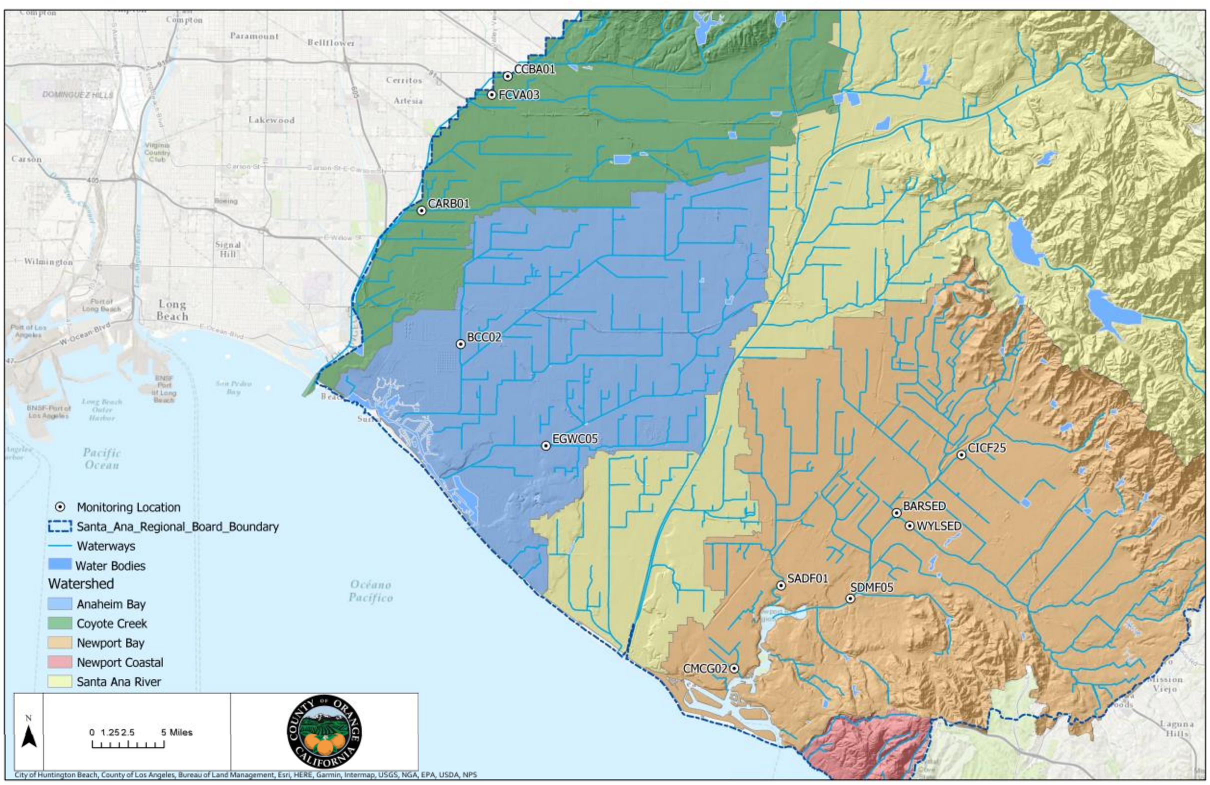
C-11-II.0 LONG TERM MASS EMISSIONS MONITORING

C-11-II.1 Core Monitoring Program

<u>Overview</u>

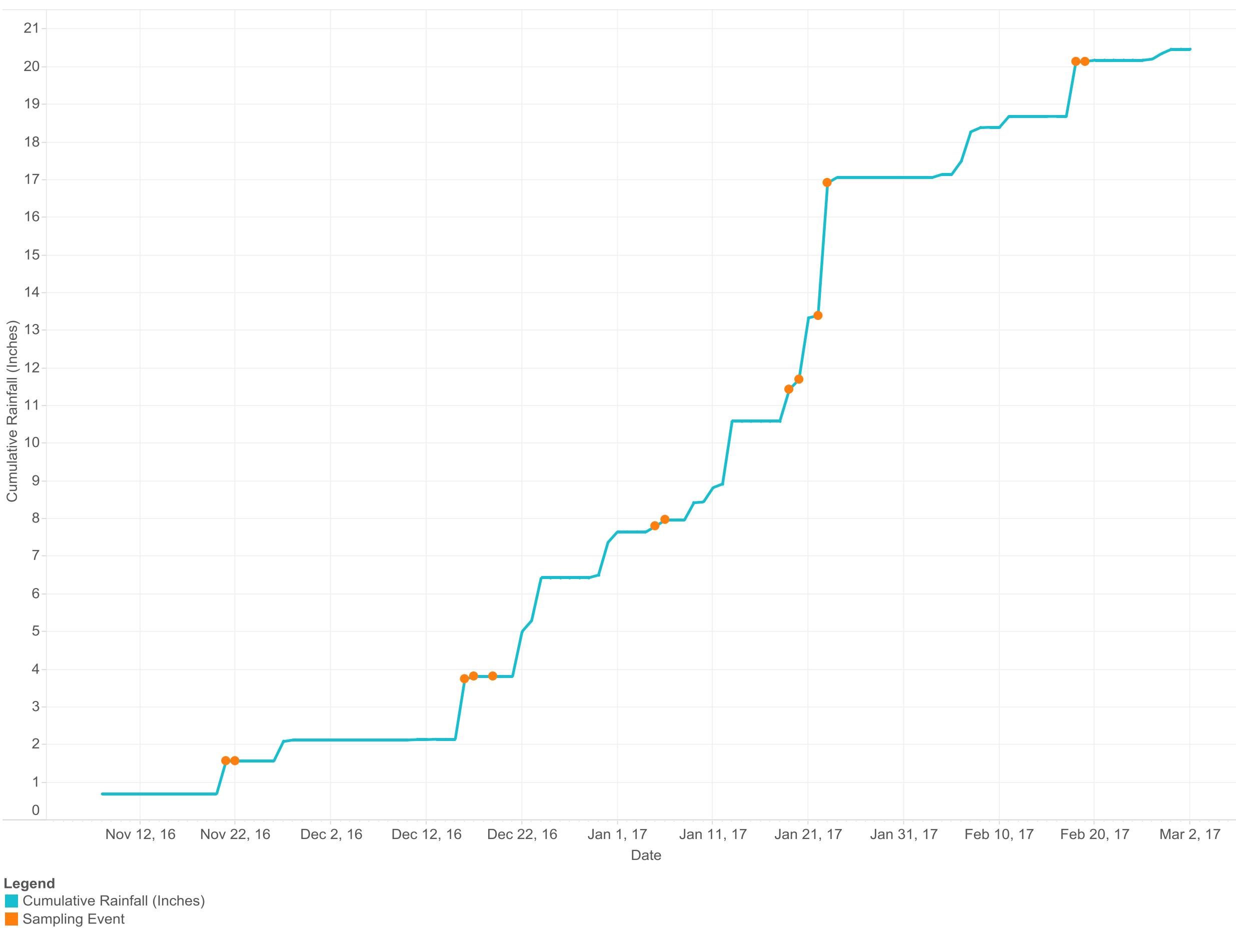
Long Term Mass Emissions (Mass Emissions) monitoring is conducted primarily to estimate the total annual load (or amount by weight) of a wide range of constituents which are transported by flood control drainage channels to receiving waters during both dry weather and stormwater runoff conditions. A secondary goal is to assess the relative toxicity of these samples, both by comparison to California Toxics Rule (CTR) criteria and from the results of aquatic toxicity tests. Water chemistry and channel discharge rates are measured to compute loads for specific dry weather and wet weather events each year. Ideally, the total annual load of a selected constituent from a channel would be determined from a continuous monitoring of the water chemistry and discharge rate throughout the year. However, the cost for analytical services and monitoring labor requirements make the continuous analysis of aquatic chemistry cost prohibitive. Consequently, monitoring of aquatic chemistry in runoff is conducted at representative times during dry weather and storm flow events and the information gathered is used to estimate the conditions throughout the year. The monitoring locations are shown in the figure below.

