutive samples
- = more than 25% detection in ten consecutive samples
& = less than 10 samples tested

* Constituent of concern

Table ES-1c. Summary of Mean Standard Error of Land Use Stations

			Normal Distribution			Lognormal Distribution			Shapiro-Wilk Normality Test				
Land Use Type	Constituent	No. of Detections	Mean	Standard Deviation	Standard Error	Mean	Standard Deviation	Standard Error	p-value for Normal Distribution	p-value for Lognormal Distribution	Distribution*	Error Rate	Is Error Rate Less Than 25%?
Transportation	Ammonia	40	0.40	0.51	0.08	0.39	0.42	0.06	0.0001	0.3012	Lognormal	**16.4%**	Y
Transportation	Bis(2-ethylhexyl)phthalate	29	13.41	17.30	3.21	14.57	25.95	4.47	0.0001	0.8236	Lognormal	**30.7%**	N
Transportation	Dissolved Copper	52	31.70	21.14	2.93	33.77	31.58	4.28	0.0002	0.0123		**9.2%**	Y
Transportation	Dissolved Nickel	22	5.69	5.15	1.10	5.55	4.05	0.86	0.0001	0.0028		**19.3%**	Y
Transportation	Dissolved Phosphorus	47	0.32	0.20	0.03	0.35	0.31	0.04	0.0116	0.0083		**9.2%**	Y
Transportation	Dissolved Zinc	52	201.02	140.87	19.53	219.04	229.64	30.90	0.0001	0.0005		**9.7%**	Y
Transportation	NH3-N	39	0.34	0.43	0.07	0.33	0.35	0.05	0.0001	0.1621	Lognormal	**16.3%**	Y
Transportation	Nitrate	50	3.65	4.06	0.57	3.55	3.38	0.47	0.0001	0.6601	Lognormal	**13.2%**	Y
Transportation	Nitrate-N	49	0.96	1.29	0.18	0.92	1.04	0.14	0.0001	0.541	Lognormal	**15.6%**	Y
Transportation	Nitrite-N	50	0.10	0.07	0.01	0.10	0.08	0.01	0.0001	0.4081	Lognormal	**10.5%**	Y
Transportation	TKN	50	2.02	1.81	0.26	1.97	1.47	0.21	0.0001	0.2096	Lognormal	**10.4%**	Y
Transportation	Total Cadmium	26	1.40	1.22	0.24	1.39	1.14	0.22	0.0001	0.0032		**17.1%**	Y
Transportation	Total Chromium	31	6.70	5.46	0.98	6.64	5.55	0.98	0.0001	0.0021		**14.6%**	Y
Transportation	Total Copper	52	59.18	58.93	8.17	56.89	40.86	5.61	0.0001	0.1899	Lognormal	**9.9%**	Y
Transportation	Total Lead	37	15.03	19.40	3.19	14.60	20.91	3.25	0.0001	0.004		**21.2%**	Y
Transportation	Total Nickel	38	7.64	7.26	1.18	7.57	6.40	1.02	0.0001	0.0156		**15.4%**	Y
Transportation	Total Phosphorus	47	0.44	0.32	0.05	0.46	0.39	0.06	0.0001	0.2144	Lognormal	**12.2%**	Y
Transportation	Total Suspended Solids	50	90.76	108.00	15.27	86.19	81.14	11.22	0.0001	0.1717	Lognormal	**13.0%**	Y
Transportation	Total Zinc	52	306.96	296.30	41.09	297.66	220.71	30.26	0.0001	0.2052	Lognormal	**10.2%**	Y
Light Industrial	Ammonia	45	0.60	0.81	0.12	0.62	1.05	0.14	0.0001	0.0132		**20.1%**	Y
Light Industrial	Bis(2-ethylhexyl)phthalate	21	9.71	9.68	2.11	10.78	17.06	3.56	0.0007	0.6052	Lognormal	**33.1%**	N
Light Industrial	Dissolved Copper	39	14.12	10.02	1.60	14.86	14.34	2.25	0.0011	0.065	Lognormal	**15.1%**	Y
Light Industrial	Dissolved Nickel	23	5.40	4.18	0.87	5.52	4.76	0.98	0.0001	0.0784	Lognormal	**17.8%**	Y
Light Industrial	Dissolved Phosphorus	44	0.21	0.16	0.02	0.22	0.23	0.03	0.0001	0.1935	Lognormal	**14.9%**	Y
Light Industrial	Dissolved Zinc	47	360.66	373.51	54.48	428.35	682.33	92.09	0.0001	0.0002		**15.1%**	Y
Light Industrial	NH3-N	46	0.49	0.66	0.10	0.49	0.77	0.11	0.0001	0.0077		**19.9%**	Y
Light Industrial	Nitrate	46	4.44	4.56	0.67	4.38	4.72	0.67	0.0001	0.3263	Lognormal	**15.4%**	Y
Light Industrial	Nitrate-N	45	1.03	1.22	0.18	1.00	1.15	0.17	0.0001	0.4249	Lognormal	**16.6%**	Y
Light Industrial	Nitrite-N	46	0.09	0.07	0.01	0.09	0.06	0.01	0.0001	0.0687	Lognormal	**9.9%**	Y
Light Industrial	TKN	45	2.68	1.97	0.29	2.72	2.24	0.33	0.0001	0.7043	Lognormal	**12.1%**	Y
Light Industrial	Total Chromium	29	6.51	5.08	0.94	6.49	5.44	1.00	0.0001	0.0015		**14.5%**	Y
Light Industrial	Total Copper	47	47.66	141.91	20.70	35.11	41.24	5.78	0	0.0122		**43.4%**	N
Light Industrial	Total Lead	33	15.41	15.58	2.71	15.78	19.77	3.31	0.0001	0.1001	Lognormal	**21.0%**	Y
Light Industrial	Total Nickel	33	10.01	13.60	2.37	9.33	8.43	1.44	0.0001	0.0231		**23.6%**	Y
Light Industrial	Total Phosphorus	43	0.36	0.30	0.05	0.38	0.42	0.06	0.0001	0.3174	Lognormal	**16.4%**	Y
Light Industrial	Total Suspended Solids	42	174.33	192.35	29.68	179.77	203.07	30.28	0.0001	0.3733	Lognormal	**16.8%**	Y
Light Industrial	Total Zinc	47	491.64	543.39	79.26	488.33	428.35	61.37	0.0001	0.0384		**16.1%**	Y
Mixed Residential	Ammonia	28	0.83	0.88	0.17	0.98	1.90	0.33	0.0001	0.0834	Lognormal	**33.5%**	N
Mixed Residential	Dissolved Copper	27	16.70	21.06	4.05	17.16	24.94	4.58	0.0001	0.0205		**24.3%**	Y
Mixed Residential	Dissolved Phosphorus	25	0.23	0.21	0.04	0.24	0.26	0.05	0.0001	0.5799	Lognormal	**20.7%**	Y
Mixed Residential	Dissolved Zinc	27	178.63	216.58	41.68	174.09	193.27	36.25	0.0001	0.3782	Lognormal	**20.8%**	Y
Mixed Residential	NH3-N	28	0.69	0.73	0.14	0.80	1.51	0.26	0.0001	0.0479		**20.0%**	Y

Table ES-1c. Summary of Mean Standard Error of Land Use Stations

			Normal Distribution			Lognormal Distribution			Shapiro-Wilk Normality Test				
Land Use Type	Constituent	No. of Detections	Mean	Standard Deviation	Standard Error	Mean	Standard Deviation	Standard Error	p-value for Normal Distribution	p-value for Lognormal Distribution	Distribution*	Error Rate	Is Error Rate Less Than 25%?
Mixed Residential	Nitrate	24	9.91	31.61	6.45	7.29	15.48	2.90	0.0001	0.0001		**65.1%**	N
Mixed Residential	Nitrate-N	24	0.77	0.46	0.09	0.83	0.76	0.15	0.1754	0.0196	Normal	**12.4%**	Y
Mixed Residential	Nitrite-N	24	0.15	0.21	0.04	0.14	0.17	0.03	0.0001	0.187	Lognormal	**23.0%**	Y
Mixed Residential	TKN	29	3.04	2.67	0.49	3.51	4.85	0.86	0.0001	0.0048		**16.3%**	Y
Mixed Residential	Total Copper	27	23.82	29.68	5.71	22.81	21.64	4.10	0.0001	0.3478	Lognormal	**17.9%**	Y
Mixed Residential	Total Phosphorus	25	0.31	0.31	0.06	0.31	0.34	0.07	0.0001	0.6015	Lognormal	**21.2%**	Y
Mixed Residential	Total Suspended Solids	23	82.13	89.10	18.58	79.81	80.22	16.44	0.0001	0.3618	Lognormal	**20.6%**	Y
Mixed Residential	Total Zinc	27	255.96	342.39	65.89	236.79	245.20	46.19	0.0001	0.0226		**25.7%**	N
Multi-Family Residential	Ammonia	26	0.55	0.81	0.16	0.60	1.39	0.24	0.0001	0.008		**28.7%**	N
Multi-Family Residential	Bis(2-ethylhexyl)phthalate	17	30.04	54.21	13.15	29.61	78.55	17.98	0.0001	0.7204	Lognormal	**60.7%**	N
Multi-Family Residential	Dissolved Copper	26	9.26	7.29	1.43	9.47	8.52	1.65	0.0004	0.0487		**15.4%**	Y
Multi-Family Residential	Dissolved Zinc	26	118.50	158.83	31.15	112.38	119.44	22.91	0.0001	0.0778	Lognormal	**20.4%**	Y
Multi-Family Residential	NH3-N	26	0.47	0.67	0.13	0.48	1.00	0.18	0.0001	0.0086		**28.2%**	N
Multi-Family Residential	Nitrate	24	7.25	4.59	0.94	7.68	7.06	1.42	0.0741	0.0786	Normal	**12.9%**	Y
Multi-Family Residential	Nitrate-N	24	1.64	1.04	0.21	1.73	1.59	0.32	0.076	0.0787	Normal	**12.9%**	Y
Multi-Family Residential	Nitrite-N	24	0.13	0.20	0.04	0.11	0.10	0.02	0.0001	0.0332		**31.7%**	N
Multi-Family Residential	TKN	28	2.40	2.52	0.48	2.29	1.70	0.32	0.0001	0.1133	Lognormal	**13.9%**	Y
Multi-Family Residential	Total Copper	31	13.44	6.63	1.19	13.65	7.51	1.34	0.007	0.2523	Lognormal	**9.8%**	Y
Multi-Family Residential	Total Suspended Solids	23	60.87	77.51	16.16	58.52	79.87	16.07	0.0001	0.1461	Lognormal	**27.5%**	N
Multi-Family Residential	Total Zinc	31	173.90	235.31	42.26	164.12	185.23	32.31	0.0001	0.0611	Lognormal	**19.7%**	Y
Educational	Ammonia	28	0.23	0.21	0.04	0.25	0.33	0.06	0.0001	0.0001		**17.4%**	Y
Educational	Bis(2-ethylhexyl)phthalate	10	14.50	15.30	4.84	16.99	30.88	10.17	0.031	0.5983	Lognormal	**59.9%**	N
Educational	Dissolved Copper	29	15.00	13.28	2.47	15.19	14.54	2.65	0.0001	0.5367	Lognormal	**17.4%**	Y
Educational	Dissolved Phosphorus	25	0.29	0.26	0.05	0.29	0.25	0.05	0.0001	0.1323	Lognormal	**17.4%**	Y
Educational	Dissolved Zinc	24	78.58	64.44	13.15	79.32	67.24	13.57	0.0001	0.0103		**16.7%**	Y
Educational	NH3-N	28	0.20	0.17	0.03	0.21	0.24	0.04	0.0001	0.0002		**16.6%**	Y
Educational	Nitrate	26	3.05	1.86	0.36	3.15	2.35	0.46	0.0176	0.2314	Lognormal	**14.5%**	Y
Educational	Nitrate-N	25	0.65	0.35	0.07	0.65	0.37	0.07	0.0111	0.3601	Lognormal	**11.3%**	Y
Educational	TKN	27	1.81	1.31	0.25	1.78	1.00	0.19	0.0001	0.0522	Lognormal	**10.8%**	Y
Educational	Total Copper	29	28.89	42.45	7.88	25.73	21.75	3.99	0.0001	0.001		**27.3%**	N
Educational	Total Phosphorus	25	0.33	0.21	0.04	0.33	0.19	0.04	0.0001	0.287	Lognormal	**11.6%**	Y
Educational	Total Suspended Solids	27	120.44	110.41	21.25	140.69	217.18	39.59	0.0003	0.2178	Lognormal	**28.1%**	N
Educational	Total Zinc	29	155.90	286.82	53.26	137.70	148.76	26.94	0.0001	0.007		**34.2%**	N
HDSFR	Ammonia	22	0.48	0.52	0.11	0.56	1.04	0.21	0.0002	0.0179		**22.8%**	Y
HDSFR	Bis(2-ethylhexyl)phthalate	15	14.22	21.84	5.64	13.51	23.86	6.03	0.0001	0.1512	Lognormal	**44.6%**	N
HDSFR	Dissolved Copper	20	11.56	8.77	1.96	12.26	12.94	2.85	0.0295	0.0624	Lognormal	**23.2%**	Y
HDSFR	Dissolved Phosphorus	21	0.34	0.17	0.04	0.34	0.20	0.04	0.1261	0.5482	Normal	**11.2%**	Y
HDSFR	NH3-N	22	0.43	0.42	0.09	0.50	0.84	0.17	0.0009	0.0137		**20.8%**	Y
HDSFR	Nitrate	21	5.29	6.32	1.38	5.07	5.51	1.18	0.0001	0.3442	Lognormal	**23.3%**	Y
HDSFR	Nitrate-N	21	1.19	1.43	0.31	1.15	1.26	0.27	0.0001	0.3775	Lognormal	**23.5%**	Y
HDSFR	TKN	25	3.20	3.30	0.66	3.13	2.93	0.58	0.0001	0.3953	Lognormal	**18.4%**	Y
HDSFR	Total Copper	26	23.06	16.35	3.21	23.81	20.22	3.92	0.0027	0.3238	Lognormal	**16.5%**	Y

