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Dry Run
&
First Flush
2012 Monitoring Report

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Introduction

Urban pollutants that are deposited on hard surfaces during dry weather are then washed away in winter rainstorms into rivers, storm drains and the ocean. The first winter rainstorm can have the highest concentration of pollutants because it is flushing months of built up pollutants that accumulate on hard surfaces during the dry weather. These pollutants can be from sources such as brake dust, emissions from cars, animal waste, detergents from car washing, pesticides and fertilizers, among other chemicals commonly found in and around homes and businesses. By monitoring the water quality of the first rain event, it can give an indication of the types of pollutants and pollution loads going into the ocean.

The Monterey Bay National Marine Sanctuary (MBNMS), the Coastal Watershed Council (CWC) and the San Mateo County Resource Conservation District (SMCRCD) teamed up with volunteers to monitor a dry weather event called the Dry Run and the water flowing into the ocean during the first major rain storm called the First Flush. The geographic scope of this program extends from Montara in coastal San Mateo County in the north, to the Carmel River in Monterey County in the south (Fig. 1).

Monterey Bay National Marine Sanctuary (MBNMS) staff were responsible for monitoring 11 sites for the Monterey Regional Storm Water Monitoring Program (MRSWMP). The Coastal Watershed Council (CWC) coordinated the monitoring of 12 Santa Cruz County sites and the San Mateo County Resource Conservation District (SMRCD) coordinated the monitoring of 9 sites in coastal San Mateo County.

For the past thirteen years, volunteers have braved winter weather and early morning hours to collect samples of water at storm drain outfalls for this event. Volunteers are on call twenty-four hours a day seven days a week. Having willing and trained volunteers is critical for a program with this range and scope. Samples are analyzed for common urban pollutants: bacteria (*Eschericia coli (E. coli)* and enterococcus), nutrients (nitrate, phosphate and urea), metals (total copper, total lead, total zinc) and total suspended solids.

The Dry Run was conducted on September 8th in Santa Cruz County, September 23rd in Monterey County, and October 9th in San Mateo County. The First Flush occurred mid- day on October 22nd in San Mateo and Monterey counties and mid morning on November 1st in Santa Cruz County. In all, thirty-one storm drain outfalls were monitored by sixty-seven extraordinary volunteers.

Figure 1. 2012 Dry Run and First Flush Sites

Methods

In mid-September and early October volunteers were trained to follow standardized procedures for field measurements and to collect water samples for laboratory analysis. Following the classroom training, field training was conducted at a local outfall, and focused on a demonstration of field measurements and sample collection. This day is known as the Dry Run. After the demonstration, teams of volunteers went to their respective sites for area familiarization, took field measurements, and collected water samples. The Dry Run is conducted well ahead of any predicted rain and provides the volunteers with a chance to test equipment at their specific sites and provides water quality information about dry weather runoff. The same analytes that are measured for the First Flush program were tested for the Dry Run. They include: nutrients (nitrate, orthophosphate, urea), bacteria (*E. coli* and enterococcus), metals (copper, lead and zinc), hardness, and total suspended solids. Field measurements were taken for water temperature, pH, electrical conductivity, and transparency.

After the Dry Run and leading up to the First Flush event, the coordinators from the SMCRCD, CWC and MBNMS closely monitored the weather, notifying volunteers of approaching storms. When a storm had the potential to generate enough rainfall for First Flush mobilization, the coordinators placed the volunteers on standby until established criteria were met. Mobilization criteria includes sheeting water on roadways, heavy flow through the storm drain system and conductivity levels less than 1000 micro Siemens (μS) and declining.

Conductivity was measured using an Oakton EC Tester; water temperature was measured using a spirit bulb or digital thermometer. Transparency and pH were not measured this year because we mobilized at night and daylight is required for these measurements. Physical observations such as trash, odor, bubbles, scum, and oil sheen were also recorded on the data sheet.

All results (field and lab) are 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, they 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 are compared to the Central Coast Basin Plan's Water Quality Objectives (WQO) for the protection of marine aquatic life. Nitrate, orthophosphate, and total suspended solids results are compared with the Central Coast Ambient Monitoring Program's (CCAMP) attention levels (see Table 1). For all analytes, Minimum Detection Limits (MDL) are noted. The MDL is the minimum concentration that a lab instrument can detect for a given analyte. For sites that have a non-detect listed, it is placed on the graph at half the MDL, however the value is somewhere between zero and the MDL.

Table 1: Water Quality Objectives (Urea is not listed)

Parameter (reporting units)	Water Quality Criterion	Source of criterion
E. coli (MPN/100ml)	Not to exceed 235 [1]	EPA Ambient Water Quality Criteria
Enterococcus (MPN/100ml)	Not to exceed 104	EPA Ambient Water Quality Criteria
Copper- Total (ppb)	Not to exceed 30[7]	Basin Plan Objective
Lead (ppb)	Not to exceed 30[7]	Basin Plan Objective
Nitrate as N (ppm)	Not to exceed 2.25 [2]	Central Coast Water Board
Orthophosphate as P (ppm)	Not to exceed 0.12 [3]	Central Coast Water Board
pH	Not lower than 6.5 or greater than 8.5	Basin Plan Objectives
Total Suspended Solids (TSS) (ppm)	Not to exceed 500[8]	Central Coast Water Board
Transparency (cm)	Not less than 20[4]	Central Coast Water Board
Turbidity (NTU)	Not greater than 25[5]	Central Coast Water Board
Water Temperature (°C)	Not more than 21[6]	Central Coast Water Board
Zinc-Total (ppb)	Not to exceed 200[7]	Basin Plan Objective

[1] Environmental Protection Agency, Updated WQO.

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

[4] Based on equivalent turbidity guideline value used for 303(d) Listing Guideline Value (Sigler et al., 1985) (http://www.secchidipin.org/Transparency_Tube.htm)

[4] 303(d) Listing guideline value, based on Sigler et al., 1985

[5]Central Coast Ambient Monitoring Program, Pajaro River Watershed Characterization Report 1998, rev 2003.