Figure C-11-II.1: Receiving Water Locations for Mass Emissions Monitoring Program.



The intent is to annually monitor each site during three periods influenced by stormwater runoff and a representative number of dry weather periods. The annual rainfall total for Santa Ana this monitoring period was 20.69 inches, and was the first above average (12.84 inches) rainfall since the 2010-11 season. With the break in drought conditions, there were ample opportunities for monitoring storm events. **Figure C-11-II.2** documents the rainfall events that were monitored for the Mass Emissions program. Storm monitoring activities at various monitoring stations in the watersheds of central (Newport Bay) and north (Anaheim Bay, Coyote Creek, and Santa Ana River) Orange County were conducted for the first flush storm event (November 2016) as well as the following other storm events: December 2016 (Newport Bay watershed focus), January 2016, and February 2016 (north County watersheds focus).

Figure C-11-II.2: Cumulative Rainfall at Station #121 in Santa Ana. The 2016-17 season rainfall total was above the historical average of 12.84 inches, the cumulative chart below shows which storms were monitored and their respective rainfall totals.



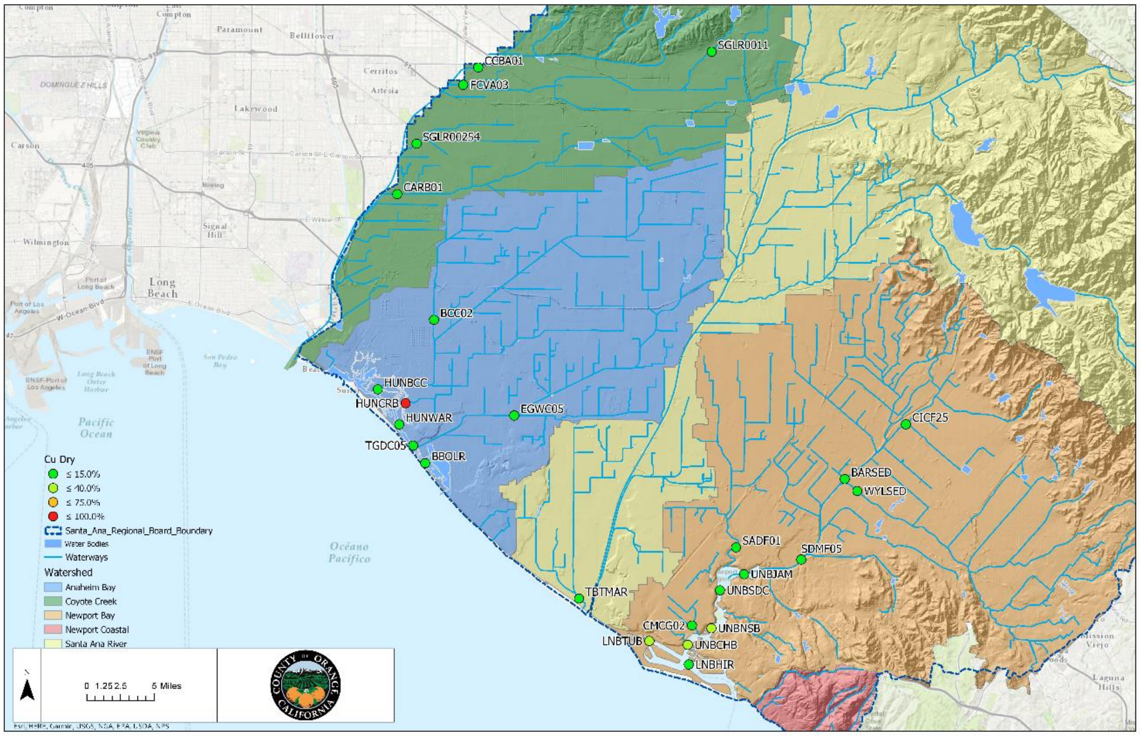
Water quality data from Mass Emissions stations were used to assess stormwater mass loads, toxicity effects associated with runoff, and compliance with respect to acute and chronic CTR criteria. Data sets below are presented in tables available at the following link: https://ocgov.box.com/v/2016-17-SAR-PEA-C-11-Datasets