Table ES-1c. Summary of Mean Standard Error of Land Use Stations

			Normal Distribution			Lognormal Distribution			Shapiro-Wilk Normality Test				
Land Use Type	Constituent	No. of Detections	Mean	Standard Deviation	Standard Error	Mean	Standard Deviation	Standard Error	p-value for Normal Distribution	p-value for Lognormal Distribution	Distribution*	Error Rate	Is Error Rate Less Than 25%?
HDSFR	Total Lead	19	20.70	23.68	5.43	23.08	44.50	9.69	0.0005	0.0348		**26.3%**	N
HDSFR	Total Phosphorus	21	0.48	0.33	0.07	0.50	0.39	0.09	0.0081	0.7729	Lognormal	**17.1%**	Y
HDSFR	Total Suspended Solids	19	131.58	124.69	28.61	135.80	141.49	31.99	0.0001	0.8471	Lognormal	**23.6%**	Y
HDSFR	Total Zinc	26	87.31	64.89	12.73	90.24	86.31	16.64	0.0027	0.0028		**14.6%**	Y
Commercial	Ammonia	30	6.54	6.46	1.18	8.32	18.85	3.06	0	0.143	Lognormal	**36.8%**	N
Commercial	Dissolved Chromium +6	26	12.28	9.03	1.77	12.57	10.57	2.05	0.002	0.857	Lognormal	**16.3%**	Y
Commercial	Dissolved Copper	26	247.83	590.58	115.82	414.86	3219.04	452.17	0	0.029		**46.7%**	N
Commercial	Dissolved Phosphorus	31	78.17	75.95	13.64	787.73	26264.38	2415.90	0	0		**17.5%**	Y
Commercial	Dissolved Zinc	22	68.15	69.89	14.90	92.22	259.13	49.32	0.003	0.021		**21.9%**	Y
Commercial	NH3-N	27	0.23	0.31	0.06	0.22	0.24	0.05	0	0.17	Lognormal	**20.5%**	Y
Commercial	Nitrate	30	49.40	47.53	8.68	53.60	77.85	13.50	0	0.108	Lognormal	**25.2%**	N
Commercial	Nitrate-N	30	3.55	3.23	0.59	3.55	3.50	0.63	0	0.169	Lognormal	**17.6%**	Y
Commercial	Nitrite-N	27	386.03	371.19	71.44	1943.80	24569.04	3072.04	0.001	0		**18.5%**	Y
Commercial	TKN	32	196.34	216.73	38.31	1009.66	19221.47	1781.57	0	0		**19.5%**	Y
Commercial	Total Cadmium	12	5.59	3.62	1.05	5.73	4.24	1.22	0.038	0.171	Lognormal	**21.4%**	Y
Commercial	Total Chromium +6	26	29.77	19.61	3.85	30.33	23.07	4.49	0.009	0.788	Lognormal	**14.8%**	Y
Commercial	Total Copper	37	714.73	1044.99	171.80	950.54	3720.60	466.62	0	0.063	Lognormal	**49.1%**	N
Commercial	Total Lead	13	42.46	42.08	11.67	42.70	45.55	12.59	0.002	0.225	Lognormal	**29.5%**	N
Commercial	Total Mercury	14	5.20	3.39	0.91	5.46	4.67	1.24	0.071	0.17	Normal	**17.4%**	Y
Commercial	Total Phosphorus	32	5.84	2.80	0.49	12.11	41.12	5.89	0	0		**8.5%**	Y
Commercial	Total Suspended Solids	29	11.30	25.91	4.81	10.07	311.76	33.05	0	0		**42.6%**	N
Commercial	Total Zinc	11	251.73	115.79	34.91	255.29	129.70	39.11	0.303	0.681	Normal	**13.9%**	Y
Vacant	Bis(2-ethylhexyl)phthalate	20	20.96	37.70	8.43	21.93	58.24	11.90	0.0001	0.2674	Lognormal	**54.3%**	N
Vacant	Nitrate	35	5.95	3.31	0.56	6.03	3.89	0.65	0.0025	0.0541	Lognormal	**10.8%**	Y
Vacant	Nitrate-N	35	1.34	0.75	0.13	1.36	0.88	0.15	0.0025	0.0543	Lognormal	**10.9%**	Y
Vacant	Nitrite-N	20	0.04	0.02	0.00	0.04	0.02	0.00	0.0001	0.2195	Lognormal	**8.7%**	Y
Vacant	TKN	35	1.16	2.23	0.38	1.01	0.97	0.16	0.0001	0.0261		**32.3%**	N
Vacant	Total Copper	25	13.98	15.98	3.20	13.67	17.48	3.38	0.0001	0.0364		**22.9%**	Y
Vacant	Total Phosphorus	24	0.13	0.15	0.03	0.12	0.12	0.02	0.0001	0.0143		**23.6%**	Y
Vacant	Total Suspended Solids	33	149.36	227.54	39.61	186.07	817.22	107.23	0.0001	0.0266		**26.5%**	N
Vacant	Total Zinc	20	48.40	50.95	11.39	46.40	40.40	8.95	0.0001	0.0114		**23.5%**	Y

* If a constituent is neither normal nor lognormal, we assume that it is normal.

HDSFR = High Density Single Family Residential

The Integrated Receiving Water Impacts Report is a requirement of the Los Angeles County Municipal Stormwater Permit No. CAS0061654. Part VII.D of the Permit states:

"The Principal Permittee shall not later than July 31, 2000, prepare and submit an Integrated Receiving Water Impacts Report. The report shall include, but not be limited to a comprehensive analysis of the results of the different monitoring data (land use, mass emissions, critical source, load assessment, receiving waters, and other pertinent studies available), and feasible environmental indicators. It should also include recommendations on future monitoring requirements, e.g., integration of storm water receiving water monitoring with regional receiving water monitoring, if applicable. This report will be an integral part of the ROWD."

1.1 PURPOSE

The goal of the Monitoring Program is to develop information to support effective watershed stormwater quality management programs. The purpose of these management programs is to reduce pollutants in stormwater discharges to the maximum extent practicable. The major objectives of the Monitoring Program outlined in the Municipal Permit are to:

- track water quality status, pollutant trends and pollutant loads, and identify pollutants of concern;
- monitor and assess pollutant loads from specific land uses and watershed areas;
- identify, monitor, and assess significant water quality problems related to stormwater discharges within the watershed;
- identify sources of pollutants in the stormwater runoff;
- identify and eliminate illicit discharges;
- evaluate the effectiveness of management programs, including pollutant reductions achieved by implementation of BMPs; and
- assess the impacts of stormwater runoff on receiving waters.

These objectives are met through three major types of monitoring and additional studies as their need arises.

1.2 REPORT ORGANIZATION

Section 2 contains a brief history of the station selection process and site descriptions. Maps and tabular descriptions of the tributary areas of each monitored watershed are displayed as Figures 2-1 through 2-14. Section 3 covers methods used for measuring, sampling and analyzing stormwater. Section 4 presents and interprets results, and Section 5 draws conclusions and makes recommendations.

Tables and figures are labeled with two numbers. The first identifies their corresponding section number, and the second is for identification only.

Appendix A contains rainfall contour maps. Program costs are included in Appendix B. An Executive Summary of the Santa Monica Bay Receiving Waters Study by SCCWRP is included in Appendix C. Appendices D and E contain the Low Flow and Wide Channel Pilot Studies respectively. River Toxicity Test results are included in Appendix G. Aerial Deposition Progress Reports are included in Appendix H. A list of people to contact for more information is included in Appendix I.

1.3 RECAP OF MAJOR MONITORING ELEMENTS

The 1994-95 storm season was the first for which stormwater monitoring was accomplished under the 1990 Los Angeles County NPDES Municipal Stormwater Permit, No. CA0061654. During the 1994-95 and 1995-96 seasons, automated and manual sampling was conducted to characterize stormwater quality and quantity in accordance with the 1990 Municipal Permit. The 1994-95 monitoring data is summarized in *Report of Stormwater Monitoring, Winter of 1994-95* (LACDPW, 1996).

The 1996-97 season was the first storm season in which stormwater monitoring was conducted under the new 1996 Municipal Permit (No. CAS614001). For the 1996-97 season the scope of the Monitoring Program was expanded to incorporate further data collection and new pilot studies. The one-year pilot studies, consisting of "Wide Channel" and "Low Flow" analyses, were completed and reported in the *Los Angeles County 1996-97 Stormwater Monitoring Report, July 15, 1997* (LACDPW and Woodward-Clyde, 1997) and are reproduced in Appendices D and E.

The monitoring program, including the Mass Emission, Land Use, and Critical Source elements continued in the 1997-98, 1998-99 and 1999-2000 storm seasons. The 1998-99 storm season also included funding from the Los Angeles County Department of Public Works (LACDPW) to the Southern California Coastal Waters Research Project (SCCWRP) to study the impacts to receiving waters by aerial deposition of pollutants.

At the request of the Natural Resources Defense Council (NRDC), the 1998-99 and 1999-2000 reports include results of the industrial stormwater permit sampling within the county. Due to the limitations of the data set, only summaries of maximum and minimum results can be provided.

In an effort to analyze the presence of PAH in stormwater, Los Angeles County Public Works lowered the detection limit of semi-volatile organics in stormwater samples in the 1999-2000 season by using modified EPA method 625.

1.3.1 Santa Monica Bay Receiving Waters Impact Study

The Santa Monica Bay Receiving Waters Impact Study was conducted for three consecutive storm seasons (1995-98). Three components were studied:

- Stormwater plume characterization
- Water column biology
- Seafloor biology

High turbidity and low salinity characterized stormwater plumes. Generally, the stormwater plumes extended 2-10 meters below the surface and up to several miles offshore. They also persisted for several days.

Toxicity tests found toxic concentrations of dissolved materials in the water column. Zinc was the main toxicant identified in stormwater. There was also toxicity detected from sources other than stormwater.

The benthic community structure remained stable throughout the study. However, there was a high accumulation of contaminants in sea urchins offshore of Ballona Creek. The effects of the bioaccumulation are unknown.

The executive summary is presented in Appendix C, and is excerpted from the *Study of the Impact of Stormwater Discharge on the Beneficial Uses of Santa Monica Bay, July 8, 1999* (SCCWRP, 1999).

1.3.2 Mass Emissions

Mass emission stations capture runoff from major Los Angeles County watersheds that generally have heterogeneous land use. There were ten mass emission stations during the 1990 Municipal Permit and there were five under the 1996 permit. The objectives of the mass emissions stations are to update estimated pollutant loads to the ocean and to identify long term trends in pollutant concentrations, if possible. Four mass emission stations under the 1990 Municipal Permit were equipped with automated samplers to collect composite samples during storms. Grab samples were also taken at these stations. All five mass emission stations under the 1996 NPDES permit had automated samplers where composite and grab samples were taken in accordance with the Municipal Permit.

During the 1998-99 storm season, the station shelter on the Los Angeles River at Wardlow Road was under reconstruction during the entire season due to the raising of the levee walls by the Army Corps of Engineers (ACOE), and the automated sampling equipment was removed. Water quality samples from the Los Angeles River were collected manually at Wardlow Road and were not composited. Results from these manually collected samples were not included in event mean concentration (EMC) calculations. Stream flow data for the Los Angeles River at Wardlow Road was synthesized from three upstream flow stations.

1.3.2.1 Pollutant Loading

Total pollutant loading, as a result of stormwater runoff was first calculated under the 1990 NPDES permit for the 1994-95 storm season. The results were presented in the *Report of Stormwater Monitoring, Winter of 1994-95* (Los Angeles County Department of Public Works, March 1996).

The 1996 NPDES permit in its Section B.4, Attachment C, states that a loads assessment for each of the six WMA's is to be conducted following the 1998-99 storm season. Results were presented in the *Los Angeles County 1998-99 Stormwater Monitoring Report* (Los Angeles County Department of Public Works, July 1999). For those rivers where mass emissions were monitored, loads were calculated from observed flow volumes and observed pollutant concentrations. For those drainage areas that were not monitored, a newly developed GIS model was employed to estimate loads.

Summaries of Total Pollutant Loading, including data from the 1999-2000 storm season, are included in this report.

1.3.3 Land Use Program

The drainage area tributary to each land use monitoring station is comprised predominantly of a single land use and is relatively homogeneous. The major objectives of this monitoring effort are to evaluate the effects of certain land uses on water quality, to identify the relative importance of specific land uses as pollution sources, and to provide data that can be used to project watershed loads from watersheds that do not have mass emission stations.

There were 14 land use monitoring stations under the 1990 Municipal Permit. Five of these stations were equipped with automated samplers to collect composite samples during storms. The 1996 NPDES permit required the re-evaluation of the location of land use specific monitoring stations. The land use monitoring program under the 1996 NPDES permit is a result of a site selection study entitled *Evaluation of Land Use Monitoring Stations* (Woodward-Clyde and Psomas and Associates, 1996). The study identified the most significant land use categories within the permit area regarding stormwater quality. The selection study yielded eight land use stations. These eight land use categories represent over 86% of all the land use within the permit area. These stations monitor flow and have automated samplers to collect flow weighted composite stormwater samples during storm events.

