

Dry Run & First Flush 2018 Monitoring Report

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Introduction

In order to alleviate flooding of communities, roadways, or businesses during heavy rainstorms, storm water is directed to storm drain systems and outfalls which then direct storm flows to creeks, rivers and the ocean. Pollutants that accumulate on hard surfaces during months of dry weather are washed away by storm runoff, especially during the first major rainstorm of the winter season. This “first flush” will often have the highest concentration of pollutants washing into local waterways from months of dry weather accumulation and can severely impact water quality. Pollutant sources can be brake dust from cars and trucks, emissions from cars, animal waste, detergents from car washing, pesticides, fertilizers, as well as other chemicals commonly found in and around homes and businesses. Dry weather runoff flows are also an important component of water quality monitoring since contaminants can be less diluted and therefore more concentrated than those of wet weather flows. Runoff samples collected during dry weather prior to the first major rainstorm provide information about dry weather flows such as pollutant concentrations, amount of groundwater base flow, or contributions from urban sources such as car washing, pressure washing, irrigation or illicit discharges. Dry and wet weather storm drain outfall monitoring results provide resource managers with evidence of problem areas that may warrant further attention.

Sampling during wet weather can be challenging and require many participants in order to simultaneously capture storm drain flows at multiple locations during peak runoff when pollutant concentrations may be highest. To achieve this goal Monterey Bay National Marine Sanctuary (MBNMS) and California Marine Sanctuary Foundation (CMSF), San Mateo Resource Conservations District (SMRCD) and Watsonville Wetlands Watch (WWW) teamed up with volunteers to monitor storm drain outfalls during dry weather, the Dry Run, and during the first major rain storm of the winter season, the First Flush.

Since 2000 MBNMS has conducted Dry Run and First Flush storm drain outfall monitoring in Monterey County and SMRCD has conducted Dry Run and First Flush monitoring in San Mateo County since 2008. While not monitoring storm drain outfalls, WWW in Santa Cruz County has monitored Watsonville area slough and river sites during the First Flush (only) since 2011 (not including 2014). Prior to 2017, the Coastal Watershed Council (CWC) also in Santa Cruz County, monitored Dry Run and First Flush sites in the cities of Santa Cruz and Capitola but in 2017 decided to discontinue their program due to funding issues. In 2018, MBNMS and CMSF with SMRCD monitored storm drain outfalls prior to and during the first major rainstorm while WWW conducted First Flush only monitoring at slough and river sites.

The geographic scope of this program extended from the City of Montara in San Mateo County in the north, to the Carmel River in Monterey County in the south (Figure 1 and Table 1).

Figure 1. 2018 Dry Run and First Flush Sites

Table 1

2018 Dry Run and First Flush Sites in San Mateo, Santa Cruz, and Monterey Counties.

	Site ID	Site Description	County
San Mateo County	202-MOSD-03	Moss Beach Storm Drain at 2nd Street Outfall	San Mateo
	202-MBSD-05	San Vicente Creek mouth	San Mateo
	202-MBSD-04	Moss Beach Storm Drain at West Point	San Mateo
	202-EGSD-04	El Granada Storm Drain at Vassar Street	San Mateo
	202-EGSD-03	El Granada Storm Drain to the outer harbor	San Mateo
	202-EGSD-06	El Granada Harbor Upland	San Mateo
	202-EGSD-01	El Granada Storm Drain at Surfers Beach North	San Mateo
	202-EGSD-02	El Granada Storm Drain at Surfer's Beach South	San Mateo
	202-HMB-07	Half Moon Bay Drainage Ditch at Roosevelt Drive	San Mateo
	202-HMB-08	Half Moon Bay Dunes Drainage Ditch	San Mateo
	202-FRENC-11	Frenchman's Creek mouth	San Mateo
	202-PILAR-12	Pilarcitos Creek mouth	San Mateo
	202-HMB-05	Half Moon Bay Storm Drain at Kelly Ave and Balboa	San Mateo
Santa Cruz County	305-HARKI-23	Harkins Slough at Buena Vista Drive	Santa Cruz
	305-HARKI-21	Harkins Slough Middle at Harkins Slough Road	Santa Cruz
	305-HARKI-22	Harkins Slough Lower	Santa Cruz
	305-WSTRU-22	West Struve Slough Upper at WERC	Santa Cruz
	305-STRUV-21	Struve Slough Upper	Santa Cruz
	305-WATSO-29	Watsonville Slough Upper	Santa Cruz
	305-WATSO-28	Watsonville Slough at Ramsay Nature Center	Santa Cruz
	305-WATSO-27	Watsonville Slough at Ford Street Walkway	Santa Cruz
	305-WATSO-26	Watsonville Slough at Ohlone Parkway	Santa Cruz
	305-WATSO-24	Watsonville Slough at Lee Road	Santa Cruz
	305-WATSO-22	Watsonville Slough Lower	Santa Cruz
	305-PAJAR-21	Pajaro River at Thurwacher Bridge	Santa Cruz
	305-BEACH-21	Beach Road ditch at Rio Boca Road	Santa Cruz
Monterey County	305-PASD-01	Pajaro Storm Drain at Main Street Bridge	Monterey
	309-SSD-02	Seaside Storm Drain at West Bay Street	Monterey
	309-MSD-03	Monterey Storm Drain Twin 51's	Monterey
	309-MSD-04	Monterey Storm Drain at San Carlos Beach	Monterey
	309-MSD-05	Monterey Storm Drain at Steinbeck Plaza	Monterey
	309-PGSD-09	Pacific Grove Storm Drain at HopkinsMon	Monterey
	309-PGSD-08	Pacific Grove Storm Drain at HopkinsPG	Monterey
	309-PGSD-01	Pacific Grove Storm Drain at 8th Street	Monterey
	309-CENTR-31	Pacific Grove Storm Drain in Greenwood Park at Central and 13th Streets	Monterey
	309-PGSD-03	Pacific Grove Storm Drain at Lovers Point Beach	Monterey
	309-PGSD-04	Pacific Grove Storm Drain between Pico and Arena Avenues	Monterey
	307-CASD-01	Carmel Storm Drain at 4th and San Antonio Avenues	Monterey
	307-CASD-02	Carmel Storm Drain at the end of Ocean Avenue	Monterey
	307-CASD-03	Carmel Storm Drain at the end of 8th Avenue	Monterey
	307-CVSD-01	Monterey County storm drain behind the Safeway at Hwy 1 and Rio Road	Monterey

Note: Sites are listed from north to south.



Figure 2. Volunteers gather at Twins (Monterey) for the Monterey County Dry Run on September 22, 2018. Photo: L. Chandler.



Figure 3. Volunteers check First Flush sites for flowing water during the Dry Run at 8th Avenue (Carmel). Photo: A. Gutierrez.



Figure 4. First Flush volunteer grabs a bucket of sudsy sample water at Twins (Monterey) during the First Flush on November 23rd, 2018. Photo: R. Bunting.

Methods

New Dry Run and First Flush volunteers attended a classroom training and participated in hands-on practice during the Dry Run: a half day event where volunteers demonstrated their skills, visited outfall sites, and collected water samples if flowing water was found. The Dry Run was conducted only in San Mateo and Monterey Counties well ahead of any predicted rain. Dry Run activities provided the volunteers with a chance to test equipment at their specific sites as well as practice collecting water quality information and dry weather runoff samples. During the Dry Run and First Flush volunteers in San Mateo and Monterey Counties collected field measurements (water temperature, pH, electrical conductivity, and transparency) and water samples for lab analysis of nutrients (nitrate, orthophosphate, and urea), bacteria (*Escherichia coli* (*E. coli*) and enterococcus), metals (total copper, total lead and total zinc), and total suspended solids. While volunteers from Santa Cruz County did not collect Dry Run samples or field measurements, during the First Flush volunteers did collect water samples for lab analysis of *E. coli*, nitrate, orthophosphate and turbidity.

Volunteers were mobilized for the First Flush when all or most mobilization criteria were met: a minimum of 0.10 inches of rain had fallen, sheeting water on roadways, and conductivity was at or below 1000 μ S (Monterey County only). Once sample collection was complete, samples and field equipment were delivered immediately to monitoring coordinators who delivered samples to labs.

Grab samples were collected during both the Dry Run and First Flush. Dry Run monitoring entailed collecting a single grab sample from each site with flowing water. During the First Flush a single grab sample was collected at San Mateo and Santa Cruz County sites, and two sets of grab samples were collected 30 minutes apart for two time series samples in Monterey County. Samples for urea were only collected in Monterey County and only during the first time series. Therefore, urea results were not an average but a single sample result for each event.

All results (field and lab) were compared to receiving water standards set for particular beneficial uses in a stream, lake, or ocean—they are not meant for end-of-pipe discharges. However, lacking any other effluent standard, these standards provide some context for the results. Dilution and/or mixing is expected to occur in the receiving waters within a short distance of each outfall. Metal results were compared to the Regional Water Quality Control Board's Water Quality Control Plan for the Central Coast (Basin Plan) Water Quality Objectives (WQO) for the protection of marine and aquatic life. Nitrate, orthophosphate, total suspended solids and turbidity results were compared with the Central Coast Ambient Monitoring Program's (CCAMP) Action Levels (AL). Bacteria (*E. coli* and enterococcus) results were compared with the U.S. EPA's Ambient Water Quality Criteria (WQO) (see Table 2).

Each analyte description includes a reporting of the Minimum Detection Limit (MDL), the smallest concentration that lab equipment can reliably detect for an analyte. MDL is a statistical analysis of the confidence of results. Results below the MDL are reported as non-detect since lab equipment cannot reliably determine where the results lay between zero and the MDL. For sites that have a non-detect listed, a marker is placed on the graph at half the MDL, however the value could be anywhere between zero and the MDL.

Table 2

Water Quality Objectives Used as a Comparison for Dry Run and First Flush Results

<u>Parameter (reporting units)</u>	<u>Water Quality Criterion</u>	<u>Source of criterion</u>
Copper (ppb)	Not to exceed 30 ¹	Water Quality Control Plan for the Central Coast- RWQCB
<i>E. coli</i> (MPN/100ml)	Not to exceed 235 ²	U.S. EPA Ambient Water Quality Criteria
Enterococcus (MPN/100ml)	Not to exceed 104	U.S. EPA Ambient Water Quality Criteria
Lead (ppb)	Not to exceed 30 ¹	Water Quality Control Plan for the Central Coast- RWQCB
Nitrate as N (ppm)	Not to exceed 2.25 ³	Central Coast Ambient Monitoring Program (CCAMP)
Orthophosphate as P (ppm)	Not to exceed 0.12 ⁴	Central Coast Ambient Monitoring Program (CCAMP)
pH (pH units)	Not lower than 6.5 or greater than 8.5	Water Quality Control Plan for the Central Coast- RWQCB
Total Suspended Solids (TSS) (ppm)	Not to exceed 500 ⁵	Central Coast Ambient Monitoring Program (CCAMP)
Transparency (cm)	Not less than 20 ⁶	Central Coast Ambient Monitoring Program (CCAMP)
Turbidity (NTU)	Not greater than 25	Central Coast Ambient Monitoring Program (CCAMP)
Water Temperature (°C)	Not more than 21 ⁷	Central Coast Ambient Monitoring Program (CCAMP)
Zinc (ppb)	Not to exceed 200 ¹	Water Quality Control Plan for the Central Coast- RWQCB

Note: Urea is not listed because it does not have a Water Quality Objective or Action Level.

Results

¹ Water Quality Control Plan for Central Coast Cold Water objective for hard water

² Environmental Protection Agency, Updated WQO.

³ Central Coast Ambient Monitoring Program, Pajaro River Watershed Characterization Report 1998, rev 2003

⁴ Williamson, The Establishment of Nutrient Objectives, Sources, Impacts and Best Management Practices for the Pajaro River and Llagas Creek, 1994.

⁵ Central Coast Ambient Monitoring Program, Salinas River Watershed Characterization Report 1999, rev. 2000.

⁶ Based on equivalent turbidity guideline value used for 303(d) Listing Guideline Value (Sigler et al., 1985)

(http://www.secchidipin.org/Transparency_Tube.htm)

⁷ 303(d) Listing guideline value, based on Moyle, P. 1976. Inland Fisheries of California. Univ. of California Press.

The Dry Run was conducted on two separate dates: September 11th for San Mateo County sites, and September 22nd for Monterey County sites. Dry Run sampling in San Mateo County entailed sampling at just one site: San Vicente Creek mouth (Moss Beach). In Monterey County, nineteen volunteers checked fifteen sites for the Dry Run but only four sites had enough flow to be sampled: Twins (Monterey), 8th Street (Pacific Grove), Greenwood Park (Pacific Grove), and Pico (Pacific Grove). Santa Cruz County sites did not have a Dry Run.