- **Table C-11-II.1** contains the stormwater mass loads of nutrients and trace elements.
- **Table C-11-II.2** contains the measured flow-weighted event mean concentrations (EMC) of these constituents.
- **Table C-11-II.3** presents the entire data set of aqueous and sediment chemistry.
- **Table C-11-II.4** summarizes the comparisons of metals samples results to the CTR criteria. The concentrations of dissolved metals and total recoverable selenium in each composite sample collected in the Mass Emissions program element are compared to the acute and chronic toxicity criteria from the CTR, where applicable. Freshwater criteria are used to evaluate channel discharges.
- **Table C-11-II.5** presents the entire set of aqueous and sediment toxicity data collected.
- **Table C-11-II.6** contains priority pollutant results.

Metals and Selenium

The complete summary of dissolved and total recoverable metals concentrations in comparison to CTR criteria are available in **Table C-11-II.4** for acute and chronic CTR criteria in both dry and wet weather. Additionally, **Figures C-11-II.3** and **C-11-II.4** display the data spatially for specific dissolved metals, split into acute (upper figure) and chronic (lower figure) criteria. Both **Table C-11-II.4** and **Figures C-11-II.3** and **C-11-II.4** also include results from the Bioassessment and Estuary /Wetlands monitoring programs for regional comparison.

Figure C-11-II.3: Patterns of CTR Exceedances for Dissolved Metals Across the Region in Dry Weather, Compared to Acute (Upper Map) and Chronic (Lower Map) CTR Criteria. This figure includes the Mass Emissions monitoring stations as well as the Estuary/Wetlands and Bioassessment stations for comparison.