The Santa Monica Pier station was down due to construction during the 1999-2000 storm season.

1.3.4 Critical Sources

The Critical Source/BMP Monitoring Study was introduced under the 1996 NPDES permit and is designed to gather baseline water quality data and assess the effectiveness of BMP implementation for critical industries and businesses. A list of critical sources were identified and ranked by their potential significance to stormwater quality (Woodward-Clyde, 1997) and are listed below:

Industrial Category	SIC code	Industrial Stormwater Permits*
• Wholesale trade (including scrap yards and auto dismantling)	50	Yes
• Automotive repair/parking	75	No
• Fabricated metal products (including electroplating)	34	Yes
• Motor freight (including trucking)	42	Yes
• Chemical manufacturing facilities	28	Yes
• Automotive dealers/gas stations	55	No
• Electric/gas/sanitary	49	No
• Miscellaneous manufacturing	39	Yes

* Industrial facilities requiring general industrial stormwater permits.

For each critical source industry, there is a multi-year study monitoring the stormwater runoff from six sites. During the first year of each study, runoff is sampled and analyzed from five storms. During subsequent years, BMPs are implemented at three of the six sites (test sites). BMP effectiveness is estimated from monitoring data gathered at the pooled test sites and pooled control sites during ten additional storms. A complete study plan is included in *Critical Source Selection and Monitoring Report* (Woodward-Clyde, 1997).

The first critical source monitoring was conducted during the 1997-98 storm season. Sites at six automotive repair shops and six auto dismantlers were monitored. These sites, plus six fabricated metal shops were monitored during the 1998-99 storm season. Six motor freight companies and six automobile dealers were added during the 1999-2000 storm season.

1.4 OTHER STUDIES

Two pilot studies were conducted during the 1996-97 storm season to identify a potential need for modifying monitoring practices. Both studies concluded that existing practices were satisfactory.

Other studies were conducted to explore the effects by aerial deposition, El Niño climatology on stormwater quality, and river toxicity.

1.4.1 Wide Channel Pilot Study

The Wide Channel Pilot Study was developed to evaluate the accuracy of a single point intake in wide channels. Samples were taken at the same time at various depths and widths across the channel to determine the level of mixing achieved.

1.4.2 Low Flow Pilot Study

The Low Flow Pilot Study was conducted to assess the feasibility of monitoring storms as small as 0.1 inches of rainfall. An existing land use monitoring station (Project 1202, Light Industrial) was used for this study.

1.4.3 Aerial Deposition

Data is currently being accumulated to estimate toxic loads deposited into the Santa Monica Bay and inland from atmospheric sources. The Data Assessment Report is scheduled for completion in September 2000. Quarterly progress reports are included in the 1998-99 Los Angeles County Stormwater Monitoring Report and herein Appendix H.

This year, the US EPA, Los Angeles County Department of Public Works, and Southern California Coastal Waters Research Project (SCCWRP) are funding the project. Other parties involved include UCLA's Institute of the Environment, the Santa Monica Bay Restoration Project (SMBRP), the US EPA's Great Water Program, and the South Coast Air Quality Management District (AQMD).

1.4.4 El Niño Study by SCCWRP

The objective of this research was to determine whether El Niño conditions influenced the toxicity of Ballona Creek stormwater or the characteristics of the stormwater discharge plume in Santa Monica Bay. The results indicated that storm size and cumulative amount of prior rainfall had little influence on stormwater toxicity. However, stormwater from rainfall preceded by more than 20 days of dry weather was found to have the highest toxicity. This relationship appeared to be independent of El Niño weather patterns.

The executive summary of the El Niño Study appears in Appendix F.

1.4.5 River Toxicity

During the 1997-98 and 1998-99 storm seasons, tests were conducted for toxicity of samples of dry and wet weather flow from the Los Angeles and San Gabriel Rivers. This testing was performed by the Southern California Coastal Waters Research Project. Toxicity was measured as impairment to sea urchin fertilization.

More details on the study are presented in Appendix G. A summary of finding is listed in Section 4.2.3.

To characterize the quality of stormwater runoff in Los Angeles County, sampling of single Land Use sites and large area Mass Emissions sites has been performed under the 1990 and the 1996 NPDES permits.

2.1 1990 NPDES PERMIT – SAMPLING SITES

2.1.1 Automated Sampling Program - 1990 NPDES permit

Starting in January 1995, in compliance with Phase I requirements of the 1990 NPDES stormwater permit, nine automated sampling stations began sampling runoff from combinations of mass emissions and land use specific watersheds within the Santa Monica Bay drainage area. Phases II and III added 15 more inland stations in 1995-1996. The 24 stations were:

Location	Land Use/ Mass Emission
Ballona Creek, Culver Dr. and Beloit Ave., City of Los Angeles.	Mass Emissions
Malibu Creek, Malibu Cyn. Rd. s/o Piuma Rd., Los Angeles Co.	Mass Emissions
Trancas Canyon, North end of Paseo Cyn. Dr., City of Malibu*	Open Space/Rec.
Kenter Cyn. Drain, Main St. and Colorado Ave., City of Santa Monica.*	Mass Emissions
Bond Issue Proj. 1105, Herondo St. and Valley Dr., City of Redondo Beach*	Mass Emissions
Bond Issue Proj. 558, Paseo Lunado and Via Anacapa, City of Palos Verdes Estates.*	Single Family Residential
Bond Issue Proj. 5401, Redondo Ave. and 11th St., City of Manahattan Beach*	Single Family Residential
Santa Monica Pier Drain, Appian and Moss Ave, City of Santa Monica.	Commercial
Drain No. 2361, Grand Ave. and 21st St., City of Los Angeles.*	Industrial /Commercial
Coyote Creek, below Spring Street, City of Long Beach	Mass Emissions
Rio Hondo Channel, Above Beverly Blvd., Pico Rivera	Mass Emissions
Los Angeles River, at Tujunga Ave., City of Los Angeles	Mass Emissions

Location	Land Use/ Mass Emission
Bouquet Creek, Upstream of Newhall Ranch Rd., Private Drain No. 2225, Santa Clarita.	Mass Emissions
San Gabriel River, downstream of San Gebriel River Parkway, Pico Rivera	Mass Emissions
Browns Creek, Rinaldi Street, Chatsworth*	Open Space Recreation
Monrovia Creek/Sawpit Creek, Arcadia	Open Space Recreation
Project 1402, Near Foothill Blvd. And Don Diablo Dr., Arcadia*	Low Density Single Family Residential
Project 3857, Near Hamlin St. and Oso Ave., Warner Center*	High Density Single Family Residential
Project 620, near Glenwood Rd. and Bruce Ave., Glendale	High Density Single Family Residential
Project 1, near Alcoa Ave. and Randolph St, Vernon *	Industrial
Dominguez Channel, near 116th St. and Isis Ave. Lennox	Transportation
Private Drain 314, near Firestone Blvd. And Phoebe Ave., La Mirada*	Commercial
Project 1202, near Wilmington Ave. and 220th St., Carson	Industrial
Los Angeles River, between Willow St. and Wardlow Rd., City of Long Beach	Mass Emissions

* Discontinued under 1996 permit.

2.2 1996 NPDES PERMIT – SAMPLING SITES

2.2.1 SITE SELECTION

2.2.1.1 Mass Emission Site Selection

The Department of Public Works monitored four major drainage areas near their outfalls to the ocean. Four of the mass emission monitoring stations installed under the original 1990 Permit were retained under the 1996 Permit; specifically the Los Angeles River, San Gabriel River, Ballona Creek, and Malibu Creek. The Coyote Creek mass emission station, which was required under the 1990 Permit but not under the 1996 Permit, was also monitored during the 1997-98, 1998-99, and 1999-2000 seasons. This station was retained in the program to provide data for the calculation of mass loading in the San Gabriel River watershed. The five mass emission monitoring stations were used to collect water quality data from over 1619 square miles and have produced the data used to calculate total loading to the ocean from these watersheds.

During the 1998-99 season, the station shelter on the Los Angeles River at Wardlow Road was under reconstruction during the entire season due to the raising of the levee walls by ACOE, and the automated sampling equipment was removed. Samples from the Los Angeles River were collected manually and were not composited. This station has been reinstalled and was fully operational for 1999-2000 season.

For mass emission sites, the Permit requires sampling a minimum of five events per station per year. These sampling events may be either dry weather or wet weather events. The Los Angeles and San Gabriel River stations were also the sites of the freshwater toxicity testing required by the permit. The 1998-99 season was the final season for freshwater toxicity testing.

2.2.1.2 Land Use Site Selection

The following is a brief summary of the land use site selection process completed between the spring and fall of 1996. The complete methods and results of this study are provided in *Evaluation of Land Use Monitoring Stations* (Woodward-Clyde and Psomas and Associates, 1996).

An initial list of 104 land use types based on the Southern California Association of Governments (SCAG) database was sorted into 37 categories. Of these, the top 12 urban uses based on total area were chosen for a field survey. The survey was performed to identify characteristics that would assist in the aggregation or subdivision of the 12 top land use categories. For each of the 12 land uses, 8 representative areas no larger than a city block were selected for the field survey during the spring of 1996. One issue investigated in the field surveys was whether the age of a development of high-density single family residential areas warranted additional monitoring sites. However, the survey indicated that there were no apparent differences between the five different age categories for high-density single-family residential land use so this land use was considered one category.

A loading model for all land uses was applied for four constituents (copper, phosphorus, COD, and TSS). The model used local and regional field-derived estimates of imperviousness and water quality. For each constituent, the land use categories were ranked by total loading. A marginal benefit analysis was applied to the ranked land uses to determine the most important for monitoring. The top land use types that ranked above or equal to the land use with the maximum marginal benefit were identified for monitoring. They were:

- Vacant
- High Density Single Family Residential
- Light Industrial
- Transportation
- Retail/Commercial
- Multifamily Residential
- Educational Facilities

The first 5 of the 7 land use types listed above (Vacant, High Density Single Family Residential, Light Industrial, Transportation, and Retail/Commercial) were already being monitored under the

1990 Municipal Permit. To comply with the terms of the 1996 Permit, one site for each of these land uses was retained for continued sampling; the remaining sites were dismantled. New stations to monitor the last two land use types, Multifamily Residential and Educational Facilities, were installed in February 1997 and were operational for the 1997-98, 1998-99, and 1999-2000 storm seasons.

In addition to the pollutant loading analysis, land uses were also ranked by total area within each of the six major Los Angeles County watershed management areas. Four land use types not already on the list were then identified as having significant area in one or more of the watersheds (i.e., ranking in the top five land uses), as follows:

- Heavy Industrial
- Rural Residential
- Utility Facilities
- Mixed Residential

On the basis of this analysis, one mixed residential land use station was installed in October 1997 and was operational for the 1997-98, 1998-99, and 1999-2000 storm seasons; all eight land use monitoring stations were operational during the 1998-99 and seven land use monitoring stations were operational during 1999-2000 season. The Retail/Commercial monitoring station on Pier Drain in Santa Monica (S08) was dismantled and not in use in 1999-2000 storm season, with prior approval from the RWQCB, to accommodate construction by the City of Santa Monica of its stormwater treatment plant.

2.2.1.3 Critical Source Site Selection

The following is a brief summary of the Critical Source selection process undertaken to identify five industrial and/or commercial critical source sites. Each critical source type is to be monitored for a minimum of two years, the first year without BMPs, and subsequent years with BMPs. The complete methods and results of this study are provided in *Critical Source Selection and Monitoring Report* (Woodward-Clyde, 1997).

Similar to the land use monitoring evaluation process, the County undertook a five step process to identify and prioritize a list of critical industries within the county that may contribute significant pollutants to stormwater runoff. Standard Industrial Classification (SIC) codes played a major role in the selection process. Once selected, appropriate sites would be monitored over a minimum two year period for the duration of the permit to measure runoff quality with and without remedial cleanup actions. These remedial actions are referred to as Best Management Practices, or BMPs.

The first step was to develop an initial list of candidate industries. This list contained industries both included and excluded under the State's General Industrial Activities Stormwater permit process. Initial candidate selection was based on prevalence in the county and the extent of outdoor activities. The resulting list yielded a group of 30 candidate industries ranked by the number of facilities.

The next step involved developing a set of criteria to prioritize the list. A number of empirical factors were used to assign levels of significance to each SIC category. Loading (Q) would be addressed by the number of sources at a site and the likelihood of release. Imperviousness (R) of a site would be represented by the percent of paved area. Pollutant toxicity (T) would be denoted by the number of toxic pollutants and the inherent toxicity of the mix. An exposure factor (E) signifies if activities are exposed to rainfall. And finally, number (N) would represent the total number of sites in the county. Each variable would be assigned a qualitative number from 1 to 10, with 10 representing the worst condition. The pollutant potential (P) used to rank the results would thus be the product of all the factors, or

$P = Q \times R \times T \times E \times N$

Based on this ranking scheme, the top "critical source" industries were:

- Wholesale Trade (scrap and auto dismantling)
- Automotive Repair/Parking
- Fabricated Metal Products
- Motor Freight
- Automobile Dealers
- Chemical Manufacturing
- Electric/Gas/Sanitary
- Miscellaneous Manufacturing

A literature search was simultaneously conducted to identify what "critical source" industries, if any, have already been analyzed. The search revealed that similar stormwater studies had yet to be performed.

