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B.0 PROGRAM MONITORING AND DATA ANALYSIS METHODS

The core monitoring program is conducted in accordance with the monitoring requirements set forth in Order No. R9-2007-0001. Collection and analysis of ambient water quality and storm water runoff at mass loading stations (MLS) and temporary watershed assessment stations (TWAS) was conducted. Ambient water samples were collected at MLS and TWAS during two events (fall and spring). Storm water samples were collected during two storm events at each MLS and TWAS. Samples were analyzed for chemical constituents, indicator bacteria, and toxicity to bioassay test organisms. Trash assessments were conducted at each MLS and TWAS during all monitoring events. After the first major rainfall of the season, post storm sediment sampling occurred at the MLS and TWAS to assess the relative concentrations of synthetic pyrethroids in sediment in receiving waters. Rapid stream bioassessment surveys were conducted during Spring of 2008 at each MLS and TWAS and coincided with the spring ambient water quality sampling. Periphyton sampling and physical habitat assessments were also conducted. Watershed assessment methods, GIS and modeling methods, and statistical analysis methods are also described in this section.

B.1 Water Quality Monitoring Methods

B.1.1 Mass Loading Station (MLS) Site Selection

The 2007–2008 monitoring program included ambient and storm water monitoring at seven MLS and nine TWAS. The data collected at each station is representative of large drainage areas with mixed land use characteristics. Monitoring at the six northern MLS stations and the MLS in Chollas Creek occurred at the same locations as in previous years. In 2007, the new TWAS monitoring site locations were selected by Weston Solutions, Inc. (Weston), working with the San Diego Copermittees' Monitoring Workgroup, and approved by the San Diego RWQCB. The primary site selection factors included:

- Suitability of the site drainage area to monitor area-wide contributions of storm water pollutant loading.
- Suitability of the site's hydrological characteristics to enable practical measurement of flow and collection of representative samples.
- Safety from traffic and other hazards.
- Suitable siting for sampling equipment.
- Accessibility for equipment communication (convenient, though not necessary for modem communications).
- Crew access for retrieving samples and maintaining equipment during storm conditions.

The MLS sites were selected to directly measure pollutant loads being discharged into San Diego's receiving waters by the major watersheds within the San Diego region. Monitoring sites were installed where flow from the catchment area passes a single hydrologically ratable point, and is suitable for water quality sampling. In some instances, sites were located upstream of the drainage area discharge point for accessibility and/or to avoid tidal influences. TWAS sites were placed at locations based on land use changes, jurisdictional borders, or where new data was needed to answer specific monitoring questions.

B.1.2 Monitoring Equipment

Flow was monitored at all stations using American Sigma flow meters. A variety of flow measurement technologies were utilized to accurately measure flow rates including ultrasonic sensors, bubblers, and submerged pressure transducers. The sensors provided a continuous measurement of river or stream stage (height) and relayed that information to the flow meter. The flow meter continually calculated flow rates by inserting the stage information into the preprogrammed discharge equation. Two stations are co-located with U.S. Geological Survey (USGS) stream gauging stations. At these sites the USGS rating curves were used.

Field crews measured the flow rate of streams using USGS stream profiling guidelines prior to the beginning of, and periodically throughout, the storm season. This was accomplished by manual rating techniques using a hand held flow meter. The resulting discharge rates were used to calculate a discharge equation, which was utilized by the flow monitoring equipment at some stations. At other stations where a discharge equation could not be developed, velocity/stage measurements were utilized to calculate discharge rates using the area velocity method.

B.1.3 Sampling Procedures

B.1.3.1 Grab Samples

Grab samples were collected for those constituents that are not amenable to composite sampling. The grab samples were analyzed for the following parameters:

- Temperature.
- pH.
- Specific conductance.
- Biochemical oxygen demand.
- Oil and grease.
- Total coliform.
- Fecal coliform.
- Enterococci.

Samples were collected from the horizontal and vertical center of the channel if possible and kept clear from uncharacteristic floating debris. Because oil and grease and other petroleum hydrocarbons tend to float, oil and grease grab samples were collected at the air/water interface. Bacteria samples were collected in a sterile sample bottle and then placed in a clean Ziploc bag and put on ice for transport to the laboratory for analysis within 6 hours.

B.1.3.2 Composite Samples

Ambient samples and storm water samples were collected as flow-weighted composites during each monitoring event. Ambient event flows typically do not fluctuate over a wide range of flow rates and were monitored over a 24-hour period to represent the conditions during both day and night. Storm event flows were monitored during the initial rise and peak of the hydrograph. When practical, the entire event was sampled. At some monitoring stations this was not practical due to the runoff characteristics of the watershed or due to the amount and duration of rainfall received. For example, San Luis Rey and San Diego Rivers are large water bodies that continue to rise following the initial flow of runoff during storm events and it is not uncommon to see a double peak in the hydrographs. The first peak (usually smaller than the second) is the immediate response from runoff. The second peak is typically the result of groundwater flowing from the unsaturated zone that appears as a much larger peak, usually hours or days after rainfall has stopped. Sampling this additional flow would dilute the analytes measured in the composite sample and would result in slightly lower concentrations. For large watersheds, the sampling strategy was determined by using best professional judgment to monitor rainfall and runoff and determine the appropriate time to terminate sampling. In some cases, safety was a factor for determining when to terminate sampling.

In general, a larger concentration of constituents from urban runoff enters the storm drainage system during the initial stages of flow and during peak flow and/or peak rainfall intensity for small rainfall events, which are typical in our region (Tiefenthaler et al., 2001; City of Austin, 1990). Therefore, a successful event was determined by capturing flow weighted aliquots during the initial rise and peak of runoff (at a minimum) from the storm event.

Storm teams evaluated telemetry data from the monitoring sites during storms to ensure all of these conditions were met before terminating sampling. Storm hydrographs for each of the monitored events are presented in Appendix G.

B.1.4 Stream Rating Methods

The stream flow rate at each of the monitoring sites was determined by stream stage (water level) sensors that are typically secured to the bottom of the channel. To quantify flow rates based on stream stage, a relationship between flow and stage was derived using standardized stream rating protocols developed by the USGS (Rantz, 1982; Oberg et al., 2005). Instantaneous flow measurements were measured at various stages at each of the sites. The measurements were combined to produce a rating curve for each site.

Methodology has been improved for the measurement and accuracy of flow estimates at MLS sites. Due to safety issues, past estimates for high flows based on stage were made based on extrapolation of the rating curve at low flow. This extrapolation was derived using a best-fit curve approach. To accurately measure flow in streams there are three critical elements needed to develop rating curves:

- An accurate survey of the stream channel cross section and longitudinal slope.
- Accurate level measurements based on a fixed point.
- Measurements of velocity and flows at several points throughout the rating curve including low flow, mid flow, and peak flow conditions.

To measure instantaneous flows during low flow and base flow conditions, two velocity measurement instruments were used: (1) a Marsh-McBirney Model 2000 Portable Flow Meter connected via a cable to an electromagnetic open channel velocity sensor, and (2) the SonTek (YSI) FlowTracker Acoustic Doppler Velocimeter. The FlowTracker is a high-precision, shallow-water velocity/flow meter that measures velocity in 3 dimensions and features an automatic discharge computation.

The velocity sensors were attached to a stainless steel top-setting wading rod. To make an instantaneous flow measurement, a tape measure was stretched across the stream, perpendicular to flow and secured on both banks of the stream. The tape was positioned so that it was suspended approximately one foot above the surface of the water. The distance on the tape directly above the waterline (where the water met the bank) was then recorded as the initial point. The first measurement was then made at the first point where there was adequate water depth (at least 0.2 feet) and measurable velocity. At this point, three measurements were made: water depth, velocity, and distance from the bank (the initial point). Subsequent depth, velocity, and distance measurements were then made incrementally across the entire width of the channel so that a minimum of ten points were measured per site. Water depth was determined from calibrations on the wading rod in tenths of feet. Velocity measurements were made at each point along the transect by positioning the velocity sensor perpendicular to flow at 60% of the water depth (from the surface) to attain an average velocity. The top setting wading rod is designed so that the sensor can be conveniently positioned at the appropriate depth. Water velocity was measured in feet per second.

Data from the field measurements were entered into a computer model that calculates the stream's cross-sectional profile from the depth and distance from bank measurements. Total flow across the channel was determined by integrating the velocity measurements over the cross-sectional surface area of the stream channel. The result is an instantaneous flow measurement in cubic feet per second.

A StreamPro Acoustic Doppler Current Profiler (ADCP) was used to measures high stage and flow conditions. The StreamPro ADCP is the USGS instrument of choice for measuring flows nation-wide (Oberg et al., 2005). The instrument is pulled across the stream either by walking across a bridge or attaching the unit to a tagline. Data are collected in real-time and transmitted via a wireless data link to a palm PC. Data can be viewed in real time and is typically post-processed following the field event in the office.

Rating curves were extended to high stream stages not measured using site-specific survey information and the Chézy-Manning formula (Linsley et al., 1982). The Chézy-Manning formula is an empirical formula for open channel flow, or flow driven by gravity:

$$Q = (1.486/n)AR^{2/3}S^{1/2}$$

where,

Q = Flow
n = Manning Roughness coefficient
A= Cross sectional area
R= Hydraulic radius
S= Hydraulic slope

The hydraulic radius is derived as:

$$R = A/P$$

Where;

A = Cross sectional area of flow (ft^2)
P = Wetted perimeter (ft)

The Chézy-Manning formula was developed for conditions of uniform flow in which the water surface profile and energy gradient are parallel to the streambed and the area, hydraulic radius, and depth remain constant throughout the reach. Field surveys of the channel geometry of each MLS were conducted in order to compute the channel characteristics for each site.

Channel cross section surveys were conducted at each site in order to derive stream discharge using the Manning equation. The cross section surveys involved placing endpoints and a benchmark on the nearest overhead bridge structure or stretched line such that the endpoints were placed at the highest point of the channel on each bank. A tape was then stretched between the endpoints such that the zero end of the tape was attached to the endpoint on the left bank of the channel (looking downstream). Using a weighted tape measure, at least twenty vertical distance measurements from a standard level on the bridge or stretched line to the channel bottom were then recorded at equal horizontal distances across the creek. A DeWalt transit level was used to survey the channel thalweg. A minimum of three elevations at increasing horizontal distances from the transit level were recorded in the channel bed. A minimum of five elevations were measured at sites with irregularly sloped or curved channel surfaces. The average channel slope was calculated from the survey data.

Channel survey data were used with the Chézy-Manning formula to produce a rating curve for each sampling site. Each rating curve was calibrated using instantaneous flow measurements by adjusting the formula roughness coefficient.

For long-term flow monitoring, instream flow measurement devices (such as the Sigma 950 flow meter) with pressure/level sensors, area velocity sensors, or ultrasonic level sensors are used. These data are downloaded bi-weekly from each site and are verified by a Senior Hydrologist to ensure accuracy and identify maintenance and calibration needs. Flow data are then entered into the data management system. All flow data are backed up and archived on a weekly basis.

B.1.5 Sample Handling and Processing

In accordance with USEPA sampling protocols and the Weston Quality Assurance Program, all samples collected were stored in the appropriate container type for the analytical method to be performed. Additionally, all samples were stored chilled in ice-chests for transfer to the laboratory and between laboratories. The sample containers used were certified as clean and sterile by the laboratory performing the analyses. Chain-of-custody forms were completed for each sample and accompanied the samples to the laboratories and between laboratories at all times.

Sample preservatives and holding time requirements for each analytical measurement (Table B-1 and Table B-2) were based on the recommendations by the Standard Methods for the Examination of Water and Wastewater and the USEPA methods. All storm water samples were transported from the field to the laboratory under Weston chain-of-custody procedures. Samples moved between laboratories were transported under the laboratories' chain-of-custody procedures. Samples not processed at Weston's laboratories were submitted by Weston to CRG Marine Laboratories, Inc. in Torrance, CA.

Table B-1. Analytical Requirements for Mass Loading Stations 2007–2008

Constituent	Volume Required	Method	Target Reporting Limit	Units	Max Holding Time
General Physical and Inorganic Non-Metals					
TDS	100 mL	SM 2540C	20	mg/L	7D
TSS	100 mL	SM2540D	20	mg/L	7D
Turbidity	100 mL	SM 2130A-B	0.1	NTU	48H
Total hardness	150 mL	SM 2340B	10	mg/L	6M
pH (field)	In field	EPA 150.1	0.1	S.U.	-
Specific conductance (field)	In field	SM 2510B	1	umhos/cm	-
Temperature (field)	In field	Meter	-	-	-
Dissolved phosphorus	250 mL	SM 4500PE	0.05	mg/L	48H
Total phosphorus	250 mL	SM 4500PE	0.05	mg/L	28D
Nitrate	200 mL	SM4500NO3E	0.1	mg/L	48H
Nitrite	200 mL	SM4500NO2B	0.05	mg/L	48H
TKN	500 mL	SM4500C	0.1	mg/L	28D
Ammonia	250 mL	SM 4500NH3D	0.1	mg/L	28D
BOD, five-day (grab only)	1000 mL	SM5210B	2	mg/L	48H
COD	25 mL	EPA 410.4	25	mg/L	28D
Total organic carbon (TOC)	125 mL	SM 5310 B	1	mg/L	28D
Dissolved organic carbon (DOC)	125 mL	SM 5310 B	1	mg/L	28D
Organics					
O&G (grab only)	500 mL	EPA 1664	5	mg/L	14D
Diazinon	1 liter	EPA 625	0.05	µg/L	14D
Chlorpyrifos	1 liter	EPA 625	0.05	µg/L	14D
Malathion	1 liter	EPA 625	0.05	µg/L	14D
Synthetic pyrethroids (storm events only)	1 liter	GC/MS NCI Mode	0.005	µg/L	7 D
MBAS	250 mL	SM 5540C	1	mg/L	48H
Chollas Creek Only (additional methods)					
PCBs	1 liter	EPA 625	0.020	µg/L	14D
Chlordane	1 liter	EPA 625	0.005	µg/L	14D
PAHs	1 liter	EPA 625	0.10	µg/L	14D
Metals – Total and Dissolved					
Antimony (Sb)	75 mL	EPA 200.8	0.002	mg/L	6M
Arsenic (As)	75 mL	EPA 200.8	0.001	mg/L	6M
Cadmium (Cd)	75 mL	EPA 200.8	0.001	mg/L	6M
Chromium (Cr)	75 mL	EPA 200.8	0.005	mg/L	6M
Copper (Cu)	75 mL	EPA 200.8	0.001	mg/L	6M
Lead (Pb)	75 mL	EPA 200.8	0.001	mg/L	6M
Nickel (Ni)	75 mL	EPA 200.8	0.002	mg/L	6M
Selenium (Se)	75 mL	EPA 200.8	0.002	mg/L	6M
Zinc (Zn)	75 mL	EPA 200.8	0.02	mg/L	6M
Bacteriological					
Total coliform	200 mL	SM 9221B	20-1.6 mil.	MPN/100mL	6H
Fecal coliform	200 mL	SM9221E	20-1.6 mil.	MPN/100mL	6H
Enterococcus	200 mL	SM 9230	20-1.6 mil.	MPN/100mL	6H
Toxicity	10 liters	-	-	-	36H
96-hr acute and seven-day chronic and reproductive test with the cladoceran *Ceriodaphnia dubia*					
Chronic test with the freshwater algae *Selenastrum capricornutum*					
96-hr acute survival test with the amphipod *Hyalella azteca*.					