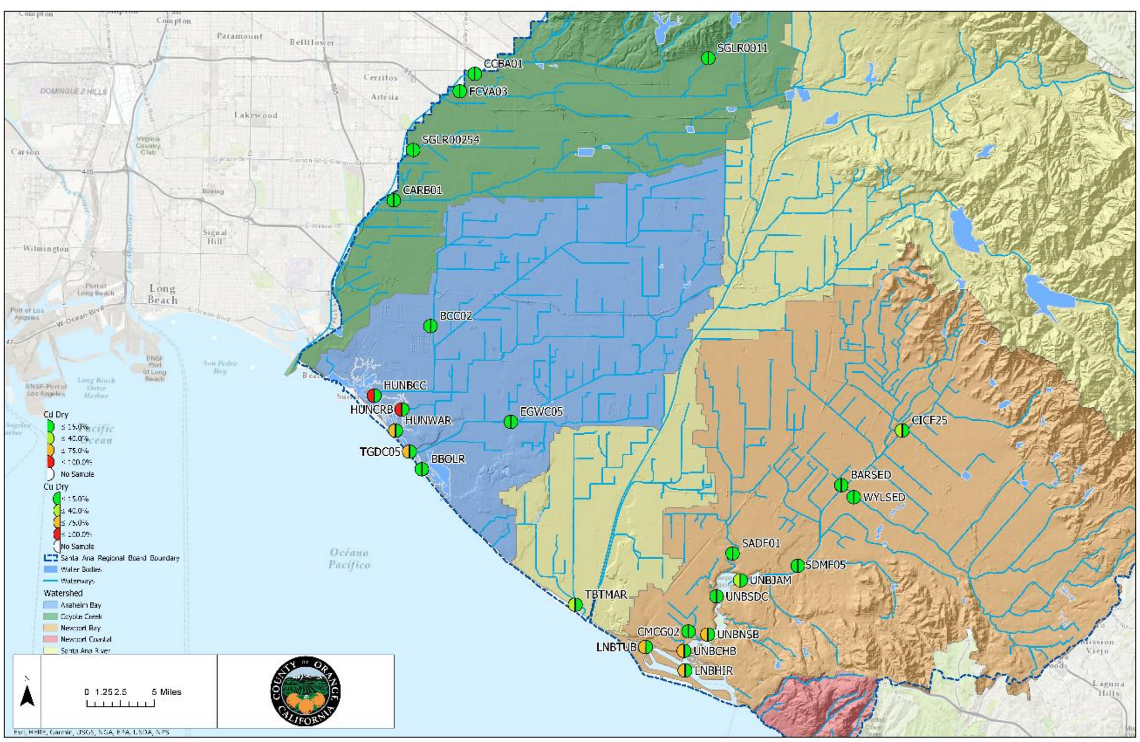
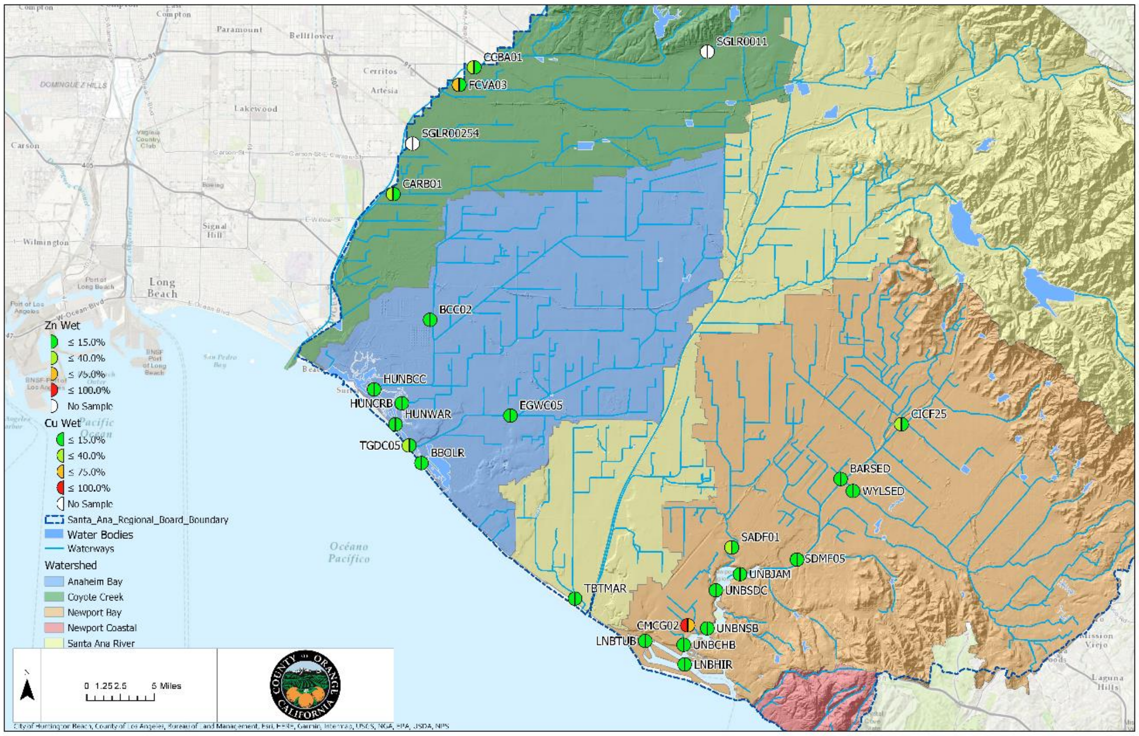
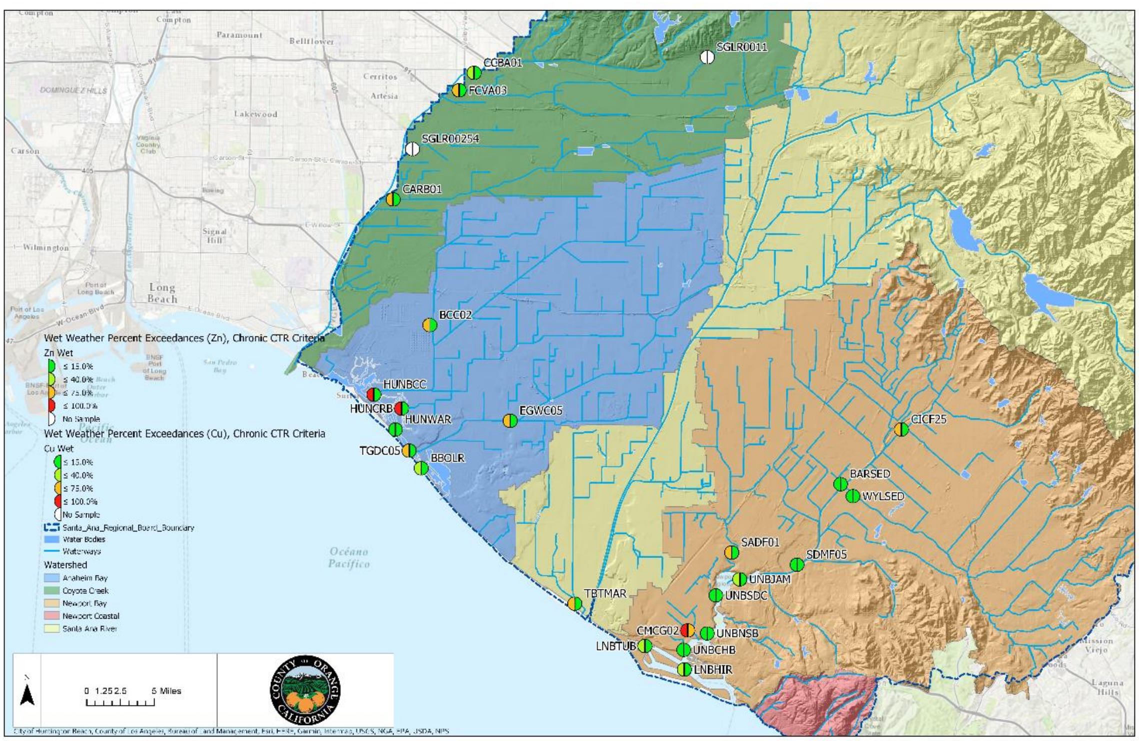


Figure C-11-II.4: Patterns of CTR Exceedances for Dissolved Metals Across the Region in Stormwater-Influenced Samples, Compared to Acute (Upper Map) and Chronic (Lower Map) CTR Criteria. This figure includes the Mass Emissions monitoring stations as well as the Estuary/Wetlands and Bioassessment stations for comparison.





Cadmium

No exceedances of the acute or chronic CTR criterion were noted for dissolved cadmium in the dry weather samples collected.

In stormwater-influenced samples, one result exceeded the acute CTR criteria for dissolved cadmium at Costa Mesa Channel (CMCG02).

Silver

No exceedances of the acute or chronic CTR criterion were noted for dissolved silver in the dry weather samples collected.

In stormwater-influenced samples, two results exceeded the acute CTR criteria for dissolved silver at Costa Mesa Channel (CMCG02).

Copper

One sample out of 34 (3%) dry weather samples collected for this program exceeded the chronic CTR criterion (adjusted for water hardness) for dissolved copper. This sample was one of four dry weather samples collected from Central Irvine Channel (CICF25).

Of the 71 stormwater-influenced composite samples collected region wide, 19 (27%) were in exceedance of the acute CTR criterion and 34 (48%) exceeded the chronic CTR criterion for dissolved copper. Exceedances of the chronic CTR criterion were noted in at least one stormwater sample from every Mass Emissions program monitoring station. Of the 11 Mass Emissions sites all but SDMF05 and WYLSED had at least stormwater sampling that contained dissolved copper exceeding the CTR criterion.