After the identification and prioritization, the Department then had the task of finding six companies of any one of the top five industries to enlist for monitoring runoff from five storms during the 1996-97 storm season. However, all six companies could not be enlisted until the end of that storm season, too late for the collection of runoff data. In 1997-98, twelve companies from two industries, automobile repair and auto dismantling, were enlisted. In the 1998-99 storm season, six companies from the metal fabrication industry were added. In the 1990-2000 storm season, half of the first three critical source industries designated as test sites were fitted with structural or nonstructural BMP at the Department's expense. The other half will remain as controls in order to evaluate BMP effectiveness. In addition, twelve companies from two industries, motor freight and automobile dealers, were enlisted for the 1999-2000 season. Sampling will continue for six years until five critical source industries and remedial BMPs are tested and evaluated.

2.2.2 LOCATION AND DRAINAGE AREA DESCRIPTIONS

Figure 2-1 is an overview of the study area with all mass emission and land use monitoring sites shown. Table 2-1 also indicates the dominant land use associated with each monitoring site and the total drainage area.

2.2.2.1 Mass Emission Monitoring Sites

Provided below is a description of the four mass emission stations required by the 1996 Municipal Permit (Ballona Creek, Malibu Creek, Los Angeles River, and San Gabriel River) and one additional mass emission station (Coyote Creek) which is not specifically required. Figures 2-2 through 2-6 show the location of each monitoring station along with a description of its land use and 1990 population.

Ballona Creek Monitoring Station (S01)

The Ballona Creek monitoring station is located at the existing stream gage station (Stream Gage No. F38C-R) between Sawtelle Boulevard and Sepulveda Boulevard in the City of Los Angeles. At this location, which was chosen to avoid tidal influences, the upstream tributary watershed of Ballona Creek is 88.8 square miles. The entire Ballona Creek Watershed is 127.1 square miles. At the gauging station, Ballona Creek is a concrete lined trapezoidal channel.

Malibu Creek Monitoring Station (S02)

The Malibu Creek monitoring station is located at the existing stream gage station (Stream Gage No. F130-9-R) near Malibu Canyon Road, south of Piuma Road. At this location, the tributary watershed to Malibu Creek is 104.9 square miles. The entire Malibu Creek Watershed is 109.9 square miles.

Los Angeles River Monitoring Station (S10)

The Los Angeles River Monitoring Station is located at the existing stream gage station (Stream Gage No. F319-R) between Willow Street and Wardlow Road in the City of Long Beach. At this location, which was chosen to avoid tidal influences, the total upstream tributary drainage area for the Los Angeles River is 825 square miles. This river is the largest watershed outlet to the Pacific Ocean in Los Angeles County. At the site, the river is a concrete lined trapezoidal channel.

San Gabriel River Monitoring Station (S14)

The San Gabriel River Monitoring Station is located at an historic stream gage station (Stream Gage No. F263C-R), below San Gabriel River Parkway in Pico Rivera. At this location the upstream tributary area is 450 square miles. The San Gabriel River, at the gauging station, is a grouted rock-concrete stabilizer along the western levee and a natural section on the eastern side. Flow measurement and water sampling are conducted in the grouted rock area along the western levee of the river. The length of the concrete stabilizer is nearly 70 feet. The San Gabriel River sampling location has been an active stream gauging station since 1968.

Coyote Creek Monitoring Station (S13)

The Coyote Creek Monitoring Station is located at the existing ACOE stream gage station (Stream Gage No. F354-R) below Spring Street in the lower San Gabriel River watershed. Although this site is not required for monitoring per the NPDES Permit, the site was added to assist in determining mass loading for the San Gabriel River watershed. At this location, the upstream tributary area is 150 square miles (extending into Orange County). The sampling site was chosen to avoid backwater effects from the San Gabriel River. Coyote Creek, at the gauging station, is a concrete lined trapezoidal channel. The Coyote Creek sampling location has been an active stream gauging station since 1963.

2.2.2.2 Land Use Monitoring Sites

The following is a description of the locations selected to monitor runoff from land-use specific drainage areas. Figures 2-7 through 2-14 show the location and drainage area of each monitoring station along with a description of its land use and 1990 population.

Santa Monica Pier Storm Drain Monitoring Station (S08)

The Santa Monica Pier Storm Drain Monitoring Station monitors runoff from land use that is predominantly commercial. The monitoring site is located near the intersection of Appian Way and Moss Avenue in Santa Monica. This storm drain discharges below the Santa Monica Pier. The Santa Monica Mall and Third Street Promenade dominate this watershed. The remaining land uses include: commercial office buildings, small shops, restaurants, hotels, and high density apartments. However, This station was dismantled and not in use in the 1999-2000 storm season to accommodate construction by city of Santa Monica's stormwater treatment plant.

Sawpit Creek Monitoring Station (S11)

The Sawpit Creek Monitoring Station is located in the Los Angeles River Watershed in the City of Monrovia. The monitoring station is in Sawpit Creek, downstream of Monrovia Creek. Sawpit Creek is a natural watercourse at this location. The overall watershed land use is predominantly vacant.

Project 620 Monitoring Station (S18)

The Project 620 Monitoring Station is located in the Los Angeles River Watershed in the City of Glendale. The monitoring station is at the intersection of Glenwood Road and Cleveland Avenue. The overall watershed land use is predominantly high density single family residential.

Dominguez Channel Monitoring Station (S23)

The Dominguez Channel Monitoring Station is located within the Dominguez Channel/ Los Angeles Harbor Watershed in Lennox, near Los Angeles International Airport (LAX). The monitoring station is near the intersection of 116th Street and Isis Avenue. The overall watershed land use is predominantly transportation, and includes areas of LAX and Interstate 105.

Project 1202 Monitoring Station (S24)

The Project 1202 Monitoring Station is located in the Dominguez Channel/Los Angeles Harbor Watershed in the City of Carson. The monitoring station is near the intersection of Wilmington Avenue and 220th Street. The overall watershed land use is predominantly industrial.

Project 474 Monitoring Station (S25)

The Project 474 Monitoring Station is located in the Los Angeles River Watershed in the Northridge section of the City of Los Angeles. The monitoring station is located along Lindley Avenue, one block south of Nordhoff Street. The station monitors runoff from the California State University of Northridge. The land use of the drainage area is primarily education.

Project 404 Monitoring Station (S26)

The Project 404 Monitoring Station is located within the Los Angeles River Watershed in the City of Arcadia. The monitoring station is located along Duarte Road, between Holly Avenue and La Cadena Avenue. The land use of the drainage area is primarily multi-family residential.

Project 156 Monitoring Station (S27)

The Project 156 Monitoring Station is located within the Los Angeles Watershed in the City of Glendale. The monitoring station is located along Wilson Avenue, near the intersection of Concord Street and Wilson Avenue. The land use of the drainage area is classified as mixed residential.

2.2.2.3 Critical Source Monitoring Sites

The general locations of the critical source monitoring sites are shown in Figure 2-15. For purposes of anonymity, the agreement reached with each of the businesses keeps the exact locations confidential. Sites C01, C02, and C03 are the control sites for the wholesale trade (auto dismantlers); T01, T02, and T03 are the sites where Best Management Practices (BMPs) will be installed for the wholesale trade industry. Similarly, C04, C05, and C06 are the control sites for automotive repair, while T04, T05, and T06 are the BMP sites for the automotive repair industry. Sites C07, C08, and C09 are the control sites for fabricated metal products; T07, T08, and T09 are the BMP sites for the fabricated metal products industry. Sites C10, C11, and T12C are the control sites for motor freight companies; T10, T11A, T11B, T12A, T12B, and T12C are the BMP sites for the motor freight companies. Sites C13, C14, and C15 are the control sites for the auto dealers; T13, T14, and T15 are the BMP sites for the auto dealers.

This section describes the field and laboratory methods used to conduct the Monitoring Program, which includes precipitation and flow monitoring, stormwater sampling, and laboratory analyses. It also includes statistical test criteria as described in the NPDES permit.

3.1 PRECIPITATION AND FLOW MEASUREMENT

3.1.1 Precipitation Monitoring

For every monitoring station, a minimum of one automatic tipping bucket (intensity measuring) rain gage is located nearby or within the tributary watershed. Large watersheds may require multiple rain gages to accurately characterize the rainfall. The Los Angeles County Department of Public Works operates various automatic rain gages throughout the county. Existing gages near the monitored watersheds are also utilized in calculating stormwater runoff and are essential to develop runoff characteristics for these watersheds.

3.1.2 Flow Monitoring

Flow monitoring equipment is needed to trigger the automated samplers because the Monitoring Program requires flow-weighted composites for many constituents. Flows are determined from measurements of water elevation as described below.

The water elevation in a storm drain is measured by the stage monitoring equipment, and the flow rate is derived from a previously established rating table for the site or calculated with an equation such as Manning's. The Los Angeles County Department of Public Works uses rating tables generated from analysis of storm drain cross sections and upstream/downstream flow characteristics. The rating tables are modified if it is demonstrated in the field through stream velocity measurements that calculated table values are incorrect. Previous stormwater flow measurement efforts indicates that all stations will require multiple storm events to gather the data necessary for calibration of the measurement devices.

The automatic samplers utilize pressure transducers as the stage measurement device. However, pressure transducers are only accurate as flow measurement devices in open channel flow regimes. Therefore, for stations monitoring flows in underground storm drains, efforts were made to select drains that do not surcharge (flow under pressure) during events smaller than a 10-year storm event.

3.2 STORMWATER SAMPLING

3.2.1 Sample Collection Methods

Grab and composite sample collection methods, defined below, are used to collect samples.

- **Grab Sample** - a discrete, individual sample taken within a short period of time, usually less than 15 minutes. This method is used to collect samples for constituents that have very short holding times and specific collection or preservation needs. For example, samples for coliforms are taken directly into a sterile container to avoid non-resident bacterial contamination.

- **Composite Sample** - a mixed or combined sample created by combining a series of discrete samples (aliquots) of specific volume, collected at specific flow-volume intervals. Composite sampling is ideally conducted over the duration of the storm event.

During a storm event, grab samples were collected during the initial portion of the storm (on the rising limb of the hydrograph) and taken directly to the laboratory.

Flow composite storm samples were obtained using an automated sampler to collect samples at flow-paced intervals. Samples collected at each station were combined in the laboratory to create a single flow-weighted sample for analysis.

During the storm season, the sampler was programmed to start automatically when the water level in the channel or storm drain exceeded the maximum annual dry weather stage. A sample was collected each time a set volume of water had passed the monitoring point (this volume is referred to as the pacing volume or trigger volume). The sample was stored in glass containers within the refrigerated sampler. A minimum of eight liters of sample was required to conduct the necessary laboratory analyses for all the constituents. The automated sampler was deactivated by field personnel when the water level in the channel or storm drain fell to about 120 percent of the observed maximum annual dry weather flow stage.

Samples were retrieved from the automated samplers as soon as possible to meet laboratory analysis holding time requirements. As samples were collected, rainfall and runoff data were logged and stored for transfer to the office.

Critical Source sampling procedures and equipment are described in the *Critical Source Selection and Monitoring report* (LACDPW and Woodward-Clyde, January 8, 199).

3.2.2 Field Quality Assurance/Quality Control Plan

Properly performed monitoring station set up, water sample collection, sample transport, and laboratory analyses are vital to the collection of accurate data. Quality Assurance/Quality Control (QA/QC) is an essential component of the monitoring program.

Evaluation of Analytes and QA/QC Specifications for Monitoring Program (Woodward-Clyde, 1996a) describes the procedures used for bottle labeling, chain-of-custody tracking, sampler equipment checkout and setup, sample collection, field blanks to assess field contamination, field duplicate samples, and transportation to the laboratory.

An important part of the QA/QC Plan is the continued education of all field personnel. Field personnel were adequately trained from the onset and informed about new information on stormwater sampling techniques on a continuing basis. Field personnel also evaluate the field activities required by the QA/QC Plan, and the Plan is updated if necessary.

Bottle Preparation

For each monitoring station, a minimum of three sets of bottles was available so that up to two complete bottle change-outs could be made for each storm event. Bottle labels contained the following information:

- LADPW Sample ID Number
- Station Number
- Station Name
- Sample Type (Grab or Composite)
- Laboratory Analysis Requested
- Date
- Time
- Preservative
- Temperature
- Sampler's Name

Bottles were cleaned at the laboratory prior to use, then they were labeled and stored in sets. Each station was provided with the same number, types, and volumes of bottles for each rotation unless special grab samples were required. Clean composite sample bottles were placed in the automated sampler when samples were collected. This practice ensured readiness for the next storm event. All bottles currently not in use were stored and later transported in plastic ice chests. Composite sample bottles were limited to a maximum of 2-1/2 gallons each, to ensure ease of handling.

Chain-of-Custody Procedure

Chain-of-custody forms were completed to ensure and document sample integrity. These procedures establish a written record which tracks sample possession from collection through analysis.

Field Setup Procedures

All field sampling locations were fixed sites, with the sampler placed on a public road or flood control right-of-way. After sample collection, field staff prepared the sampler for collection of the next set of samples either in storm mode or in dry weather mode. Inspection of visible hoses and cables was performed to ensure proper working conditions according to the site design. Inspection of the strainer, pressure transducer, and auxiliary pump was performed during daylight hours in nonstorm conditions.

The automated sampler was checked at the beginning of the storm (during grab sample collection) to ensure proper working condition and to see if flow composite samples were being collected properly. Dry weather collection techniques were similar, with grab and 24-hour composite samples being collected.

Bottles were collected after each event and packed with ice and foam insulation inside individually marked ice chests. Chain-of-custody forms were completed by field staff before transportation of the samples to the laboratory. Under no circumstance were samples removed from the ice chest during transportation from the field to the laboratory.