B.1.6 Laboratory Analysis

B.1.6.1 Chemical Constituents

General physical and chemical constituents were analyzed by CRG Marine Laboratories, Inc. with the exception of field measured constituents (pH, conductivity, and temperature). Field measurements were conducted by Weston's field scientists during field sampling activities. The chemical constituents measured in this monitoring program are presented in Table B-1 and Table B-2. Additional chemical analyses were conducted in the San Dieguito River Watershed Management Area to characterize fire impacts within the watershed (Table B-3).

Table B-2. Synthetic Pyrethroid Analytes

Constituent	Volume Required	Method	MDL	Units	Holding Time
Synthetic Pyrethroids	2 L	EPA 625-NCI Mode			Extraction-7 Days Analysis-40 Days
Allethrin			0.005	µg/L	
Bifenthrin			0.005	µg/L	
Cyfluthrin			0.005	µg/L	
Cypermethrin			0.005	µg/L	
Danitol			0.005	µg/L	
Deltamethrin			0.005	µg/L	
Esfenvalerate			0.005	µg/L	
Permethrin			0.005	µg/L	
Prallethrin			0.005	µg/L	

Table B-3. San Dieguito River Fire Impact Assessment Analytes

Constituent	Volume Required	Method	Target Reporting Limit	Units	Max Holding Time
General Physical and Inorganic Non-Metals					
Sulfate	200 mL	EPA 300.0	0.05	mg/L	28D
Organics					
PAHs	1 liter	EPA 625	0.005	µg/L	14D
Metals – Total and Dissolved					
Mercury (Hg)	75 mL	EPA 245.7	0.02	µg/L	28D

B.1.6.2 Toxicity Testing

Toxicity testing is performed on flow-weighted composite samples collected from the MLS and TWAS at the same time as the chemistry constituents. Toxicity testing is an effective tool for assessing the potential impact of complex mixtures of unknown pollutants on aquatic life in receiving waters. Rather than performing chemical analysis on a sample for a host of compounds potentially toxic to aquatic life, this approach utilizes a laboratory test species to provide a direct measure of the toxicity of the sample. Interactions among the complex mixture of chemicals and physical constituents can lead to additive or antagonistic effects, potentially causing an individual compound to become either more or less toxic than it would be were it isolated. While the potential effects of these interactions cannot be derived from simple chemical measurements, they are directly accounted for in toxicity tests. If persistent toxicity is detected, specialized toxicity identification evaluations (TIE) may be used to help characterize and identify constituent(s) causing toxicity. Toxicity testing can provide information on both potential short-term or "acute" effects as well as longer-term "chronic" effects. Historically, toxicity tests, including TIEs, have been used to assess both short and long-term impacts of point source discharges (e.g., Publicly Owned Treatment Works (POTW), power plant and industrial effluents) on aquatic life in a receiving water body. However, these tools can be applied to non-point source discharges, such as urban runoff.

Toxicity testing provides the only direct means to assess the potential toxicity waters within the receiving waters. Living organisms are able to integrate effects of multiple contaminants and account for the inherent properties of the sample matrix (e.g., hardness and alkalinity of a storm water sample) that influence bioavailability and hence toxicity. However, the same elements that make these tools so effective can contribute to variability in the response. Living organisms respond to a host of factors other than contaminants. If test organisms are stressed in any way prior to testing, variability of the test organism response may increase and produce equivocal results. The use of controls and reference toxicant testing are quality assurance and quality control measures that have been put in place to identify changes in test organism sensitivity due to stress or other factors. Naturally occurring characteristics of the sample matrix can also affect organism response. For example, mortality of test organisms can result from extreme variations in water hardness. Consequently, understanding the importance of such features on test organism response is critical for the accurate interpretation of test results. The test procedures employed to date represent the culmination of some 40 years of research. While this does not guarantee that they are employed properly in every circumstance, there is a wealth of information to document the utility of such procedures.

Freshwater species were used to evaluate the potential impacts of urban runoff in the receiving waters at each MLS and TWAS. It is important to note that, ultimately, all of the receiving water bodies for these drainage basins are estuarine/marine habitats (e.g., San Diego Bay, Mission Bay, various coastal lagoons and estuaries). The extrapolation of these freshwater species tests to evaluate the potential impact in the downstream marine/estuarine environments can be problematic. For example, the organic ligands present in an estuarine environment may make contaminants unavailable for uptake and reduce toxicity. In addition, marine organisms often have different sensitivities to contaminants than freshwater organisms.

Three species were used in this monitoring program. The cladoceran, *Ceriodaphnia dubia*, represents the invertebrates that live in the water column and serve as a source of food for larger invertebrates and small fish. This species is known to be sensitive to metals and pesticides in water, as well as other contaminants. The freshwater amphipod, *Hyalella azteca,* is an invertebrate that is associated with the sediment at the bottom of streams and lakes. It again serves as a food source for larger invertebrates as well as fish. This species is generally sensitive to metals and pesticides, as well as nitrogen compounds such as ammonia. *Hyalella azteca* is also known to be sensitive to synthetic pyrethroids in low concentrations that tend to bind to sediments (Amweg et al., 2005; Anderson et al., In Press; and Maund et al., 2002). The freshwater plant, *Selenastrum capricornutum,* is a unicellular algae that is present in the water column of lakes and streams. It is at the base of the food chain in freshwater systems. It is sensitive to herbicides and metals, but its growth is also greatly affected by nutrient loads (e.g., nitrates and phosphorus) in a water body. Nutrients tend to stimulate the growth of *S. capricornutum* (causing an algal bloom) and, if the nutrient loads are high enough in a water body, they can offset the toxic effect that contaminants might otherwise produce. All toxicity tests were conducted by Weston's laboratory in Carlsbad, California.

Ceriodaphnia dubia

Samples from mass loading stations were tested for toxicity according to the USEPA protocol (EPA-821-R-02-013). This protocol was developed for testing the chronic toxicity of point-source discharges where the effluent is diluted considerably in the receiving waters. Laboratory test organisms are placed in small containers of effluent sample and monitored over time to compare the response of organisms placed in non-toxic control water to the sample water. The sample is diluted (with control water) to several known concentrations before the test and test organisms are added to each concentration. The standard USEPA recommended dilution series (100%, 50%, 25%, 12.5%, 6.25%, and a control) are used for all toxicity tests. The test solutions are renewed and test organisms are fed daily. In the *Ceriodaphnia* chronic test, single females are placed in individual test chambers (ten test chambers per concentration) and the number of dead organisms along with the number of offspring produced per organism is recorded each day. When the controls reach an average of at least fifteen young per surviving adult, and 60% of the controls have had three broods, the test is terminated (day six to eight). Additionally, the acute, 96-hour (4-day) endpoint data (survival) is also collected from the seven-day chronic test. Only the original test organisms with which the test was begun were used for the calculation of both the acute and chronic survival endpoints.

Test Acceptability

Acceptability of the test is determined by evaluating the response of the control organisms. The test is considered acceptable if control survival is greater than 80%, control reproduction is greater than or equal to an average of fifteen young per adult, and more than 60% of the adults produce three broods by day eight of the test. If any one of these test acceptability standards is not met then the test is considered invalid and no further analysis is performed.

A reference toxicant test is also run to establish whether the test organisms used fall within the normal range of sensitivity. The reference toxicant test is conducted with known concentrations of a given toxicant (e.g., copper sulfate is used for *Ceriodaphnia*). The effect on the survival and reproduction of the test organisms is compared to historical laboratory data for the test species and reference toxicant. If the values are within two standard deviations of the historical average, the test organisms are considered to fall within the normal range of sensitivity.

The concentration that causes 50% mortality of the organisms (the median lethal concentration, or LC_{50}) is calculated from the data for 96 hours (96-hour acute LC_{50}) and for day seven (seven-day chronic LC_{50}) using USEPA methods. The LC_{50} values are point-estimates expressed as "percent sample;" the lower the LC_{50} percentage the more toxic the sample. For acute and chronic regulatory standards, the No Observed Effect Concentration (NOEC), for both survival and reproduction is calculated. This is the highest concentration tested in which there was no effect on the survival or reproduction compared to the control response. The lower the NOEC, the more toxic the sample.

Hyalella azteca

Storm water samples from each of the mass loading stations were also evaluated for acute toxicity using the freshwater amphipod, *Hyalella azteca,* according to a modified version of the USEPA protocol for testing sediment-associated contaminants with freshwater invertebrates (EPA-821-R-02-012). This protocol provides test methods for measuring acute toxicity in *Hyalella* exposed to freshwater sediments, as well as a test method for conducting a water-only acute reference toxicant test. The reference toxicant test protocol was modified to conduct the toxicity testing on samples collected from the mass loading stations. The test solution is prepared using the dilution series described above, and placed in 250-mL aliquots into 4 replicate test chambers. Clean sand is placed as a thin "monolayer" in the bottom of the test chamber and 10 organisms per replicate are added. The test organisms are exposed for four days and fed on day 2. At the end of the test, the survivors are removed from the sand and counted. A 96-hour LC_{50} is calculated from this data.

Prior to analysis of the data, test acceptability is determined by evaluating the response of the control organisms. The test is considered invalid if survival of control test organisms is less than 90%. As with *Ceriodaphnia*, a reference toxicant test using copper sulfate is also conducted with *Hyalella* to establish whether the test organisms used fall within the normal range of sensitivity. If the test data meet acceptability criteria, the LC_{50} is calculated from the 96-hour test data. Values are reported as the NOEC for the purposes of this report.

Selenastrum capricornutum [*]

In years prior to 2001, toxicity testing for the storm water monitoring program was conducted using a freshwater vertebrate species: the fathead minnow (*Pimephales promelas*). Results of tests conducted with this species failed to show any toxicity relative to the other species tested. Consequently, the San Diego Regional Water Quality Control Board (RWQCB) approved the replacement of this test with a chronic *Hyalella* toxicity test measuring a sublethal endpoint (e.g., growth). Attempts to develop a short-term sublethal toxicity test with *Hyalella* during the 1999-2000 and 2000-2001 storm seasons proved unsuccessful, due to the variability of the growth endpoint. Consequently, it was recommended and the RWQCB subsequently approved replacing the proposed *Hyalella* chronic test with the *Selenastrum capricornutum* chronic test.

[*] The name of this species has been changed to *Pseudokirchneriella subcapitata*, however, *Selenastrum capricornutum* will continue to be utilized for the purposes of continuity with previous testing.

This algal species has the potential to be sensitive to metals (in waters low in nutrients) and herbicides.

Samples from the mass loading stations were tested for toxicity according to the USEPA protocol (EPA-821-R-02-013) using the unicellular algae *Selenastrum*. This protocol was developed for testing the 96-hour chronic toxicity of point-source discharges. The sample and the control water are spiked with equal amounts of nutrients and subsequently filtered to remove any unicellular algae that might be present prior to test initiation. The concentration series is prepared and 50-mL aliquots are placed into four replicate test chambers. Approximately 10,000 cells per mL are added to the test chamber and placed in random order under high-intensity 24-hour light for four days. The test chambers are shaken twice and randomized daily. At the end of the test period, chambers are analyzed for chlorophyll *a* concentrations (fluorescence).

Test acceptability is determined by evaluating the response of the control organisms. The test is considered invalid if the criterion of a mean cell density of 1,000,000 cells per mL in the control is not met. Variability between the control replicates should not exceed 20%. A reference toxicant test using copper sulfate is also run parallel with the test to establish the sensitivity of the organisms.

Alterations to the *S. capricornutum* testing protocol were put into effect with the promulgation of the updated EPA guidelines in October 2002. The most significant changes to the protocol involve the addition of ethylenediaminetetraacetic acid (EDTA) as a component of the nutrient stock for conducting the test. The addition of EDTA has been determined to greatly reduce the incidences of false positives and increase the precision of the test method. This chemical has the ability of reducing the toxicity of certain metals by making them unavailable to the test organism. The guidance document warns that this method may underestimate the toxicity of metals and should be used in conjunction with multiple species tests, such as in this program, to monitor toxicity. Another alteration to test protocol was increasing the acceptability criterion of a mean cell density 200,000 algal cells per mL in the control to 1,000,000 cells per mL.

If the test data meet acceptability criteria, inhibition concentrations, an IC_{25} and an IC_{50}, are calculated from the data: the concentrations that cause a 25% or 50% inhibition in the growth, or cell density, of the algae. A NOEC is also calculated from this data and is used for reporting purposes.

B.1.6.3 Microbiology Testing

Measures of bacteria from grab samples were made by the Weston microbiology laboratory located in Carlsbad, California. Samples were collected during the each monitoring event using grab poles and aseptic techniques by Weston’s field technicians and scientists and delivered to the microbiology laboratory within the six hour holding time requirement. Sample analyses were initiated immediately upon receipt for all three indicators by multiple tube fermentation; total coliform using SM 9221B, fecal coliform using SM 9221E, and enterococcus using SM 9230B. All results were reported to a most probable number value (MPN/100 mL). “Greater than” values were utilized for MPN values that exceeded 16,000,000.

B.2 Rapid Stream Bioassessment Methods

Weston conducted stream bioassessment pursuant to RWQCB Order No. 2001-01 to assess the ecological health of the watershed units in San Diego County. The assessment was undertaken utilizing a protocol that samples and analyzes populations of benthic macroinvertebrates (BMIs). This program supplements the monitoring program conducted by the California Department of Fish and Game (CDFG) Water Pollution Control Laboratory from 1997 to May 2001, under contract to the RWQCB. For the 2007–2008 program, Weston followed the sampling protocols of the Surface Water Ambient Monitoring Program Standard (SWAMP) *Operating Procedures for Collecting Benthic Macroinvertebrates and Associated Physical and Chemical Data* (Ode, 2007) for field collections. Laboratory sample processing followed the protocols of the California Stream Bioassessment Procedure (CSBP) (Harrington, 2003) and taxonomic identifications were to standard taxonomic level I (Genus level for most insects, Class or Order for most non-insects) as defined by the most recent version of the *Southwestern Association of Freshwater Invertebrate Taxonomists List of Macroinvertebrate Taxa from California and Adjacent States and Ecoregions; and Standard Taxonomic Effort* (SAFIT, 2006).

The SWAMP sampling protocol includes the collection of stream benthic macroinvertebrates and also assesses the quality and condition of the physical habitat in detail (note: a physical habitat index based on the SWAMP procedure has not been developed at the time of this report). Benthic macroinvertebrates reside in streams for periods ranging from a month to several years, and have varying sensitivities to the multiple stressors associated with urban runoff. Utilizing species specific tolerance values and community species composition, numerical biometric indices are calculated, allowing for comparison of relative habitat health among streams in a region. By assessing the invertebrate community structure of a stream, a cumulative measure of stream habitat health and ecological response is obtained.