After the Dry Run and leading up to the First Flush event, monitoring coordinators from SMCRCDC, WWWW and MBNMS closely watched the weather and notified volunteers of approaching storms. When a storm had the potential to generate enough rainfall for First Flush mobilization, coordinators notified the volunteers to be on stand-by. Mobilization criteria were finally achieved for SMCRCDC staff and volunteers at 9:00 pm on Wednesday November 21st, 2018 when thirteen San Mateo County sites were monitored by sixteen volunteers. Santa Cruz County WWWW volunteers mobilized at 8:30 am on Friday November 23rd, 2018 and sampled all thirteen sites in the Watsonville area. Monterey County volunteers mobilized on November 23rd, 2018 at 11:15 am when a total of thirty volunteers collected samples at fifteen outfall and two receiving water sites that day. First Flush samples for San Mateo County sites were not collected during daylight hours and do not include field measurements for pH and transparency. Santa Cruz County sites did not include field measurements. Samples from Monterey County sites were collected during daylight hours, and therefore include field measurements for pH and transparency as well as temperature and conductivity.

Staff and volunteers from SMCRCDC were responsible for sampling sites in the Cities of El Granada, Moss Beach, Montara, and Half Moon Bay. Staff and volunteers from WWWW sampled Santa Cruz County sites in and around the City of Watsonville. Staff and volunteers from MBNMS and CMSF were responsible for monitoring sites for the Monterey Regional Storm Water Monitoring Program (MRSWMP) in Monterey County, which included areas in Pajaro, Carmel Valley, and the Cities of Carmel, Monterey, Pacific Grove, Seaside and Sand City.

The range of field and lab results for both the Dry Run and First Flush are presented in Table 3. Field results for conductivity, pH, transparency, and water temperature are not individually discussed below but are presented to provide an understanding of environmental conditions during the two events. Field results did not exceed any WQO or AL for any parameter *except* transparency during the First Flush when results for transparency exceeded the AL in twenty-four out of forty-one sites (59%).

Table 3

Range of Field and Lab Results for Dry Run and First Flush 2018.

Parameter	Units	Dry Run	First Flush
Conductivity	µS	1067 - 2300	50 - >2000
Copper- total	µg/L	ND	ND - 216
<i>Escherichia coli</i> (<i>E. coli</i>)	MPN/ 100 ml	52 - >24196	586 - >241960
Enterococcus	MPN/ 100 ml	31 - 15531	8474 - 198630
Lead- total	µg/L	ND	ND - 964
Nitrate as N	mg-N/L	0.5 – 2.6	ND – 24.9
Orthophosphate as P	mg-P/L	ND – 0.20	ND – 3.90
pH	pH units	6.25 – 7.5	6.0 – 8.5
Total Suspended Solids	mg/L	ND - 7	16 - 314
Transparency	cm	45 - >120	5 - 78
Turbidity (Santa Cruz County only)	NTU	Not collected	7.2 – 55.9
Urea (Monterey County only)	µg/L	ND - 587	24 - 1120
Water temperature	°C	13.4 – 18.1	12.8 – 18.0
Zinc- total	µg/L	ND - 74	ND - 284

Note: First Flush range of results are not averaged, both time series samples are considered.

Analyte descriptions below are listed alphabetically and include box and whisker graphs showing the data divided into dry weather monitoring (DR) and wet weather monitoring (FF) by site. Box and whisker graphs show a distribution of the dataset in a convenient format for making comparisons between sites and the range of concentrations over the years. The box represents the range of 50% of the data with the median indicated. The lines above and below the boxes are upper and lower whiskers and represent the remaining upper and lower 25% of the data. The end point of each whisker represents the maximum and minimum result for that analyte at that location and provides an indication of the best- and worst-case results. Each graph includes a marker for the most recent year's results for comparison to historical data. A few analytes have graphs that are split along the y-axis to encompass the entire dataset.

Copper

Storm water runoff in coastal urban areas is known to contain trace metals from sources such as automobile brake pads, tires, and industrial waste. Very low concentrations of copper in the marine environment can cause reduced reproduction, developmental deformities, and mortality. The Water Quality Control Plan for the Central Coast WQO established for total copper is 30 µg/L; the MDL for total copper was 10.0 µg/L for the Dry Run and First Flush. Total copper was not measured in Santa Cruz County.

For the **Dry Run**, copper concentrations met the WQO at all sites. All five sites had non-detects: San Vicente Creek Mouth (Moss Beach), Twins (Monterey), 8th Street, (Pacific Grove), Greenwood Park, (Pacific Grove), and Pico (Pacific Grove) (Figures 5 and 6).

During the **First Flush**, twelve of the twenty-eight sites (43%) where total copper was sampled for, met the WQO. The highest concentration for copper was during the second time series sample at 4th Avenue (Carmel) with a result of 216 µg/L (Figures 5 and 6).

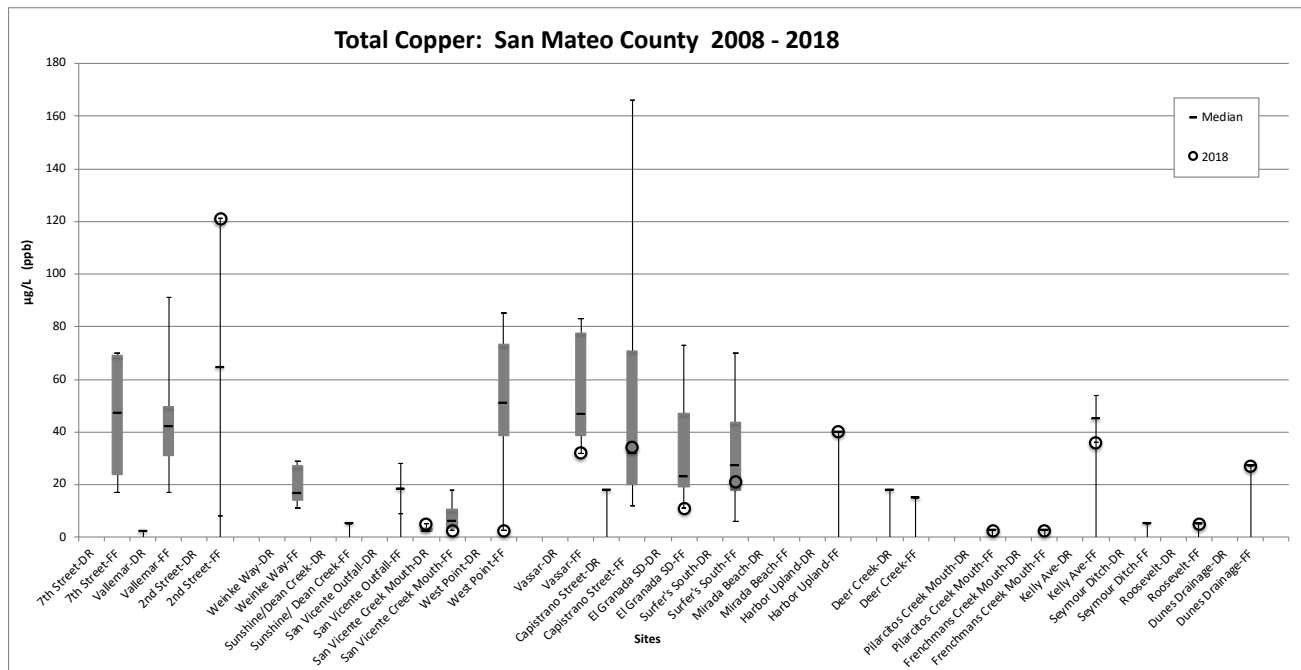


Figure 5. Single sample results for total copper for the Dry Run (DR) and First Flush (FF) in San Mateo County. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between the zero and the MDL. All sites grouped by city from north to south- Montara, Moss Beach, El Granada and Half Moon Bay.

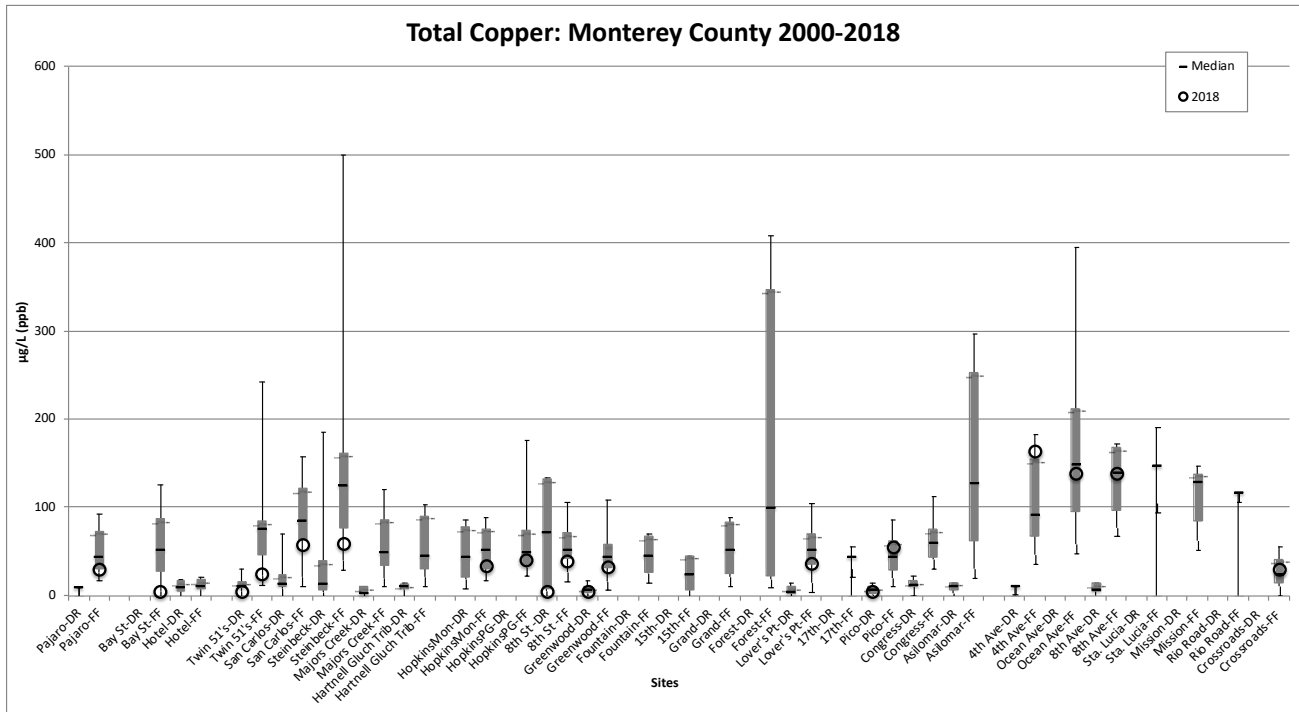


Figure 6. Single sample results for total copper results for the Dry Run (DR), and time series averages for First Flush (FF) in Monterey County. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between the zero and the MDL. All sites grouped by city from north to south- Pajaro (Monterey County), Seaside, Monterey, Pacific Grove and Carmel.

E. coli

Escherichia coli (*E. coli*) is a type of fecal indicator bacteria. *E. coli*, found in the intestines of warm-blooded animals, make its way into waterways and the ocean from wildlife populations, through improper domestic animal waste disposal, as well as failing sewer or septic systems. While these bacteria don't necessarily cause disease in humans, their presence indicates the potential for other human specific pathogens to be present. The U.S. Environmental Protection Agency water quality criterion for grab samples of *E. coli* is 235 MPN/100 ml. The MDL for *E. coli* was 10 MPN/100ml for the Dry Run and First Flush in San Mateo and Santa Cruz Counties, 1 MPN/100 ml for the Dry Run in Monterey County, and 100 MPN/ 100ml for the First Flush in Monterey County.

For the **Dry Run**, just one of the five (80%) sites monitored for bacteria met the WQO for *E. coli*. The highest concentration for *E. coli* was >24,196 MPN/100 ml from 8th Street (Pacific Grove) (Figures 7 and 9).

During the **First Flush**, none of the sites (100%) monitored for *E. coli* met the WQO. The highest concentration of *E. coli* was in the first time series sample at both Pajaro (Monterey County) and Pico (Pacific Grove) with a result of >241,960 MPN/100 ml. Other *E. coli* samples from San Mateo could be higher than the Pajaro (Monterey County) or Pico (Pacific Grove) results, but due to the low end-point the lab in San Mateo County uses, results are simply provided as >24,196 MPN/100 ml (Figures 7, 8 and 9).

