LA County Dept. of Public Wor--
1994 - 2000 Monitoring Report
2001

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).

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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.

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.

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