Zinc

No dissolved zinc exceedances were observed in the 34 dry weather composite samples collected for the entire program across all stations.

Four of the 71 (5.6%) stormwater-influenced samples collected exceeded both the acute and chronic freshwater CTR criteria (adjusted for water hardness) for dissolved zinc. These samples were collected at CMCG02.

Lead

No dissolved lead exceedances were observed in the 34 dry weather composite samples collected for the entire program across all stations.

Three of the 71 (4.2%) stormwater-influenced samples collected exceeded the chronic freshwater CTR criteria (adjusted for water hardness) for dissolved lead. These samples were collected at CMCG02 and SADF01.

Nickel

No dissolved nickel exceedances were observed in the 34 dry weather composite samples collected for the entire program across all stations.

One stormwater-influenced sample collected exceeded the chronic freshwater CTR criteria (adjusted for water hardness) for dissolved nickel. This sample was collected at CMCG02.

Selenium

Total selenium is evaluated instead of dissolved selenium, and the CTR only lists a chronic criterion for total recoverable selenium in freshwater. A total of 34 selenium samples were collected during dry weather, 15 (44%) of which showed an exceedance of the chronic CTR criterion for total recoverable selenium. Exceedances of the selenium chronic CTR criterion were collected from the Newport Bay watershed at BARSED (4 of 4 samples), SDMF05 (3 of 4 samples), San Diego Creek at Harvard Avenue (WYLSED – 4 of 4 samples), and SADF01 (4 of 4 samples). The chronic CTR criterion for total recoverable selenium was exceeded in 7 out of 71 stormwater-influenced samples. These samples were also all collected from the Upper Newport Bay watershed at SDMF05 (2 of 9 storm samples), BARSED (4 of 7 storm samples), and SADF01 (1 of 8 samples).

Toxicity

Aquatic Toxicity

Aquatic toxicity testing is conducted on selected dry weather and stormwater-influenced runoff samples across the region for the Mass Emissions program. Toxicity testing provides a cumulative perspective of pollutant effects on receiving water aquatic species. The toxicity test results for all available samples analyzed during 2016-17 are contained in **Table C-11-II.5**.

Samples were considered to be toxic if the organism response test results (i.e., survival, reproduction, or growth) were less than (<) 80% effect (e.g., less than 80% survival) compared to the control sample. Results indicate that toxicity effects in receiving waters across the region differed between dry weather and storm events as shown in **Figure C-11-II.5** and **Figure C-11-II.6** (see below), respectively. Toxicity occurred in 4 of 150 (2.6%) dry weather tests in comparison to 24 of 189 tests (13%) of stormwater-influenced samples collected from inland receiving waters.

As with **Figures C-11-II.3** and **C-11-II.4**, **Figures C-11-II.5** and **C-11-II.6** below also include data from Estuary/Wetlands and Bioassessment program data for regional comparisons. **Figure C-11-II.5** summarizes available dry weather 2016-17 toxicity data across the Santa Ana Region monitoring sites. Similarly, **Figure C-11-II.6** depicts stormwater-influenced toxicity results.

Figure C-11-II.5: Patterns of Toxicity across the Region in Dry Weather. The data provided includes Mass Emissions and Estuary/Wetlands stations for comparison.