[6] 303(d) Listing guideline value, based on Moyle, P. 1976. Inland Fisheries of California. Univ. of California Press.

[7] Basin Plan Cold Water Objective for hard water.

[8] Central Coast Ambient Monitoring Program, Salinas River Watershed Characterization Report 1999, rev. 2000.

Results/Discussion

Dry Run samples were collected in the Santa Cruz area on September 8th, the Monterey area on September 23rd, and the coastal San Mateo County area on October 9th. All sites were visited for the Dry Run but only 14 of the 32 sites had enough flow to be sampled (Appendix 1).

Dry Run monitoring results are from a single sample in comparison to First Flush sampling results, which are either one sample (San Mateo County and Soquel), or two time series samples separated by 30 minutes (Monterey County, Seaside, Monterey, Pacific Grove, and Carmel), or two time series samples separated by 60 minutes (Santa Cruz and Capitola).

The First Flush occurred on October 22nd 2012 in San Mateo and Monterey Counties. At 1:30 am on October 22nd, 13 San Mateo County volunteers mobilized to collect samples at 9 sites. Later in the day at 10:30 am, 29 volunteers mobilized to collect samples at 11 sites in Monterey County. Santa Cruz did not get the necessary rain to mobilize and waited until 7:00 am on November 1st to mobilize the 31 volunteers to sample at their 12 sites. A total of 32 sites were monitored for the First Flush 2012.

The City of Pacific Grove has a dry weather diversion system in place during dry weather months to take storm drain flows and divert them into the sanitary sewer system. This year fewer sites were monitored in Pacific Grove because the dry weather diversion system remained on during the First Flush.

Table 2: Range of results for Dry Run and First Flush 2012

Parameter	Dry Run 2012	First Flush 2012
Conductivity	925 - 1960 µS	70 - 873 µS
Transparency	37.2 - >120 cm	3 – 120 cm
Water temperature	14 – 17.1 ^{o}C	12.6 – 17.2 ^{o}C
pH	6.0- 7.77	6.0-8.3
Urea	ND - 35 µg/L	ND - 478 µg/L
Nitrate as N	ND - 4.08 mg-N/L	ND – 2.67 mg-N/L
Orthophosphate as P	ND - 0.17 mg-P/L	ND – 1.82 mg-P/L
Total Copper	ND - 11 µg/L	ND - 147 µg/L
Total Zinc	ND - 240 µg/L	15 - 392 µg/L
Total Lead	ND - 16 µg/L	ND - 23 µg/L
Total Suspended Solids (TSS)	ND - 10 mg/L	ND – 550 mg/L
Escherichia coli *(E. coli)*	ND - 31,062 MPN/100ml	100 – 130,847 MPN/100ml
Enterococcus	20 - 14,540 MPN/100ml	100 – >241,960 MPN/ 100ml

Nutrients

Nitrate

Although nitrate and phosphate are needed for plant growth, they are not normally found in elevated concentrations in aquatic systems. Nitrate, as with other nutrients, can lead to algal blooms that degrade water quality as those plants die off and consume oxygen in their decomposition. Nitrate sources include runoff from fertilized lawns, agricultural and pasture lands, construction sites and septic/sewer systems. The CCAMP attention level for nitrate as N (NO_3-N) is 2.25 mg-N/L. The minimum detection limit (MDL) is 0.05 mg-N/L.

For the **Dry Run**, two of the fourteen sites monitored (14%) were above the attention level for nitrate. The highest result was in Santa Cruz (Creekside Plaza) with a value of 4.08 mg-N/L (Fig. 2). Three sites in Soquel had non-detects: Creekside- Upper, Soquel Creek- Mid, Soquel Creek- Mouth.

During the **First Flush**, one of the thirty-two monitored sites was above the attention level for nitrate. The highest concentration was in Monterey (Steinbeck) with a time series average of 2.67 mg-N/L (Fig. 2). The only sites with non-detects were in Soquel: Creekside-Upper, Soquel Creek-Mid.