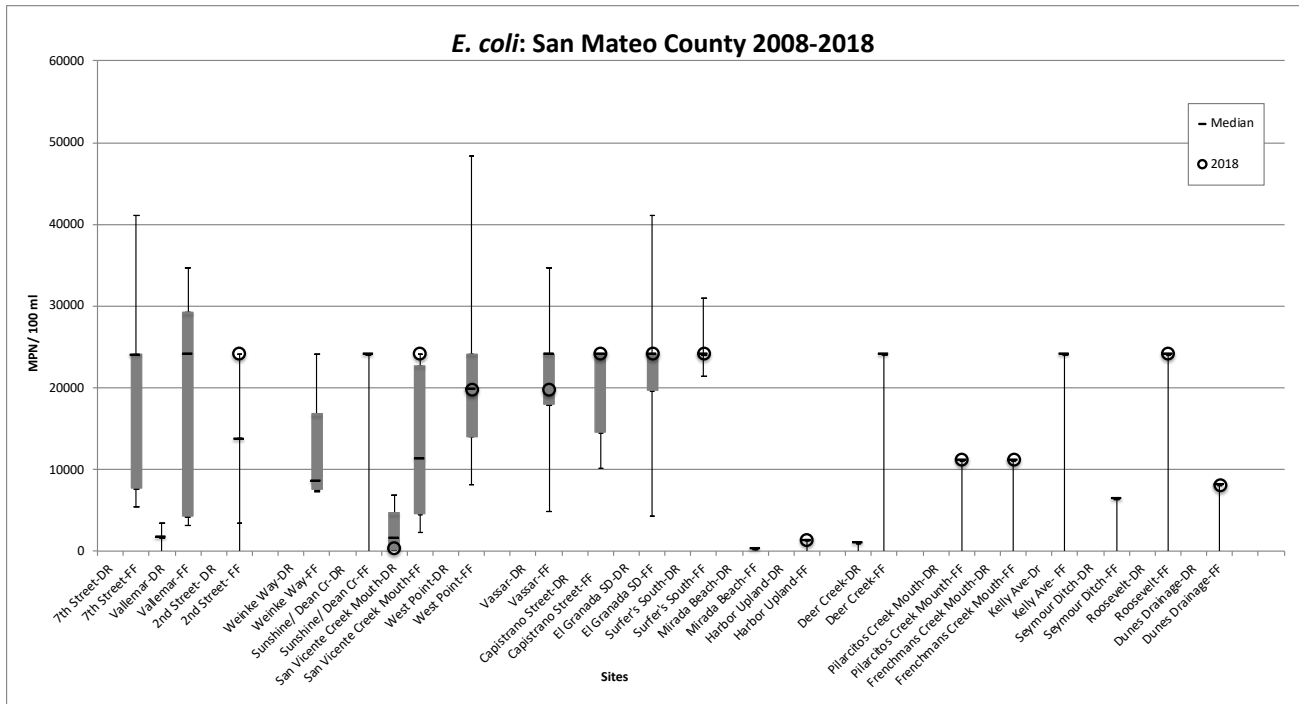


Figure 7. Single sample results for *E. coli* for the Dry Run (DR) and First Flush (FF) in San Mateo County. Sample results of >X are given that numerical value (X) despite a higher actual result. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between the zero and the MDL. All sites grouped by city from north to south- Montara, Moss Beach, El Granada and Half Moon Bay.

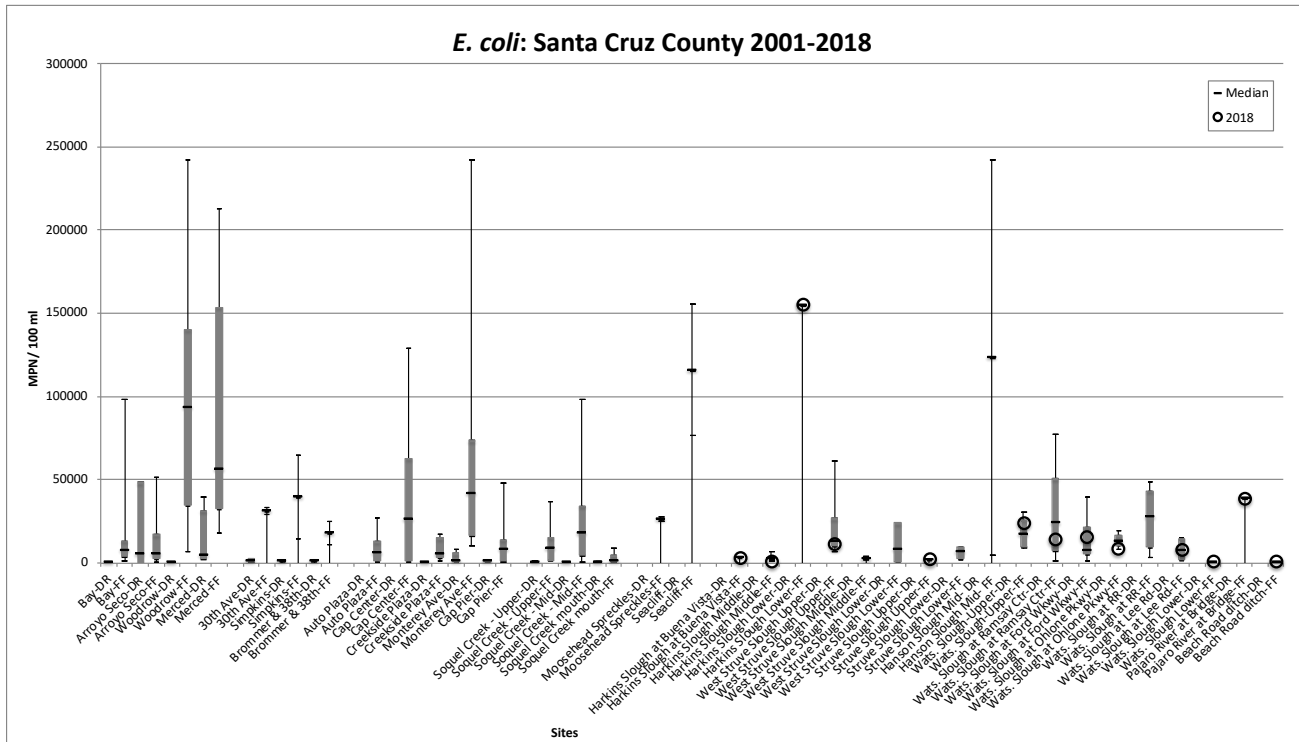


Figure 8. Single sample results for *E. coli* for the First Flush (FF) in Santa Cruz County. Sample results of >X are given that numerical value (X) despite a higher actual result. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between the zero and the MDL. All sites grouped by city from north to south Santa Cruz, Live Oak, Capitola, Aptos and Watsonville.

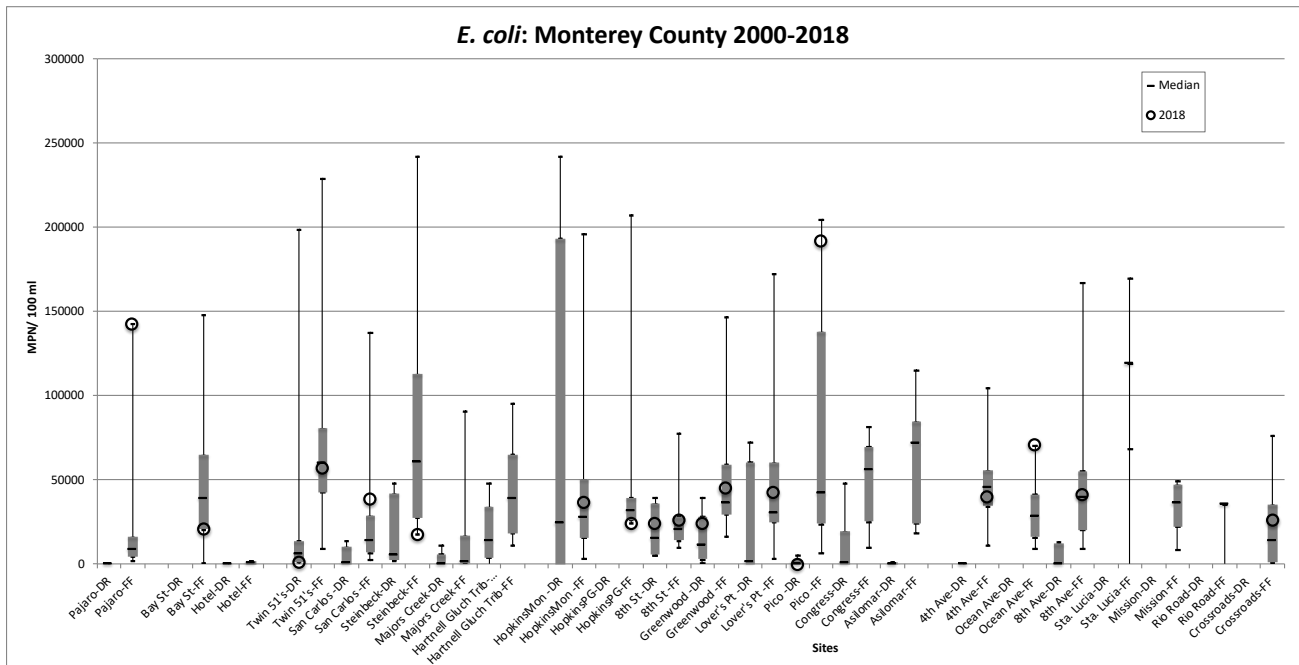


Figure 9. Single sample results for *E. coli* for the Dry Run (DR), and time series averages for First Flush (FF) in Monterey County. Sample results of >X are given that numerical value (X) despite a higher actual result. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between the zero and the MDL. All sites grouped by city from north to south- Pajaro (Monterey County), Seaside, Monterey, Pacific Grove and Carmel.

Enterococcus

Enterococcus is a type of fecal indicator bacteria found in the intestines of warm-blooded animals. Enterococcus make its way into waterways and the ocean from wildlife populations, through improper domestic animal waste disposal, as well as failing sewer or septic systems. While these bacteria don't necessarily cause disease in humans, their presence indicates the potential for other human specific pathogens to be present. The U.S. Environmental Protection Agency water quality criterion for grab samples of enterococcus is 104 MPN/100 ml. The MDL for enterococcus was 10 MPN/100ml for the Dry Run in both counties, 10 MPN/100ml for the First Flush in San Mateo County, and 100 MPN/ 100ml for the First Flush in Monterey County. Enterococcus was not measured in Santa Cruz County.

For the **Dry Run**, just one of the five sites (20%) monitored for bacteria met the WQO for enterococcus. The highest enterococcus concentration of 15,531 MPN/ 100 ml was from Greenwood Park (Pacific Grove) (Figures 10 and 11).

During the **First Flush**, none of the twenty-eight (100%) sites monitored for enterococcus met the WQO. The highest concentration for enterococcus was in the second time series sample at Pico (Pacific Grove) with a result of 198,630 MPN/100 ml (Figures 10 and 11). Other enterococcus samples from San Mateo County could be higher than the Pico (Pacific Grove) results, but due to the low end-point the lab in San Mateo County uses, results were simply provided as >24,196 MPN/100 ml.