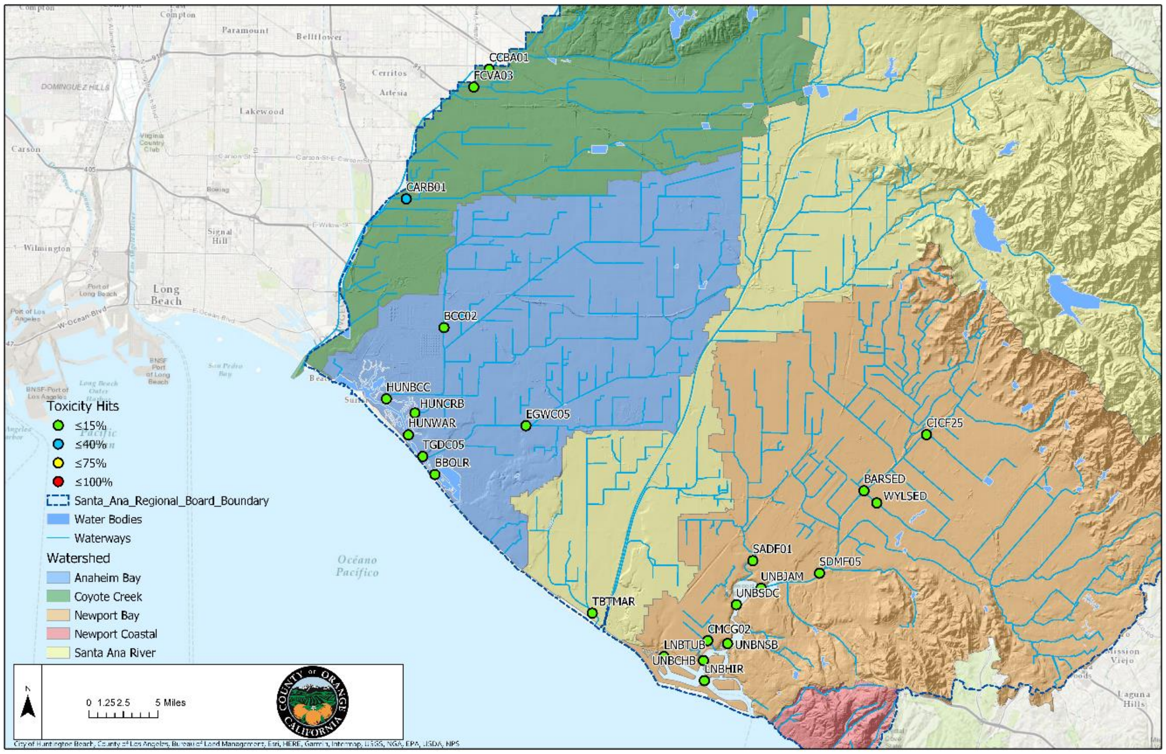
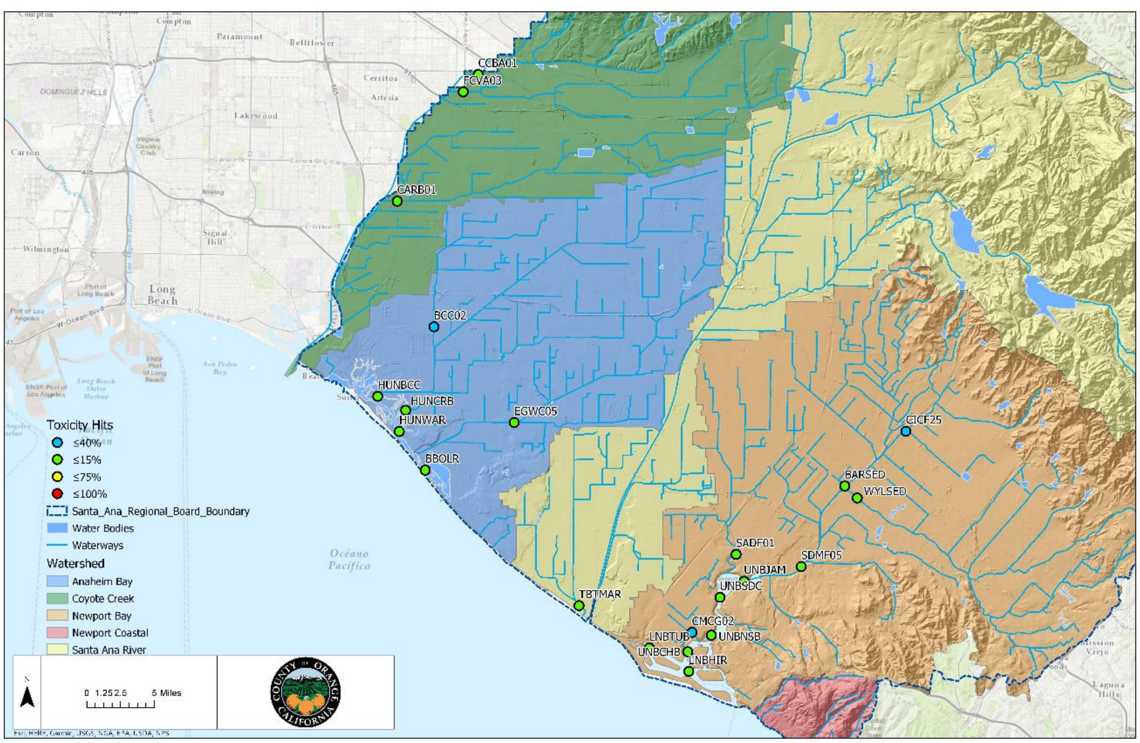


Figure C-11-II.6: Patterns of Toxicity across the Region in Wet Weather. The data provided includes Mass Emissions and Estuary/Wetlands stations for comparison.



The tests on the dry weather runoff samples are conducted with freshwater organisms, while the stormwater-influenced samples are evaluated with a combination of freshwater and marine organisms. The tests involve a statistical comparison of the mean organism responses (e.g., survival, growth, reproduction, or fertilization rates) in a series of sample dilutions to the mean value of responses in laboratory control samples. A summary of toxicity test result statistics for samples collected during dry weather is provided in the table below, along with the individual organism used for each test.

Table C-11-II.7: Dry Weather Toxicity Testing Statistics. Testing results were considered to be toxic if the organism response results (i.e. survival, reproduction, or growth) were less than 80% effect relative to responses in control samples. Mean and Min refer, respectively, to the mean of all test results and the minimum result in any single test. The Total column indicates the number of toxic sample results out of the total number of tests conducted.

***Organism* - Endpoint**	**Mean**	**Min**	**Total**
Ceriodaphnia dubia - Reproduction	110.28%	62.74%	2 of 30
Ceriodaphnia dubia - 7 Day Survival	96.78%	70.00%	1 of 30
Ceriodaphnia dubia - 48 Hour Survival	100.04%	90.00%	0 of 30
Hyalella azteca - 96 Hour Survival	96.72%	70.59%	1 of 30
Selanastrum capricornutum - Cell Density	130.53%	84.33%	0 of 30

As indicated above, toxicity occurred in 3% of dry weather sample tests conducted (4 out of 150 tests), suggesting that sites in the Santa Ana Region are predominantly above the water quality objectives for aquatic toxicity during dry weather. The following summarizes the tests that showed toxicity:

- One sample collected at Carbon Creek Channel (CARB01) exhibited toxicity for *Ceriodaphnia dubia* survival and reproduction and *Hyallela Azteca* 96 hour survival. This was the only station sampled to exhibit toxicity for multiple end points and species in dry weather.

- One additional sample collected at Peters Canyon Wash (BARSED) exhibited toxicity for *Ceriodaphnia dubia* reproduction.

The toxicity test results for stormwater-influenced samples collected during 2016-17 were slightly different from the dry weather samples statistics and are summarized in the table below.

Table C-11-II.8: Wet Weather Toxicity Testing Statistics. Testing results were considered to be toxic if the organism response results (i.e. survival, reproduction, or growth) were less than 80% effect. Mean and Min refer, respectively, to the mean of all test results and the minimum result in any single test. The Total column indicates the number of toxic sample results out of the total number of tests conducted.