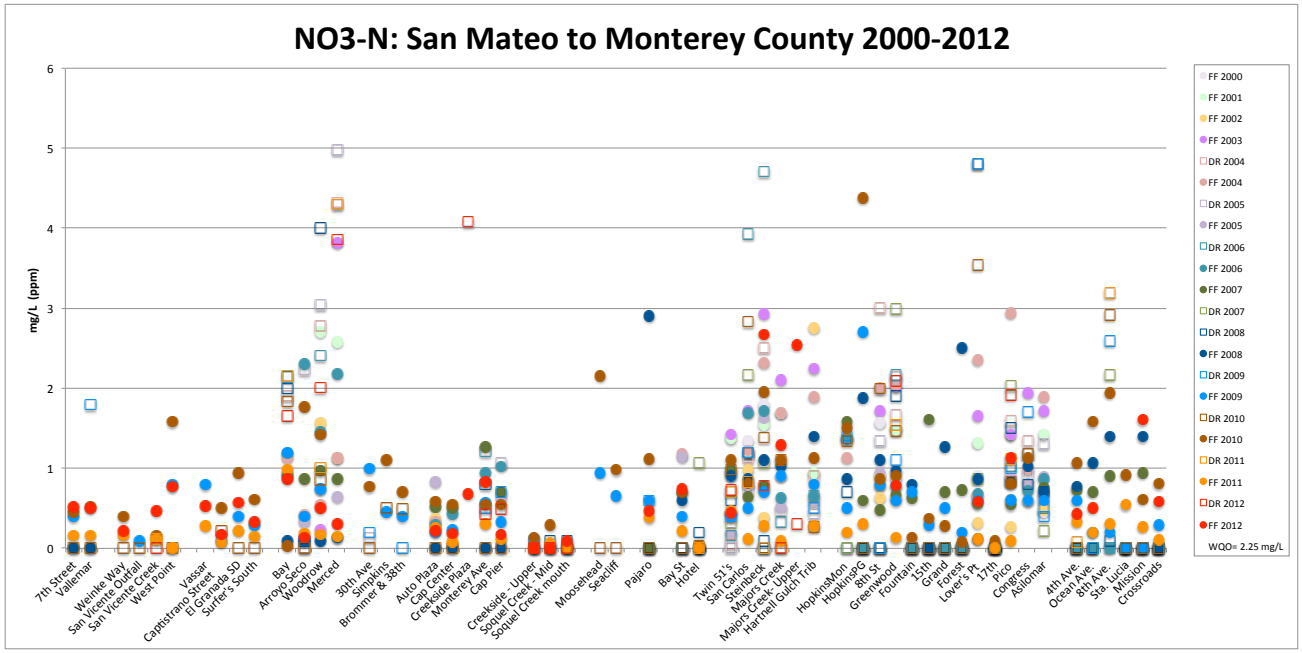

Figure 2. Results for Nitrate-N for the Dry Run and time series averages for First Flush. Not included on the graph is a 2006 result for Seaside (Bay Street) of **13.20 mg-N/ L** which compressed the rest of the results and so was removed from the graph. All sites grouped by city from north to south- Montara, Moss Beach, El Granada, Santa Cruz, Capitola, Soquel, Pajaro (Monterey County), Seaside, Monterey, Pacific Grove and Carmel.

Orthophosphate

Orthophosphate, like nitrate, is also necessary for plant growth. 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 some detergents. The CCAMP attention level for orthophosphate (PO_4-P) is 0.12 mg-P/L. The MDL is 0.05 mg-P/L.

For the **Dry Run**, three of the fourteen sites monitored (21%) were at or above the attention level of 0.12 mg-P/L. The highest value was in Santa Cruz (Merced) with a result of 0.17 mg-P/ L (Fig. 3). Non-detects were reported for five sites across the region: Moss Beach (San Vicente Creek Mouth), Capitola (Monterey Ave and Capitola Pier), Soquel (Creekside-Upper) and Pacific Grove (Pico).

During the **First Flush**, twenty-seven sites (84%) monitored were at or above the attention level for orthophosphate. Monterey (Steinbeck) had the highest average time series concentration for orthophosphate with a result of 1.82 mg-P/L (Fig. 3). Non-detects were noted for multiple sites across the region: Capitola (Monterey Ave) and Soquel (Creekside- Upper, Soquel Creek- Mid, Soquel Creek- Mouth).

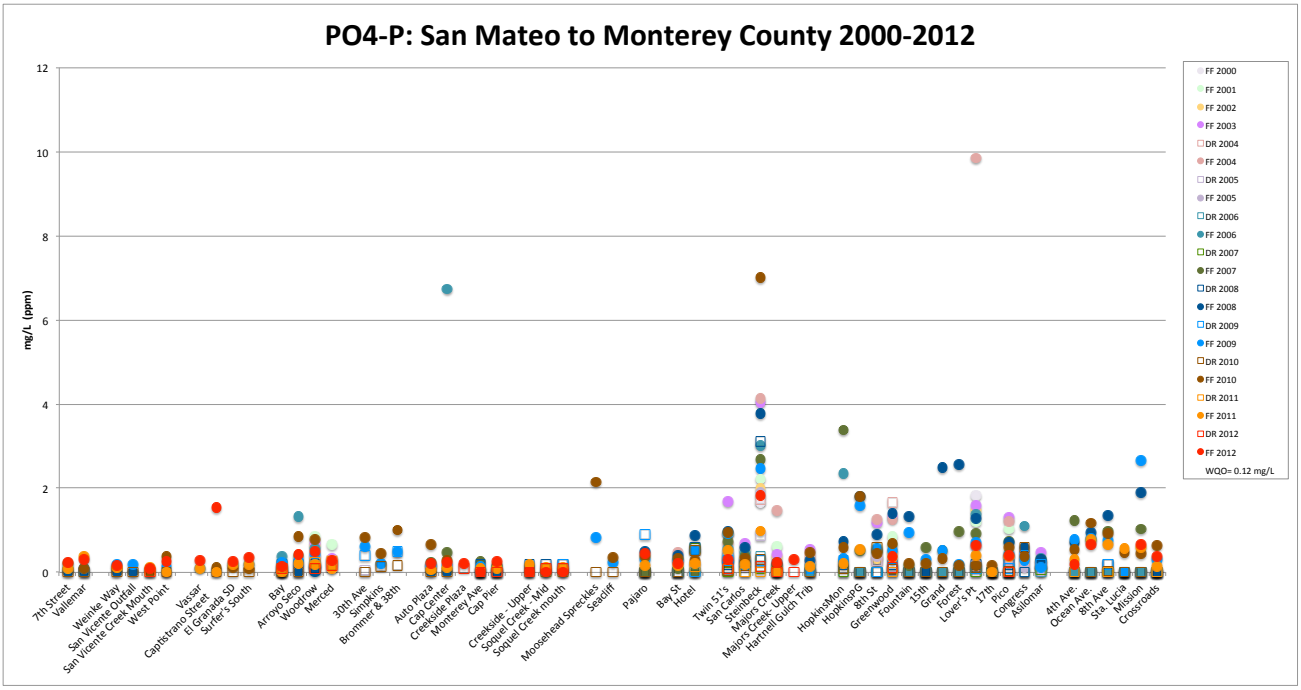

Figure 3. Orthophosphate-P results for the Dry Run and time series averages for First Flush. All sites grouped by city from north to south- Montara, Moss Beach, El Granada, Santa Cruz, Capitola, Soquel, Pajaro (Monterey County), Seaside, Monterey, Pacific Grove and Carmel.

Urea

Urea is an organic compound that is soluble in water; therefore 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. This was the fifth year that urea was analyzed for this program. 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 collected during the first time series at all sites. The MDL is 10 µg/L.

For the **Dry Run**, the highest urea result was in Monterey (Twins) with a concentration of 32 µg/L (Fig. 4).

During the **First Flush**, urea was only measured during the first time series. Monterey (Steinbeck) had the highest result of 478 µg/L (Fig. 4).