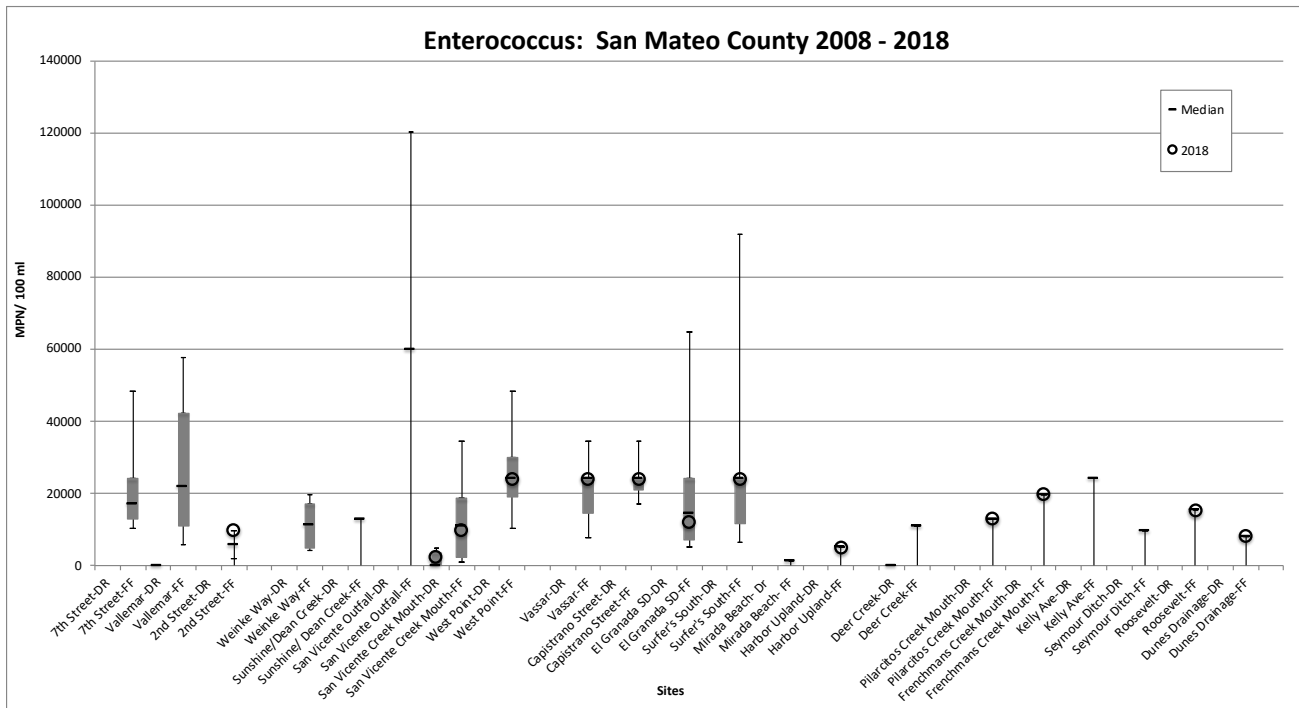


Figure 10. Single sample results for enterococcus for the Dry Run (DR) and First Flush (FF) in San Mateo County. Sample results of >X are given that numerical value (X) despite a higher actual result. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between the zero and the MDL. All sites grouped by city from north to south- Montara, Moss Beach, El Granada and Half Moon Bay.

Lead

Storm water runoff in coastal urban areas is known to contain trace metals from sources such as automobile brake pads, tires, and industrial waste. Very low concentrations of lead in the marine environment can cause reduced reproduction, developmental deformities, and mortality. Lead was only measured in San Mateo and Monterey Counties. The Water Quality Control Plan for the Central Coast WQO for total lead is 30 µg/L. The MDL for lead was 1 µg/L for the Dry Run and First Flush. Lead was not measured in Santa Cruz County.

For the **Dry Run**, all sites met the WQO for lead, and two sites had non-detects: San Vicente Creek Mouth (Moss Beach) and Pico (Pacific Grove) (Figures 12 and 13).

For the **First Flush**, all of the twenty-eight sites monitored for total lead met the WQO. Four sites had non-detects for all samples: Surfer's Beach North (El Granada), Roosevelt Drive (Half Moon Bay), Pilarcitos Creek Mouth (Half Moon Bay), and Bay Street (Seaside and Sand City) (Figures 12 and 13).

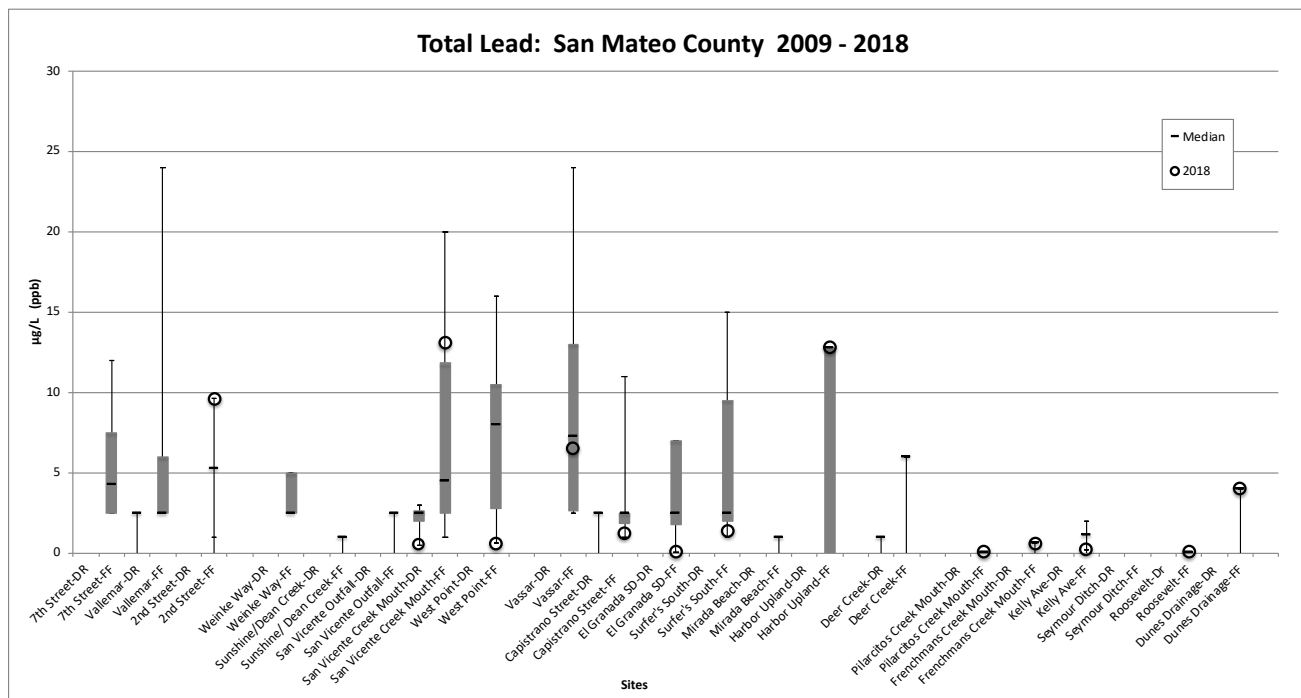


Figure 12. Single sample results for total lead for the Dry Run (DR) and First Flush (FF) in San Mateo County. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between the zero and the MDL. All sites grouped by city from north to south- Montara, Moss Beach, El Granada and Half Moon Bay.

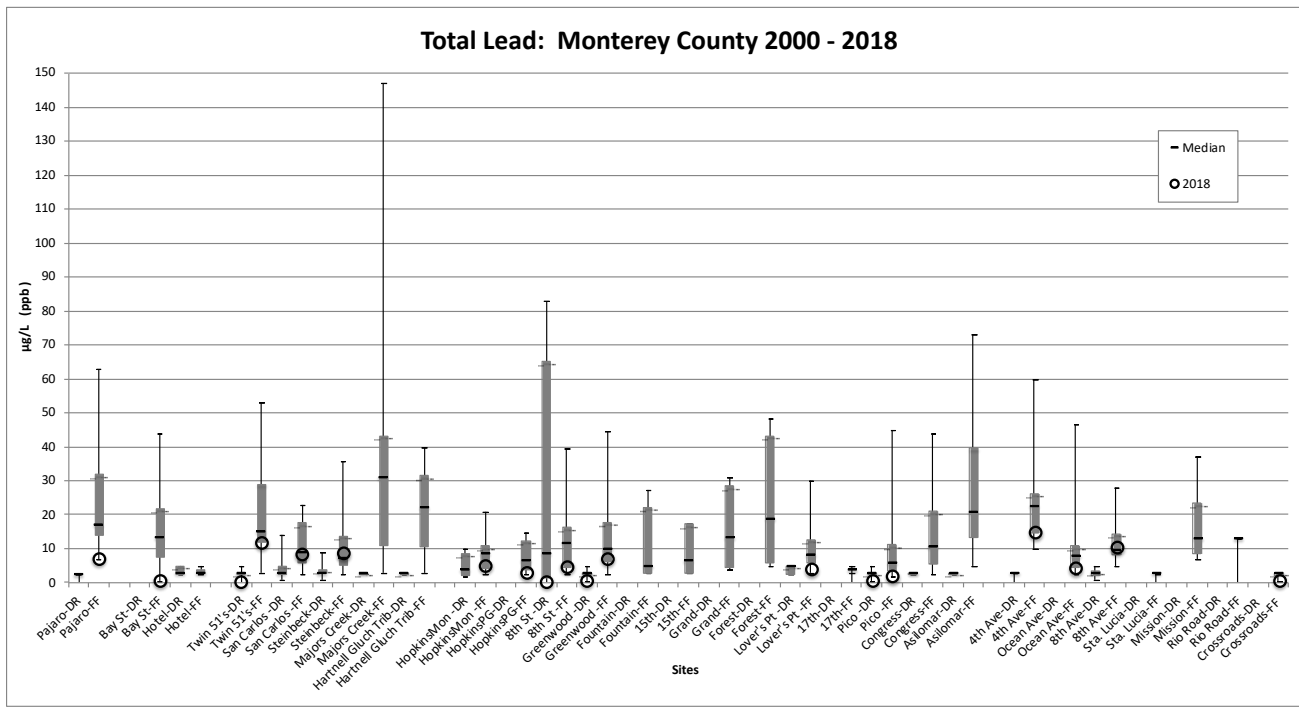


Figure 13. Single sample results for total lead for the Dry Run (DR), and time series averages for First Flush (FF) in Monterey County. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between the zero and the MDL. All sites grouped by city from north to south- Pajaro (Monterey County), Seaside, Monterey, Pacific Grove and Carmel.

Nitrate

Nitrate is needed for plant growth but is not naturally found in elevated concentrations in aquatic systems. Nitrate, as with other nutrients, can lead to algal blooms that degrade water quality as plants die off and consume oxygen in their decomposition. Nitrate sources include runoff from fertilized landscaping, agricultural and pasture lands, construction sites, as well as failing septic or sewer systems. The CCAMP Action Level for nitrate as N ($\text{NO}_3\text{-N}$) is 2.25 mg-N/L. The minimum detection limit (MDL) was 0.1 mg-N/L for both the Dry Run and First Flush in San Mateo and Monterey Counties, and 0.04 mg-N/L for First Flush in Santa Cruz County. Nitrate was measured in all three counties.

For the **Dry Run**, four of the five sites (80%) sampled for nitrate as N met the Action Level. The highest result of 2.6 mg-N/L was from 8th Street (Pacific Grove) (Figures 14 and 16).

During the **First Flush**, thirty-four of the forty-one monitored sites (83%) had concentrations that met the Action Level for nitrate as N. The two highest concentrations of nitrate as N were in Santa Cruz County with results of 24.9 mg-N/L was from West Struve Slough Lower, and 23.4 mg-N/L from Beach Road Ditch (Figures 14, 15 and 16).