Organism **- Endpoint**	**Mean**	**Min**	**Total**
Ceriodaphnia dubia - Reproduction	94.25%	0.00%	4 of 27
Ceriodaphnia dubia - 7 Day Survival	90.37%	0.00%	2 of 27
Ceriodaphnia dubia - 48 Hour Survival	94.07%	0.00%	2 of 27
Americamysis bahia - 7 Day Growth	84.93%	0.00%	11 of 27
Americamysis bahia - 7 Day Survival	86.47%	0.00%	4 of 27
Americamysis bahia - 48 Hour Survival	95.75%	27.50%	1 of 27
Strongylocentrotus purpuratus - Fertilization	99.86%	91.02%	0 of 27

As indicated above, toxicity occurred in approximately 13% of storm event sample tests (24 of 189 tests), across *Americamysis bahia* and *Ceriodaphnia dubia.* Additional data analysis is provided below:

- Consistent with data from prior reports, the results show that the most toxic responses in stormwater-influenced samples were seen in the *Americamysis bahia* tests. The most widespread *Americamysis bahia* toxic effects for growth were observed on the January 20th sampling event in the Newport watershed.
- Four stations saw toxicity for *Ceriodaphnia dubia* reproduction: CICF25, CMCG02, BARSED, and CCBA01. The samples taken at both CICF25 and CMCG02 were also toxic for *Ceriodaphnia dubia* survival.
- None of the stormwater-influenced samples analyzed for *Strongylocentrotus purpuratu*s were toxic.

On a regional basis, the 2016-17 monitoring results indicate that the Santa Ana Region portion of Orange County is above the target objective (less than 80% effect relative to the control) for toxicity in 90% of all tests conducted.

Sediment Toxicity

Sediment samples were collected quarterly during dry weather and tested using the 10 day *Hyallela azteca* survival test. Sediment toxicity samples ranged from 0% to 100% survival with a mean response of 81% survival compared to the control sample. Toxicity in the 10 day *Hyallela azteca* survival test occurred in 6 of 16 (38%) samples, with the toxic samples collected from BARSED, SADF01, SDMF05 and WYLSED.

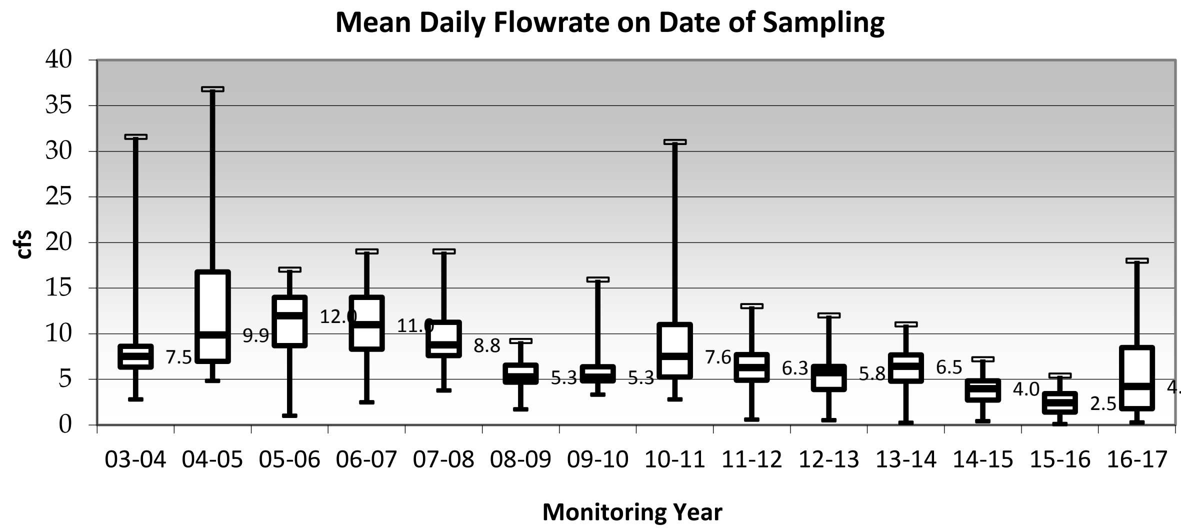
C-11-II.2 Regional Monitoring

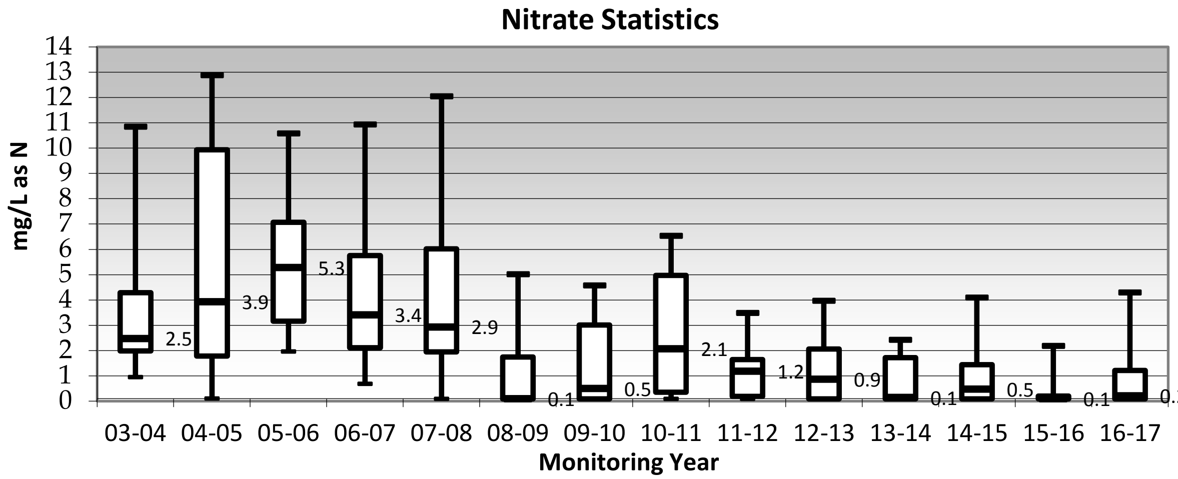
Dry weather monitoring for nutrients is conducted at the Mass Emissions sites and other stations in the Newport Bay watershed as part of the Nutrient TMDL program. Nutrient TMDL monitoring and reporting requirements were adjusted by the Regional Board on December 12, 2014, and implementation of the monitoring was changed accordingly. Monitoring changes included reduced sampling frequencies at existing monitoring locations, typically to either a monthly or quarterly frequency, as well as the removal of the Lane Channel monitoring station. Additionally, data reports are now prepared and submitted to the Regional Board on an annual basis (in lieu of quarterly). Electronic copies of the data reports have been submitted separately to the Santa Ana Regional Board and can be found on the www.ocwatersheds.com website in the OC Watersheds Document Library (http://prg.ocpublicworks.com/DocmgmtInternet/Search.aspx).