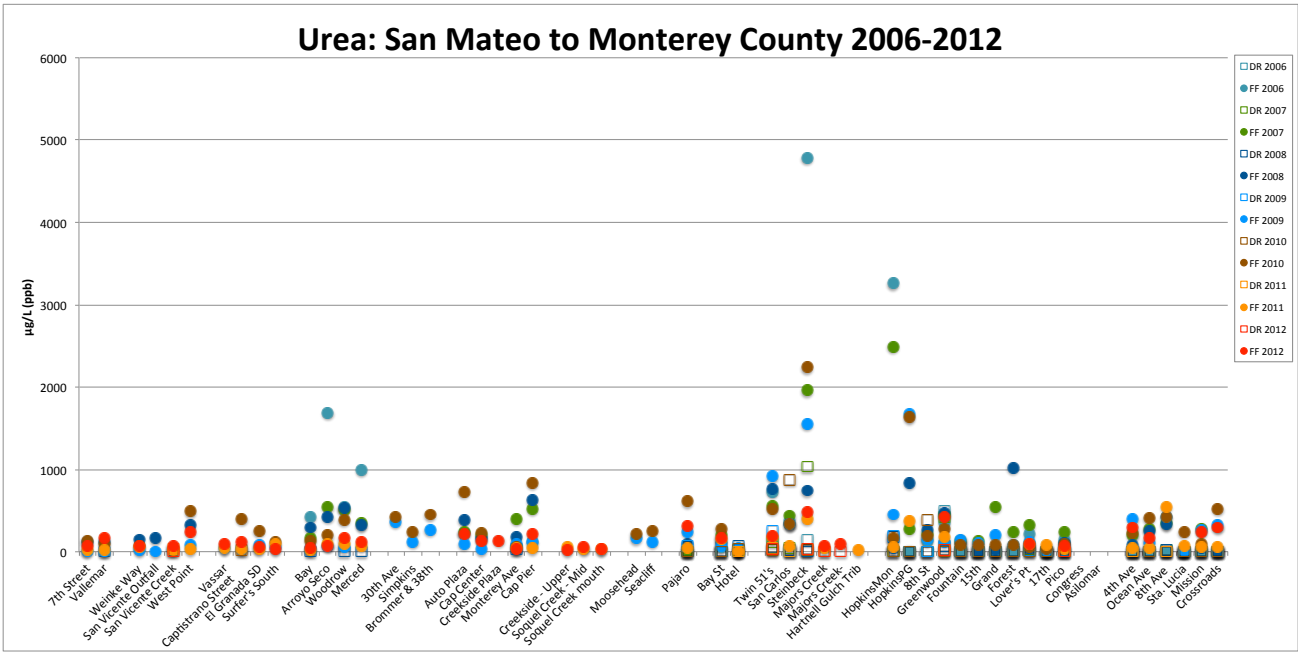

Figure 4. Urea results for the Dry Run and First Flush. All sites grouped by city from north to south- Montara, Moss Beach, El Granada, Santa Cruz, Capitola, Soquel, Pajaro (Monterey County), Seaside, Monterey, Pacific Grove and Carmel.

Bacteria

Escherichia coli (E. coli) and enterococcus are two types of fecal indicator bacteria. *E. coli* and enterococcus, found in the intestines of warm blooded animals, make their 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 does indicate the potential for other human specific pathogens to be present. The U.S. Environmental Protection Agency water quality criterion for grab samples for *E. coli* is 235 MPN/100 ml and for enterrococcus, 104 MPN/100 ml. The MDL for both *E.coli* and enterococcus is 1 MPN/100ml.

For the **Dry Run,** nine of the fourteen sites (64%) monitored were above the WQO for *E. coli*. The highest *E. coli* result was 31,062 MPN/100 ml at Pacific Grove (Greenwood Park) (Fig. 5). For enterococcus, ten of the fourteen sites (69%) were above the WQO of 104 MPN/100 ml. The highest enterococcus result was 14,540 MPN/ 100 ml in Pacific Grove (Greenwood Park) (Fig. 6).

During the **First Flush** both types of bacteria were present in all cities and at all sites. Thirty-one of the thirty two sites monitored (97%) were above the WQO for *E.coli* and enterococcus. The highest average result for *E.coli* was 130,847 MPN/100 ml in Monterey (Steinbeck), and the highest average result for enterococcus was >241,960 MPN/100 ml in Monterey County (Crossroads) (Fig. 5 and 6).