This report presents the results from stream bioassessment surveys conducted in May 2008 as well as summary data since the beginning of the program in 2001. The data include a taxonomic listing of all benthic macroinvertebrates identified in the surveys, and calculation of the biological metrics listed in the CSBP. Additionally, calculation of two indices that rate the overall BMI community quality was performed. These included the Index of Biotic Integrity (IBI) (Ode et al., 2005) and the O/E ratio of Observed to Expected taxa.

Benthic macroinvertebrate sampling

B.2.1 Monitoring Reaches

From 2001 to 2007, a minimum of 23 monitoring reaches were sampled in each survey, including three reference sites per survey. In 2008, the program was re-structured and a total of 20 monitoring reaches were sampled including six MLS sites, nine TWAS sites, three reference sites, and two additional sites. Descriptions of the locations are presented in Table B-4 and a map illustrating these locations is shown in Figure 2-1. The goal for the survey was to sample the same monitoring reaches as the wet and dry weather sampling sites.

Reference sites have been designated by CDFG and the RWQCB based on upstream land use characteristics as determined by GIS datasets. When selecting reference monitoring sites for comparison with urban affected sites, elevation was considered, and most of the reference sites were at similar elevation to the urban sites. One exception was the Doane Creek reference site (REF-DC), located on Palomar Mountain at an elevation of nearly 5,000 feet. It may be noted that the locations of the reference sites was in the upper erosional portion of the hydrologic units while the test monitoring sites were generally in lower depositional areas and this may affect benthic community composition independent of water quality.

Comparison of urban monitoring sites to reference sites is not limited to the three reference sites sampled in this program. The benthic community summary indices (described below in Section B2.8) that provide community quality ratings already incorporate a broad range of historical reference sites throughout the region. For example, Ode et al. used 275 different reference sites to develop the Index of Biotic Integrity, and the scoring criteria are based on mean metric values for all of these sites. Reference sites monitored concurrently with the urban sites provide a direct temporal correlation that includes seasonal environmental variables (e.g., rainfall).

Table B-4. San Diego County: Stream Bioassessment Monitoring Sites (June 2001–May 2008)

Watershed Name	Receiving Water	Station Identification	Site Description	Station Coordinates	Jun-01	Oct-01	May-02	Oct-02	May-03	Oct-03	May-04	Oct-04	May-05	Oct-05	May-06	Oct-06	May-07	May 08
Reference Sites																		
Santa Margarita River	Sandia Creek	REF-SC	Reach consisted of 5 riffles along Sandia Creek Drive	33 25.482' 117 14.942'	x	x	x	x	x	x								
Santa Margarita River	Sandia Creek	REF-SC2	Reach consisted of 5 riffles along De Luz Road	33 29.529' 117 16.020'							x	x	x	x	x	x	x	x
Santa Margarita River	Sandia Creek	REF-SCCR	Reach consisted of 5 riffles downstream of Carancho Road	33 29.529' 117 16.020'		x												
Santa Margarita River	San Mateo Creek	REF-SMC	Reach consisted of 3 riffles upstream of San Mateo Road	33 25.248' 117 32.000'	x													
Santa Margarita River	De Luz Creek	REF-DLC	Reach consisted of 5 riffles downstream of De Luz Road	33 26.483' 117 19.434'	x		x		x	x	x							
Santa Margarita River	De Luz Creek	REF-DLC3	Reach consisted of 5 riffles along De Luz-Murietta Road	33 27.574' 117 17.456'				x		x		x						
San Luis Rey River	Doane Creek	REF-DC	Reach consisted of 5 riffles upstream of Doane Pond in Palomar Mt. State Park	33 20.124' 116 53.496'							x	x	x	x	x	x	x	x
San Luis Rey River	Keys Creek	REF-KC	Reach consisted of 5 riffles at Old Lilac Road	33 17.744' 117 05.149'		x	x	x										
San Diego River	Boulder Creek	REF-BCR	Reach consisted of 5 riffles upstream of Boulder Creek Road	32 57.827' 116 39.731'										x	x	x	x	x

Table B-4. San Diego County: Stream Bioassessment Monitoring Sites (June 2001–May 2008)

Watershed Name	Receiving Water	Station Identification	Site Description	Station Coordinates	Jun-01	Oct-01	May-02	Oct-02	May-03	Oct-03	May-04	Oct-04	May-05	Oct-05	May-06	Oct-06	May-07	May 08
San Diego River	Cedar Creek	REF-CC	Reach consisted of 5 riffles upstream of Cedar Creek Road	33 01.154' 116 38.029'					x									
Tijuana River	Wilson Creek	REF-WC	Reach consisted of 5 riffles upstream of Lyons Valley Road	32 42.449' 116 44.231'									x					
Urban Influenced Sites																		
Santa Margarita River	Santa Margarita River	SMR-WGR	Reach consisted of 5 riffles upstream of Willow Glen Road	33 25.614' 117 11.861'				x	x	x	x	x	x	x	x	x	x	x
Santa Margarita River	Rainbow Creek	RC-WGR	Reach consisted of 150 meters upstream of Willow Glen Road	33 24.468' 117 12.109'														x
Santa Margarita River	Santa Margarita River	SMR-MIS-2 (SMR-DLR)	Reach consisted of 5 riffles downstream of De Luz Road	33 23.844' 117 15.734'				x										x
Santa Margarita River	Santa Margarita River	SMR-CP	Reach consisted of 5 riffles downstream of Santa Margarita Road, Camp Pendleton	33 20.457' 117 19.897'					x	x	x	x	x	x	x	x	x	
San Luis Rey River	San Luis Rey River	SLR-MLS (SLRR-BR)	Reach consisted of 2 riffles near the USGS gauging station at Benet Road	33 13.095' 117 21.569'			x	x	x	x	x	x	x	x	x	x	x	x
San Luis Rey River	San Luis Rey River	SLR-TWAS-1 (SLRR-MR)	Reach consisted of 3 riffles upstream of Mission Road	33 15.587' 117 14.176'	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Carlsbad	Loma Alta Creek	LAC-ECR	Reach consisted of 3 riffles up and downstream of El Camino Real	33 11.995' 117 19.878'	x	x	x	x										
Carlsbad	Loma Alta Creek	LAC-CB	Reach consisted of 5 riffles of College Blvd.	33 12.363' 117 17.087'	x	x	x											
Carlsbad	Loma Alta Creek	LAC-TWAS-1	Reach consisted of 150 meters downstream of I-5	33 11.301' 117 21.697														x
Carlsbad	Buena Vista Creek	BVC-TWAS-1 (BVR-ED)	Reach consisted of 5 riffles downstream of Santa Fe Av.	33 10.840' 117 19.717'	x	x	x											x
Carlsbad	Buena Vista Creek	BVR-CB	Reach consisted of 5 riffles downstream of College Blvd.	33 10.809' 117 17.918'		x	x	x		x						x		
Carlsbad	Buena Vista Creek	BVR-SVW	Reach consisted of 5 riffles downstream of South Vista Way.	33 10.840' 117 19.713'	x													
Carlsbad	Agua Hedionda Creek	AHC-TWAS-1 (AHC-MR)	Reach consisted of 5 riffles upstream of Melrose Road	33 09.132' 117 14.454'	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Carlsbad	Agua Hedionda Creek	AHC-MLS (AHC-ECR)	Reach consisted of 5 riffles downstream of El Camino Real	33 08.940' 117 17.830'	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Carlsbad	San Marcos Creek	SMC-M	Reach consisted of 5 riffles upstream of McMahr Road	33 07.831' 117 11.575'	x	x	x											

Table B-4. San Diego County: Stream Bioassessment Monitoring Sites (June 2001–May 2008)

Watershed Name	Receiving Water	Station Identification	Site Description	Station Coordinates	Jun-01	Oct-01	May-02	Oct-02	May-03	Oct-03	May-04	Oct-04	May-05	Oct-05	May-06	Oct-06	May-07	May 08
Carlsbad	San Marcos Creek	SMC-SP	Reach consisted of 5 riffles downstream of Santar Place	33 08.501' 117 08.740'	x	x	x											
Carlsbad	San Marcos Creek	SMC-RSFR	Reach consisted of 4 riffles downstream of Rancho Santa Fe Road	33 06.191' 117 13.609'	x	x	x											
Carlsbad	San Marcos Creek	SMC-LCCC	Reach consisted of 5 riffles upstream of La Costa Country Club	33 05.466' 117 14.664'	x	x	x	x				x						
Carlsbad	Encinitas Creek	ENC-GVR	Reach consisted of 3 riffles southwest of El Camino Real and La Costa Blvd	33 04.697' 117 16.000'	x	x	x											
Carlsbad	Cottonwood Creek	CC-E	Reach consisted of 4 riffles downstream of Hwy 101 along Encinitas Blvd.	33 02.905' 117 17.629'	x	x	x											
Escondido Creek	Escondido Creek	ESC-HRB	Reach consisted of 5 riffles downstream of Harmony Grove Bridge	33 06.550' 117 06.688'	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Escondido Creek	Escondido Creek	ESC-TWAS-1 (ESC-CC)	Reach consisted of 5 riffles downstream of Country Club Road	33 05.925' 117 07.836'			x											x
Escondido Creek	Escondido Creek	ESC-EF	Reach consisted of 5 riffles downstream of the old Elfin Forest Resort	33 04.417' 117 09.853'	x	x	x	x	x	x	x	x	x	x	x	x	x	
Escondido Creek	Escondido Creek	ESC-VC	Reach consisted of 5 riffles in Vista Canyon	33 03.617' 117 10.802'			x											
Escondido Creek	Escondido Creek	ESC-MLS	Reach consisted of 150 meter reach upstream of El Camino del Norte	33 02.912' 117 13.543														
Escondido Creek	Escondido Creek	ESC-RSFR	Reach consisted of 3 riffles upstream of Rancho Santa Fe Road	33 02.365' 117 13.837'	x	x	x											
San Dieguito River	San Dieguito River	SDC-TWAS-2	Reach consisted of 150 meters upstream of Lake Hodges	33 03.637 117 01.869														x
San Dieguito River	Green Valley Creek	SDC-TWAS-1 (GVC-WB)	Reach consisted of 5 riffles downstream of West Bernardo Drive	33 02.625' 117 04.567'				x	x	x	x	x	x	x	x	x	x	x
San Dieguito River	San Dieguito River	SDC-MLS	Reach consisted of 150 meters at Morgan Run Golf Course	32. 59.743' 117 12.378'														x
San Dieguito River	San Dieguito River	SD-DDH	Reach consisted of 5 riffles along Del Dios Highway downstream of Lake Hodges	33 02.459' 117 08.595'				x	x	x	x	x	x	x	x	x	x	

Table B-4. San Diego County: Stream Bioassessment Monitoring Sites (June 2001–May 2008)

Watershed Name	Receiving Water	Station Identification	Site Description	Station Coordinates	Jun-01	Oct-01	May-02	Oct-02	May-03	Oct-03	May-04	Oct-04	May-05	Oct-05	May-06	Oct-06	May-07	May 08
Los Peñasquitos Creek	Los Peñasquitos Creek	LPC-CCR	Reach consisted of 5 riffles upstream of Cobblestone Creek Road	32 56.949' 117 04.214'	x	x	x		x	x	x	x	x	x	x	x	x	
Los Peñasquitos Creek	Los Peñasquitos Creek	LPC-TWAS-2	Reach consisted of 150 meters upstream of Springbrook Dr.	33 56.553’ 117 05.018’														x
Los Peñasquitos Creek	Los Peñasquitos Creek	LPC-BMR	Reach consisted of 5 riffles downstream of Black Mountain Road	32 56.349' 117 07.864'	x	x	x	x										
Los Peñasquitos Creek	Los Peñasquitos Creek	LPC-MLS (LPC-805)	Reach consisted of 5 riffles upstream of I-805 at Mass Load Station	32 54.288' 117 13.379'												x	x	x
Los Peñasquitos Creek	Carroll Canyon Creek	LPC-TWAS-1 (CCC-805)	Reach consisted of 5 riffles downstream of I-805 at Sorrento Valley Road	32 53.403' 117 12.717'	x	x	x	x	x	x	x	x	x	x	x			x
Mission Bay	Rose Creek	MB-RC	Reach consisted of 5 riffles downstream of Highway 52	32 50.056' 117 13.887'				x	x	x	x	x	x	x	x	x	x	
Mission Bay	Tecolote Creek	TC-TCNP	Reach consisted of 4 riffles downstream of Mt. Acadia Blvd	32 47.874' 117 11.339'	x	x	x	x	x	x	x	x	x	x	x	x	x	
San Diego River	San Diego River	SDR-MT	Reach consisted of 5 riffles in Mission Trails Park	32 49.249' 117 03.866'			x	x	x	x	x	x	x	x	x	x	x	
San Diego River	San Diego River	SDR-1	Reach consisted of 5 riffles downstream of Mission Valley Golf Course	32 45.736' 117 11.557'			x	x	x	x	x	x	x	x	x	x	x	
San Diego Bay	Chollas Creek	CC-FB	Reach consisted of 5 riffles downstream of Federal Boulevard	32 43.606' 117 04.219'					x	x	x	x	x	x	x	x	x	x
Sweetwater River	Long Canyon Creek	SR-AD	Reach consisted of 5 riffles along Acacia Drive	32 39.394' 117 00.800'				x										
Sweetwater River	Sweetwater River	SR-WS	Reach consisted of 5 riffles along Bonita Road	32 39.436' 117 02.717'			x		x	x	x	x	x	x	x	x	x	
Sweetwater River	Sweetwater River	SR-94	Reach consisted of 5 riffles at Highway 94	32 44.005' 116 56.348'			x			x	x		x	x	x	x	x	
Tijuana River	Campo Creek	CC-C	Reach consisted of 4 riffles up/downstream of H94 bridge in Campo	32 36.552' 116 26.448'							x	x	x	x	x	x	x	
Tijuana River	Campo Creek	CC-H94	Reach consisted of 4 riffles at the Highway 94 USGS gauging station	32 35.456' 116 31.551'					x									
Tijuana River	Tijuana River	TJ-BF	Reach consisted of 2 riffles near the International Boundary border fence	32 32.539' 117 02.619'													x	
Tijuana River	Tijuana River	TJ-DM	Reach consisted of 5 riffles upstream of Dairy Mart Road	32 32.816' 117 03.741'					x				x		x			

B.2.2 Monitoring Reach Delineation

The sampling points specified in the SWAMP protocol include targeted riffle sampling for high gradient monitoring reaches and reach wide benthic sampling for lower gradient sites lacking riffle habitat in which samples are collected from evenly spaced transects. Riffle habitat is an area of rapid flow with some surface disturbance and a complex and stable substrate and these areas generally provide increased colonization potential for benthic invertebrates. Using SWAMP methodology, every monitoring reach was 150 m in length and was sampled from downstream to upstream.