Travel Blanks and Field Duplicates

Potential field contamination was assessed through analysis of travel blanks and duplicate grab samples. Field travel blanks were collected for each monitoring station during every sampling event to quantify post sampling contamination. The monitoring program also included field duplicates to assess the precision of laboratory results. A field duplicate, the origin of which was unknown to the laboratory, was collected for each sampling event. This methodology for assessing post sampling contamination and laboratory testing procedures provided data to measure the precision and accuracy of the laboratory results.

3.2.3 Sampling Frequency

During the 1996-97 storm season, the Permit required the Department to sample up to 100 "station events" for the land use sites. During subsequent years (1997-98, 1998-99, 1999-2000), the Department was required to sample up to 200 “station events”. A station event is defined as collection of one sample at one station. The Municipal Permit specifies sampling at mass emission stations to total five events per year during dry weather, storm, or a combination of both for all years.

3.3 LABORATORY ANALYSES

The Department of Agricultural Commissioner/Weights and Measures (ACWM) Environmental Toxicology Laboratory provides water quality laboratory and related services to the LACDPW. The ACWM lab is state certified to perform the water quality analyses contracted by LACDPW. The ACWM Lab maintains a laboratory analysis program that includes Quality Assurance and Quality Control protocols consistent with the objectives of the monitoring program required by the Permit (Section 3.3.3).

3.3.1 Possible Constituents of Concern

Possible constituents of concern for each element of the Monitoring Program are specified in the Municipal Permit. The constituents of concern for land use station monitoring are:

- Total Suspended Solids
- Total Nitrogen
- Total Phosphorus
- Cadmium
- Chromium
- Copper
- Lead
- Mercury
- Nickel
- Selenium
- Silver
- Zinc
- Chlordane
- Chlorpyrifos
- Diazinon
- Malathion
- Simazine
- Total DDT
- Total PAHs
- Total PCBs

Constituents of concern for mass emission monitoring include those listed above plus:

- Bacteria
- Total Phenols
- TPH
- Oil and Grease
- Cyanide

3.3.2 Analytical Suite and Analytical Methods

The suite of analytes and associated detection limits for samples collected at the land use stations and mass emission stations are specified in the Municipal Permit. Constituents of concern for derivation of event mean concentrations are also specified by the Permit. All the laboratory methods used for analysis of the stormwater samples are approved by the California Department of Health Services and are in conformance with USEPA approved methods.

The laboratory made an effort to provide the lowest detection limits attainable without compromising the reliability of the data. "Detection limit" (DL) is defined by the USEPA as "the concentration above which we are 99% confident that the analyte is present at a concentration greater than zero" (40 CFR Part 136 Appendix B). For this project the laboratory made some allowance for interference in the analysis due to the complex nature of the sample matrix by performing a DL study using a water sample collected from a channel during dry weather. These 'matrix specific' DLs are the reported DLs in the data tables. Data below the DL are reported as zero. The Practical Quantitation Limit (PQL) is the concentration above which the analyte can be accurately quantified. Reported PQLs were developed by the laboratory during the analysis of stormwater runoff samples using professional judgment to account for matrix interferences. Data that fall between the DL and PQL are reported by the laboratory at the apparent concentrations. When reviewing these data it should be noted that the concentrations below the PQL are estimated.

For some pollutants, the EPA Water Quality Criteria were lower than the required Monitoring Program method detection limits. As a result, detection limits for some constituents were lowered (beginning in the 1996-97 storm season) to a level below the EPA Criteria concentrations. This also enhanced the value of the data by improving the quality of the data sets and allowed for more rigorous statistical analyses and data interpretation techniques.

Detection limits of many semi-volatile organic compounds (SVOCs) were lowered in the 1999-2000 storm season, including all PAHs, for the land use and mass emission studies at the request of the Los Angeles Regional Water Quality Control Board. Modifications to detection limits are presented in Table 3-1.

3.3.3 Quality Assurance and Quality Control

The primary objective of the laboratory quality assurance/quality control program is to ensure that the analyses are scientifically valid, defensible, and of known precision and accuracy. The ACWM laboratory maintains quality assurance/quality control procedures (as described in their Quality Assurance Manual) in accordance with requirements of the California Department of Health Services. The ACWM laboratory standard operation procedures include method validation, equipment calibration, preventive maintenance, data validation procedures, assessment of accuracy and precision, corrective actions, and performance and system audits.

The QA/QC review and data validation for the monitoring data was conducted by ACWM Lab, and the QA/QC documentation is available within the ACWM Lab files. The validated data as provided by the ACWM Lab were used for data analysis and interpretation with no further QA/QC review.

3.4 STATISTICAL TEST CRITERIA

3.4.1 Land Use

There are two provisions in the Permit which allow for discontinuing monitoring of specific land use constituents. The first is achieving an event mean concentration (EMC) at an error rate of 25% (Criteria 1). The second is detecting less than 25% of any constituent in 10 consecutive samples (Criteria 2).

Criteria 1

Section B.1.c of Attachment C of the NPDES Permit states: "The land use stations shall be monitored during the term of this Order or until such time that event mean concentrations (EMC) are derived, at the 25% error rate, for the following constituents of concern:"

PAHs
Copper
Chromium
Selenium
Total Phosphorus
Chlorpyrifos
Total DDT
Chlordane
Nickel
Silver
Mercury
Total Suspended Solids
Malathion
Total PCBs
Cadmium
Lead
Zinc
Total Nitrogen
Diazinon
Simazine

The RWQCB agreed to substitute the mean standard error in place of the error rate (Swamikannu, 1999). The findings are presented in Table 4-14. Constituents appearing have at least 10 samples and an 80% detection rate.

Criteria 2

Section B.1.e of Attachment C of the NPDES Permit states: "If a constituent is not detected at the method detection limit (MDL) for its respective test method listed in Attachment C-3 in more than 25 percent of the first ten sampling events or on a rolling basis using ten consecutive sampling events, it will not be further analyzed unless the observed occurrences show high concentrations and are cause for concern." The results of this test are presented in Table 4-13.

Constituents meeting this criteria (with an X corresponding to a site) can be considered for discontinuation. However, if there is still concern for the constituent, monitoring will continue. Specific constituents of concern are marked with an asterisk in the table.

3.4.2 Mass Emissions

The only criteria required to discontinue monitoring constituents at mass emissions sites is the detection of less than 25% in 10 consecutive samples (Section B.2.c of Attachment C of the NPDES Permit). The results of this test are presented in Table 4-7.

Constituents meeting this criteria (with an X corresponding to a site) can be considered for discontinuation. However, if there is still concern for the constituent, monitoring will continue. Specific constituents of concern are marked with an asterisk in the table.

4.1 HYDROLOGY: PRECIPITATION AND FLOW

Over the past six years, Los Angeles County has experienced weather patterns that have resulted in very diverse storm seasons. The two most significant seasons were the 1997-98 El Niño and the 1998-99 La Niña storm seasons.

The term El Niño refers to the disruption of the entire oceanic-atmospheric system in the tropical Pacific Ocean. This occurrence often causes a major departure from average temperatures and precipitation amounts on a global scale. During El Niño, the trade winds relax in the central and eastern Pacific and upwelling of deep colder ocean water is inhibited. Therefore, in the eastern Pacific, the water temperature rises. Increases in temperature in the central and eastern Pacific result in an increase of evaporation and convection, or thunderstorm activity. This activity can be observed, especially in the winter, as the subtropical jet stream flows from Southern California, through the Gulf Coast region.

The effects of the 1997-98 El Niño were the strongest observed for the past 40 years (National Oceanic and Atmospheric Administration). Rainfall associated with El Niño was greater later in the storm season as compared to previous years. The month of February of 1998 produced over fifteen inches of rain at the downtown Los Angeles raingage compared to the 110 year average of 3.17 inches for the same raingage. The previous year, the same raingage recorded only 0.06 inches of rain.

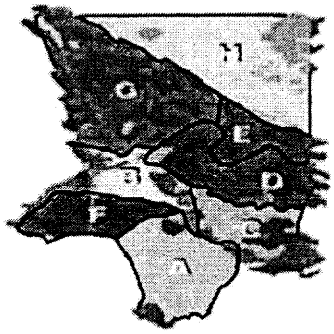
Furthermore, the total wet season runoff volume at the Los Angeles River station as of March, 1998, was nearly 300,000 acre-ft. By comparison, the 1996-97 storm season runoff volume at the same location was 58,309 acre-ft, approximately one-fifth.

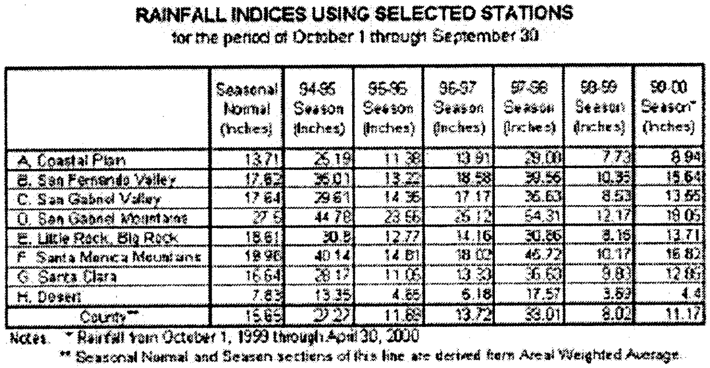
In contrast, the 1998-99 storm season was considered a La Niña storm season. La Niña climatology is characterized by unusually cold ocean temperatures in the eastern equatorial Pacific that impact global weather patterns. La Niña tends to bring nearly opposite effects of El Niño to the United States. It often features drier than normal conditions in the Southwest in late summer trough the subsequent winter. La Niña conditions recur every few years and can persist as long as two years.

The month of February of 1999 produced only 0.4 inches of rain at the downtown Los Angeles raingage compared to the 110 year average of 3.17 inches for the same raingage. The same raingage during the El Niño season, by contrast, produced over 15 inches of rain. Similarly, the total rainfall for the 1998-1999 season at the Ballona Creek station was only 9.48 inches, and the total wet season runoff volume at the Ballona Creek station was 10,700 acre-ft. By comparison, the rainfall total during the previous storm season at this station was 28.28 inches and the runoff volume was 18,300 acre-feet.

Figures 4-20 and 4-21 respectively show the Los Angeles annual and monthly wet season rainfall at the downtown Los Angeles station.

Furthermore, the figure and table below display aerial weighted rainfall totals for the Los Angeles County by area. As expected, the San Gabriel and Santa Monica Mountains recorded the highest precipitation totals throughout the years while the dessert areas recorded the lowest. San Gabriel and San Fernando Valleys recorded very similar precipitation values. Again, it can be seen that El Niño season of 1997-98 produced twice as much rainfall as the seasonal normal, while La Niña season of 1998-99 recorded less than half the seasonal normal.





RAINFALL INDICES USING SELECTED STATIONS
for the period of October 1 through September 30

	Seasonal Normal (Inches)	94-95 Season (Inches)	95-96 Season (Inches)	96-97 Season (Inches)	97-98 Season (Inches)	98-99 Season (Inches)	99-00 Season* (Inches)
A. Coastal Plain	13.71	25.19	11.38	13.91	29.00	7.73	8.94
B. San Fernando Valley	17.62	35.01	13.22	18.58	39.56	10.35	15.64
C. San Gabriel Valley	17.64	29.61	14.36	17.17	36.63	8.53	13.65
D. San Gabriel Mountains	27.5	44.78	23.66	26.12	54.31	12.17	19.06
E. Little Rock, Big Rock	18.81	30.8	12.77	14.16	30.86	8.16	13.71
F. Santa Monica Mountains	18.96	40.14	14.81	18.02	45.72	10.17	16.82
G. Santa Clara	16.64	28.17	11.06	13.33	36.63	9.83	12.86
H. Desert	7.83	13.35	4.85	6.18	17.57	3.63	4.4
County**	15.65	22.27	11.68	13.72	33.01	8.02	11.17

Notes. * Rainfall from October 1, 1999 through April 30, 2000
** Seasonal Normal and Season sections of this line are derived from Areal Weighted Average.

Table 4-1 summarizes the hydrological data for each station for the 1994-95, 1996-97, 1997-98, 1998-99, and 1999-2000 seasons.

A collection of rainfall contour maps for the 1994-95, 1995-96, 1996-97, 1997-98, 1998-99, and 1999-2000 storm seasons are included in Appendix A.

Refer to Appendices of preceding annual Stormwater Monitoring Reports for hydrographs of monitored sites and rainfall contour maps for each storm event.

4.2 STORMWATER QUALITY

4.2.1 Overall Imperviousness

Overall watershed imperviousness has been linked to stormwater quality problems (Center for Watershed Protection, 1996). The following table gives the overall imperviousness of each of the major Watershed Management Areas under the 1996 Municipal Stormwater Permit:

Imperviousness of Watershed Management Areas

WATERSHED MANAGEMENT AREA	AREA, Sq. Mi.	OVERALL IMPERVIOUSNESS, %
Dominguez Channel/ L. A. Harbor	110	62
Ballona Creek	211	45
Los Angeles River	834	35
San Gabriel River	683	30
Malibu Creek	203	6
Santa Clara River	1029	5

Notes. - Values were calculated using the DPW GIS Pollutant Loading Model
- Land use distribution is based on 1993 SCAG data
- Imperviousness values for each land use were taken from the LACDPW Hydrology Manual, 1991

4.2.2 Bacterial Indicators

Los Angeles County has been monitoring a selection of bacterial indicators, including total coliforms and fecal bacteria (fecal coliforms, fecal streptococcus, and fecal enterococcus), at two of the mass emission monitoring stations (Ballona Creek and Malibu Creek) since the 1994-95 rainy season. Bacteria monitoring in 1994-95 and 1995-96 also involved land use sampling. All four of the mass emission monitoring stations currently required by the Permit (Ballona Creek, Malibu Creek, Los Angeles River, and San Gabriel River) have been sampled for bacteria since the 1995-96 storm season. Bacteria were not sampled at the Coyote Ck. station, which was not a requirement of the Permit, and land use sampling for bacteria was also not a requirement under the current Permit.