Natural Treatment System Wetlands off San Diego Creek

Since the late spring of 2008, samples collected from SDMF05 station have generally contained lower levels of nitrate during the periods when the Irvine Ranch Water District (IRWD) Natural Treatment System wetlands were operational. **Figure C-11-II.7** below shows the trends in dry-weather nitrate concentrations and mean daily flow rates at Campus Drive over the last 14 years. The nitrate statistics from 2016-17 are higher than 2015-16 but continue to demonstrate a historical downward trend, and mean daily flow rate during sampling events has increased over 15-16.

Figure C-11-II.7: Nitrate as N (mg/L) Statistics (Upper Chart) and Mean Daily Flow Rate on Date of Sampling (Lower Chart) at San Diego Creek at Campus, 2003-2017. The nitrate concentrations and mean daily flow rates are higher than 15-16, but lower than trends in the mid-2000s.





The decreased nitrate concentrations beginning in 2008-09 appear to be a function of diversion of flow to the IRWD Natural Treatment System wetlands. The maximum diversion rate of water from San Diego Creek to the IRWD Natural Treatment System wetlands is 2,600 gpm or 5.8 cfs. The median flow rate in San Diego Creek at Campus Drive during the 2016-17 reporting year was 4.3 cfs suggesting that a significant portion of the water in the creek entered the diversion system and was treated by the wetlands.

C-11-II.3 Special Studies on Pesticides

The standard suite of analyses was expanded to include additional organic compounds in selected dry weather and stormwater samples from the Mass Emissions sites. The analyses included organophosphate (dry weather and wet weather) and synthetic pyrethroid (wet weather) pesticides. A review of dry weather sampling results is incorporated into **Table C-11-II.9** below. In general, exceedances for organophoshate pesticides were infrequent overall, with malathion detected in 4.4% (2 out of 45 samples) of dry weather samples, and chlorpyrifos detected in 4.4% (2 out of 45 samples) in dry weather. Bifenthrin was the most frequently detected pyrethroid pesticide, with 29% (7 out of 24 samples) of samples detected. However, when assessing the impacts of these detections, only two samples exceeded the 96 hour lethal concentration (9.3 ng/L LC50) for H*yalella azteca*. Median values were at the detection limit for each compound.

Table C-11-II.9: Pesticides in Dry Weather (ng/L) at Mass Emissions Monitoring Sites, 2016-17. Table includes both organophosphate and synthetic pyrethroid pesticides, compounds that were not detected have been omitted from this table.

Pesticide	Samples	Detected	Min	Max	Median	Samples above LC50 for *Hyalella Azteca*
Organophosphates						
Chlorpyrifos	45	2	<1	25.1	<1	0
Malathion	45	2	<5	40.1	<6	0
Synthetic Pyrethroids						
Bifenthrin	24	7	<2	49.3	<2	2
Cyfluthrin	24	2	<2	6	<2	
Cypermethrin	24	2	<2	6.1	<2	

*Medians calculated using full detection limit values.

Samples were also collected and analyzed for pesticide constituents from the Mass Emissions stations during wet weather. **Table C-11-II.10** below summarizes the results of pesticide sampling during storm events completed during 2016-17, including both organophosphates and synthetic pyrethroids. Similary to dry weather conditions, the only wet weather organophoshate pesticides detections were for chlorpyrifos (17%, 10 out of 58 samples) and malathion (8.6%, 5 out of 58 samples). Pyrethroid detections in wet weather were frequent, with detections for all tested pesticides except permethrin and esfenvalerate. The most frequent detections were for cypermethrin (56%, 42 out of 75 samples), cyfluthrin (80%, 60 out of 75 samples), and bifenthrin (100% of 75 samples). Bifenthrin concentrations ranged from 3.4 to 499.5 ng/L, with all but 3 detections above the *Hyalella azteca* LC50 of 9.3 ng/L. Eleven bifenthrin results were also above the *Ceriodaphnia dubia* LC50 of 142 ng/L.

Table C-11-II.10: Pesticides in Stormwater (ng/L) at Mass Emissions Monitoring Sites, 2016-17. Table includes both organophosphate and synthetic pyrethroid pesticides.

Pesticide	Samples	Detected	Min	Max	Median	**Samples above LC50**	
						Hyalella	*Ceriodaphnia*
Organophosphates							
Chlorpyrifos	58	10	<1	145.4	<1	2	2
Malathion	58	5	<5	312.2	<6	0	0
Synthetic Pyrethroids							
Allethrin	75	2	<2	12.6	<2		
Bifenthrin	75	75	3.4	499.5	40.4	72	11
Cis-Permethrin	32	1	<4	33.2	<4		
Cyfluthrin	75	60	<2	95.5	6.1		
Cypermethrin	75	42	<2	48.1	2.3		
Deltamethrin	53	5	<2	39.2	<2		
L-Cyhalothrin	69	10	<2	76.7	<2		
Prallethrin	75	2	<2	12.5	<2		
Trans-Permethrin	32	1	<2	61.8	<2		

*Medians calculated using full detection limit values.