B.2.3 Macroinvertebrate Sample Collection

Benthic invertebrates were collected using a 1-ft-wide, 0.5-mm-mesh, D-frame kick-net. A 1-ft^2 area upstream of the net was sampled by disrupting the substrate and scrubbing the cobble and boulders, so that the organisms were dislodged and swept into the net by the current. The duration of the sampling generally ranged from 1 to 3 minutes, depending on substrate complexity. Targeted riffle sampling collected nine 1-ft^2 areas and reach-wide benthic sampling collected eleven 1-ft^2 areas which were then combined into a single composite sample for the reach. Samples were transferred to one-quart jars, preserved with 95% ethanol, and returned to Weston's laboratory for processing.

B.2.4 Multihabitat Periphyton Sample Collection

Periphyton was collected using the "multihabitat" procedure which employs an objective method for selecting subsampling locations within the same transects used for benthic macroinvertebrate collection. For the mulithabitat procedure, the sample location was alternated between left, center and right positions within the transect reach and a single sample was collected at a distance of 1 m downstream of each transect. Depending on the substrate type and stream habitat, one of three sampling devices was used to collect the substrate sample. If the sampling location was in an erosional habitat (e.g. rocks, wood, etc.), the substrate was collected and placed in a plastic washtub. A rubber delimiter was used to define a 12.6 cm^2 area on the upper surface of the substrate. A toothbrush was used to dislodge the attached algae from the substrate surface in the defined area and the detached algae were rinsed into the washtub using a wash bottle. If the sampling location was in a depositional habitat (e.g. sand, sediment gravel, etc.), a clean PVC delimiter with a diameter of 4 cm was pressed into the top 1 cm of the substrate. A clean spatula was placed beneath the delimiter to assisting in containing the substrate and the contents were transferred to the washtub. If the sampling point was on substrate that could not be removed from the water (e.g. bedrock, boulder, concrete, etc.), a "syringe scrubber" (Davies and Gee, 1993) was used to collect algae from the surface. If the sampling point was on a mat of macroalgae, the PVC delimiter and spatula were used to cut a circle out of the mat. Once all transects were sampled, the collected substrate was massaged to dislodge any algae. The algae and remaining liquid were then collected into a clean sample bottle and the volume was recorded. The liquid portion of the composite was filtered in the field and the filters were placed on ice and/or frozen until delivery to the analytical laboratory.

B.2.5 Field Based Rapid Periphyton Survey

Benthic algal biomass was assessed using a viewing bucket marked with a 50-dot grid. Three transects were randomly chosen across the 150-m transect reach. Three locations along each transect (left, center and right) were surveyed by immersing the bucket in the water at each location. The macroalgal biomass was characterized by counting the number of dots that occurred over macroalgae. The microalgal biomass was characterized by counting the number of dots that occurred over substrata, which was of suitable size for microalgal accumulation. The thickness of the microalgae under each dot was estimated and recorded. Thin thickness microalgae were classified as 0–1 mm thick. Medium thickness microalgae were classified as 1 mm – 2 cm thick.

B.2.6 Physical Habitat Quality Assessment

Physical habitat assessment

For each monitoring reach sampled, the physical habitat of the stream and its adjacent banks were assessed to provide a record of the overall physical condition of the reach. Parameters such as substrate complexity, channel alteration and human influence, frequency of riffles, and width and quality of riparian zones help to provide a more comprehensive understanding of the condition of the stream. Additionally, specific characteristics of the sampled riffles were measured, including substrate size classes, stream depth, gradient, sinuosity, and flow volume.

Water quality measurements were taken at each of the monitoring sites using a YSI Model 6600 environmental monitoring system. Measurements included water temperature, specific conductance, pH, and dissolved oxygen. Samples were collected for laboratory analysis of alkalinity. Stream flow velocity was measured with a Marsh-McBirney Model 2000 portable flow meter, or was visually estimated when the water was too shallow for the flow meter.

B.2.7 Laboratory Processing and Analysis

At the laboratory, samples were poured over a No. 35 standard testing sieve (0.5-mm stainless steel mesh), and the ethanol was retained for re-use. The sample was gently rinsed with fresh water, and large debris, such as wood, leaves, or rocks was removed. The sample was transferred to a tray marked with grids approximately 50 cm^2 in size. One grid was randomly selected, and the sample material contained within that grid was removed and processed. In cases where the test organisms appeared extremely abundant, a fraction of the grid may have been removed. The material from the grid was examined under a stereomicroscope, and all the invertebrates were removed, sorted into major taxonomic groups, and placed in vials containing 70% ethanol. If there were less than 600 test organisms in the grid, another grid was selected and processed. This process was repeated until 600 organisms were removed from the sample, or until the entire sample was sorted. Organisms from a grid in excess of the 600 were counted and placed in a separate vial labeled “remaining test organisms,” so that estimated total organism abundance and density for the sample could be calculated. Terrestrial organisms, vertebrates, water-column associated organisms (e.g., copepods), and nematodes were not removed from the samples. Processed material from the sample was placed in a separate jar and labeled "sorted," and the unprocessed material was returned to the original sample container and archived. Sorted material was retained for quality assurance purposes.

All organisms were identified to SAFIT standard taxonomic level I. Quality assurance of sample sorting was performed on a minimum of 10 percent of the samples to ensure at least a 90% removal rate of organisms. Taxonomic quality assurance was performed on 10% of the samples by taxonomists at the CDFG Aquatic Bioassay Laboratory in Rancho Cordova, CA.

B.2.8 Data and Statistical Analysis

A taxonomic list of BMIs identified from the samples was created using Microsoft Excel. Metric values based on the BMI community were calculated from the database. A list of these metric values is presented in Table B-5, including a brief description of what they signify and how they respond to ecological stressors.

For every monitoring reach, an Index of Biotic Integrity (IBI) was calculated utilizing the most recent method developed by CDFG (Ode et al., 2005). The IBI is derived from seven individual metrics and gives a numeric value to the benthic community based on the range of reference conditions in the region. The IBI scores are then classified into quality rating categories that range from Very Poor to Very Good. The IBI can also be used to evaluate community conditions over time to monitor the effects of habitat degradation or the success of restoration efforts.

Additional analysis of the data included an analysis of the trends of the monitoring results since the beginning of the program in May 2001 and calculation of the O/E ratio. Like the IBI, the O/E approach produces an easily understood and ecologically meaningful summary of the biological condition at a site. The O/E ratio is the number of taxa observed ("O") at a test site compared to the number of taxa expected to occur ("E") based on local reference conditions. O/E ratio values can theoretically vary from over 1 (better than mean reference conditions) to zero (completely degraded - all expected taxa are missing). O/E is not based on raw taxa richness. Instead, O/E is constrained to include only those taxa predicted to naturally occur at a site (e.g., non-native taxa are generally excluded from the analysis). The relative value of each taxon observed is not equal and each has a predetermined percent probability of capture and a sensitivity index that factor into the results. The predictive model for most San Diego County sites is associated with warm, dry, flashy stream types. This model uses the classification variables of longitude, percent sedimentary bedrock, and long-term mean annual precipitation. This model works well for low gradient depositional coastal streams that are dominated by fine particulate sediment.

Table B-5. Bioassessment Metrics Used to Characterize BMI Communities

BMI Metric	Description	Response to Impairment
Richness Measures		
Taxa Richness	Total number of individual taxa	Decrease
EPT Taxa	Number of taxa in the Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly) insect orders	Decrease
Dipteran Taxa	Number of taxa in the insect order (Diptera, “true flies”)	Increase
Non-Insect Taxa	Number of non-insect taxa	Increase
Composition Measures		
EPT Index	Percent composition of mayfly, stonefly, and caddisfly larvae	Decrease
Sensitive EPT Index	Percent composition of mayfly, stonefly, and caddisfly larvae with tolerance values between 0 and 3	Decrease
Shannon Diversity Index	General measure of sample diversity that incorporates richness and evenness (Shannon and Weaver, 1962)	Decrease
Tolerance/Intolerance Measures		
Tolerance Value	Value between 0 and 10 weighted for abundance of individuals designated as pollution tolerant (higher values) or intolerant (lower values)	Increase
Percent Dominant Taxa	Percent composition of the single most abundant taxon	Increase
Percent Chironomidae	Percent composition of the tolerant dipteran family Chironomidae	Increase
Percent Intolerant Organisms	Percent of organisms in sample that are highly intolerant to impairment as indicated by a tolerance value of 0, 1 or 2	Decrease
Percent Tolerant Organisms	Percent of organisms in sample that are highly tolerant to impairment as indicated by a tolerance value of 8, 9 or 10	Increase
Functional Feeding Groups (FFG)		
Percent Collector-gatherers	Percent of macrobenthos that collect or gather fine particulate matter	Increase
Percent Collector-filterers	Percent of macrobenthos that filter fine particulate matter	Increase
Percent Scrapers	Percent of macrobenthos that graze upon periphyton	Variable
Percent Predators	Percent of macrobenthos that prey on other organisms	Variable
Percent Shredders	Percent of macrobenthos that shreds coarse particulate matter	Decrease
Percent Others	Percent of macrobenthos that are parasites, macrophyte herbivores, piercer herbivores, omnivores, and xylophages	Variable
Abundance		
Estimated Abundance	Estimated number of BMIs in sample calculated by extrapolating from the proportion of organisms counted in the subsample	Variable
Source: SDRWQCB, 1999		

B.3 Ambient Bay and Lagoon Monitoring

The Ambient Bay, Lagoon, and Coastal Receiving Water Monitoring Program (ABLM) completed three years of monitoring during the summer of 2005. The data collected under this program were evaluated to determine if any linkage was observed between sediment conditions in the bays, estuaries, and lagoons and the freshwater conditions at upstream mass loading stations. A final report was prepared and was included as Appendix J in the San Diego County Municipal Copermittees 2005–2006 Urban Runoff Monitoring Report (Weston, 2007).

The ABLM program was not conducted during the 2007–2008 monitoring seasons. Per the June 12, 2008 letter from John Robertus of the SDRWQCB, the Copermittees were allowed to redirect the 2007-2008 resources from the ABLM program towards Bight 08 on the eutrophication study in the San Diego Lagoons.

B.4 Watershed Management Area Assessment and Long-Term Effectiveness Assessment Rating Methods

B.4.1 Watershed Management Area Assessment Methods

With the implementation of the new monitoring program design, the Copermittees are faced with assessing new data sets with the goal of complying with the permit and that will provide information that leads to reasonable management actions. The Copermittee Monitoring Workgroup recognizes that the data assessment process needs to transition to assess new data under the new permit. The monitoring workgroup will be reviewing the data assessment process during 2009. For the purposes of this report, interim watershed data assessments were prepared using the interim guidance document "Watershed Data Assessment Framework" (June 2004) which closely resembles the "Model Storm Water Monitoring Program for Municipal Separate Storm Sewer Systems in Southern California" developed by the Storm Water Monitoring Coalition's (SMC) Model Monitoring Technical Committee. A complete description of methods and tools used to perform the watershed assessment can be found in the guidance document. The monitoring workgroup will be reviewing the data assessment process during 2009 to develop an assessment process for future monitoring reports.

The watershed assessments are intended to provide a management tool for Copermittees to utilize in the development of short and long-term actions to address potential or actual water quality problems in the watershed. During the annual water quality assessment, the high, medium or low frequency of occurrence for constituents of concern (COC(s)) is evaluated for each watershed using the latest data collected and potential water quality issues are determined. In some cases confirmation of water quality problems will require that additional data be collected or assessed to understand the extent of the problem. Additional information to assess if a water quality problem exists may be available from third party data or a special study that can be used to answer questions relating to sources of the COC(s). In some instances, data from third parties or special studies may be used to further define the problem both spatially and temporally. The watershed assessment process leads to a prioritization of water quality issues by individual Watershed Copermittees and should assist them in short and long-term planning efforts, and developing activities directed at maintaining or improving water quality.

The watershed assessment methodology was designed around the previous monitoring program under Order 2001-01 and primarily assessed storm event concentrations, toxicity, and bioassessment data. The Copermittees monitoring program under Order R9-2007-0001 presented significant changes to the monitoring program and includes the addition of temporary watersheds assessment stations (TWAS), ambient monitoring events, and a rotational schedule between the north and south portions of the County. The previous watershed assessment framework did not include ambient condition assessments. However, the framework was modified to include an ambient assessment and likely provides a more complete assessment of the general ecological conditions in receiving waters and the relation to urban runoff impacts.

The watershed assessment process can be broken into seven steps:

1) Compare chemistry results to water quality benchmarks and action levels
2) Examine exceedance percentages, bioassessment rankings and toxicity results
3) Apply the Interim Criteria Ranking System to results
4) Evaluate third party data and 303(d) listing information
5) Examine any available trend information
6) Apply triad decision matrix to data
7) Identify priorities and recommend actions

Watershed area assessments occur in a three fold process:

1) Wet weather data assessments are conducted
2) Dry weather data assessments are conducted
3) An integrated data assessment of items 1 and 2 are presented

Receiving Water Monitoring Data

Wet weather and ambient chemistry data (physical, chemical, and bacteriological measurements) from the MLS and TWAS were compared to the water quality benchmarks shown in Table B-6 to determine constituent exceedances. The benchmark source information with associated links to documents (where available) is provided in Table B-7. Wet weather sample data are compared to the wet weather benchmarks and ambient sample data are compared to the ambient benchmarks. The tables are not inclusive of all analytical measurements that can be conducted, but represent the constituents that are most common to water quality monitoring and those that are required by the permit. If other chemistry data are available, the appropriate standards or water quality benchmarks are identified. In general, water quality objectives are defined in the San Diego County Copermittee program as benchmarks for comparison to monitoring results and do not necessarily reflect regulatory compliance for municipal storm water discharges.

In order to allow for comparison of wet weather data with exceedances at jurisdictional dry weather monitoring program stations (DWS), for which different Action Levels are used, modifications were made to the wet weather benchmarks for bacterial indicators. Wet weather results were compared against the dry weather action levels to determine exceedances for total coliforms and enterococci.

The benchmarks utilized are the same across all watersheds in San Diego County except for total dissolved solids and fecal coliform. Total dissolved solids benchmarks are applied by hydrologic area or hydrologic sub-area as noted in the 1994 Basin Plan. Fecal coliform REC-2 standards are applied at Tecolote Creek, Chollas Creek, and Tijuana River, while REC-1 standards are used for all other watersheds.

The California Toxics Rule (CTR) metals criteria are used for the water quality benchmarks for metals results. Previous annual monitoring reports compared total metals to a dissolved metals criteria after applying a conversion factor. The dissolved metals criteria are used because they are biologically available. Because this program analyzes for dissolved metals, only the dissolved metals criteria are applied. This may result in some previously identified total metals identified as priority constituents to be removed from the diamond rating tables for establishing frequency of occurrence.

