MORRO BAY NATIONAL ESTUARY PROGRAM

Morro Bay National Estuary Program's
Implementation Effectiveness Program

Stormwater Monitoring Report 2009

Agreement Number
08-309-550-1
Task 11.5

Submitted by

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April 26, 2010

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Background

Urban runoff is generally considered to be one of the leading causes of water quality contamination in many areas. In an effort to measure pollutant levels in urban runoff which enters the Morro Bay estuary, the Morro Bay National Estuary Program (MBNEP) conducts two monitoring efforts, First Flush and Urban Watch.

'First Flush' is a monitoring effort to measure pollutant levels in stormwater runoff from the first heavy rainstorm of the season, which typically generates the most contaminated runoff of the year. After months of dry weather, stormwater picks up particles and contaminants that have accumulated on driveways, streets, yards and in storm drain catch basins. This pollution is deposited, untreated, into our local waterways including creeks and Morro Bay. The purpose of this monitoring is to highlight for agencies and the public the potential impacts from urban runoff.

The MBNEP, in conjunction with the Central Coast Regional Water Quality Control Board (CCRWQCB), conducted First Flush (FF) monitoring events in the Morro Bay watershed during the 1995-6, 1996-7 and 1997-8 storm seasons. Monitoring was conducted at 22 drainage inlet and outfall sites throughout Morro Bay and Los Osos and at five sites within Camp San Luis Obispo and the San Luis Obispo (SLO) County Operations Center along Chorro Creek. Samples were analyzed for pH, conductivity, turbidity, dissolved oxygen, temperature, suspended sediments, nutrients, and total and fecal coliform. Samples from some sites were analyzed for heavy metals, gasoline and diesel.

First Flush monitoring was reinstated during the 2005-6 rainy season with a reduced scope of monitoring. Seven sites were monitored for pH, conductivity, turbidity, dissolved oxygen, temperature, suspended and dissolved solids, total coliforms, *E. coli*, oil and grease, and dissolved metals. The 2006-7 effort expanded on the 2005-6 effort and monitored 13 sites for the same suite of parameters. In 2007-8, the effort was scaled back to eight sites, four of which were in Los Osos and four in Morro Bay.

In the 2008-9 season, the monitoring effort was structured differently than in all previous seasons. An early, unseasonable storm in mid-August generated enough runoff for sampling at five outfall sites in Morro Bay. The high intensity, short duration storm resulted in pollutant concentrations that were considerably higher than the levels seen in previous year's FF results. Following analysis of the results from the August event, the decision was made to conduct time series sampling at two outfalls on a subsequent storm. Two outfalls in Morro Bay were sampled every 15 minutes for an hour in a storm during October of that same year. Due to logistical considerations, the decision was made to cancel FF monitoring at any sites in Los Osos during the 2008-9 season.

In the 2009-10 season, monitoring was conducted at five sites in Morro Bay during the first runoff of the season. No time series data was collected. As in the previous season, FF monitoring was not conducted at sites in Los Osos due to logistical considerations.

Urban Watch (UW) is a monitoring effort to measure pollutant levels in urban runoff during the dry season. The source of flow is typically anthropogenic sources, whether from irrigation, car washing or other activities which cause excess water to flow through the storm drain system,

transporting pollution from streets and yards, and depositing it into the creeks and bay. The purpose of this monitoring is to improve our understanding of the pollutants contained in these dry season discharges and identify areas with the greatest amount of dry season flow.

The UW monitoring season typically begins in June and continues until the FF storm event occurs. Eight sites in Morro Bay and six sites in Los Osos are monitored approximately weekly to check for dry season flows. If water was flowing through a drain such that a sample could be collected, it was analyzed for temperature, pH, total chlorine, conductivity, ammonia, nitrates as nitrogen, orthophosphates as PO_4, turbidity and total coliform.

This report summarizes the results from Urban Watch monitoring which took place in June through September 2009 and First Flush monitoring which took place in October of 2009.