In addition to wet weather sampling, a number of dry weather samples were analyzed since 1994 to support other in-house studies, most notably for the low flow diversion projects at various locations along the shore line in Los Angeles County. Dry weather bacteria results are presented in Tables 4-5b and 4-5c.

Fecal bacteria are normal residents of the digestive tracts of humans and other warm-blooded animals. They are usually not pathogenic themselves but they can serve as indicators for the presence of potential pathogens (including bacteria, viruses, and protozoa that may cause human health problems) if contamination of surface waters with sewage had occurred. Fecal coliforms are a subgroup of the total coliform group.

Fecal coliforms, fecal streptococcus, and fecal enterococcus are three independent residents of the gastro-intestinal tracts of warm-blooded animals, and their distribution among warm-blooded species varies. Unfortunately, none of the bacteria is totally specific to humans, so none can serve as the ultimate indicator and warning signal for the presence of potential human pathogens.

Total coliforms and fecal bacteria (fecal coliforms, fecal streptococcus, and fecal enterococcus) were detected in all stormwater samples tested since 1994 at densities (or most probable number, MPN) between several hundreds to several million cells per 100 ml. Table 4-8 and Figure 4-4 show the wet weather sample results obtained between 1994 and 2000 for the different bacterial groups. The geometric mean (labeled as "log mean" for consistency with reports from other Los Angeles agencies) for each storm season is shown as one bar. Results are shown for the four mass-emission stations tested. Dry weather bacteria results are presented in Tables 4-5b and 4-5c.

The Malibu Creek station appears to have consistently lower counts than other mass emission stations and is consistently lower for all four groups of bacteria. There is no apparent pattern of differences between monitoring years, although the 1995-96 season appears to have higher mean densities than other years. At 75% of normal, this was not a particularly rainy season.

A study of the raw microbial data for wet weather and dry weather from 1994 to 2000 indicates the following:

- Every wet weather mass emission bacteria sample taken exceeded the public health criteria for indicator bacteria. All of the dry weather bacteria samples taken for the low flow diversion projects exceeded the public health criteria. Most of the dry weather mass emission bacteria samples taken exceeded the public health criteria. Wet weather flows contained bacteria densities at much higher levels (three to four orders of magnitude) than dry weather flows.

- Except for 1996-97, densities observed during the first storm of each rainy season were not necessarily higher than during consecutive storm events, suggesting that there was no consistent "first-flush" effect in these watersheds. Peak densities were observed at different times each year. In 1995-96, the peak density at all four mass emission stations and one land use station coincided with the peak storm of the season.

- Except for somewhat lower densities at Malibu Creek, there was no seasonal or regional consistency in cell densities. There was a very wide range of densities for all stations.

- There was one storm event, January 9, 1998, that yielded extremely high counts in all stations for all bacterial strains. The available data do not provide an explanation, or suggest whether this could be a contamination artifact.

- The 1996-97 season had one event, November 21, 1996, that yielded runoff with high counts in all stations for all species.

- During the 1998-99 season, the event of March 15, 1999 was associated with high bacterial counts for most stations and the events of March 25, 1999 and April 4, 1999 were associated with unusually low counts for most stations.

The following table gives the storm date when the peak fecal coliform reading was observed for that season:

Comparison of Storm Dates to Peak Fecal Coliform Dates

		1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000
Date of First Storm > 0.1”		10/04/94	12/13/95	10/29/96	11/10/97	11/08/98	11/08/99
Date of Largest Storm		01/07/95	02/20/96	01/20/97	02/21/98	04/11/99	03/03/00
Depth of Largest Storm (inches)		6.65	4.39	3.54	5.08	1.15	2.01
MONITORING STATION	Ballona Creek	01/10/95	02/20/96	10/29/96	01/09/98	02/09/99	02/10/00
	Malibu Creek	03/03/95	02/20/96	10/29/96	01/09/98	03/15/99	02/23/00
	Los Angeles River	N/A	02/20/96	11/21/96	01/09/98	03/15/99	02/23/00
	San Gabriel River	N/A	02/20/96	11/21/96	01/09/98	03/15/99	03/08/00
	Retail/Commercial	03/21/95	12/23/95	N/A	N/A	N/A	N/A
	Vacant	N/A	12/23/95	N/A	N/A	N/A	N/A
	HDSFR	N/A	03/12/96	N/A	N/A	N/A	N/A
	Transportation	N/A	12/23/95	N/A	N/A	N/A	N/A
	Light Industrial	N/A	02/20/96	N/A	N/A	N/A	N/A

It appears from the table that in a number of instances, peak fecal coliform counts occurred at different monitoring stations in different parts of the county during the same storm. Further, in 1995-96, the highest fecal coliform readings at five stations coincided with the largest storm of the season. Also, in 1996-97, the highest fecal coliform readings at two stations coincided with the first storm of the season greater than 0.1" rainfall. These observations suggest that peak fecal coliform levels may be related to regional hydrologic conditions.

4.2.3 Stormwater Toxicity

Two studies required by the 1996 Municipal Stormwater Permit examined stormwater toxicity. The Santa Monica Bay Receiving Waters study examined water column and sediment toxicity impacts on Santa Monica Bay from stormwater from Ballona and Malibu Creeks. The Southern California Coastal Waters Research Project (SCCWRP), the University of Southern California, and the University of California Santa Barbara were the principal investigators. In addition, dry and wet weather toxicity tests were performed on the Los Angeles and San Gabriel Rivers in 1997-98 and 1998-99. This testing was performed by the Southern California Coastal Waters Research Project. Toxicity was measured as impairment to sea urchin fertilization.

An Executive Summary of the Bay Receiving Waters study is included in Appendix C. Major findings of the stormwater toxicity studies (SCCWRP, 1999) are repeated below:

- Virtually every sample of Ballona Creek stormwater tested was toxic to sea urchin fertilization.

- The first storms of the year produced the most toxic stormwater in Santa Monica Bay during the study.
- The toxic portions of the stormwater plume were variable in size, extending from 1/4 to 2 miles offshore of Ballona Creek.
- Surface water toxicity caused by unidentified sources was frequently encountered during dry weather in Santa Monica Bay.
- Zinc was the most important toxic constituent identified in stormwater in Santa Monica Bay, but zinc concentrations in the toxic portion of the discharge plume were usually below levels shown to cause toxicity in the laboratory.
- Copper and other unidentified constituents may also be responsible for some of the toxicity measured in Santa Monica Bay.
- The measured concentrations of zinc and copper in Ballona Creek stormwater were estimated to account for only 5% - 44% of the observed toxicity.
- The fate of most stormwater constituents discharged to Santa Monica Bay is unknown.
- For two years in a row, wet weather toxicity was significant in the Los Angeles River. Dry weather toxicity was significant the second year, but not the first.
- For the San Gabriel River, wet weather toxicity was significant the first year, but not the second. Dry weather toxicity was not significant either year.
- For both rivers, wet weather toxicity was higher for the first storm tested, suggesting a seasonal "fist flush" phenomenon for toxicity.

4.2.4 Contaminated Sediments and Total Suspended Solids

Sea floor habitat and sediment contamination were studied in the Santa Monica Bay Receiving Waters study and were investigated by the Southern California Coastal Waters Research Project. Major findings of the sea floor habitat and sediment contamination study (SCCWRP, 1999) are repeated below:

- The sea floor is where stormwater particles, and associated contaminants, eventually settle.
- The sediments on the sea floor can accumulate runoff inputs over an entire storm, over several storms, or over several seasons.
- Sediments offshore of Ballona Creek generally had higher concentrations of urban contaminants, including common stormwater constituents such as lead and zinc.
- Sediments offshore of Ballona Creek showed evidence of stormwater impacts over a large area.
- Sampled biological communities offshore of Ballona Creek were similar to those offshore of Malibu Creek. Both areas had comparable abundance and similar species composition.
- Sampled biological communities offshore of Ballona and Malibu Creeks were also similar to background reference conditions established in previous studies of southern California.

The County of Los Angeles Department of Public Works has also participated on the Los Angeles Basin Contaminated Sediment Task Force. The management committee of the Task Force is comprised of the U. S. Army Corps of Engineers, the U.S. Environmental Protection Agency (Region IX), the California Water Quality Control Board (Los Angeles Region), and the California Coastal Commission. One of the goals of the Task Force is to promote and implement region-wide efforts at source reduction through watershed management. The Task Force, in its Long Term Management Strategy Action Plan (no date), states:

- Informal surveys of potential users and past projects suggest that the major sources of contaminated dredge material will continue to be Marina del Rey, the ports of Los Angeles and Long Beach, and the mouth of the Los Angeles River.
- Some of the sediments dredged from these harbors contain elevated levels of heavy metals, pesticides, and other contaminants. In most cases, the concentrations of these contaminants do not approach hazardous levels.

The Corps of Engineers, in a draft study (2000) sought to identify possible inland sources of contaminated sediments in the Ballona Creek watershed by sampling dry weather sediments in the bottom of Ballona Creek and major tributaries. The draft study found:

- Four of 21 sites were without any chemical concentration exceeding the National Oceanographic and Atmospheric Administration's "Effect Range-Low" (ERL) values: storm drain Bond Issue Project 9408, Project 425, Ballona Creek at Sawtelle Blvd., and Centinela Channel.
- Sediments on the bottoms of storm drain Bond Issue Projects 648, 51, 494, and 503 ranked by dry weight most consistently as the most contaminated sites with respect to metals and polycyclic aromatic hydrocarbons (PAHs).
- The two areas of the main Ballona Ck. channel that ranked, by dry weight, as most contaminated and exceeding ERLs were just downstream of Madison Ave. and Fairfax Ave.
- With respect to the potential for contamination from PAHs, sites in Ballona Ck. at Pickford St. and Fairfax Ave., Higuera St. drain, Projects 51 and 3867, and Culver City Acquisition and Improvement District No. 4 drain appeared most contaminated.
- Bed load sediment in the major tributary drains of Sepulveda and Centinela Channels were among the least contaminated samples.
- According to a Corps geographic information system used to model unit aerial loading, the area within the Ballona Ck. drainage area of expected highest stormwater loading of metals, oil, and grease extends from Hollywood to Culver City in a 1- to 2-mile wide, 5- to 6-mile long strip parallel and east of the San Diego (I-405) Freeway.

In an effort to analyze the presence of PAH in stormwater, Los Angeles County Public Works lowered the detection limit of semi-volatile organics in stormwater samples in the 1999-2000 season by using modified EPA method 625 (see Table 3-1). An analysis of stormwater mass emission mean concentrations (Table 4-6b) shows that two PAH compounds, phenanthrene and pyrene, exceeded the California Ocean Plan objective at the Malibu Creek station. No other PAH compound exceedences appeared through this comparison.

Given the connection between contaminated sediments and suspended solids (Stenstrom et al, 1997, in U. S. Army Corps of Engineers, 2000), we calculated suspended solids loadings at the five mass emission monitoring stations from 1994 to present (Table 4-10 and Fig. 4-5a) where data was available. The data shows that the Los Angeles River is the largest contributor of suspended solids. This finding is expected because the L. A. River drainage area is the largest monitored watershed (825 square miles at the monitoring station). However, during the El Niño season of 1997-98, suspended solid loading was disproportionately higher than Ballona Creek loading (88.8 square miles at the monitoring station). It should be noted, however, that the Ballona Ck. monitoring station was out of service during February of 1998.

Total suspended solids were high during the 1999-2000 storm season at the vacant land use site. This may have been due to modifications to the Sawpit Dam located upstream of the sampling station.

4.2.5 Comparison of Mass Emissions Concentrations to the Ocean Plan, Basin Plan, and California Toxics Rule

Table 4-6a shows the list of constituents analyzed from the stormwater mass emission monitoring sites since 1994. Both the annual mean and median of the analyses of these constituents were compared to the water quality objectives outlined in the California Ocean Plan, the Los Angeles Basin Plan, and the California Toxics Rule. Stormwater bacteria indicators were compared to the standards in AB411. It should be noted that, except for bacteria indicators, there are no numerical water quality standards that apply to stormwater or nonpoint source pollution. Current federal and state numerical standards apply only to point source pollution, such as sanitary sewage, industrial and point source discharges to the ocean and other water bodies. Water quality standards described in the 1995 Los Angeles Region Basin Plan or the 1997 California Ocean Plan do not apply to stormwater runoff, and any exceedence of values should not indicate violation nor noncompliance with the plans. Furthermore, a direct comparison of the sampling results with the Ocean Plan standards cannot be made since the results presented in the table are detected values before dilution, a factor allowed by the Ocean Plan.

Table 4-6b shows those constituents whose annual mean or median virtually exceeded the three objectives described above. For bacteria indicators, the log mean of the Most Probable Number per 100 ml was compared to the objectives of AB411. The table shows that the bacteria indicator standards were exceeded at every monitoring station where sampled for every year. The next most prominent virtual exceedences occurred with total and dissolved copper and bis (2-ethylhexyl) phthalate, followed by turbidity, total zinc, and total lead. The table also shows that 1997-98, the El Niño season, contributed the most virtual exceedences at all monitoring stations except Coyote Creek. Finally, the table shows that the Los Angeles River produced the most virtual exceedences of any other mass emission monitoring station.