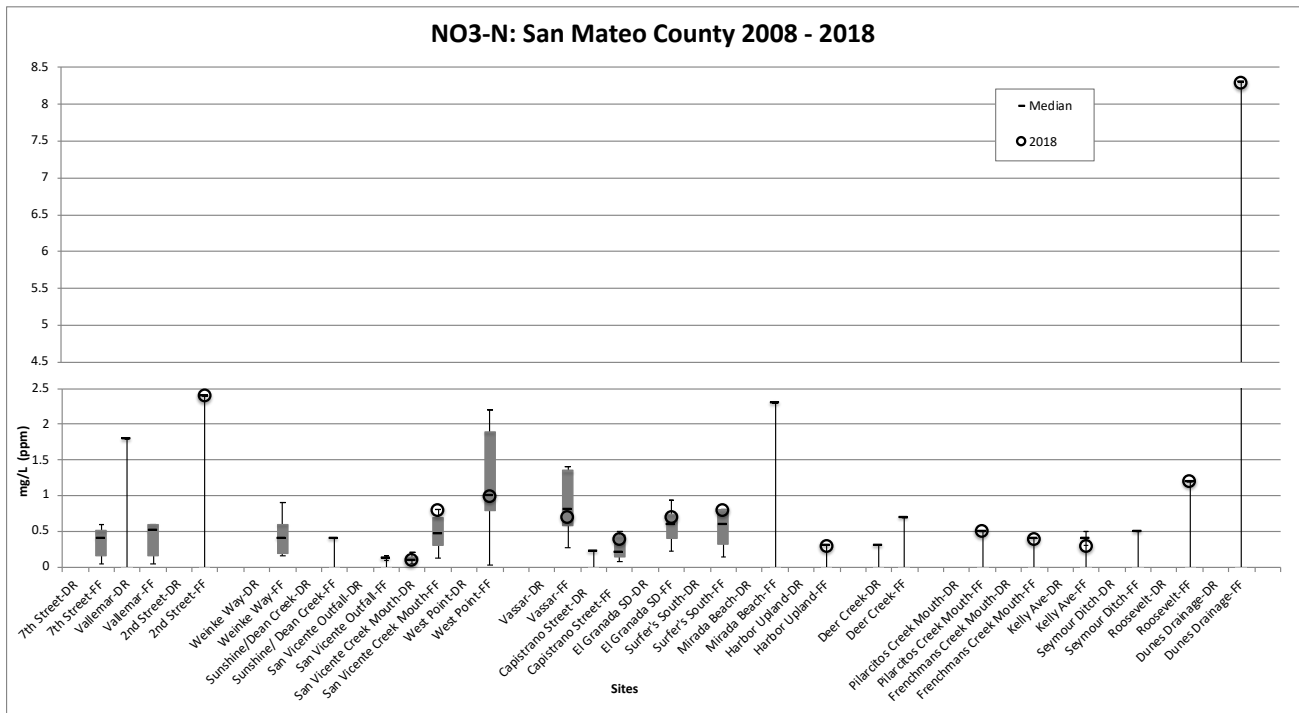


Figure 14. Single sample results for nitrate as N for the Dry Run (DR) and First Flush (FF) in San Mateo County. To better illustrate results, the scale on the graph is split between 4 and 7 mg-N/L. As a result, the First Flush 2018 result of 8.4 mg-N/L from Dunes Drainage (Half Moon Bay) is in the upper portion of the graph. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between the zero and the MDL. All sites grouped by city from north to south- Montara, Moss Beach, El Granada and Half Moon Bay.

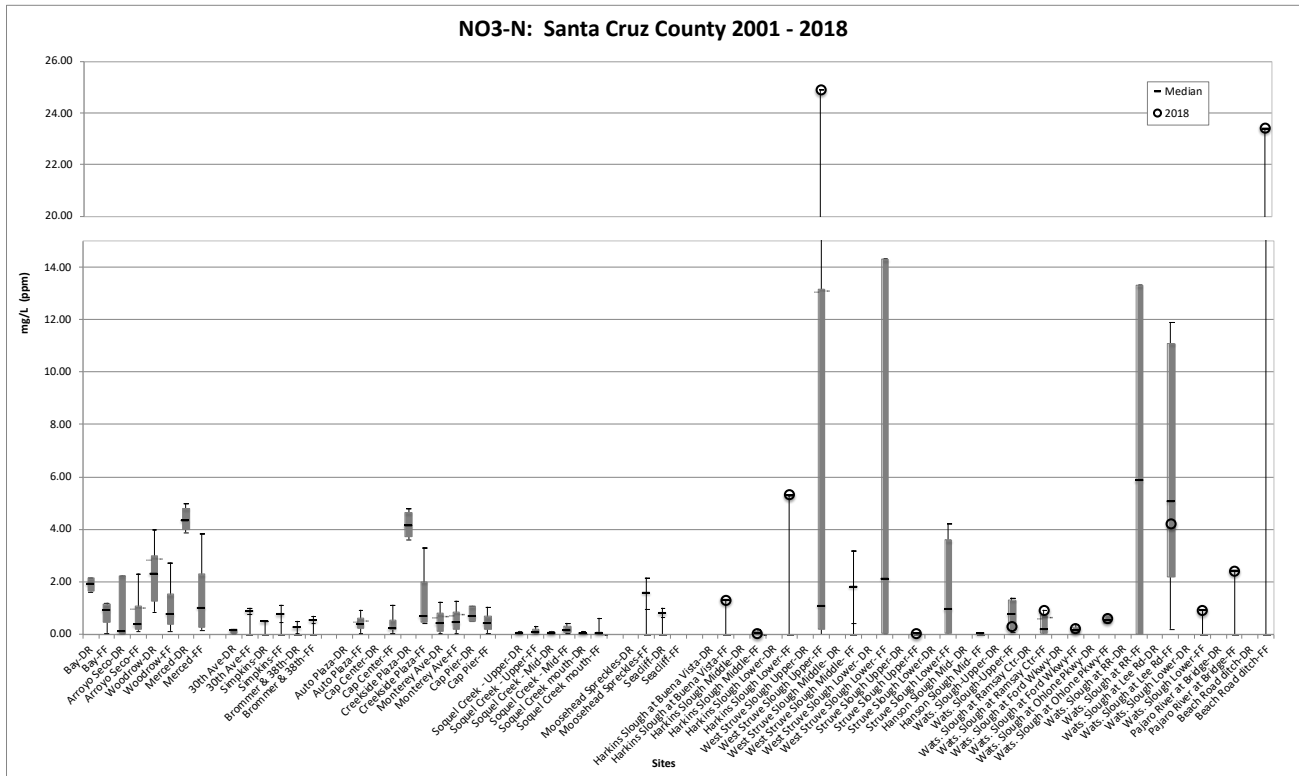


Figure 15. Single sample results for nitrate as N for the First Flush (FF) in Santa Cruz County. To better illustrate results, the scale on the graph is split between 15 and 20 mg-N/L. As a result, the First Flush 2018 results of 24.9 mg-N/L from West Struve Slough Lower and 23.4 mg-N/L from Beach Street Ditch are in the upper portion of the graph. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between zero and the MDL. All sites grouped by city from north to south Santa Cruz, Live Oak, Capitola, Aptos and Watsonville.

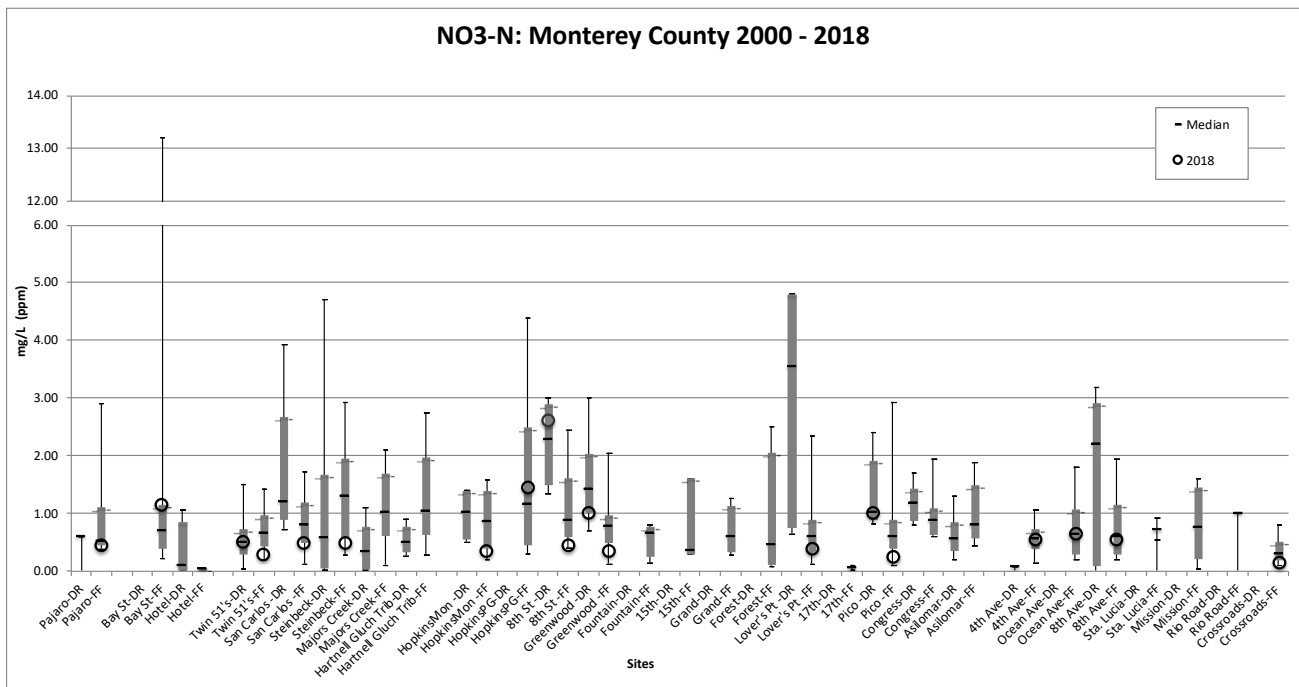


Figure 16. Single sample results for nitrate as N for the Dry Run (DR), and time series averages for First Flush (FF) in Monterey County. To better illustrate results, the scale on the graph is split between 6 and 12 mg-N/L. As a result, the First Flush 2006 result of 13.2 mg-N/L from Bay Street (Seaside) is in the upper portion of the graph. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between zero and the MDL. All sites grouped by city from north to south- Pajaro (Monterey County), Seaside, Monterey, Pacific Grove and Carmel.

Orthophosphate

Orthophosphate, like nitrate, is necessary for plant growth and not commonly found in elevated levels in aquatic systems. As with nitrate, orthophosphate can lead to degradation of water as plants grow uncontrolled, complete their life cycle and decompose, taking up oxygen in the process. Sources of orthophosphate are similar to those for nitrate: leaks in sewer or septic systems, excess fertilizers from urban or agricultural areas, and detergents. The CCAMP Action Level for orthophosphate ($\text{PO}_4\text{-P}$) is 0.12 mg-P/L. The MDL was 0.10 mg-P/L for both the Dry Run and First Flush in San Mateo and Monterey Counties, and 0.08 for First Flush in Santa Cruz County. Orthophosphate was measured in all three counties.

For the **Dry Run**, four of the five sites (80%) sampled for orthophosphate met the Action Level. The highest result for orthophosphate of 0.2 mg-P/L was from 8th Street (Pacific Grove). Two other sites had non-detects for orthophosphate during the Dry Run: San Vicente Creek Mouth (Moss Beach) and Pico (Pacific Grove) (Figures 17 and 19).

During the **First Flush**, six of the forty-one sites (15%) monitored for orthophosphate met the Action Level. The highest concentration of 2.1 mg-P/L was in the first time series sample at Steinbeck (Monterey) (Figures 17, 18 and 19).

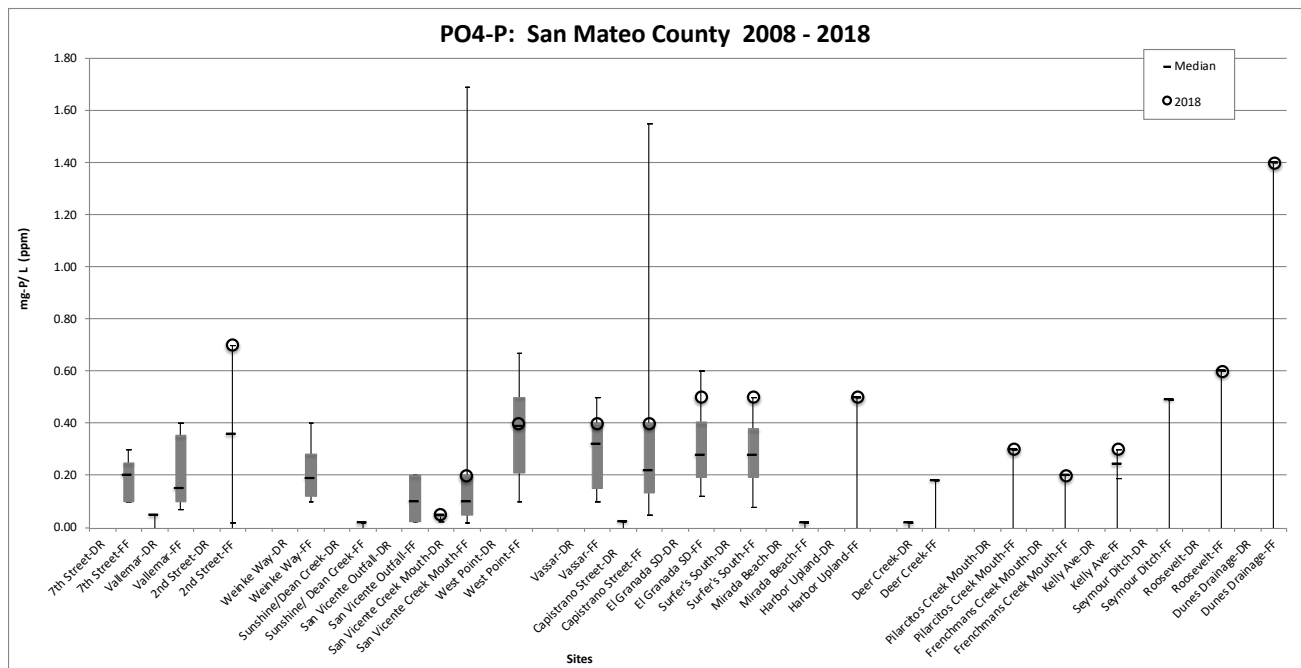


Figure 17. Single sample results for orthophosphate as P for the Dry Run (DR) and First Flush (FF) in San Mateo County. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between the zero and the MDL. All sites grouped by city from north to south- Montara, Moss Beach, El Granada and Half Moon Bay.