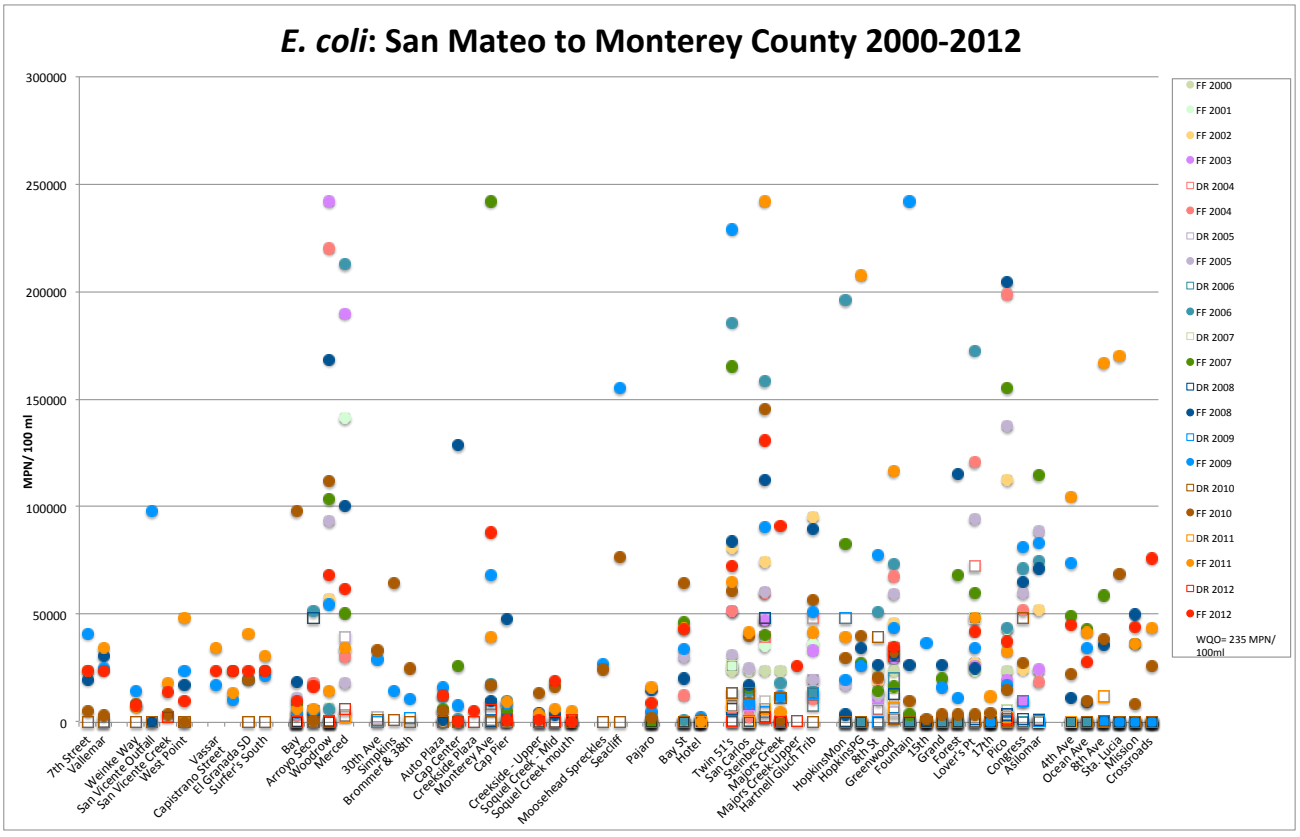

Figure 5. *E.coli* results for the Dry Run and time series averages for First Flush. All sites grouped by city from north to south- Montara, Moss Beach, El Granada, Santa Cruz, Capitola, Soquel, Pajaro (Monterey County), Seaside, Monterey, Pacific Grove and Carmel.

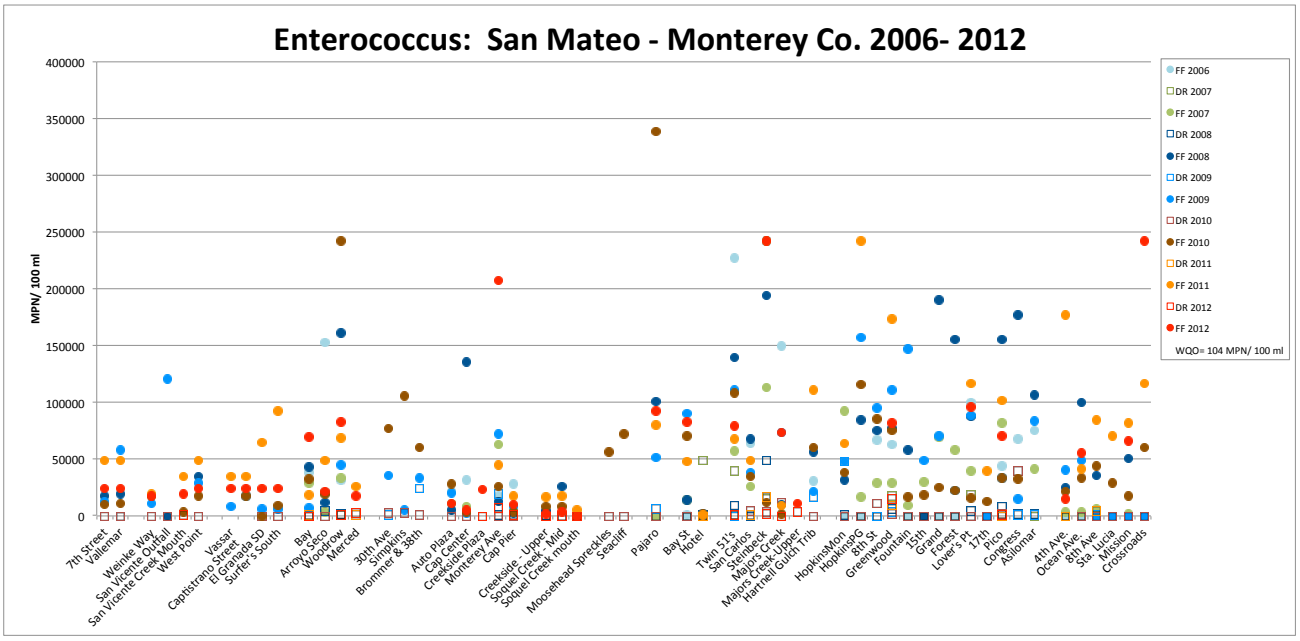

Figure 6. Results for enterococcus for the Dry Run and time series averages for First Flush. All sites grouped by city from north to south- Montara, Moss Beach, El Granada, Santa Cruz, Capitola, Soquel, Pajaro (Monterey County), Seaside, Monterey, Pacific Grove and Carmel.

Metals

Storm water runoff in coastal urban areas is known to contain trace metals from sources such as automobile brake pads, tires, industrial waste, and metal roofs or downspouts. Very low concentrations in the marine environment can cause reduced reproduction, developmental deformities, and mortality. For the Dry Run and First Flush, samples were analyzed for total zinc (Zn), total copper (Cu), and total lead (Pb).

Zinc

The Basin Plan WQO for Zn is <200 µg/L; and the MDL for zinc is 10 mg/L.

For the **Dry Run**, zinc concentrations exceeded the WQO of 200 µg/L at one site in Santa Cruz (Bay Street) with a result of 240 µg/L (Fig. 7).

For the **First Flush**, six of the thirty-two sites (19%) were above the WQO for zinc. The highest average zinc concentration was 392 µg/L in Monterey (Steinbeck) (Fig. 7).