Table B-6. Water Quality Benchmarks for use in the San Diego County Regional Copermittee Monitoring Program

Constituent	Units	Wet Weather Water Quality Benchmark	Ambient Water Quality Benchmark	Source
General / Physical / Organic				
Electrical conductivity	umhos/cm	NA	900-1600-2200 Varies by Watershed	2. CCR, 5. Goldbook
Oil and grease	mg/L	10	10	1 Basin Plan, 3. Anacostia River TMDL, 4. MSGP 2000
pH	pH Units	6.5-9.0	6.5-9.0	1. Basin Plan
Bacteriological				
Enterococci	MPN/100 mL	NA	151	1. Basin Plan
Fecal coliform	MPN/100 mL	400/4,000	400/4,000	1.Basin Plan REC-1/REC-2
Total coliform	MPN/100 mL	NA	NA	1. Basin Plan (Bays and Estuaries and Shell Criteria)
Wet Chemistry				
Ammonia As N	mg/L	CMC (Salmonids Absent) Calculation based on pH, Temp	CCC (early life stages present) Calculation based on pH, Temp	6. U.S. EPA Water Quality Criteria (Freshwater)
Biochemical oxygen demand	mg/L	30	10	4. MSGP 2000, 8. McNeeley (1979)
Chemical oxygen demand	mg/L	120	120	4. MSGP 2000
Dissolved phosphorus	mg/L	2	*(1)	4. MSGP 2000, 19. U.S. EPA Nutrient Numeric Endpoint Tool
Nitrate As N	mg/L	10	*(1)	1. Basin Plan, 19. U.S. EPA Nutrient Numeric Endpoint Tool
Nitrite As N	mg/L	1	*(1)	1. Basin Plan, 19. U.S. EPA Nutrient Numeric Endpoint Tool
Surfactants (MBAS)	mg/L	0.5	0.5	1. Basin Plan
Total dissolved solids	mg/L	500-2100 (Varies by watershed)	500-2100 (Varies by watershed)	1. Basin Plan
Total kjeldahl nitrogen	mg/L	NA	NA	
Total phosphorus	mg/L	2	*(1)	4. MSGP 2000, 19. U.S. EPA Nutrient Numeric Endpoint Tool
Total suspended solids	mg/L	100	58	4. MSGP 2000, 14. NSQD, Basin Plan
Turbidity	NTU	20	20	1. Basin Plan
Pesticides				
Chlorpyrifos	µg/L	0.02 (acute) / 0.014 (chronic)	0.02 (acute) / 0.014 (chronic)	12. CA Dept. of Fish & Game, 2000
Diazinon	µg/L	0.08 acute and 0.05 chronic [Chollas 0.072 (acute) / 0.045 (chronic)]	0.08 acute and 0.05 chronic [Chollas 0.072 (acute) / 0.045 (chronic)]	12. CA Dept. of Fish & Game, 2000, 11. Chollas Creek TMDL for Diazinon, 10. U.S. EPA, Aquatic Life Ambient Water Quality Criteria Diazinon
Malathion	µg/L	0.43	0.43 acute / 0.1 chronic	13. CA Dept. of Fish & Game, 1998, 5. Goldbook
Synthetic Pyrethroids				
Allethrin	µg/L	NA	NA	
Bifenthrin	µg/L	0.0093	NA	15. Anderson et al. in press
Cyfluthrin	µg/L	0.344 ug/L; 0.20 ug/L with PBO	NA	17. Wheelock et al. 2004
Cypermethrin	µg/L	0.683 ug/L; 0.005 ug/L with PBO	NA	17. Wheelock et al. 2004
Danitol	µg/L	NA	NA	
Deltamethrin	µg/L	NA	NA	
Esfenvalerate	µg/L	0.25 ug/L; 0.21 ug/L with PBO	NA	17. Wheelock et al. 2004
L-Cyhalothrin	µg/L	0.20 ug/L; 0.005 ug/L with PBO	NA	17. Wheelock et al. 2004
Permethrin	µg/L	0.021	NA	15. Anderson et al. in press
Prallethrin	µg/L	NA	NA	
Piperonyl Butoxide	µg/L	650 ug/L	NA	18. El-Merhibi et al. 2004
Hardness				
Total Hardness	mg CaCO3/L	NA	NA	

Table B-6. Water Quality Benchmarks for use in the San Diego County Regional Copermittee Monitoring Program

Constituent	Units	Wet Weather Water Quality Benchmark	Ambient Water Quality Benchmark	Source
Total Metals				
Antimony	mg/L	NA	0.006 for MUN water	1. Basin Plan
Arsenic	mg/L	NA	0.05 for MUN water	1. Basin Plan
Cadmium	mg/L	NA	0.005 for MUN water	1. Basin Plan
Chromium	mg/L	NA	0.05 for MUN water	1. Basin Plan
Copper	mg/L	NA	1.0 for MUN water	1. Basin Plan
Lead	mg/L	NA	NA	
Nickel	mg/L	NA	0.1 for MUN water	1. Basin Plan
Selenium	mg/L	NA	0.005	16. 40 CFR 131.38
Zinc	mg/L	NA	5.0 for MUN water	1. Basin Plan
Dissolved Metals				
Antimony	mg/L	0.006	0.006	1. Basin Plan
Arsenic	mg/L	0.34 (acute)	0.34 (acute) and 0.15 (chronic) / 0.05 for drinking water	16. 40 CFR 131.38
Cadmium	mg/L	CTR (acute)	CTR (acute and chronic)	16. 40 CFR 131.38
Chromium	mg/L	CTR (acute)	CTR (acute and chronic)	16. 40 CFR 131.38
Copper	mg/L	CTR (acute)	CTR (acute and chronic)	16. 40 CFR 131.38
Lead	mg/L	CTR (acute)	CTR (acute and chronic)	16. 40 CFR 131.38
Nickel	mg/L	CTR (acute)	CTR (acute and chronic)	16. 40 CFR 131.38
Selenium	mg/L	NA	NA	16. 40 CFR 131.38
Zinc	mg/L	CTR (acute)	CTR (acute and chronic)	16. 40 CFR 131.38

* NA indicate no criteria or published value was available or applicable to the matrix or program.

*(1) Nutrient analytes for ambient conditions are assessed based on a weight of evidence approach using the EPA's Nutrient Numeric Endpoint Tool to determine if beneficial uses have potential for impairment.

Table B-7. San Diego County Copermittee Benchmark Sources

Reference ID #	Source	Document Link
1	San Diego Regional Water Quality Control Plan for the San Diego Region (Basin Plan), 1994 (with amendments effective prior to April 25, 2007)	http://www.waterboards.ca.gov/sandiego/programs/basin_plan/Update%2010-22-07/Chapter%203%20-%20April%2025,%202007.pdf
2	California Code of Regulations 64449.	http://www.co.kern.ca.us/eh/pdfs/WaterWells/CaliforniaCodeOfRegulationsTitle22.pdf
3	District of Columbia Final Total Maximum Daily Load for Oil and Grease in Anacostia River, October, 2003	http://ddoe.dc.gov/ddoe/frames.asp?doc=/ddoe/lib/ddoe/tmdl/fin_ana_oil_grease.pdf
4	Multisector General Permit for Industrial Activities, Section2,	http://www.epa.gov/npdes/pubs/msgp_permit_section2.pdf
5	U.S. EPA, Quality Criteria for Water, May 1, 1986, EPA 440/5-86-001. (Goldbook)	http://www.epa.gov/waterscience/criteria/goldbook.pdf
6	U.S. EPA, 1999 Update of Ambient Water Quality Criteria for Ammonia, EPA-822-R-99-014, December 1999	http://www.epa.gov/waterscience/standards/ammonia/99update.pdf
7	U.S. EPA, Ambient Water Quality Criteria for Ammonia (Saltwater)-1989, EPA-440/5-88-004, April 1989	http://www.epa.gov/waterscience/criteria/library/ambientwqc/ammoniasalt1989.pdf
8	Mcneely, R.N., Neimasis, V.P., Dwyer, L. (1979), Oxygen-chemical oxygen demand. In: *Water Quality Sourcebook. A guide to water quality parameters*. Water Quality Branch Inland Waters Directorate, Environment Canadá, Ottawa, p.32-33.	
9	U.S. EPA, Ambient Water Quality Criteria Recommendations, Information Supporting the Development of State and Tribal Nutrient Criteria, Rivers and Streams in Nutrient Ecoregion III (EPA 822-B-00-016, December, 2000)	http://www.epa.gov/waterscience/criteria/nutrient/ecoregions/rivers/rivers_3.pdf
10	U.S. EPA, Aquatic Life Ambient Water Quality Criteria Diazinon FINAL, EPA-822-R-05-006, December 2005.	http://www.epa.gov/waterscience/criteria/diazinon/final-doc.pdf
11	California Regional Water Quality Control Board San Diego Region, Technical Report for Total Maximum Daily Load for Diazinon in Chollas Creek Watershed San Diego County, Final, August 14, 2002.	http://www.waterboards.ca.gov/sandiego/tmdls/tmdl_files/chollas%20creek%20diazinon/FinalTechTMDL(29Apr03).pdf
12	Water quality criteria for diazinon and chlorpyrifos: California Department of Fish and Game, 2000.	http://www.krisweb.com/biblio/cal_cdfg_siepmannetal_2000.pdf
13	Hazard Assessment of the Insecticide Malathion to Aquatic Life in the Sacramento-San Joaquin River System: California Department of Fish and Game, Office of Spill Prevention and Response Administrative Report 98-2, 1998.	http://www.cdpr.ca.gov/docs/emon/surfwtr/hazasm/hazasm98_2.pdf
14	Research Progress Report, Findings from the National Stormwater Quality Database, January, 2004.	http://www.cwp.org/NPDES_research_report.pdf
15	Anderson B.S., B.M. Phillips, J.W. Hunt, S.A. Huntley, K. Worcester, N. Richard, and R.S. Tjeerdema. In Press. Evidence of pesticide impacts in the Santa Maria River watershed (California, USA). Environmental Toxicology and Chemistry.	
16	40 CFR 131.38	http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=401d1fa5a85e820674e669b8a3edf23b&rgn=div5&view=text&node=40:21.0.1.1.18&idno=40#40:21.0.1.1.18.4.16.8
17	Wheelock, C.E., Miller, J.L., Miller, M.J., Gee, S.J., Shan, G., Hammock, B.D. 2004.Development of toxicity identification evaluation procedures for pyrethroid detection using esterase activity. Environmental Toxicology and Chemistry, 23:2699–2708.	
18	El-Merhibi, A et al. (2004) Role of piperonyl butoxide in the toxicity of chlorpyrifos to *Ceriodaphnia dubia* and *Xenopus laevis* Ecotoxicol Environ Saf 57:202-12	
19	Technical Approach to Develop Nutrient Numeric Endpoints for California, Prepared for U.S. EPA Region 9 and California State Water Resources Control Board Planning and Standards Implementation Unit. Prepared by Tetra Tech, Inc., July 2006.	http://rd.tetratech.com/epa/Documents/CA_NNE_July_Final.pdf

Wet Weather Metals Benchmarks

Wet weather dissolved metals are compared to the hardness based criteria maximum concentration (CMC) termed the acute benchmark. Because storm events are relatively short term events, the wet weather benchmarks are not compared to the criteria continuous concentration (CCC) termed the chronic benchmark. The benchmark for each metal is based on the hardness measured in the specific sample collected. Samples with relatively lower hardness concentrations will have lower benchmarks for those metals based on the CTR calculation.

Ambient Metals Benchmarks

Ambient water quality samples for total metals are compared to Basin Plan standards which are based on municipal water supply standards with the exception of selenium which is based on CTR. Ambient dissolved metals results are compared to both the acute (CMC) and chronic (CCC) benchmarks. Because ambient events are representative of conditions normally found in the receiving waters, these comparisons provide the ability to assess whether conditions are protective of municipal water beneficial uses, and to relate chemistry results to any observed toxicity measured at the time of sampling in order to assess impacts to stream ecological health.

Toxicity

Toxicity testing at the MLS does not measure a constituent. Toxicity testing determines if an analyte (chemical or other) or group of analytes is present in concentrations capable of causing toxicity in the selected species. Toxicity testing results for the acute and chronic endpoints are reported as the no observed effect concentration (NOEC) of 100% in the test sample. The seven-day chronic effects are estimated using the NOEC for both survival and reproduction. This is the highest concentration tested in which there was no statistically significant effect on the survival or reproduction compared to the control response. Lower NOEC values equate to higher toxicity in the sample. Therefore, a concentration of less than 100% is considered to have some degree of toxic effect. The toxicity benchmarks used in the regional monitoring program are shown in Table B-8.

Table B-8. Toxicity Benchmark Water Quality Objectives for wet weather monitoring at Mass Loading Stations

Species/Test	Units	WQO	Source[1]
Toxicity			
Ceriodaphnia 96-hr	NOEC (%)	100	NPDES Order 2007-0001
Ceriodaphnia 7-day survival	NOEC (%)	100	NPDES Order 2007-0001
Ceriodaphnia 7-day reproduction	NOEC (%)	100	NPDES Order 2007-0001
Hyalella 96-hr	NOEC (%)	100	NPDES Order 2007-0001
Selenastrum 96-hr	NOEC (%)	100	NPDES Order 2007-0001

Persistent toxicity is evident when more than 50% of the toxicity tests conducted to date for any given species at a specific site have a NOEC of less than 100%. The results of this determination are then combined with the high frequency constituents of concern (chemistry data) and benthic data in the Triad Decision Matrix to determine the actions to be taken. If persistent toxicity is identified at a site (e.g., more than 50% frequency of occurrence) the source (compound or compound class) of the toxicity can be identified using toxicity identification evaluations (TIE).

Comparison of Water Quality Benchmark Ratios

Sample results are normalized to the appropriate benchmark and are presented graphically for those constituents that have most frequently been above its respective water quality benchmark across all watersheds for the monitoring season. The ratio to the water quality benchmark for each constituent was determined by dividing the constituent result by its respective benchmark for each sample event monitored. Mean ratios to the water quality benchmark were determined for each constituent to compare results to the mean of the historical results. Santa Margarita River was not sampled during 2004-2005 and 2006-2007, therefore only the mean ratios to the benchmark WQO are presented for this MLS. Toxicity ratios were determined by dividing the no observed effect concentration (NOEC %) by 100 and then subtracting one. For example, a NOEC of 50% indicates toxicity was only observed in the undiluted sample based on the dilutions presented in the toxicity methods section. The ratio to the benchmark of an organism with a NOEC of 50% is 1 [(100/50)-1=1] which is indicative of a toxic effect.

Jurisdictional Dry Weather Monitoring Data

In addition to the wet weather monitoring discussed above, a separate dry weather monitoring program is carried out by each jurisdiction. Dry weather monitoring reports are provided separately by each jurisdiction in its Jurisdictional Urban Runoff Management Program (JURMP) Annual Report. Dry weather data are also provided in a regional data sharing format which is used for the watershed management area assessments and regional comparisons in this report. Dry weather monitoring sites with field parameter and chemistry results are summarized in each section of the individual WMA sections. Dry weather sample data are compared to dry weather action levels. The data are tabulated indicating the number of results above the action level, the total number of samples collected in each WMA, the average ratio of exceedance, and the standard deviation of the ratio of exceedance.

Dry weather action levels are established by the Copermittees to trigger investigations upstream of the sampling location and to eliminate illicit connections and illegal discharges (ICID). Dry weather action levels were initially established in 2002 and are updated on a yearly basis, as necessary. The WMA assessments compare wet and dry weather exceedances. In some cases, the wet weather water quality objectives are not comparable with dry weather action levels. For example, turbidity action levels in dry weather samples are evaluated using Best Professional Judgment; while in wet weather and ambient sample events (at the MLS and TWAS) the Basin Plan water quality objective of 20 NTU is used. In order to allow for direct comparison with exceedances at the MLS and TWAS, when assessing dry and wet weather samples for turbidity at a watershed level the Basin Plan objective was used. See Table B-9 for a summary of the dry weather action levels used to perform the data evaluation.