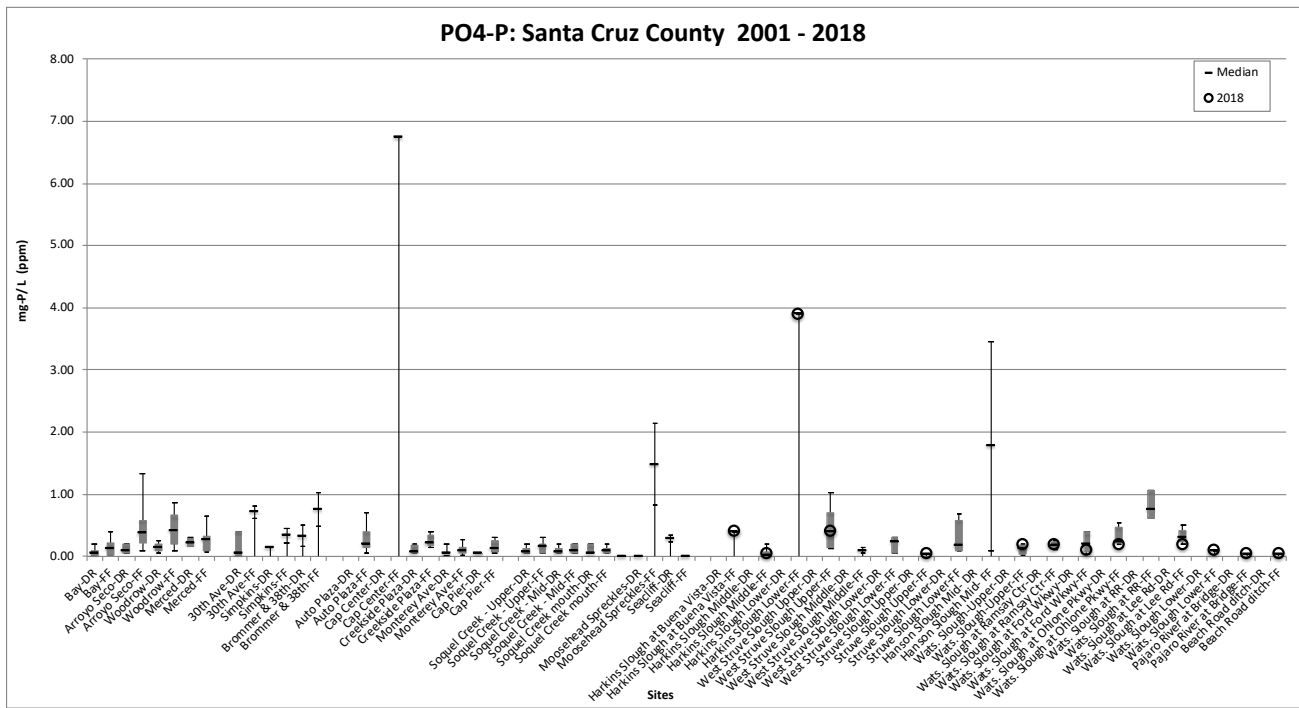


Figure 18. Single sample results for orthophosphate as P for the First Flush (FF) in Santa Cruz County. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between the zero and the MDL. All sites grouped by city from north to south Santa Cruz, Live Oak, Capitola, Aptos and Watsonville.

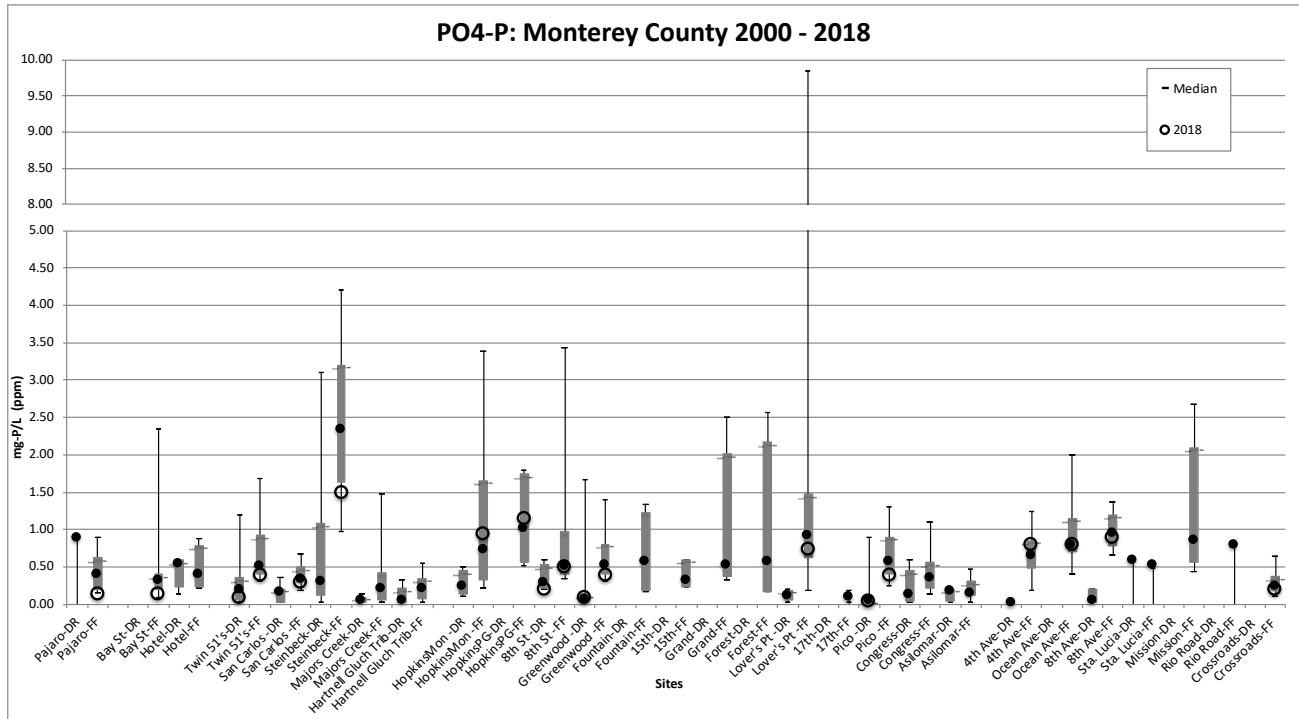


Figure 19. Single sample results for orthophosphate as P for the Dry Run (DR), and time series averages for First Flush (FF) in Monterey County. To better illustrate results, the scale on the graph is split between 5 and 8 mg-P/L. As a result, the First Flush 2004 result of 9.85 mg-P/L from Lovers Pt (Pacific Grove) is in the upper portion of the graph. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between the zero and the MDL. All sites grouped by city from north to south- Pajaro (Monterey County), Seaside, Monterey, Pacific Grove and Carmel.

Total Suspended Solids

Total suspended solids are particulate matter in water that attract charged particles such as pesticides and metals. Total suspended solids can additionally impact the environment through sedimentation causing a reduction in the ability of aquatic and marine organisms to respire. Some sources of total suspended solids are construction sites with improper sediment control, bank erosion from rivers or streams, runoff from agricultural fields, and over-irrigation. Total suspended solids were only measured in San Mateo and Monterey Counties. The CCAMP Action Level for total suspended solids is 500 mg/L, with an MDL of 2 mg/L for both the Dry Run and First Flush.

For the **Dry Run**, all of the sites (100%) monitored for total suspended solids met the Action Level. One site, Pico (Pacific Grove), had a non-detect (Figures 20 and 21).

For the **First Flush**, all of the sites (100%) monitored for total suspended solids met the Action Level (Figures 20 and 21).

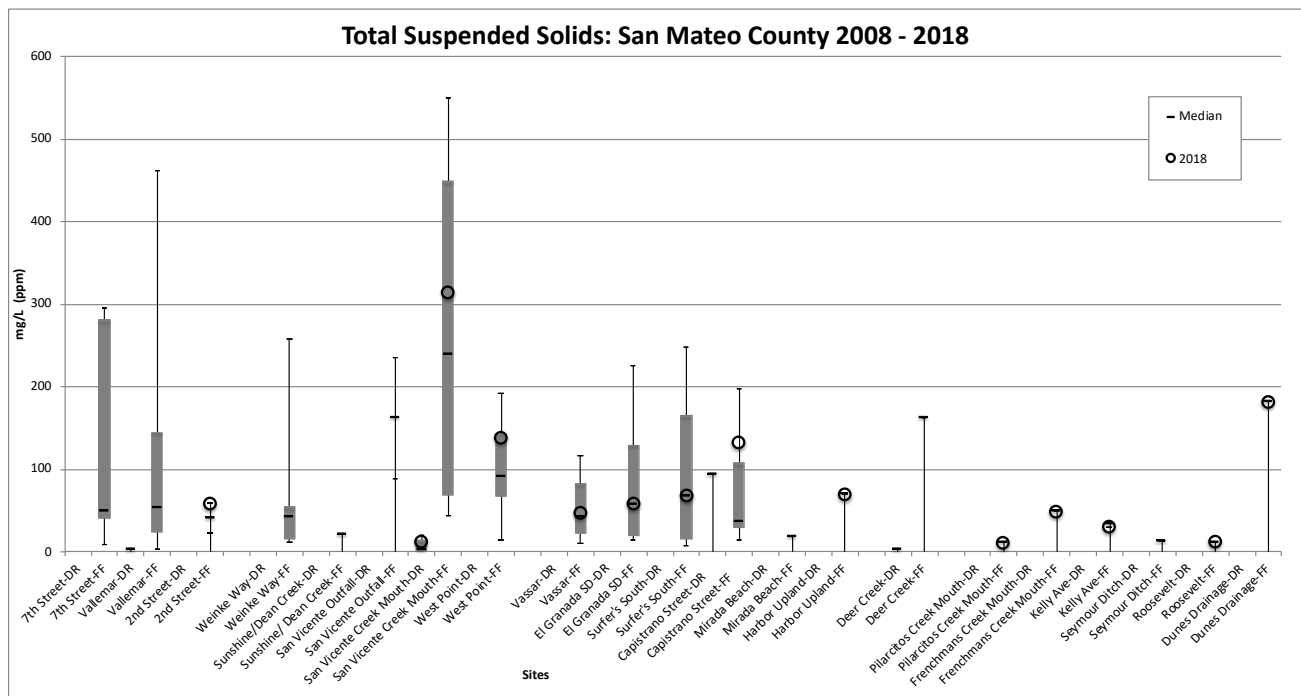


Figure 20. Single sample results for total suspended solids results for the Dry Run (DR) and First Flush (FF) in San Mateo County. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between the zero and the MDL. All sites grouped by city from north to south- Montara, Moss Beach, El Granada and Half Moon Bay.