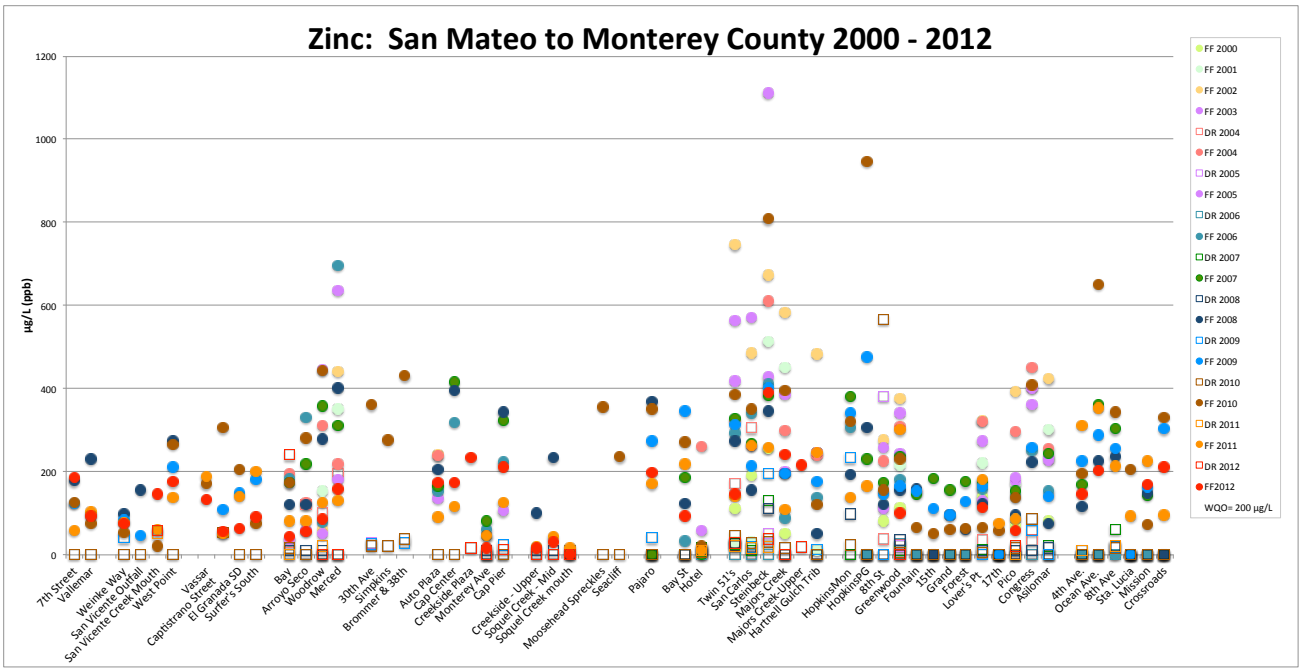

Figure 7. Total zinc results for all sites for Dry Run and time series averages for First Flush. All sites grouped by city from north to south- Montara, Moss Beach, El Granada, Santa Cruz, Capitola, Soquel, Pajaro (Monterey County), Seaside, Monterey, Pacific Grove and Carmel.

Copper

The Basin Plan WQO established for total Cu is 30 µg/L; the MDL for copper is 4.0 µg/L.

For the **Dry Run**, copper concentrations were all below the WQO. Eleven sites had non-detects: Moss Beach (San Vicente Creek Mouth), Santa Cruz (Woodrow, Merced), Capitola (Creekside Plaza, Monterey Ave, Capitola Pier), Soquel (Creekside- Upper, Soquel Creek-Mid, Soquel Creek- Mouth), Pacific Grove (Greenwood Park, Pico) (Fig. 8).

During the **First Flush**, seventeen of the thirty-two monitored sites (53%) were above the WQO. The highest copper concentration was in Monterey (Steinbeck) with an average of 147 µg/L (Fig. 8). Two sites had non-detects: Soquel (Soquel Creek- Upper, Soquel Creek-Mouth).