Table B-9. Dry Weather Action Levels

Constituent	Action Level	Note
pH	<6.5 or >9.0	
Orthophosphate-P	2.0 mg/L	
Nitrate-N	10.0 mg/L	
Ammonia-N	1.0 mg/L	
Turbidity	20 NTU	Used Basin Plan benchmark WQO instead of BPJ when comparing with MLS data
Conductivity	5000 us/cm	Based on best professional judgment (BPJ)
MBAS	1.0 mg/L	
Oil and grease	15 mg/L	
Diazinon	0.5 µg/L	
Chlorpyrifos	0.5 µg/L	
Dissolved cadmium	CTR	Used CTR table, 1-hour criteria. Action level is based on hardness. Where hardness data were not available, the average value for the watershed was substituted.
Dissolved copper	CTR	
Dissolved lead	CTR	
Dissolved zinc	CTR	
Total coliform	50,000 MPN/100 mL	2005 Action Levels defined by 95th percentile were applied at the MLS for comparison with DWS data. Basin Plan objectives are only available for fecal coliform (REC-1 and REC-2).
Fecal coliform	20,000 MPN/100 mL	
Enterococci	10,000 MPN/100 mL	

Establishing Frequency of Occurrence to Determine Constituents of Concern

Previous Urban Runoff Monitoring Program reports under Order 2001-01 assessed three storm water events in the receiving water at one MLS. With the addition of the TWAS and ambient monitoring, the Copermittees are now able to assess the general health of the receiving waters both spatially and with respect to storms vs. ambient conditions. The monitoring results (including all monitoring years' data) are examined to establish if percentages of the data collected exceed water quality benchmarks or action levels, toxicity results are prioritized, and bioassessment results are ranked. The matrix of findings is developed for each watershed by wet weather and ambient events separately (Table B-10 and Table B-11 respectively). The matrix includes the number of observations that were measured above water quality benchmarks at the MLS and TWAS for each monitoring season. A cumulative exceedance rate is then calculated.

Table B-10. Interim Wet Weather Condition Matrix of Findings

San Luis Rey River																				
Constituents With Any Wet Weather Benchmark or Dry Weather Action Level Exceedance	Wet Weather Receiving Water Results at MLS and/or TWAS																Urban Runoff Program Results[1]		Frequency of Occurrence	Criterion No.
	2001/2002		2002/2003		2003/2004		2004/2005		2005/2006		2006/2007		2007/2008		CUMULATIVE		2007*			
	#/3	%	#/3	%	#/3	%	#/3	%	#/3	%	#/3	%	#/4	%	#/22*	%	#	%		
Conventional Parameters																				
pH	0	0	1	33	0	0	0	0	0	0	0	0	0	0	**1**	**5**	3	9	-	-
Conductivity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	1	3	-	-
BOD	0	0	0	0	1	33	0	0	0	0	1	33	0	0	**2**	**9**	NA	NA	-	-
Total dissolved solids	3	100	3	100	3	100	3	100	3	100	3	100	4	100	**22**	**100**	NA	NA	♦♦♦	1
Total suspended solids	0	0	1	33	0	0	1	33	0	0	0	0	3	75	**5**	**23**	NA	NA	-	-
Turbidity	0	0	1	33	0	0	2	67	0	0	1	33	4	100	**8**	**36**	7	20	♦	9
Ammonia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	3	7	-	-
Nutrients																				
Orthophosphate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	4	9	-	-
Nitrate as N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	3	7	-	-
Bacteriological																				
Total coliform	0	0	0	0	0	0	1	33	0	0	1	33	3	75	**5**	**23**	0	0	-	-
Fecal coliform	0	0	1	33	1	33	3	100	3	100	3	100	4	100	**15**	**68**	0	0	♦♦♦	4
Enterococci	0	0	1	33	0	0	2	67	0	0	1	33	2	50	**6**	**27**	0	0	♦	9
Pesticides																				
Diazinon	1	33	0	0	0	0	0	0	0	0	0	0	0	0	**1**	**5**	0	0	-	-
Chlorpyrifos	0	0	0	0	0	0	0	0	0	0	0	0	1	25	**1**	**5**	0	0	-	-
Toxicity																			**EVIDENCE OF PERSISTENT TOXICITY?**	
Ceriodaphnia 7-day reproduction	1	33	0	0	1	33	0	0	0	0	0	0	1	25	**3**	**14**	NA	NA	No	
Hyalella 96-hour acute	0	0	0	0	0	0	0	0	0	0	1	33	0	0	**1**	**5**	NA	NA	No	
Selenastrum 96-hour	0	0	0	0	1	33	0	0	0	0	0	0	0	0	**1**	**5**	NA	NA	No	
Bioassessment	**IBI Rating**																		**EVIDENCE OF BENTHIC ALTERATION?**	
San Luis Rey River, at Benet Rd., (Downstream of MLS)	Very Poor		Very Poor		Very Poor		Very Poor		Very Poor		Very Poor		Very Poor		**Very Poor**		NA		Yes	
San Luis Rey River, TWAS[2]	Very Poor		Very Poor		Very Poor		Very Poor		Very Poor		Very Poor		Very Poor		**Very Poor**		NA			
Doane Creek, Ref. Site	-		-		-		Very Good		Good		Very Good		Very Good		**Very Good**		NA			

[1] Urban Runoff Program results from Jurisdictional Dry Weather Program, Wet MS4 Outfall, and Wet Source ID Monitoring Programs.
* = Total number of observations varied among constituents.
NA = Not assessed, Not Applicable, or Not Analyzed.
- = Constituent results are below the defined requirements for a Low Frequency of Occurrence rating.
♦ = Low Frequency of Occurrence rating.
♦♦ = Medium Frequency of Occurrence rating.
♦♦♦ = High Frequency of Occurrence rating.
[2] Data from Fall 2001-Spring 2007 were collected approximately two miles downstream at the Mission Rd. Bridge under the Order R9-2001-01.

Table B-11. Interim Ambient Condition Matrix of Findings

San Luis Rey River								
Constituents With Any Ambient Receiving Water Benchmark or Dry Weather Action Level Exceedance	Ambient Receiving Water Results at MLS and/or TWAS				Urban Runoff Program Results[1]		Frequency of Occurrence	Criterion No.
	2007/2008		CUMULATIVE		2007*			
	#/4	%	#/4	%	#	%		
Conventional Parameters								
pH	0	0	**0**	**0**	3	9	-	-
Conductivity	0	0	**0**	**0**	1	3	-	-
BOD	0	0	**0**	**0**	NA	NA	-	-
Chemical oxygen demand	1	25	**1**	**25**	NA	NA	♦	9
Total dissolved solids	4	100	**4**	**100**	NA	NA	♦♦♦	1
Turbidity	1	25	**1**	**25**	7	20	♦	8
Ammonia	0	0	**0**	**0**	3	7	-	-
Nutrients								
Orthophosphate	0	0	**0**	**0**	4	9	-	-
Nitrate as N	0	0	**0**	**0**	3	7	-	-
Bacteriological								
Total coliform	0	0	**0**	**0**	0	0	-	-
Fecal coliform	1	25	**1**	**25**	0	0	♦	9
Enterococci	3	75	**3**	**75**	0	0	♦♦♦	4
Pesticides								
Diazinon	0	0	**0**	**0**		0	-	-
Toxicity							**EVIDENCE OF PERSISTENT TOXICITY?**	
Ceriodaphnia 7-day reproduction	0	0	**0**	**0**	NA	NA	No	
Selenastrum 96-hour	0	0	**0**	**0**	NA	NA	No	
Bioassessment	**IBI Rating**						**EVIDENCE OF BENTHIC ALTERATION?**	
San Luis Rey River, at Benet Rd., (Downstream of MLS)	Very Poor		**Very Poor**		NA		Yes	
San Luis Rey River, TWAS	Very Poor		**Very Poor**		NA			
Doane Creek, Ref. Site	Very Good		**Very Good**		NA			

[1] Urban Runoff Program results from Jurisdictional Dry Weather Program, Dry-Coastal Storm Drain Monitoring Program, Dry MS4 Outfall, and Dry Source ID Monitoring Programs.
* = Total number of observations varied among constituents.
NA = Not assessed, Not Applicable, or Not Analyzed.
\- = Constituent results are below the defined requirements for a Low Frequency of Occurrence rating.
♦ = Low Frequency of Occurrence rating.
♦♦ = Medium Frequency of Occurrence rating.
♦♦♦ = High Frequency of Occurrence rating.

Jurisdictional dry weather monitoring exceedances, Coastal Storm Drain Monitoring (CSDM) data (bacteria only during ambient conditions), and relevant third party data results exceeding action levels or relevant water quality benchmarks are included to provide an urban runoff exceedance rate (also in Table B-10). Jurisdictional dry weather data collected prior to the receiving water monitoring events are used. Such as, for the 2007–2008 monitoring season, the 2007 dry weather data is used for assessment. Jurisdictional dry weather data is used in the same manner for both ambient event assessments and wet weather assessments. Coastal Storm Drain Monitoring data is used differently. For ambient assessments, CSDM data from May 1, 2007 – September 30, 2007 is used. For wet weather assessments, CSDM bacteria data from October 1, 2007 – April 30, 2008 was used. Any third party data provided is assessed in a similar fashion.

The constituent of concern (COC) frequency of occurrence ranking of "high", "medium", or "low" is established using the 2002–03 interim criteria (Table B-12). This was the same criteria used during each successive annual report and was modified in this 2007–2008 monitoring season in order to incorporate ambient condition assessments and TWAS. The interim criteria take into account the exceedances at the MLS and TWAS, DWS and coastal outfalls; and classify each COC as high, medium or low frequency of occurrence in the watershed. The classification of COC can change from year to year in response to the changes in the levels of the pollutants and with respect to observed trends.

Jurisdictional Dry Weather Station (DWS) data were given less weight in the determination of watershed COC due to factors that include:

1) The dry weather monitoring program's main focus is to identify illicit connections and illegal discharges (ICID) in the MS4. Sample stations may not be representative of overall urban runoff quality since they include samples of ponded water.
2) Dry weather monitoring parameters are a subset of receiving water monitoring parameters at the MLS and TWAS.
3) DWS may be located in the MS4 upstream of BMPs (detention basins, etc.) and samples may not be representative of urban runoff entering the receiving water.

Only DWS located upstream of the MLS are taken into account when applying the interim COC criteria. In addition, only DWS samples collected during routine monitoring and not as part of the ICID investigation phase of the program are used in the assessment. The majority of the 2007 dry weather data used for the assessment represented routine site visits.

If the number of DWS sampled was small, best professional judgment was used when applying the interim COC criteria. For example, if only three samples were collected and one exceedance was observed, then the 33% exceedance frequency may not be representative of watershed conditions.

Table B-12. Interim Criteria for Evaluating Constituents of Concern Frequency of Occurrence

COC Frequency of Occurrence	Criterion No.	Definition
High ♦♦♦	1	Mass loading station MLS or temporary watershed assessment station (TWAS) tests results exceed benchmark WQO in greater or equal to 80% of samples.
	2	The last six consecutive sample events at the MLS or TWAS exceed water quality benchmark.
	3	Less than 80% and greater than or equal to 50% of the MLS or TWAS samples exceed the water quality benchmark and at least one DWS exceedance in the past year.
	4	Less than 80% and greater than or equal to 50% of the MLS or TWAS samples exceed the water quality benchmark and a significant increasing trend is found.
Medium ♦♦	5	Less than 80% and greater than or equal to 50% of the MLS or TWAS samples exceed the water quality benchmark and no exceedances or data available for DWS in the past year.
	6	Less than 80% and greater than or equal to 50% of the MLS samples exceed the water quality benchmark and one or more exceedances found in last 2 years of monitoring at the MLS or TWAS (generally applies to historical datasets).
	7	Greater than 50% of the DWS samples have exceedances in the past year.
Low ♦	8	DWS exceedances in 10 to 50% of the samples in the past year.
	9	MLS or TWAS exceedances found in 25% to less than or equal to 50% of the samples and at least one exceedance found in last 2 years at the MLS or TWAS (with or without DWS exceedances in the past year).
	10	Greater than 50% of the MLS or TWAS samples have exceedances and no exceedances in the last 2 years at the MLS or TWAS.
Coastal Storm Drain Program	11	Persistent exceedances (greater or equal to 80% of samples). Add one ♦ to bacteria determination (up to three ♦ maximum for ambient conditions only).

Note: Best professional judgment applies when unique situations arise (fewer samples at a site; sewage spills) and for toxicity once it is linked to a specific COC.
1. Definitions were updated to incorporate ambient data, TWAS data, and trash assessment data associated new programs detailed in RWQCB Order No. R9-2007-0001.

Benchmarks for bacterial levels are assessed differently in the receiving water and DWS. The receiving water benchmarks for fecal coliform are derived from the Basin Plan (REC-1 and REC-2) standards while DWS levels are compared to Copermittee defined action levels for all three bacterial indicators (total coliform, fecal coliform, and enterococcus). In order to compare the two datasets, the DWS action levels are applied to the receiving water wet weather total coliform and enterococcus data. Otherwise, identification of bacterial indicators as potential COCs in the watershed between these two different data sets would not have been feasible. During ambient event assessments, the receiving water enterococcus results are applied to the Basin Standard of 151 MPN/100mL.

Trash assessments were conducted separately from this analysis due to few data points collected during the 2007–2008 monitoring period and with the foresight that an extensive amount of data will be available for future assessments. Trash assessments were evaluated in a separate section prior to the integrated assessment.

Integrated Watershed Data Assessment

Assessment of the watershed during both wet weather and ambient monitoring conditions is presented in an integrated manner to present managers with an overall assessment of the watershed to provide answers to the core management questions. The integrated assessment provides the results of the receiving water assessments and urban runoff assessments during both storm events and ambient events and provides a summary of the overall watershed findings. It is anticipated that MS4 Outfall Program data and Source Identification Program monitoring data will bolster the assessment process as the data becomes available. Integrated watershed assessments are presented in table format as presented in Table B-13.