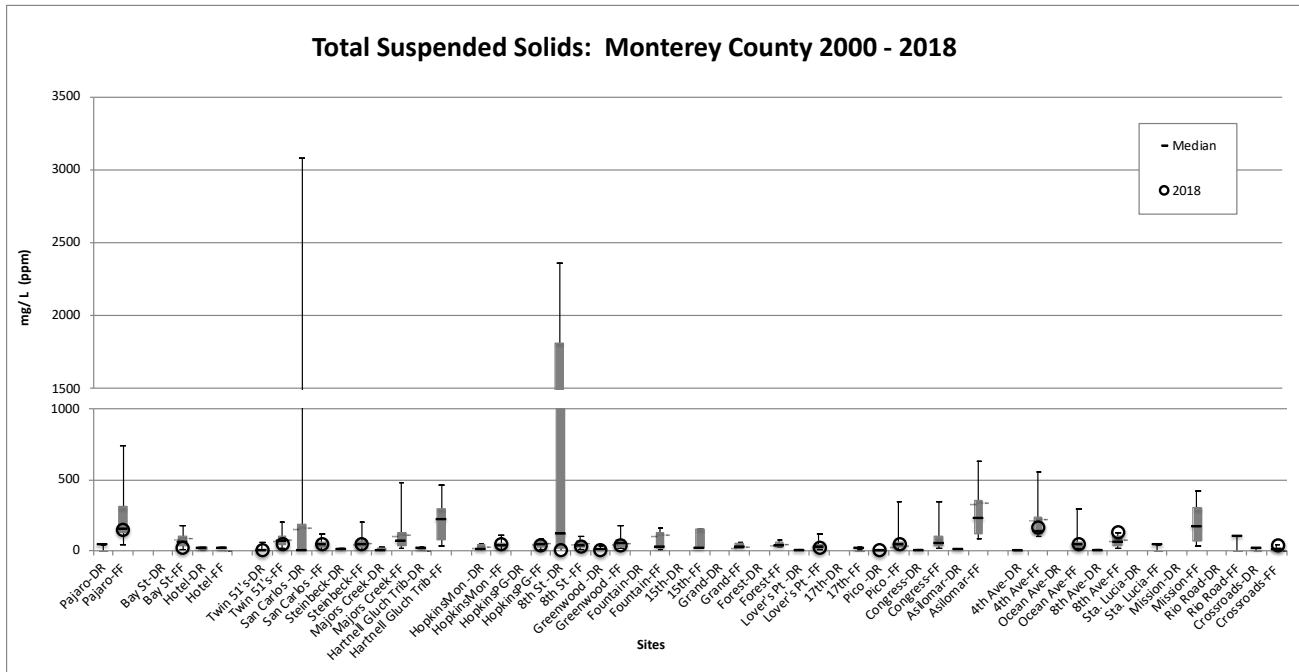


Figure 21. Single sample results for total suspended solids for the Dry Run (DR), and time series averages for First Flush (FF) in Monterey County. To better illustrate results, the scale on the graph is split between 1000 and 1500 mg/L. Due to this split two results are in the upper portion of the graph: First Flush 2007 result of 3080 mg/L from San Carlos (Monterey) and Dry Run 2005 result of 2358 mg/L from 8th Street (Pacific Grove). Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between the zero and the MDL. All sites grouped by city from north to south- Pajaro (Monterey County), Seaside, Monterey, Pacific Grove and Carmel.

Turbidity

Turbidity is a measure of the clarity of a liquid. Normal turbidity measurements vary for different water bodies, but in general, high turbidity levels can indicate problems such as erosion, nutrient loading or extraordinary algae growth. Turbidity is determined using a turbidity meter that measures the amount of light that can penetrate a sample tube of water. CCAMP’s Action Level for turbidity is not greater than 25 Nephelometric Turbidity Units (NTU’s). Turbidity was measured in Watsonville slough and river sites in Santa Cruz County for the First Flush only and in Monterey County during the Dry Run and First Flush. Turbidity was not measured in San Mateo County. The MDL for turbidity during the First Flush was 0.05 NTU in Santa Cruz County and 0.03 in Monterey County.

For the **Dry Run**, all of the sites (100%) monitored for turbidity met the Action Level (Figure 23).

During the **First Flush**, thirteen of the twenty-six sites (50%) that had turbidity measured met the Action Level. The highest turbidity measurement of 118 NTU was from the Pajaro River storm drain outfall (Monterey County) (Figure 22 and 23).

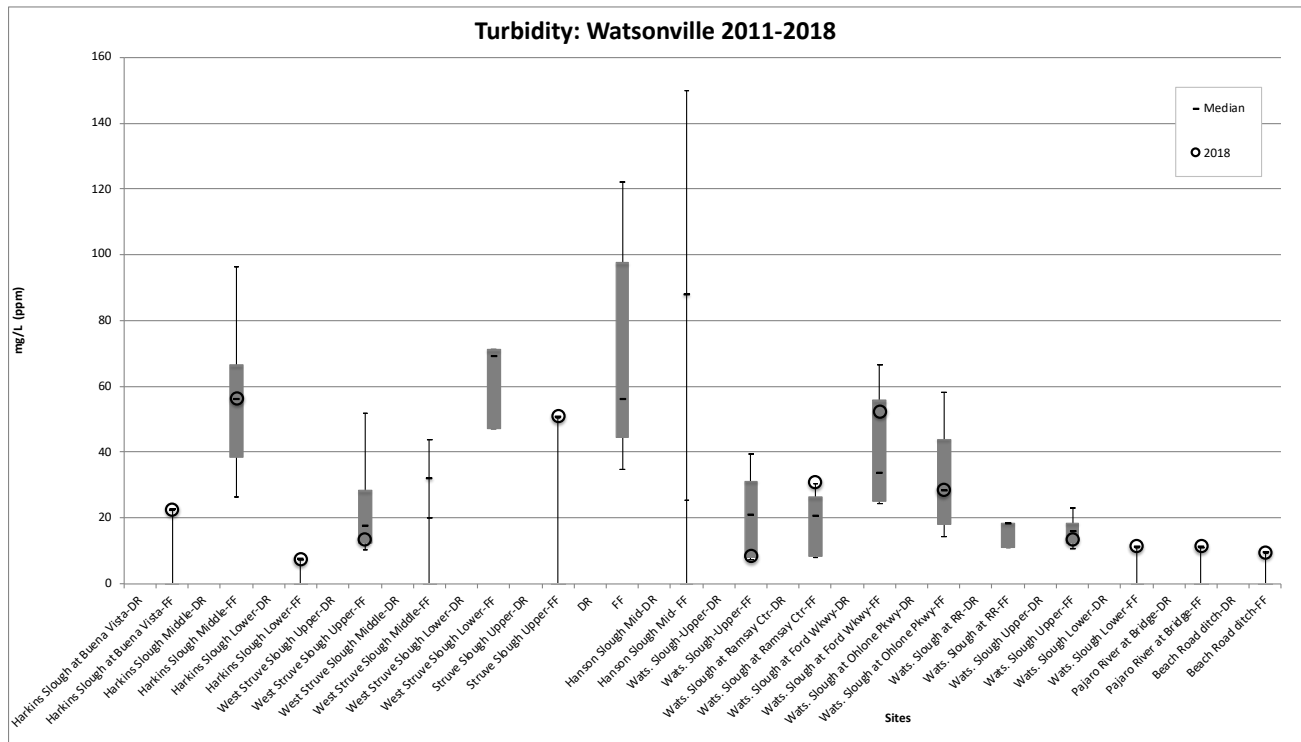


Figure 22. Single sample results for turbidity for the First Flush (FF) in Santa Cruz County. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between the zero and the MDL. All sites grouped by city from north to south in Watsonville.

Turbidity: Monterey County 2013 - 2018

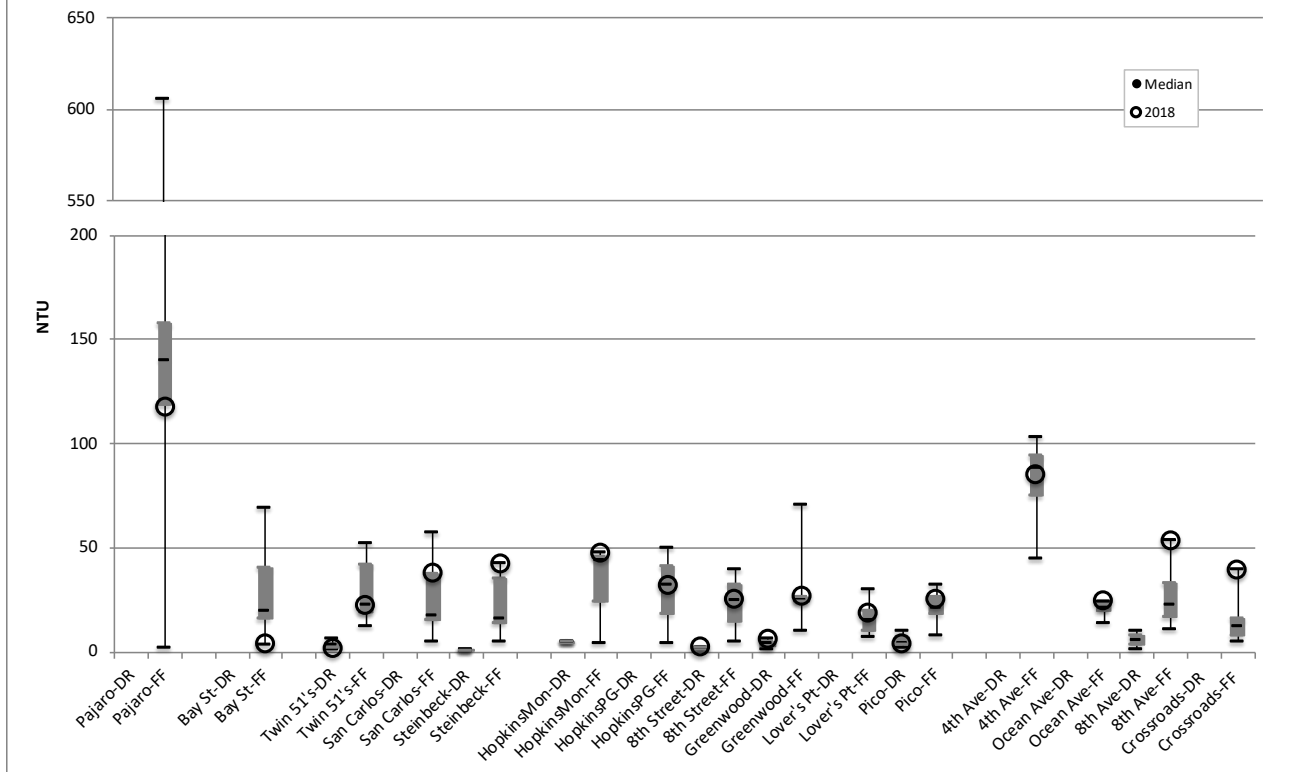


Figure 23. Single sample results for turbidity results for the Dry Run (DR), and time series averages for First Flush (FF) in Monterey County. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between the zero and the MDL. All sites grouped by city from north to south- Pajaro (Monterey County), Seaside, Monterey, Pacific Grove and Carmel.

Urea

Urea is an organic compound that is soluble in water; it is an excellent fertilizer and is often used for agricultural applications. There are many sources of urea including fire retardants, cigarettes, fertilizers, animal feeds, detergents, and mammalian urine. While there is no water quality objective for urea, values are noted and compared to previous year's results in order to monitor trends. Urea was only measured in Monterey County. The MDL was 10 µg/L for the Dry Run and First Flush. Urea was only measured in Monterey County. The MDL was 10 µg/L for the Dry Run and First Flush.

For the **Dry Run**, the highest result of 587 µg/L was from 8th Street (Pacific Grove) (Figure 24).

During the **First Flush**, urea was only measured during the first time series at all sites in Monterey County. The highest result of 1120 µg/L was from Steinbeck (Monterey) (Figure 24).

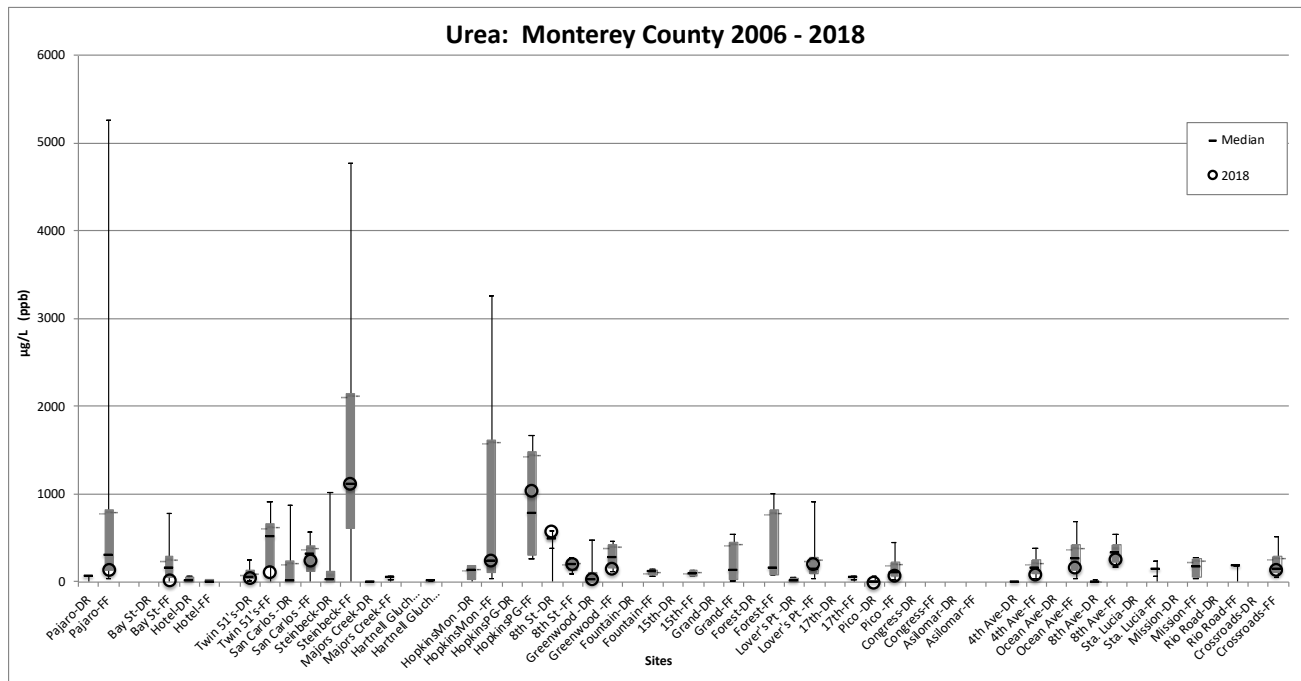


Figure 24. Single sample results for urea for the Dry Run (DR) and First Flush (FF) in Monterey County. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between the zero and the MDL. All sites grouped by city from north to south- Pajaro (Monterey County), Seaside, Monterey, Pacific Grove and Carmel.