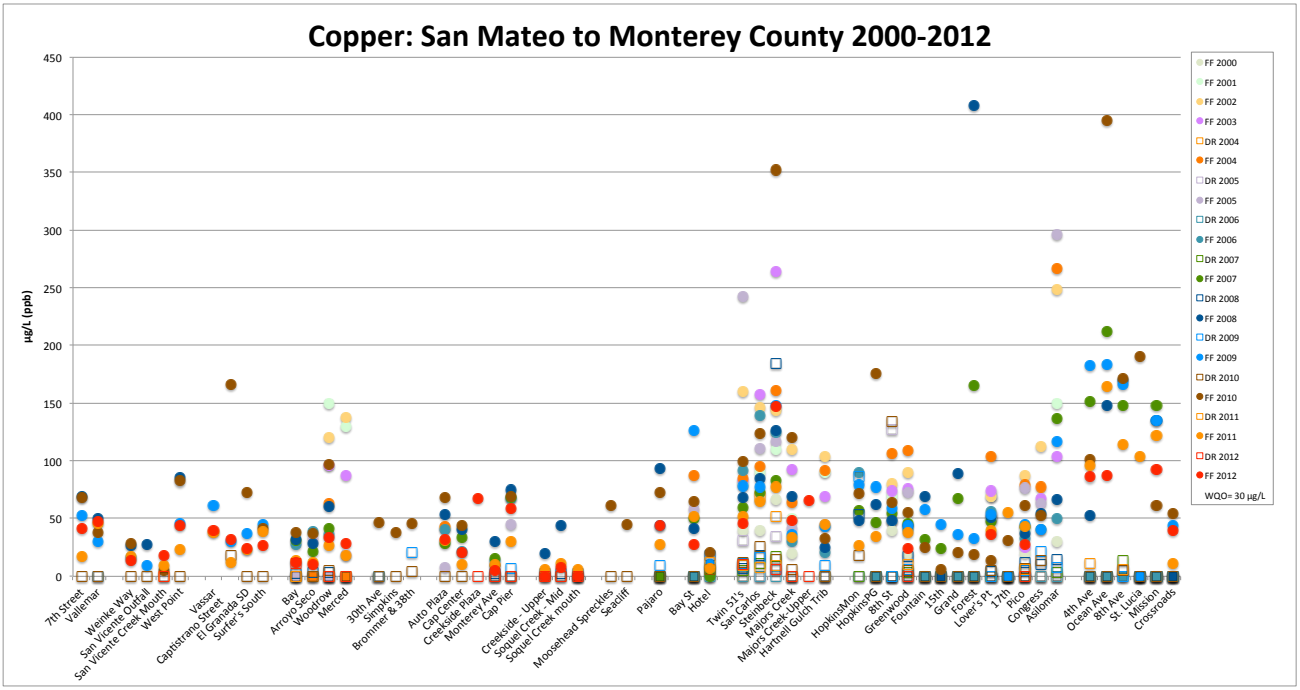

Figure 8. Total copper results for the Dry Run and time series averages for First Flush. All sites grouped by city from north to south-Montara, Moss Beach, El Granada, Santa Cruz, Capitola, Soquel, Pajaro (Monterey County), Seaside, Monterey, Pacific Grove and Carmel.

Lead

The Basin Plan WQO for total lead (Pb) is 30 µg/L. The MDL for lead is 5 µg/L.

For the **Dry Run**, lead concentrations were above the WQO at one site: Santa Cruz (Bay Street) with a result of 16 µg/L (Fig. 9).

For the **First Flush**, none of the thirty-two monitored sites were above the WQO and fourteen had non-detects: Montara (Vallemar), El Granada (Capistrano, El Granada, Surfers South), Santa Cruz (Bay Street, Arroyo Seco), Capitola (Auto Plaza, Capitola Center, Monterey Avenue), Soquel (Creekside- Upper, Soquel Creek- Mid, Soquel Creek- Mouth), Pacific Grove (Pico) and Monterey County (Crossroads) (Fig. 9).

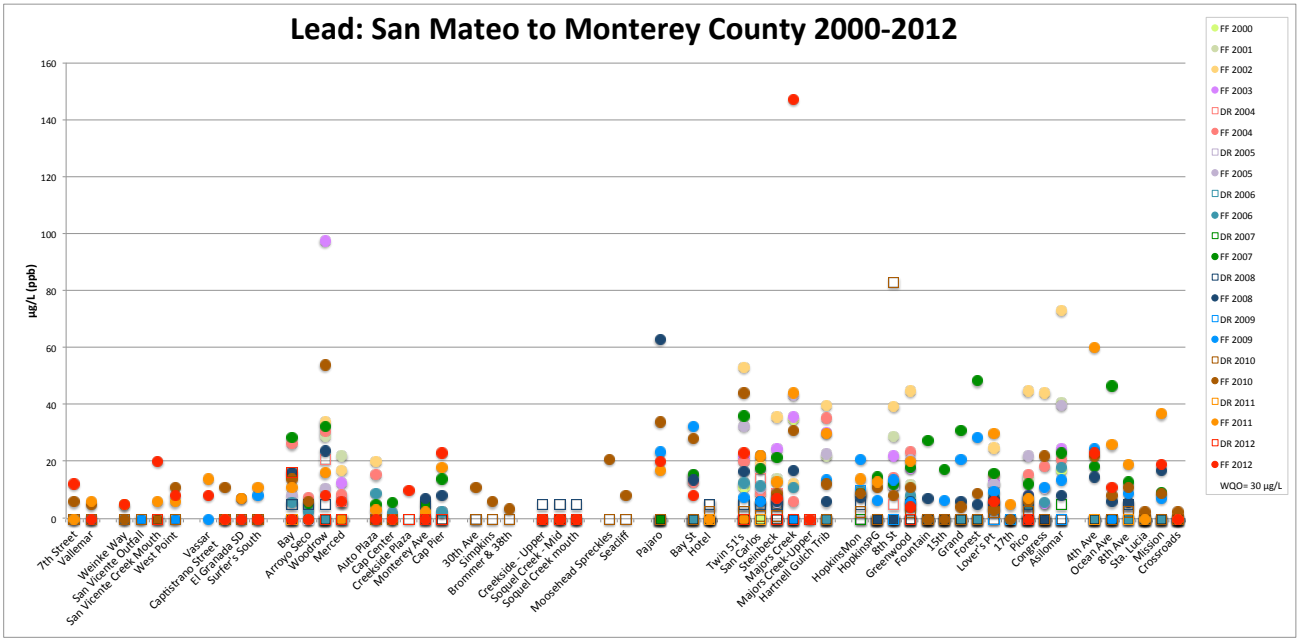

Figure 9. Total lead results for all sites for Dry Run and time series averages for First Flush. All sites grouped by city from north to south- Montara, Moss Beach, El Granada, Santa Cruz, Capitola, Soquel, Pajaro (Monterey County), Seaside, Monterey, Pacific Grove and Carmel.

Total Suspended Solids (TSS)
TSS are particulate matter in water that attract charged particles which can often include pesticides and metals. TSS can additionally impact the environment through sedimentation and reduction in the ability of marine organisms to respire. Some sources of TSS are construction sites with improper sediment control, bank erosion from rivers or streams, runoff from agricultural fields, and over irrigation in urban areas. The attention level for TSS is 500 mg/L, with an MDL of 5 mg/L.

For the **Dry Run**, none of the sites were above the WQO (Fig. 10).

For the **First Flush**, one site of the thirty-two monitored (3%) was above the attention level. That site was in Moss Beach (San Vicente Creek Mouth) with a result of 550 mg/L (Fig. 10).