Table B-13. Interim Integrated Watershed Area Management Assessment

San Luis Rey WMA Integrated Watershed Management Area Assessment

Assessment Category		Program	Frequency of Occurrence Assessment Findings	Persistent Toxicity Observed	Evidence of Benthic Impairment	Integrated WMA Assessment Summary
 Ambient	**Ambient Receiving Water**	MLS, TWAS, and Bioassessment Monitoring	♦♦♦-TDS, enterococci ♦-COD, turbidity, fecal coliform	No	Yes	TDS is identified as a high frequency of occurrence COC in receiving waters during ambient conditions and wet weather conditions. TDS is associated with importation of drinking water, irrigation, and potential recycled water uses (San Diego Regional 303(d) Workgroup, 2002). COD, turbidity, and fecal coliform were also identified as low frequency of occurrence COCs in receiving waters. A link between urban runoff and receiving water conditions appears related only to turbidity with a possible link for bacteria. Bacteria re-growth issues may exist in the receiving water based on a study recently conducted in Tecolote Creek (WESTON, 2008).
	Ambient Urban Runoff Areas	Jurisdictional Dry Weather Monitoring, Coastal Storm Drain Monitoring, MS4 Program Data, Source Identification Monitoring	♦-Turbidity	NA		
 Wet Weather	**Wet Weather Receiving Water**	MLS, TWAS, and Bioassessment Monitoring	♦♦♦-TDS, fecal coliform ♦-Turbidity, enterococci	No		TDS was identified as a high frequency of occurrence COC during both ambient and wet weather conditions. Fecal coliform and enterococci frequency of occurrence COCs vary depending on season and is a function of the benchmarks used for comparison.
	Wet Weather Urban Runoff Areas	MS4 Program Data and Source Identification Monitoring	(No data from the programs to date)	NA		

Interim Triad Assessment

For each watershed, all three elements of the triad (chemistry, toxicity, and benthic community) are assessed. Chemistry data provide an indication of the pollutant concentration and load during storm events or ambient conditions. Toxicity data provide a direct measure of the ecological health during specific sample events in the receiving water and provides the ability to determine if water quality conditions are impacting aquatic organisms. Dry weather chemistry data provide an indication of urban runoff pollutants. The benthic community data collected during stream bioassessment surveys provide a more direct indication of the ecological health throughout the year of the watershed in terms of insect/benthic community abundance and diversity.

The triad assessment does not consider fecal coliform and total dissolved solids for the purposes of triggering a decision or action. The bacteria parameters are not considered in the triad because they are not believed to influence toxicity responses in bioassay test organisms. Further, the REC-1 (water contact) and REC-2 (non-contact) water quality benchmarks for bacterial indicators are set for the protection of human health. Total dissolved solids are not considered since the water quality objectives for this constituent as defined in the Basin Plan are set for municipal drinking water and do not necessarily reflect impacts to the ecology of the watersheds. However, fecal coliform and total dissolved solids data may be used to define high priority COC that lead to management actions even though they bypass the application of the triad decision matrix. Persistence in several indicators provides an indication of an ecological concern that triggers the need to conduct short-term actions, such as conducting a TIE to identify the constituents in the watershed that may be responsible for water column toxicity and/or benthic community degradation. Where long-term datasets are available, all the data are evaluated to identify persistent conditions. The majority of MLS are in their seventh year (2007–2008) of monitoring and have data from 20 storm events available for the triad assessment. The addition of TWAS in some watersheds adds to the total number of events in some cases and provides the ability to assess the watershed spatially. The addition of ambient events provides the ability to assess the watershed during different conditions which help to focus management actions and watershed priorities. Persistence was determined for three elements of monitoring (chemistry, toxicity, and benthic community assemblage) using the definitions in Table B-14.

Table B-14. Interim Triad Definitions for San Diego Storm Water Monitoring Program

Triad Component	Definition
Persistent Exceedance of Water Quality Benchmarks	A high frequency of occurrence constituent of concern based on receiving water data, jurisdictional dry weather data, and coastal storm drain monitoring data exceedances compared to established list of benchmarks or action levels.
Evidence of Persistent Toxicity	More than 50% of the toxicity tests for any given species have a NOEC of less than 100%.
Indication of Benthic Alteration	IBI score of Poor or Very Poor.

Once persistence is determined in each watershed, the determination of short-term actions, namely TIEs are made using the Triad Approach to Determining Follow-Up Actions (Table B-15). The tabular decision matrix was obtained from the Section III.A.4 (Table 3) of the permit.

Table B-15. Triad Approach to Determining Follow-Up Actions (Section III.A.4, Table 3 of the Receiving Waters and Urban Runoff Monitoring and Reporting Program, No. R9-2007-0001)

	Chemistry	Toxicity	Bioassessment	Action
1.	Persistent exceedance of water quality objectives (high frequency constituent of concern identified).	Evidence of persistent toxicity.	Indications of alteration.	Conduct TIE to identify contaminants of concern, based on TIE metric. Address upstream sources as a high priority.
2.	No persistent exceedances of water quality objectives.	No evidence of persistent toxicity.	No indications of alteration.	No action necessary.
3.	Persistent exceedance of water quality objectives (high frequency constituent of concern identified).	No evidence of persistent toxicity.	No indications of alteration.	Address upstream sources as a low priority.
4.	No persistent exceedances of water quality objectives.	Evidence of persistent toxicity.	No indications of alteration.	Conduct TIE to identify contaminants of concern, based on TIE metric. Address upstream sources as a medium priority.
5.	No persistent exceedances of water quality objectives.	No evidence of persistent toxicity.	Indications of alteration.	No action necessary to address toxic chemicals. Address potential role of urban runoff in causing physical habitat disturbance.
6.	Persistent exceedance of water quality objectives (high frequency constituent of concern identified).	Evidence of persistent toxicity.	No indications of alteration.	If chemical and toxicity tests indicate persistent degradation, conduct TIE to identify contaminants of concern, based on TIE metric and address upstream source as a medium priority.
7.	No persistent exceedances of water quality objectives.	Evidence of persistent toxicity.	Indications of alteration.	Conduct TIE to identify contaminants of concern, based on TIE metric. Address upstream sources as a high priority. Address potential role of urban runoff causing physical habitat disturbance.
8.	Persistent exceedance of water quality objectives (high frequency constituent of concern identified).	No evidence of persistent toxicity.	Indications of alteration.	Address upstream source as a high priority.

B.4.2 Water Quality Priority Ratings – Long-Term Effectiveness Assessment Methodology

The Baseline Long-Term Effectiveness Assessment (BLTEA) report (WESTON, MOE, & LWA, 2005) was used to create water quality priority ratings using the five years of monitoring data collected at the end of the 2005–2006 monitoring season. This data set was used by the Copermittees to prioritize activities based on the available data set for the next permit cycle. The water quality priority ratings establish a process to relate water quality information to the overall effectiveness of the management program. Water quality characterization and prioritization is achieved through the water quality priority rating process conducted for each of the constituent/stressor groups on a sub-watershed and watershed basis. These constituent groups include:

- Heavy Metals
- Dissolved Minerals (Manganese, TDS, Sulfate)
- Organic Compounds
- Oil and Grease
- Sediment (TSS, Turbidity)
- Pesticides (Chlorpyrifos, Diazinon, Malathion)
- Nutrients (forms of Phosphorus, Nitrogen)
- Gross Pollutants (pH, Ammonia, BOD, COD, MBAS)
- Bacteria/Pathogens

The tables are updated every five years and are presented for the purposes of reviewing program activities. The detailed methods used to prepare the 2005–2006 water quality priority ratings tables can be found in the San Diego County Municipal Copermittees 2005–2006 Urban Runoff Monitoring Report (Weston, 2007).

The water quality priority ratings were determined using the full data set collected over the five years for the program. The dry weather data set provided results on a sub-watershed basis. However, the data set was limited and focused on sampling of storm sewers as opposed to receiving waters. In order to augment the current data set, the wet weather data from the MLS was used to project results up into the watershed as discussed below. The assessment of the water quality on a sub-watershed basis for the constituent groups was also supplemented using the ABLM results for sediment analysis. Therefore, the water quality rating on a sub-watershed and watershed basis for the nine constituent groups was based on results from the dry weather program, data from the Surface Water Ambient Monitoring Program (SWAMP) and from Padre Dam Municipal Water District (Padre Dam), the wet weather results from the MLS, and the sediment results from the ABLM program.

The additional evaluated stressor groups included Benthic Alteration and Toxicity. These last two groups were evaluated separately as they represented a stressor group that may be impacted by multiple constituents and/or stressors, as compared to the other groups that represented specific constituents. The basis for the water quality ratings for the Toxicity stressor group included the toxicity testing results from the wet weather sampling at the MLS and the sediment sampling conducted as part of the ABLM program. Dry weather toxicity data from the SWAMP dataset (2002–2004) were also included. These results were projected up the watershed as discussed below to provide a rating on a sub-watershed basis. The Benthic Alteration stressor group rating was based on the results at the regional bioassessment stations (Index of Biological Integrity, IBI), and the ABLM benthic community structure results (Benthic Response Index, BRI) conducted on sediment samples.

The constituent data representing the highest frequency of exceedance were then used to develop the prioritization ratings based on a score of 0 – 3. From the numerical score, a prioritization rating was assigned. The highest priority rating is A, followed by a rating of B, C, and D. D therefore represents a low priority rating.

Six method steps were used in development of the water quality priority rating for the nine constituent groups listed above (Figure B-1). The tables are updated every five years and are presented for the purposes of reviewing program activities. The detailed methods used to prepare the 2005–2006 water quality priority ratings tables can be found in the San Diego County Municipal Copermittees 2005–2006 Urban Runoff Monitoring Report (Weston, 2007).

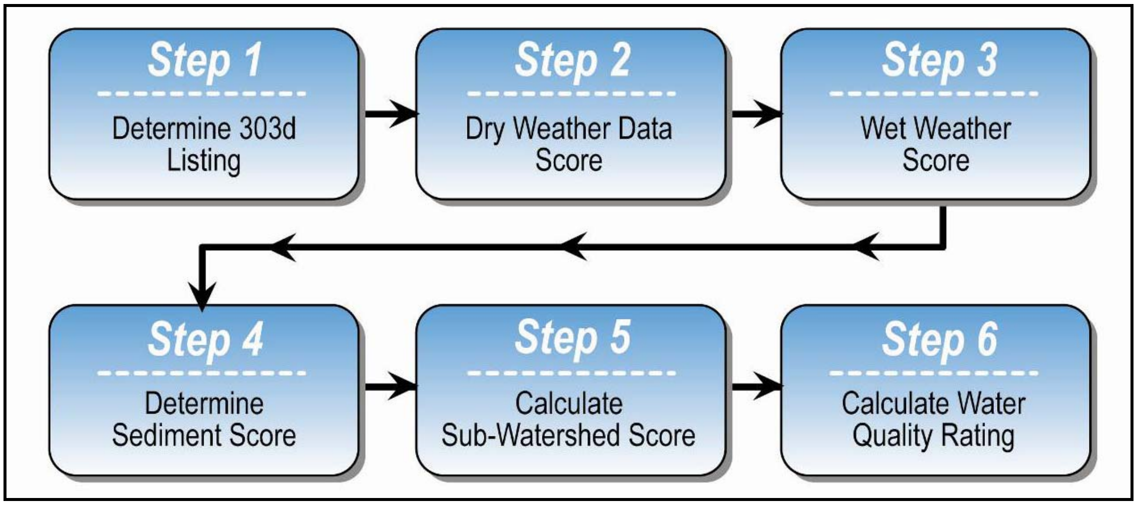

Figure B-1. Water Quality Priority Rating Methodology

B.5 Statistical Methods

The goals of the cross-watershed comparison are to assess all information from each watershed together to identify regional issues. Assessing all data from the region together also provides the ability to evaluate relationships among constituent and between toxicity effects and constituent.

B.5.1 Trend Analysis

Trend analysis was conducted for constituents and toxicity measured at each MLS station using current and historical data. Water quality data possess distributional characteristics that generally require specialized approaches to trend testing. Water quality data sets can contain censored (less than) values, outliers, multiple detection limits, missing values, and serial correlation. These characteristics commonly present problems in the use of conventional parametric statistics based on normally distributed data sets. The presence of censored data, non-negative values, and outliers generally lead to a non-normal data distribution which is common for many data sets. These skewed data sets require use of specific non-parametric statistical procedures for their analysis. Nonparametric statistical tests are more powerful when applied to non-normally distributed data, and almost as powerful as parametric tests when applied to normally distributed data (Helsel and Hirsch, 1992).

The nonparametric Mann-Kendall test for linear trend was used to evaluate whether a constituent or toxicity has increased or decreased significantly since the base year (Mann, 1945; Kendall, 1975). The test is non-parametric, rank order based, and insensitive to missing values. Sen's slope estimator (Sen, 1968) was used to estimate the magnitude of change over time when a significant trend was observed. Sen's slope estimator is a non-parametric method that is insensitive to outliers and can be used to infer the magnitude of a trend in the data.

The dataset contains constituent measurement with levels below the detection limit of the analytical method. These values were assigned the value of one-half the detection limit. Over time, several of the laboratory analytical techniques have lowered their limit of detection. An artifact of this advance is that the lower detection limit values of measurements later in the data record may be falsely detected as a downward trend. To avoid this, water quality values are censored to the one-half of highest detection limit of the analysis period as part of the data handling prior to analysis.

Data sets having large numbers of values below detection limit (BDLs) may create statistical problems for trend analyses. The Mann-Kendall test for trend adjusts variance estimates upward for ties in magnitude (Gilbert, 1990). Since BDL values in the raw data set produce such ties, trend analyses of data sets with high percentages of BDLs will be based upon greater variances than those without BDLs. Thus, the power of the trend analyses for the data sets with BDLs are reduced compared to those without detection limits censoring.

A simulation analysis on the effect of BDLs on Mann Kendall test and Sen slope estimator has provided standard guidelines for reporting trend statistics (Alden et al., 2000). These guidelines are widely accepted based on the percentage of BDLs present in the data set (Ebersole et al., 2002). The simulation analysis found that the power of the Mann-Kendall test begins noticeably to decline when censoring exceeds 35 %. However, if the Mann-Kendall test produces a significant result when the level of censoring is between 35% and 50%, this result may be valid in spite of the loss of power. If the Mann-Kendall test fails to produce a significant result when censoring is in the 35% to 50% interval, this failure may have resulted from a loss of power. Also; the Sen slope estimator begins to exhibit noticeable bias when censoring exceeds 15%. At levels of censoring of 15% or less, both the Mann-Kendall test results and the Sen slope estimator were found to be reliable.

The following guidelines were used to report trend information:

- If the percentage of BDL observations is 15 or less, report the trend test p-value, direction, and magnitude of the trend (i.e., Sen Slope).
- If the percentage of BDL observations is greater than 15 and less than or equal to 35, report the trend test p-value and direction only. Do not report the trend magnitude.
- If the percentage of BDL observations is greater than 35 and less than or equal to 50 and the trend test p-value indicates a significant trend, report the trend test p-value and direction. Do not report the trend magnitude.

- If the percentage of BDL observations is greater than 35 and less than or equal to 50 and the trend test p-value does not indicate a significant trend, report that there are too many observations below the detection limit to determine the presence or absence of trend.
- If the percentage of BDL observations is greater than 50, report there are too many observations below the detection limit to determine the presence or absence of trend.

The current and historical data used in the trend analysis are shown in a series of scatterplots (Appendix C). Scatterplots provide a visual comparison across all the years of data of collection. Scatterplots provide a visual representation of the relative concentrations of constituents between stations and storm events. Scatterplots are simple plots of concentrations of constituents plotted on the y-axis against time identified on the x-axis. Relevant trend information is reported with each scatterplot based on the guidelines described above.