4.2.6 Loading

The above discussion points to dissolved zinc and copper and total suspended solids as constituents worthy of further examination. If these are important constituents, it would be helpful to look at what watersheds are producing the greatest amounts of these constituents. A loading analysis, that is pounds of constituent per season, would make this indication. To calculate annual loading, the annual mean concentration of the constituents of interest are multiplied by the annual volume of runoff measured at each mass emission station. Loading results are shown in Table 4-10 and Figures 4-5a through 4-12.

As expected, loading was greatest during 1997-98, the El Niño season. This analysis indicates that the Los Angeles River delivered the highest loadings of total suspended solids (approx. 220,000 tons), dissolved copper (approx. 28 tons), total copper (approx. 40 tons), dissolved zinc (approx. 170 tons), and total zinc (approx. 230 tons). Further, it appears that Los Angeles River loading for the metals is disproportionate by drainage area to the other watersheds.

Total and dissolved zinc loading is also prevalent among unmonitored watersheds. The Dominguez Channel/L. A. Harbor watershed contributed the highest loadings for dissolved zinc (approx. 2.3 tons) and dissolved copper (approx. 30 tons) and was the highest for each year.

Loading calculations from unmonitored watersheds were accomplished by a GIS model (Table 4-11 and Figures 4-16 through 4-19). Comparison of loadings between monitored and unmonitored watersheds should not be made at this time because the model is not fully calibrated.

4.2.6.1 GIS Model

To assist in implementing this requirement, the Department developed a GIS application called the Pollutant Loading Model. A brief description of the model follows:

Hardware Requirements

- IBM-compatible, running Windows NT 4.0 or Windows 95
- 8 MB hard disk space (data/project on network); 600MB hard disk space (local)
- 64 MB RAM or higher

Software Requirements

- ArcView 3.1
- Spatial Analyst 1.1 for ArcView

Data Requirements

Geographic -

- Thomas Brothers Maps® data sets, County of Los Angeles
- Southern California Association of Governments Land Use
- Watershed Management Area Boundaries
- Rain gage locations and depths
- Watershed sub-basin boundaries
- Municipal Boundaries
- Water Quality Monitoring Station locations

Tabular -

- Rain gage data for each rainfall event
- Event Mean Concentration data

The Pollutant Loading application computes total pollutant loading for selected pollutants originating in user-defined watersheds or political boundaries. It draws upon many existing data sources, such as predetermined drainage subbasins, land use, historical and event rainfall data, water quality monitoring station results, and multiple underlying geographic data including political boundaries, natural boundaries, census tracts, forest boundaries, streets, and drains.

The user is given the option of hand-digitizing a study area or graphically selecting a predetermined drainage subbasin, monitoring station watershed, city, or other municipal boundary to use as a study area. The user can also locate an area of interest by typing an address or selecting a Thomas Brothers Maps® page.

The user selects a rainfall event from historical records. Rainfall data comes in the form of a previously processed grid of the user-selected storm event or as a rain gage data file, in which case, the model will prepare a rainfall grid using the Spatial Analyst extension. There is also an option to use average annual rainfall.

The application uses the rainfall data to calculate the amount of runoff, based on the imperviousness of the land use polygons it intersects. See equations used at the end of this Section.

The user then has the ability to choose the pollutants for the study from over 257 constituents. The Water Quality data comes from over 24 monitoring stations the County has operated at some point since the 1994-95 storm season. The user can quickly select constituents from pre-classified groups such as General Minerals, Heavy Metals, Pesticides, etc. By default the model will select the 25 pollutants of concern (made up of 61 constituents) listed in the NPDES permit.

The model will then tabulate total pollutant load for the study area using previously calculated Event Mean Concentrations of the selected pollutants. A report of the results is generated in Crystal Reports. The application also produces maps as ArcView layouts showing the area of study, rainfall isohyets, landuse distribution, rain gage locations and values.

Equations Used

- Runoff Volume = (Rainfall Volume)*(Runoff Coefficient)
  Where:
  Runoff Coefficient = (0.8*Imperviousness) + 0.1
- Load = (Pollutant concentration)*(Runoff Volume)

Assumptions and Limitations

- An imperviousness value used for the calculations is associated with 104 different landuse categories.
- The 104 SCAG land use categories have been aggregated into 34 categories covering 100% of the County.

- Water quality data collected from 8 different landuse monitoring stations yields Event Mean Concentration (EMC) values. The remaining landuse categories (34-8 = 26) use assumed EMC values based on their association with the 8 monitored landuse types.
- All polygons of the same landuse type are assumed to have the same EMC value regardless of their spatial location within the county.
- Annual pollutant loadings use previously calculated seasonal EMCs for their calculation.
- Rainfall grid cell sizes are 500 feet by 500 feet. Rainfall depth does not vary within the grid cell.
- The model does not account for variation over time in soil permeability which influences surface runoff in undeveloped watersheds. In other words, a given coefficient of discharge for a particular land use type will not change regardless of previous soil conditions (saturated soil versus dry soil)

The primary operations that are inherent to both observed and modeled methods are described below.

Comparison of Observed and Modeled Load Calculation Methods

ITEM	OBSERVED METHOD	MODEL CALCULATIONS
STORM RUNOFF VOLUME	Flow rate taken directly from stream gage data and integrated over duration of storm to develop runoff volume. Note that this parameter includes base flow and storm runoff. Calculations can be made to estimate a base flow and separate it from the observed runoff.	Rain gage rainfall depths are used to prepare a rainfall grid surface. Rainfall grid cells are 500' x 500'. Equations: (1) Runoff coeff. = (0.8 x Imperviousness) + 0.1 (2) Rainfall volume = (Rainfall depth) x Area (3) Runoff volume = (Rainfall vol.) x (Runoff coeff.)
POLLUTANT EVENT MEAN CONCENTRATION (EMC)	Flow composited samples obtained at the mass emission monitoring sites are analyzed by the lab. Resulting pollutant concentrations are EMCs.	(1) The entire county is comprised of 34 general land use types. Storm runoff from the 8 most significant types is flow-weight sampled by automated equipment. The monitored watersheds of the eight significant types are chosen to represent typical examples of that land use. (2) Water quality results from the 8 monitored land use stations are assigned to the remaining 26 unmonitored land use types based on similarities of land use. (3) Any given land use type is assumed to yield the same EMC anywhere in the county (i.e. a given polygon defined as Single Family Residential (SFR) is assumed to yield the same EMC as any other SFR polygon in the county).
POLLUTANT LOAD	Observed concentration (EMC) multiplied by observed runoff volume.	Observed and assigned concentrations (EMC) for each land use multiplied by the modeled runoff volume for each land use summed within the area of study.

The model does not take into account possible degradation or adsorption of the pollutant as it is transported downstream. These results therefore should not be taken as absolute; rather, they should be used for unmonitored watersheds or smaller portions of monitored watersheds for comparative purposes only.

4.2.7 Constituents of Concern

Table 4-6b includes sixteen chemical constituents that were identified from the comparison of mass emission annual concentrations to the objectives of the California Ocean Plan, the Los Angeles Basin Plan, and the California Toxics Rule. Two organophosphate pesticides, diazinon and chlorpyrifos, are also included in Table 4-6b because of their identification of stormwater toxicity in other independent studies (Lee, 1998). Indicator bacteria (total coliform and fecal coliform, streptococcus, and enterococcus) are also included due their exceedence of AB411.

As of yet, Total Maximum Daily Loads (TMDLs) are not part of the Los Angeles Municipal Stormwater Permit. However, constituents identified by the 303d list that were not already identified through the comparison process, namely nutrients, are also included in Table 4-6b. It should be noted that there were no virtual exceedences by nutrients (compounds of nitrogen and phosphorus) of the three water quality objectives. Further, a report by the Las Virgenes Municipal Water District (May, 2000) found that beneficial use impairment due to algae growth is not a problem during storm season in Malibu Creek.

4.2.8 Identification of Possible Sources

With the identification of dissolved zinc and copper as stormwater toxicants in the Santa Monica Bay receiving water study (SCCWRP, 1999), and the implication of suspended solids (U. S. Army Corps of Engineers, 2000), it is helpful to look at land use and critical source runoff quality data (Tables 4-12 and 4-15 and Figures 4-1 and 4-3) to see if any particular land uses or industries could be singled out as notable or significant for those constituents. Figures 4-22 and 4-23 also show which constituents were prevalent at which land use.

Light industrial, transportation, and retail/commercial land uses displayed the highest median values for total and dissolved zinc, with light industrial the highest at about 300 • g/l for dissolved zinc and about 360 • g/l for total zinc. Runoff concentrations from the remaining land use types (high density single family residential, education, multifamily residential, and mixed residential) were significantly less.

Light industrial and transportation land uses displayed the highest median values for total and dissolved copper, with transportation the highest at about 28 • g/l for dissolved copper and about 40 • g/l for total copper.

Median concentrations of total suspended solids were highest coming off of the light industrial land use category, at about 130 mg/l.

These land use observations, particularly from the light industrial and retail/commercial categories, can be narrowed down by looking at the stormwater zinc, copper, and suspended solids sampled under the Critical Source program. The critical source industries sampled to date fall under the following SCAG land use categories:

Critical Industry Land Use Types

Critical Source Industry	SCAG Land Use
Auto Dismantling (Wholesale Trade)	Heavy Industrial
Auto Repair	Retail/Commercial
Metal Fabrication	Heavy Industrial
Motor Freight	Transportation
Auto Dealerships	Retail Commercial

Table 4-15 and Figure 4-3 show the highest median value for total zinc (approx. 450 • g/l), dissolved zinc (approx. 360 • g/l), total copper (approx. 240 • g/l), and dissolved copper (approx. 110 • g/l) were produced at the fabricated metal sites (labeled "control"). This finding holds true for those critical source industries added and sampled in 1999-2000, namely motor freight and auto dealerships, which are discussed in the 1999-2000 annual monitoring report. However, levels for total and dissolved zinc did not appear to be significantly different between the industry types.

By contrast, levels for total and dissolved copper did appear significantly higher for the fabricated metals sites over the other critical industry categories. The highest median level for suspended solids was also produced at the fabricated metals sites, but no industry was significantly higher or lower than another for suspended solids.

Bacteria indicators were analyzed for the first time from the critical source sites in 1999-2000.

4.2.9 Best Management Practices for Critical Source Industries

In the 1999-2000 season, items of equipment called Best Management Practices (BMPs) were purchased by the County for installation at half of the companies from the auto dismantling, auto repair, and metal fabrication industries. These preventive-type BMPs took the form of good housekeeping and spill containment measures (Table 4-16). Each business owner agreed to be responsible for installing and using the BMPs. The County encouraged the business owners to utilize the BMPs during the storm season, but the County had no jurisdiction or control over how or when they were used.

Table 4-15 and Fig. 4-3 compare the results of those companies fitted with BMPs to those without. For total and dissolved zinc, the median concentration lowered or stayed nearly the same with the implementation of BMPs at the auto dismantling, auto repair, and fabricated metals industries. (For the auto dismantling and auto repair industries, the median actually increased slightly.) In none of the circumstances was the difference significant.

For total and dissolved copper, however, where the fabricated metal industry had displayed the highest median concentrations, levels were significantly reduced with the implementation of BMPs. The auto dismantling and auto repair businesses showed no significant difference.

5.1 OBJECTIVES ACHIEVED

Since 1994, the goal of the Monitoring Program has been to develop information to support effective watershed stormwater quality management programs. The primary objectives of the Monitoring Program, as outlined in the Permit and Section 1 of this report, follow.

5.1.1 Track Water Quality Status, Pollutant Trends and Pollutant Loads, and Identify Pollutants of Concern

Water quality status and pollutant trends and loads were successfully addressed by all of the major monitoring program elements: the Santa Monica Bay receiving waters impact study, the mass emission monitoring element, the land use monitoring element, and the critical source monitoring element.

The Santa Monica Bay receiving waters impact study extended from the 1996-97 through the 1998-99 storm seasons and focused on discharge from Ballona and Malibu Creeks.

The five mass emission stations located on major tributaries to the Pacific Ocean sampled runoff from 1220 of 2086 square miles of the Los Angeles coastal basin. The only major watershed not monitored for mass emissions was the largely undeveloped Santa Clara River watershed in the northwest part of the permit area. The mass emission data was also used to identify pollutants of concern and to calculate seasonal loads. Since January 1995, 212 station events have been sampled. Generally, sampling activities were conducted according to plan, and attempts were made to capture as many storms as possible. Initial mechanical difficulties with the sampling equipment were overcome over the years of use.

The siting of these stations was dictated in large part by accessibility and the availability of public right of way. All five mass emission stations were set up in existing Department of Public Works stream gauge shelters. Two of the mass emission stations, Ballona Creek and Malibu Creek, have the longest record, sampling since January 1995, and the balance of the mass emission stations have been sampling since the 1995-96 storm season. The automated equipment also provided the collection of flow-weighted composite samples, which reflect and allow for varying constituent concentrations throughout the storm event.

The sampling of runoff from land use specific drainage areas also began in January 1995 with the installation of automated equipment in the Santa Monica Pier drain (retail/commercial). By the 1995-96 season, four more of the current land use monitoring stations were installed (high density SFR, vacant, light industrial, and transportation). When the current permit came into effect in July, 1996, two more land use stations were installed (multifamily residential and educational). The final land use monitoring station (mixed residential) was installed by the 1997-98 storm season. Similar flow-weighted compositing was accomplished through the use of automated equipment for sampling runoff from land use-specific drainage areas.