Zinc

Storm water runoff in coastal urban areas is known to contain trace metals from sources such as automobile brake pads, tires, and industrial waste. Very low concentrations of total zinc in the marine environment can cause reduced reproduction, developmental deformities, and mortality. Total zinc was only measured in San Mateo and Monterey Counties. The Water Quality Control Plan for the Central Coast WQO for total zinc is $<200 \mu\text{g/L}$. The MDL for total zinc was $10 \mu\text{g/L}$ for the Dry Run and First Flush.

For the **Dry Run**, total zinc concentrations met the WQO at all sites. Three sites had non-detects: 8th Street (Pacific Grove), Greenwood Park (Pacific Grove), and Pico (Pacific Grove) (Figures 25 and 26).

For the **First Flush**, twenty-four of the twenty-eight sites (86%) monitored for total zinc met the WQO. The highest result of $284 \mu\text{g/L}$ was from the first time series sample at HopkinsPG (Pacific Grove) (Figures 25 and 26).

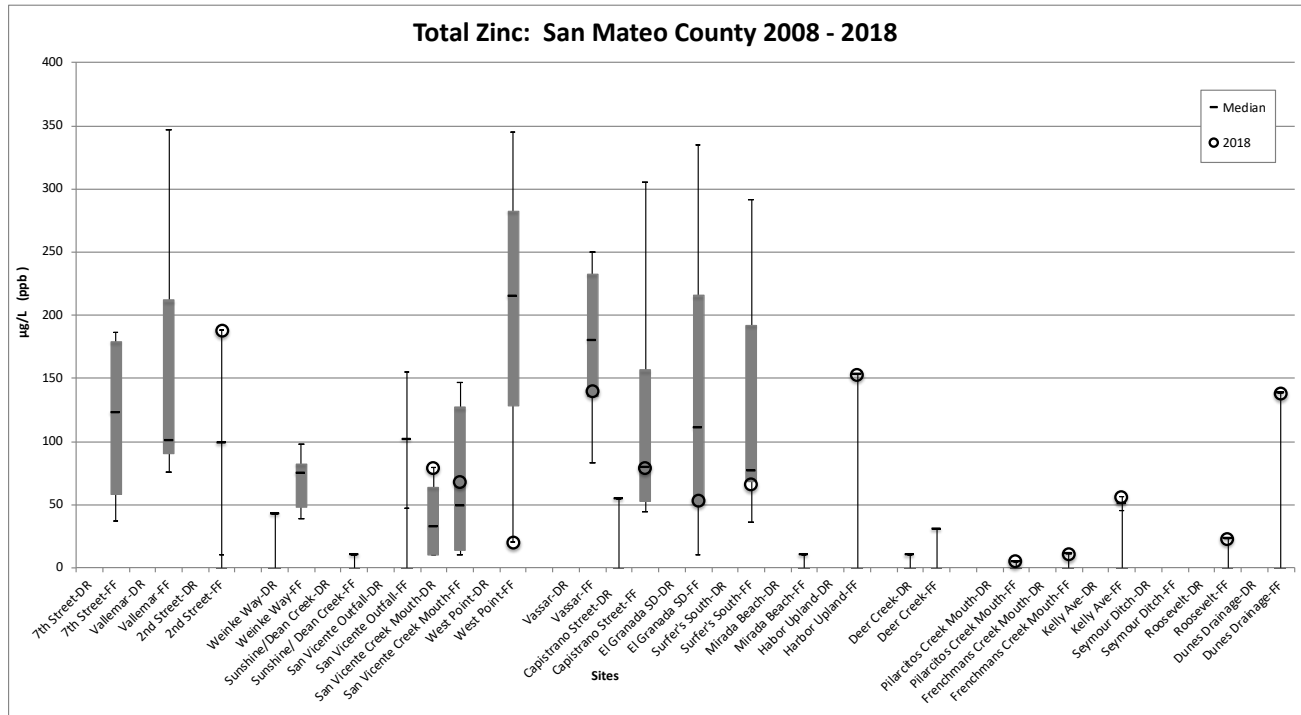


Figure 25. Single sample results for total zinc results for the Dry Run (DR) and First Flush (FF) in San Mateo County. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between the zero and the MDL. All sites grouped by city from north to south- Montara, Moss Beach, El Granada and Half Moon Bay.

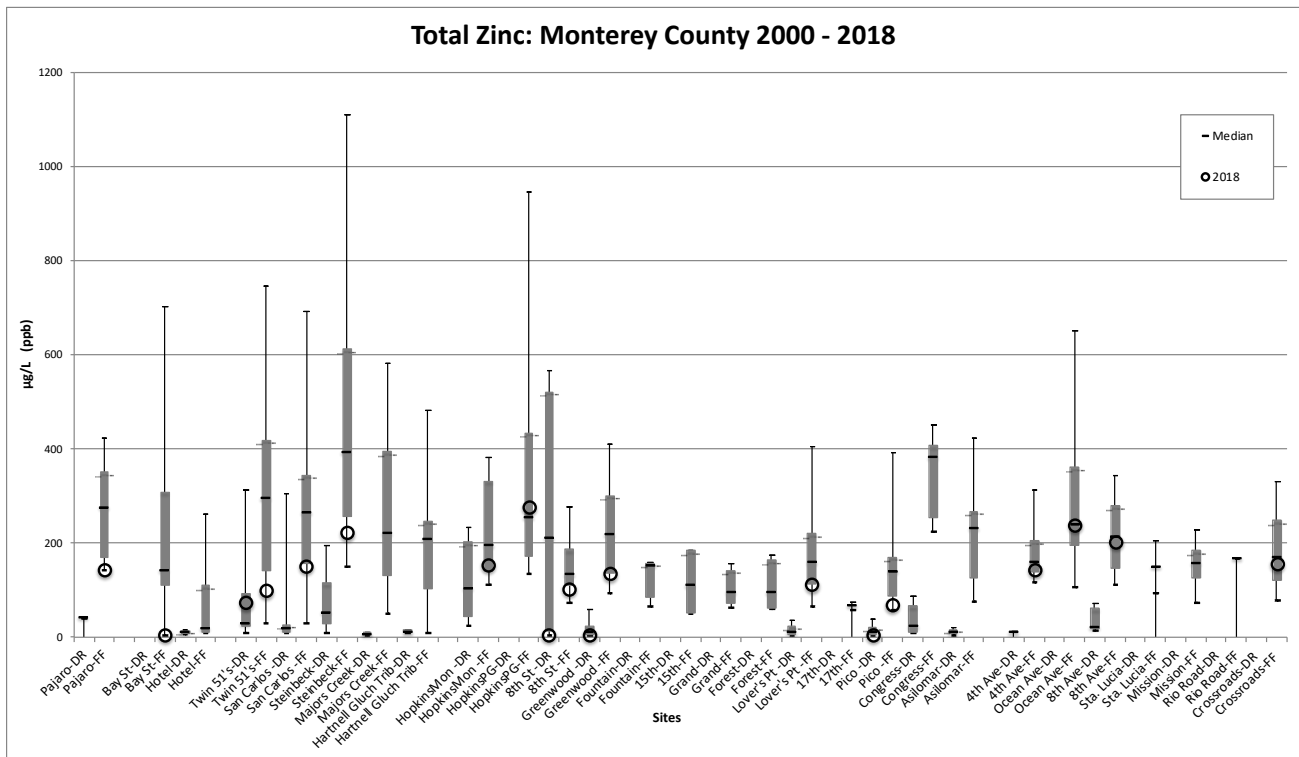


Figure 26. Single sample results for total zinc results for the Dry Run (DR), and time series averages for First Flush (FF) in Monterey County. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between the zero and the MDL. All sites grouped by city from north to south- Pajaro (Monterey County), Seaside, Monterey, Pacific Grove and Carmel.

Conclusion

For the past nineteen years, the Dry Run and First Flush have provided Central California coastal area residents and municipalities with valuable information about the quality of water running from storm drains into the ocean. Results from this and other Dry Run and First Flush events provide managers and researchers with information on pollutant concentrations during two critical times: late season dry weather and the initial flushing events when the most polluted water is expected.

The Dry Run was conducted in San Mateo and Monterey Counties only. Results from the 2018 Dry Run event show that:

- Copper concentrations met the WQO for the Dry Run at all San Mateo and Monterey County sites.
- *E. coli* results for the Dry Run in San Mateo and Monterey Counties met the WQO at only one site in Monterey County: Pico (Pacific Grove).
- Enterococcus results for the Dry Run in San Mateo and Monterey Counties met the WQO at only one site in Monterey County: Pico (Pacific Grove).
- Lead concentrations met the WQO for the Dry Run for all San Mateo and Monterey County sites.
- Nitrate concentrations met the Action Level in 80% of the Dry Run samples from San Mateo and Monterey County sites.
- Orthophosphate concentrations met the Action Level in 80% of the Dry Run samples from San Mateo and Monterey County sites.
- Total suspended solids concentrations met the Action Level for the Dry Run at all San Mateo and Monterey County sites.
- Turbidity concentrations met the Action Level in 100% of the sites where it was measured.
- Zinc concentrations met the WQO for the Dry Run in all San Mateo and Monterey County sites.

The First Flush was conducted in three counties: San Mateo, Santa Cruz and Monterey. Results from the 2018 First Flush show that:

- Copper concentrations in San Mateo County met the Action Level for 62% of the sites monitored, while in Monterey County only 27% of the sites monitored met the Action Level. Copper was not measured in Santa Cruz County.
- *E. coli* results for 100% of First Flush sites in all three counties did not meet the WQO.
- Enterococcus results for 100% of First Flush sites in all three counties did not meet the WQO. Enterococcus was not measured in Santa Cruz County.
- Lead concentrations met the WQO during the First Flush at all sites in San Mateo and Monterey Counties. Lead was not measured in Santa Cruz County.
- Nitrate concentrations met the Action Level for the First Flush for 85% of San Mateo County sites, 62% of Santa Cruz County sites, and 100% of Monterey County sites.
- Orthophosphate concentrations met the Action Level in 46% of sites in Santa Cruz County. However, all sites in San Mateo and Monterey Counties did not meet the Action Level.

- Total suspended solids concentrations met the Action Level for the First Flush in 100% of the sites in both San Mateo and Monterey Counties. Total suspended solids were not measured in Santa Cruz County.
- Turbidity concentrations met the Action Level during the First Flush for 50% of the sites where it was measured.
- Zinc concentrations met the WQO in 100% of First Flush sites in San Mateo County and 73% in Monterey County. Zinc was not measured in Santa Cruz County.

First Flush data helps us to better understand *our* pollutants of concern over a very large area and helps to identify where concentrations are highest. Our hope is that this report informs the placement of target projects and Best Management Practices (BMPs) that address specific contaminants. First Flush does not necessarily inform us as to whether our efforts are improving water quality—that requires a different monitoring design—but with the information provided by the First Flush event a prioritization of problem watersheds can be accomplished. Local cities have used First Flush information and addressed pollutant concentrations by cleaning out storm drains prior to the rains, installing dry weather diversions and litter-debris removal systems, as well as identifying opportunities to slow down runoff through vegetation and permeable surfaces. By addressing these issues on a watershed level more water quality improvements may be achieved.