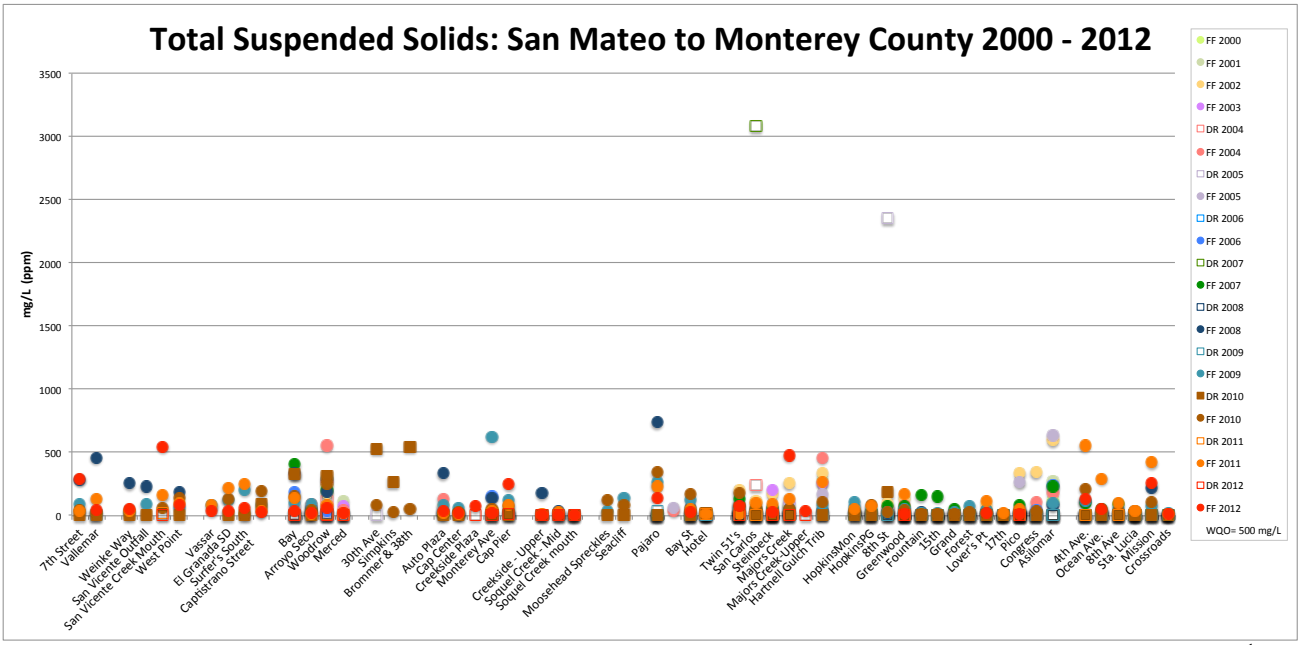

Figure 10. TSS results for all sites for Dry Run and time series averages for First Flush. For two sites, Twins in Monterey and 17th in Pacific Grove, results are based upon one sample. All sites grouped by city from north to south- Montara, Moss Beach, El Granada, Santa Cruz, Capitola, Pajaro (Monterey County), Seaside, Monterey, Pacific Grove and Carmel.

At each site during the First Flush 2012, volunteers recorded the presence of trash, sewage (sited or smelled), oil sheen, and scum (Table 3).

Table 3: Visual Observations. An X indicates presence of trash, oil sheen, odor of sewage, or scum and/or bubbles.

	Trash	Oil Sheen	Sewage Smells	Scum and/or Bubbles
7th Street (Montara)				
Vallemar (Montara)				X
Weinke Way (Moss Beach)				X
San Vicente Creek Mouth (Moss Beach)				
West Point (Moss Beach)				
Vassar (El Granada)	X			
El Granada SD (El Granada)	X			
Surfer's South (El Granada)				X
Capistrano Street (El Granada)	X			
Bay Street (Santa Cruz)				
Arroyo Seco (Santa Cruz)	X			X
Woodrow (Santa Cruz)				X
Merced (Santa Cruz)	X	X		X
Auto Plaza (Capitola)	X			X
Capitola Center (Capitola)		X		
Creekside Plaza	X			
Monterey Ave (Capitola)				X
Capitola Pier (Capitola)	X			X
Creekside- Upper (Soquel)	X			
Soquel Creek- Mid (Soquel)	X		X	
Soquel Creek Mouth (Capitola)	X			
Pajaro (Monterey County)	X			X
Bay Street (Seaside)				
Twins (Monterey)	X			X
Steinbeck (Monterey)	X			X
Greenwood Park (Pacific Grove)	X			
Lover's (Pacific Grove)			X	X
Pico (Pacific Grove)				X
4th Street (Carmel)				X
Ocean Avenue (Carmel)				X
Mission (Carmel)			X	X
Crossroads (Monterey County)				X

Conclusion

For the past thirteen 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 the storm drains to the ocean. Results from this event provide managers and researchers with pollutant concentrations during two critical times: late season dry weather and the initial flushing events when the most polluted water is expected. Results from the 2012 events show that:

- Nitrate concentrations are generally higher during the dry weather monitoring, yet still below the attention level. Nitrate concentrations were below the attention level for all but one site during the First Flush.
- Orthophosphate results continue to be above the action level for many sites during the First Flush: In Monterey County 100% of the sites were over the attention level. In Santa Cruz County 67% of sites and in San Mateo County 89% of the sites and were over the attention level.
- Copper and zinc concentrations appear to be consistently higher at sites in the southern half of the Monterey Bay region. In Monterey County 89% of the sites were above the Water Quality Objective for copper with 40% of the sites in Santa Cruz County and 56% in San Mateo County.
- Lead concentrations were below the WQO during both wet and dry weather events.
- As in previous years, *E. coli* and enterococcus results during First Flush were above the WQO. In 2012, 97% of the sites exceeded the WQO for both *E. coli* and enterococcus.

First Flush data helps us to better understand what *our* pollutants of concern are over a very large area through the help of many courageous volunteers. First Flush data identify where concentrations are highest and help to target practices to address those specific contaminants. First Flush does not necessarily inform us as to whether our efforts are improving water quality. That requires a different monitoring design that uses the information provided by the First Flush event to prioritize problem watersheds, and inform the design of a monitoring program that identifies potential sources and determines effectiveness of particular practices. 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 CDS units (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 accomplished.