In contrast to the mass emission stations, land use monitoring stations are largely located in underground drains. Their siting was therefore more complicated, requiring the identification of locations where the drainage area was the predominant land use, where there was a manhole near available power in available right-of-way, where the drain was not surcharged in a moderate storm, and where personnel would be relatively safe. Since 1995, 396 station events have been sampled.

The land use monitoring was successful at characterizing runoff from land use specific drainage areas and developing seasonal mean concentrations. Seasonal mean concentrations (also called Event Mean Concentrations) were used for calculating loading from unmonitored watersheds. It was found that seasonal mean concentrations were below the 25% error rate in 77% of circumstances.

Monitoring at the land use stations and mass emission stations included a broad constituent suite including bacteria, metals, organics, major ions, and nutrients. The laboratory analytical efforts achieved detection limits (DL) as required by the Permit for all constituents, and achieved DLs that were lower than Permit requirements for many analytes, particularly for constituents of concern.

5.1.2 Monitor and Assess Pollutant Loads from Specific Land Uses and Watershed Areas

The mass emission and land use monitoring elements were successful at assessing loading. Loading was first reported in the 1994-95 Los Angeles County Stormwater Monitoring Report. Subsequent loading based on both observed and modeled data was also reported in the 1998-99 and 1999-2000 Reports. The County's GIS Loading Model has been recognized as an innovative solution to estimating loading in unmonitored watersheds.

5.1.3 Identify, Monitor, and Assess Significant Water Quality Problems Related to Stormwater Discharges Within the Watershed

The monitoring program was successful at identifying significant water quality problems associated with stormwater discharge. First, the Santa Monica Bay receiving waters impacts study identified zinc and copper from Ballona Creek discharge as being toxic to the fertilization rate of simple marine animals. Toxicity testing of dry and wet weather flow in the Los Angeles and San Gabriel Rivers also identified toxicity problems. The extent and severity of bacterial indicators was better understood through wet weather mass emission sampling and ad hoc dry weather sampling.

5.1.4 Identify Sources of Pollutants in Stormwater Runoff

All of the major monitoring program elements were used successfully to identify stormwater pollutant sources. The Santa Monica Bay receiving waters study identified Ballona Ck., and not Malibu Ck., as a contributor of stormwater toxicity. Further, it identified zinc and copper as two metals contributing to the toxicity. The mass emission monitoring identified the Los Angeles River as consistently contributing the most zinc, copper, and suspended solids.

The land use monitoring identified light industrial, transportation, and retail/commercial land uses as developing the highest median concentrations for total and dissolved zinc. Light industrial and transportation land uses displayed the highest median concentrations for total and dissolved copper, and light industrial produced the highest concentrations of suspended solids.

Finally, the critical source monitoring program identified fabricated metal businesses as producing the highest median concentrations for zinc, copper, and suspended solids.

5.1.5 Identify and Eliminate Illicit Discharges

Each Permittee has a program to identify and eliminate illicit connections to the storm drain system to the maximum extent practicable. One of the programs developed for the elimination of illicit connections is open channel and underground storm drain inspections.

Most Permittees perform random area surveillance during dry and wet weather to inspect for potential illegal discharges. The Permittees also conduct educational site visits at businesses. During these visits, flyers with information on Best Management Practices (BMPs) applicable to that business are distributed.

The County, maintaining the majority of the storm drains within Los Angeles County, conducts routine inspections of the storm drain system for illicit connections/illicit discharges. Maps and connection inventory reports for 1,304 storm drains have been prepared to facilitate these inspections, which have resulted in the discovery of 1,993 undocumented connections as of July of 1999. These connections are either removed or permitted.

A toll free number 1-888-CleanLA was created for the public to report observed illicit connections/illicit discharges to the storm drain system.

It is recommended that the IC/ID model program approved by the Regional Board on March 23, 1999, be continued.

5.1.6 Evaluate the Effectiveness of Management Programs including Pollutant Reductions Achieved by Implementation of Best Management Practices (BMPs)

The Critical Source element of the monitoring program was successful at examining the potential effectiveness of good housekeeping and preventive types of voluntary Best Management Practices at one critical source industry. While two of the industries showed no significant improvement as the result of implementing BMPs, the fabricated metal industry showed significant improvement for total and dissolved copper.

5.1.7 Assess the Impacts of Stormwater Runoff on Receiving Waters

The receiving waters impact study, one of the first to assess stormwater impacts on the marine environment, was very successful at assessing stormwater impacts on Santa Monica Bay. The study was performed by the Southern California Coastal Waters Research Project, the University of Southern California, and the University of California Santa Barbara. The plume study found that freshwater plumes extended for a number of miles out to sea and often persisted for a number of days after a storm. The toxicity study found that the stormwater discharge from Ballona Creek was toxic to sea urchin fertilization and that dissolved zinc and copper were contributors to the toxicity. The study also found that sediments offshore of Ballona Creek generally had higher concentrations of urban contaminants, including common stormwater constituents such as lead and zinc.

5.2 WIDE CHANNEL PILOT STUDY

The purpose of the wide channel pilot study (Woodward-Clyde et al, 1996) was to evaluate the accuracy of a single point water quality intake in representing the water quality in wide channels. Ballona Creek, Los Angeles River, San Gabriel River, and Coyote Creek can be considered wide channels. The pilot study found the water homogenous through the depth and the width of the channel. Thus, the single point intake produces a representative sample, and no adjustments were made to the monitoring stations. A complete report of this pilot study may be found in Appendix E.

Additional analysis was conducted in 1998 confirming that vertical mixing was achieved.

5.3 LOW FLOW PILOT STUDY

The purpose of the low flow pilot study (Woodward-Clyde et al, 1996) was to assess the feasibility of modifying the automated sampling equipment at land use stations in order to sample storms as small as 0.1 inch rainfall. The pilot study concluded that: operational effectiveness of automated equipment dropped significantly for storms as low as 0.1" rainfall, the feasibility and effectiveness of sample retrieval and transport became very difficult for such storms, and the ability to program and maintain low flow settings at other automated samplers could only be accomplished through large investments in telemetry. A complete report of this pilot study may be found in Appendix D.

Further analysis was conducted in 1998 that concluded 94 percent of total runoff volumes are monitored using the 0.25 inch threshold. Therefore, monitoring continued unaltered.

5.4 FUTURE MONITORING RECOMMENDATIONS

The following recommendations include monitoring, research, and studies that should be considered or undertaken to advance the understanding of stormwater quality science and support future TMDL development. Because of their scope, such studies should be undertaken by various entities, such as the Regional Water Quality Control Board, NPDES permittees, or by collaborative efforts between private and public organizations.

5.4.1 Mass Emission Element

Because the Pacific Ocean is a primary resource to Southern California, it is recommended that mass emission monitoring continue at the five existing sites for up to five storm events per season.

Non-Detection Test: The Permit states that if a given constituent is not detected in at least 25% of the samples taken in ten consecutive storm events at a given station, then that constituent may qualify for removal from the analytical suite for the associated station. For mass emission stations, several constituents met this criterion (see Table 4-7). Carbonate, the majority of heavy metals (24 of the 38), and all of the pesticides met the criteria in each of the mass emission sites. All of the semi-volatile constituents that had more than 10 samples met the criteria in each mass emission site as well. (Due to the change in detection limits of many SVOCs, there were fewer than 10 samples tested under the new limit.) Cyanide, total phenols, MBAS, dissolved aluminum, dissolved nickel, and total lead had less than 25% detection in four of the five sites. It is recommended that these constituents be removed from the analytical suite for the associated stations.

5.4.2 Land Use Element

One of the goals of the land use monitoring element was to develop Event Mean Concentrations (EMCs) for constituents of concern. The EMCs are used in the County's GIS Loading Model to calculate seasonal loading from unmonitored watersheds.

EMC Test: The Permit allows the discontinuation of monitoring at a land use station for specific constituents once the event mean concentration (EMC) is derived with an error rate of 25% or less. We used the mean standard error as a substitute for error rate as mutually agreed upon with the RWQCB (Swamikannu, 1999). Nitrate-Nitrogen achieved the 25% error rate at each of the land use monitoring sites. Total kjeldahl nitrogen (TKN) and total phosphorus met the criteria at seven of the eight land use sites. Dissolved copper, total zinc, dissolved zinc, ammonia-nitrogen, nitrate, and dissolved phosphorus met the criteria at six of the eight sites.

Of 115 station-constituents under investigation, 26 of them had an EMC with a mean standard error higher than 25% (Table 4-14). In other words, there were 26 station-constituents which had a standard error (standard deviation of the mean) larger than 25% of their corresponding mean concentrations. Carbonate, the majority of heavy metals (24 of the 38), and all of the pesticides met the criteria in each of the land use sites. All of the semi-volatile constituents that had more than 10 samples met the criteria in each land use site as well. (Due to the change in detection limits of many SVOCs, there were fewer than 10 samples tested under the new limit.) Flouride, MBAS, dissolved aluminum, and total lead had less than 25% detection in seven of the eight sites.

Given the findings of both the non-detect test and the EMC test, it is recommended that the following land use stations monitor the following constituents only:

Constituents for Future Land Use Monitoring

LAND USE STATION	DRAINAGE SYSTEM	FUTURE MONITORING
Retail/Commercial	Santa Monica Pier Drain	Ammonia, total and dissolved copper, nitrate, total lead, TSS, PAH, diazinon, chlorpyrifos.
Vacant	Sawpit Wash	TKN, TSS, PAH, diazinon, chlorpyrifos.
High Density Single Family Residential	Bond Issue Project 620	Total Lead, PAH, diazinon, chlorpyrifos.
Transportation	Dominguez Channel	PAH, diazinon, chlorpyrifos.
Light Industrial	Bond Issue Project 1202	Total Copper, PAH, diazinon, chlorpyrifos.
Education	Bond Issue Project 474	Total Copper, Total Zinc, TSS, PAH, diazinon, chlorpyrifos.
Multifamily Residential	Bond Issue Project 404	Ammonia, Ammonia Nitrogen, Nitrite Nitrogen, TSS, PAH, diazinon, chlorpyrifos.
Mixed Residential	Bond Issue Project 156	Ammonia, Nitrate, Total Zinc, PAH, diazinon, chlorpyrifos.

Note that the retail/commercial site was removed in 1999 for construction of the City of Santa Monica's stormwater treatment plant. Future monitoring at this site may be in jeopardy.

5.4.3 Critical Source Element

Limited success was achieved in evaluating BMP effectiveness for two of the first three industries. The reasons for no discernable differences in concentrations before and after BMP implementation at the two industries are not obvious, but may include the voluntary nature of the BMP usage. However, valuable baseline data has been collected to date, and success was seen at one critical source industry. Therefore, it is recommended that the critical source program continue as described in the 1996 Municipal Stormwater Permit until eight critical industries are studied.

5.4.4 TMDLs in Los Angeles County

By March, 2006, at least 22 impaired water bodies in Los Angeles County will come under Total Maximum Daily Load (TMDL) regulation due to the recent Consent Decree (Los Angeles Regional Water Quality Control Board et al, 1999). The pollutants claimed to be causing impairment include trash, nutrients, coliform, nitrogen, metal, PCBs, pesticides, and chlordane. It is recommended that receiving water impact studies be performed on significant impaired water bodies to identify impacts due to stormwater. Such impact studies could include assessments of bioassessment.

5.4.5 Constituents of Concern

The following recommendations are based on the observation of problems identified by the monitoring program, namely: dry and wet weather bacteria indicators, zinc and copper toxicity in Ballona Ck., suspended solids linked to contaminated sediments, and toxicity in the Los Angeles and San Gabriel Rivers. These recommendations also recognize the concerns regarding possible stormwater impairment to water bodies under the forthcoming TMDL regulations.

5.4.5.1 Bacteria

Wet weather observations suggest that peak coliform levels may be related to regional hydrologic conditions. In an effort to characterize the presence and persistence of indicator bacteria in dry and wet weather, the Southern California Coastal Waters Research Project is conducting research and calibrating water quality models. Participation in these studies is recommended. It is further recommended that similar studies be initiated for other parts of the County where indicator bacteria impair beneficial uses.

5.4.5.2 Contaminated Sediments

Because contaminated sediments can be linked to suspended solids in stormwater, participation in the Corps of Engineers' Sediment Control Management Plan and the Coastal Commission Sediment Task Force is recommended. It is further recommended that receiving water impacts due to aerial deposition studies be conducted on inland watersheds.

5.4.5.3 Stormwater Toxicity

With the identification of zinc and copper in Ballona Creek stormwater discharge, it is recommended that major tributaries to Ballona Creek be surveyed to find possible contributing areas and sources.

It is recommended that two dry weather and two wet weather Toxicity Identification Evaluations be conducted for a full range of constituents on freshwater species on the L. A. River and Dominguez Channel.

It is recommended that two wet weather Toxicity Identification Evaluations be conducted for a full range of constituents on freshwater species on the San Gabriel River.

5.4.6 Receiving Waters Impacts

It is recommended that follow-up studies be conducted in Santa Monica Bay that address the persistence of stormwater plumes following storm events, the toxicity of stormwater on species other than sea urchins, and the fate of sediments in the Bay.

It is further recommended that a study be conducted assessing the impacts due to stormwater on San Pedro Bay.

5.4.7 Other Monitoring Activities

Participation and cooperation with local and regional monitoring programs is recommended, including but not limited to the Santa Monica Bay Restoration Project, the City of Long Beach, and the developing Southern California Regional Stormwater Monitoring Coalition.

It is also recommended that Best Management Practices and impacts be formally evaluated. Examples would include the City of Santa Clarita demonstration projects, catch basin inserts and deflectors, groundwater impacts due to stormwater infiltration, the Department of Public Works' parking lot retrofit, and storm drain low flow diversions.

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