Regional trend analysis was completed for constituents that showed similar trends in four or more watersheds by testing the homogeneity of stations. Following the methods outlined in Gilbert (1987), data collected at several different stations were analyzed to test if a regional-wide statement could be made about trends. A general statement about the presence or absence of monotonic trends is meaningful if the trends at all stations are in the same direction (i.e., all upward or all downward). In order to do this the Mann-Kendall statistic, computed for each station as described above, was used in the procedure developed by van Belle and Hughes (1984) to test for homogeneity of trends across the region. The van Belle and Hughes procedure does the following:

- Computes the homogeneity chi-square statistic.
- Compares chi-square statistic with the critical value (M-1) in Table A19 (Gilbert, 1987).
- If the chi-square statistic exceeds the critical value, reject the null hypothesis (H_O) of homogeneous station trends (accepting the alternative hypothesis (H_A)). This would conclude that no regional-wide statements could be made about trend direction.
- Conversely, if the chi-square statistic is less than the critical value, accept the null hypothesis (H_O), concluding that homogeneity trend exists across the region (or stations) over the monitoring period.

B.5.2 Constituent Comparisons

Statistical analyses for regional assessment included the magnitude of the ratio of observed concentration to the benchmark WQOs and Mann-Kendall trend analysis. The regional assessment of the magnitude of benchmark WQO ratios for key constituents was based on the ratio of the annual mean concentration for all available data to the appropriate benchmark WQO. These comparisons provide for identification of water quality issues specific to a watershed or common among several or all watersheds in the region. Scatterplots for each constituent for the years monitored were discussed in the individual watershed sections and presented in Appendix H.

Scatterplots provide a visual representation of the relative concentrations of constituents between stations and storm events. Scatterplots are plots of the constituent concentrations plotted on the y-axis against time identified on the x-axis. Each constituent and toxicity test is represented by a series of scatterplots for each of the MLS monitoring during 2007–2008. Non-detectable results were plotted at one-half the detection limit. MLS not monitored during the 2007–2008 period are also included in Appendix H. All constituents were monitored at mass loading stations during three storms each year (with the exception of Santa Margarita River), prior to the 2007–2008 monitoring period. During 2007–2008, two storms were monitored at a sub-set of MLS located in Northern San Diego County. All available data are included in scatterplots.

B.6 Discharge Volume Calculation and Flow Modeling for Loading Estimates

Pollutant loadings to each MLS were calculated for the monitored events by applying the average event mean concentration from the annual wet weather season to the volume of wet weather stream flow discharge as a result of precipitation during each runoff event. Event volumes were calculated by summing the incremental observed flow values multiplied by the time elapsed between observations as follows:

Cubic ft/sec * incremental time (seconds) = Cubic Feet

A graphical representation of each storm water hydrograph was used to determine the length of the runoff event. The event mean concentration (EMC), calculated from the samples collected during the monitoring period, was then applied to the total runoff volume to obtain event loadings for each storm.

Long term flow volumes to calculate annual loadings to each MLS were calculated using available USGS flow monitoring data for watersheds that contain gaging stations. For watersheds that do not contain USGS flow monitoring gages, WESTON estimated the annual surface water volumes to each MLS using a hydrologic computer model. The USACE HEC-HMS hydrologic model was originally proposed to simulate the watersheds. However, due to long run times and computational processing limitations for a year-long simulation of large watersheds lead to the selection of the United State Environmental Protection Agency (USEPA) Stormwater Management Model (SWMM) version 5.0.013. In addition to faster processing times, the SWMM model has water quality simulation capabilities that can be used in future efforts to evaluate pollutant sources based on land use and evaluate the impact of proposed BMPs.

B.7 USGS Gaged Watersheds

The larger watersheds, specifically Santa Margarita, San Luis Rey, and San Diego Rivers contain USGS flow monitoring gages. There are USGS gages in the Santa Margarita River, San Luis Rey, and San Diego River Watersheds at the same location or within relatively close proximity to each MLS. The USGS gaging stations were used to estimate annual flow volumes for those watersheds. The USGS gaging stations are also used to validate flow monitoring data collected at the MLS which uses standard flow rating techniques across all watersheds.

B.8 SWMM Model Overview

The USEPA SWMM model was selected to simulate the surface water flow to each MLS in the ungaged watersheds because the model has the capability to calculate storm water runoff based on drainage basin characteristics and route flow through a watershed. SWMM is a dynamic rainfall-runoff simulation model that can simulate single events or long-term (continuous) runoff quantity and quality. The runoff component of SWMM operates using a collection of subcatchment areas on which rain falls and runoff is generated. Depth of water over the subcatchment is continuously updated with time by solving a numerical water balance equation over the subcatchment. The routing portion of SWMM transports this runoff through a conveyance system of channels and pipes by selecting uniform flow, kinematic wave, or dynamic wave equations. Water quality parameters can also be input to SWMM to simulate pollutant loadings based on land use within each watershed.

The objectives of the surface water modeling effort were:

1. To more accurately determine the volume of stream flow at each MLS;
2. To obtain a calibrated hydrologic simulation of each watershed so that gaps in observed data can be estimated in the event of equipment failure; and,
3. To fill in historic data gaps for the purpose of investigating trends in watershed loadings over the course of several years.

The USEPA SWMM model can be used as a planning tool by updating the land use coverage or conveyance structures and simulating changes in storm water runoff from various development scenarios. The model was used only as a tool to estimate stream flow volumes for this reporting period. Water quality parameters can be assigned to each land use and BMP efficiencies can be assigned to proposed projects to evaluate their effectiveness in the future.

B.9 Hydrologic Input Parameters

Hydrologic parameters were developed from the USGS Medium-Resolution (1:100k) National Hydrography Dataset (NHD Plus), NRCS Soil Survey Geographic (SSURGO) Database (USDA, 2003) and 2007 land use data from San Diego Association of Governments (SANDAG). This section explains the source and purpose of the data input to the SWMM Runoff Model.

B.9.1 SWMM Runoff Module

The runoff component of SWMM simulates both the quantity and quality runoff phenomena of a subwatershed. The program accepts precipitation data and makes a step by step accounting of snowmelt, infiltration and evaporative losses, and surface detention and overland flow to calculate a runoff hydrograph for the subwatershed and direct these data to the routing module for surface flow routing.

The following characteristics affect the amount of precipitation that becomes storm water runoff:

- Precipitation distribution and intensity
- Evaporation rates
- Subwatershed properties
  - Area
  - Topography and slope
  - Land Use
  - Soils

Values to describe these characteristics for each watershed were developed and input to the SWMM model, as described in the following subsections.

B.9.1.1 Precipitation

WESTON has observed precipitation data at each MLS and TWAS for the period from 13 September 2007 through June 2008. These data were used to calibrate the model and produce runoff hydrographs that matched the observed flow data at each MLS as closely as possible.

Once a calibrated model was developed for each MLS, the long-term precipitation from the County of San Diego Flood Control ALERT network was entered into the model to simulate annual stream flows. Annual flow volumes were developed for the period from 1 July through 30 June beginning with 2002–2003 through 2007–2008.

B.9.1.2 Evaporation

The evaporation rate varies with temperature, wind speed, sunshine, and relative humidity. Rough daily evaporation rates for this model were extrapolated from maps of average monthly evaporation produced by the National Weather Service (http://www.cpc.ncepnoaa.gov/soilmst/e.html). Table B-16 lists the typical monthly evaporation (millimeters per month) and estimated daily evaporation rate for the San Diego area. This value is significant when running the model in continuous simulation mode.

Table B-16. Evaporation Rates for San Diego County

Month	Average Monthly Evaporation Rate (in/day)*
January	0.107
February	0.113
March	0.157
April	0.203
May	0.213
June	0.187
July	0.227
August	0.223
September	0.193
October	0.163
November	0.127
December	0.110

Source: National Weather Service CPC Soil Moisture Monitoring
*Based on monthly evaporation data divided by the number of days in the month

B.9.1.3 Drainage Area

The National Hydrography Dataset (NHD Plus) for California (Hydrologic Region 18, production unit a) was the source of the catchment boundaries (subwatersheds) for the area draining to each MLS. Elevation-based subwatersheds in the NHD Plus database were input to the SWMM model. Hydrologic input parameters, such as the watershed width, were calculated for each of catchments using data available in the NHD Plus database.

B.9.1.4 Topography and Slope

Surface slope and subwatershed shape have profound effects on runoff flow within a subwatershed. The overland flow path for headwater subwatersheds was measured from a point on the watershed boundary to the outlet. The overland flow path for the downstream subwatersheds was assumed to be the “flow-length” parameter in the NHD Plus database. Overland flow length is a constituent of the calculation for the watershed width parameter that describes the shape of each subwatershed and is the primary calibration parameter within the SWMM model. Watershed widths were calculated by dividing the subwatershed area by the maximum overland flow length. The calculated watershed width parameter was adjusted during model calibration as to produce output hydrograph results from the model that match the observed hydrographs at the MLSs as closely as possible.

B.9.1.5 Land Use

Land use is an important and variable originator of storm water runoff. As natural vegetation is replaced with impermeable surfaces such as pavement and buildings, the amount of rainfall that runs off the land surface and the rate at which it flows are greatly increased. The 2007 land use coverage from SANDAG was the source of land use information (SANDAG, 2007). Land uses with similar hydrologic characteristics, such as percent impervious cover, were aggregated into one category to simplify input to the SWMM model by reducing the number of necessary input parameters. Table B-17 includes the land use-dependent input values for each land use in the SWMM simulation of the San Diego County watersheds.

Table B-17. Hydrologic Parameters for Each Land Use

Model Land Use	Manning's Roughness Coefficient		Impervious Area (%)	
	Impervious	Pervious	Total Impervious Area %	Directly Connected Impervious Area %
Agriculture	0.015	0.300	2	1
Commercial	0.015	0.100	70	60
Commercial with Open Land	0.015	0.200	50	35
Parks and Recreation	0.015	0.400	5	3
Industrial	0.015	0.100	65	60
Military Open Land	0.015	0.150	5	3
Open Space Beaches	0.015	0.100	2	1
Open Space Landscape	0.015	0.350	2	1
Open Space	0.015	0.350	2	1
Residential	0.015	0.300	40	25
Rural Residential	0.015	0.350	10	5
Construction Site	0.015	0.030	70	60
Transportation	0.015	0.100	50	40
Water	0.015	0.100	100	100

Note: Initial Estimates for Manning's Roughness Coefficients for overland flow were obtained from Huber and Dickinson, 1998, p.107

B.9.1.6 Directly Connected Impervious Area (DCIA)

The percent impervious area for each land use category is an important input parameter for hydrologic simulation. The impervious surface area within a subwatershed tends to increase as development intensity increases. For example, commercial development will typically have more impervious surface than single family residential development. A refinement of the estimate of impervious area in each land use category to a more specific parameter, the amount of directly connected impervious area (DCIA), is required to simulate storm water runoff in SWMM. DCIA includes only impervious surfaces that flow directly into storm sewers, drains, channels, or other waterways without flowing over any pervious surfaces.

Impervious surfaces collect pollutants that can be rapidly washed into streams when it rains. These surfaces include rooftops, driveways, sidewalks, paved roads, and parking lots. Impervious surfaces prevent natural filtering of polluting materials that normally occurs before storm water enters a stream. The amount of impervious area within each land use category was obtained from literature values found in Dallman and Piechota, 2000 and Camp, Dresser, and McKee, 1996.

Initial assumptions for percent impervious area were derived from the Back River Watershed Water Quality Management Plan (Camp, Dresser & McKee, 1996), Stormwater: Asset not Liability (Dallman and Piechota, 2000), and from professional judgment. The initial DCIA assumptions were refined during the hydrologic calibration of the model. Values of DCIA and other hydrologic input parameters for the subareas within each modeled watershed are presented in subsequent sections of this report.

B.9.1.7 Soils

The soils underlying the land uses also control how much rainfall can infiltrate in areas that remain in pervious land cover. Infiltration rate values for each soil type that were input to the SWMM model are shown in Table B-18.

Table B-18. Hydrologic Parameters for Soils

NRCS	Maximum	Minimum
	Infiltration Rate	Infiltration Rate
Hydrologic Soil Group	Inches per hour (in/hr)	Inches per hour (in/hr)
A	5.0	0.3
B	3.0	0.15
C	1.5	0.05
D	0.5	0.0

Source: James et al., 1999.

B.9.2 Calculation of Hydrologic Data Input Using ArcGIS

The following GIS files were compiled to perform the data conversion to SWMM input:

- Topographic data, including watershed boundaries and subwatershed boundaries.
- Hydrologic soil groups.
- Land use categories.

Land uses were aggregated into the 14 categories listed in Table B-17. The land use coverage was overlaid onto the subwatershed boundaries to determine the land use composition of each subwatershed. Land use percentages were used to calculate area weighted percent DCIA, pervious/impervious Manning's coefficients, and pervious/impervious depression storage.

The SSURGO database for San Diego County and portions of Riverside County was used to map the hydrologic soil group (A-D) for the watershed management areas. These data were then intersected with the land use data by subwatershed. Through this process, the runoff characteristics of each variation in soil/land use combination were determined. The ability to rapidly calculate the many variations in these combinations have maximized the accuracy and utility of hydrologic simulations when compared to those performed with manually calculated input data.

B.10 Hydraulic Simulation Input Parameters

The routing portion of SWMM performs dynamic routing of storm water flows throughout the major storm drainage system to the outfall point and the receiving water body. Hydrographs generated by the runoff component are automatically interfaced with the routing portion and storm water runoff is routed through the network. The stream channels were simulated in the models as conduits. Nodes were created to connect the conduits and route the storm water through the system. The NHD Plus database contains upstream and downstream nodes for each subwatershed. Channel slope was automatically calculated from the channel length and the elevations associated with the upstream and downstream node associated with each channel.

For this initial effort, channel dimensions were assumed based on the Stream Order (obtained from the NHD Plus database). Channels were assumed to be eight-point trapezoids with the following dimensions (Table B-19).

Table B-19. Stream Order Assumed Dimensions

Stream Order	Bottom Width (ft)	Bank to Bank Width (ft)	Total Width (ft)	Bankfull Depth (ft)
1	2	4	26	2
2	5	9	49	2
3	10	16	56	3
4	15	45	85	5
5	20	60	100	5

A Mannings roughness coefficient value of 0.09 for all channels and overbank areas was assigned to all channels for this effort. Channel dimensions and roughness characteristics can be refined during future efforts to increase the level of detail for model input parameters.

B.11 SWMM Model Calibration

After the input parameters were calculated and the best estimate was assigned to all of the coefficients, the SWMM model was run. Assigning the appropriate precipitation gage to each subwatershed was the initial calibration effort. Data from the closest ALERT rain gages were used to supplement the precipitation recorded at the MLS. The area influenced by each available source of rainfall data was adjusted until the output hydrograph shape matched the shape of the observed stream flow hydrograph at the MLS. Once the rainfall data source was set, other parameters were adjusted to obtain the magnitude of runoff being recorded at the MLS. Parameters input to SWMM, such as the watershed width, percent DCIA, and Manning's Roughness Coefficient for overland flow were adjusted for each land use until the SWMM outflow hydrograph at the MLS most closely matched the observed hydrograph at the MLS.