First Flush

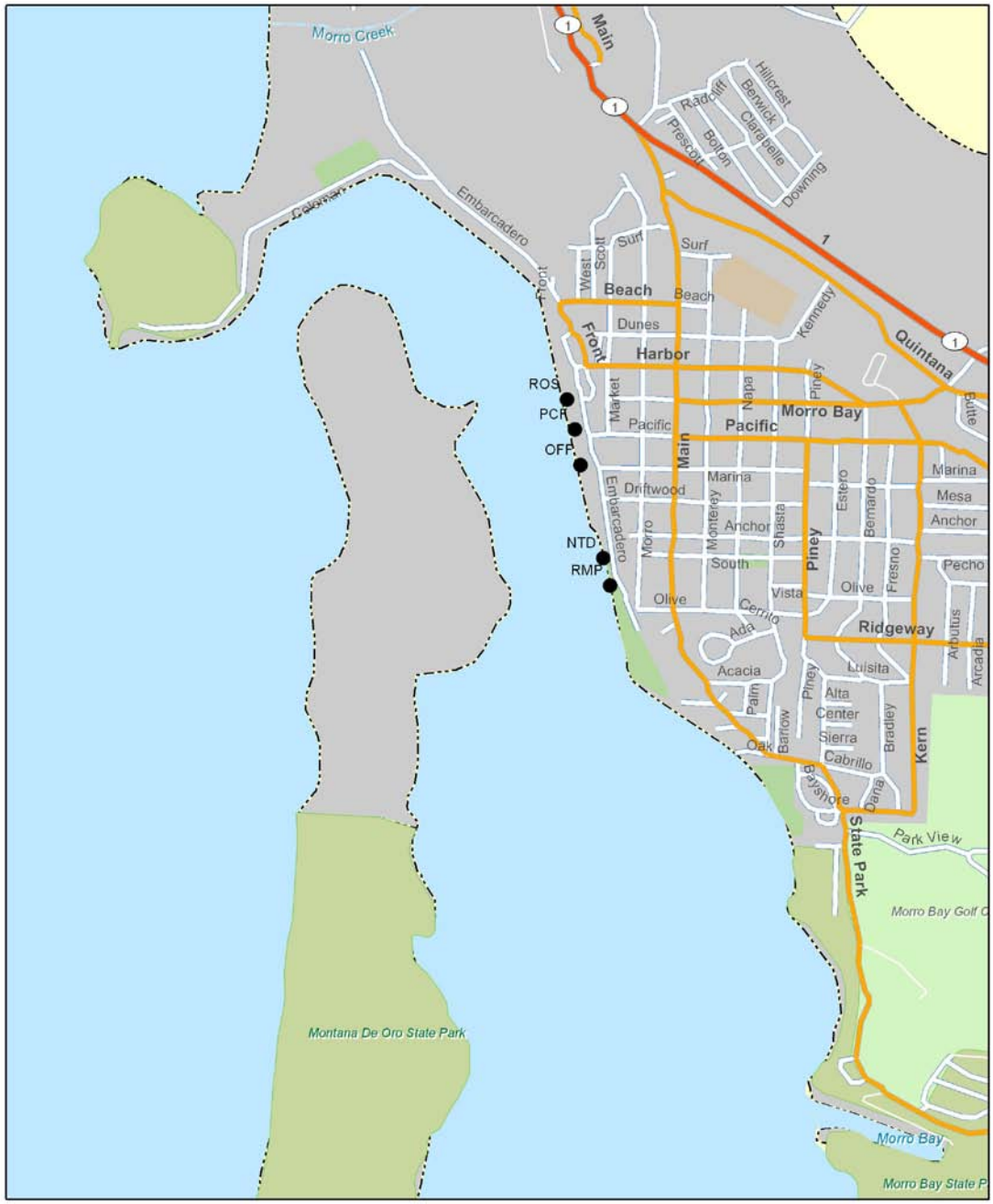
Study Design

Site Selection
The 2005, 2006, 2007, 2008 and 2009 efforts were organized and conducted by the MBNEP's Volunteer Monitoring Program (VMP). In designing the FF effort for the 2009-10 rainy season, sites with safe access and those monitored during the previous FF efforts were selected. Other factors for site selection included locations where UW monitoring was taking place. Preference was given to sites that had considerable history of dry season flows, as noted by the UW monitoring effort.

For the 2009-10 rainy season, the decision was made to collect runoff from the first storm of the season that was logistically possible to sample. Rainfall during a weekend or holiday would not be collected due to logistical concerns, including staff availability and analytical lab schedules. The sites in Los Osos were not sampled due to lack of available staff.

Five sites in Morro Bay were selected as follows:

- Culvert beneath the ramp to the public boat dock at Tidelands Park (RMP)
- Large black HDPE culvert located near 451 Embarcadero. (NTD)
- Culvert draining into the bay at end of Marina St. on the Embarcadero. (OFF)
- Culvert draining into the bay at the end of Pacific St. on the Embarcadero. (PCF)
- Large concrete culvert near public access dock between Rose's Landing and Embarcadero Grill Restaurants on the Embarcadero. (ROS)



Sample Collection

Based on advice from Jennifer Bitting of the CCRWQCB, the goal was to conduct all sample collection during the first hour following the initiation of sheet flow off of paved streets. This approach is useful when comparing sites to each other – it identifies the areas of concern and pollutants of concern. She suggested that sampling of outfalls would produce the most beneficial information.

A storm passed over the Central Coast in the early hours of October 13, 2009 with an approximate start of measurable rainfall at 4:15 a.m. Sampling took place from 7:30 to 7:45 a.m. when the rainfall gauge at Canet Road, Morro Bay read approximately 0.22”. The total rainfall for the storm was measured at 4.56” from 3:14 a.m. on October 13 through 9:30 a.m. on October 14 at the Canet Road gauge.

At each site, observations were made on rainfall, wind, water clarity of the runoff and pollution observed in the runoff (i.e., oily sheen, trash, foam, etc.) Samples were delivered to the MBNEP office immediately following collection and were stored in coolers with blue ice until they could be transported to the labs.

In past years, the samples were filtered for dissolved metal analysis before delivery to the lab. Because of the difficulty of filtering the samples and because the labs were already open, the decision was made to deliver the samples unfiltered. All dissolved metal samples were filtered by the laboratory shortly after they were received. Additionally, pH was not analyzed within 15 minutes of collection, as stated in SM 4500-H B. The samples were analyzed for pH upon delivery to the laboratories in San Luis Obispo by 9:35 a.m. on October 13. Thus, pH levels must considered approximations. The bacteria samples were delivered to the county lab for analysis on October 13 at approximately 9:20 a.m., and the samples were analyzed soon after. The six-hour hold time was met for the bacteria analysis.

A duplicate sample and a blank were analyzed. The duplicate was analyzed for the full suite of analytes. The sample blank was analyzed for TDS, TSS, turbidity, dissolved copper and dissolved zinc.

Sample Analysis
The analytes for First Flush monitoring were determined based on historically monitored analytes and on advice from CCRWQCB staff.

Analysis for the following parameters was completed by Creek Environmental Laboratories.

- Oil & grease
- Nitrates as N
- Orthophosphates as P
- Total dissolved solid (TDS)
- Total suspended solids (TSS)
- Dissolved metals (copper, lead, nickel and zinc)
- Electrical conductivity
- pH and
- Turbidity

The SLO County Public Health Laboratory in San Luis Obispo conducted analysis for the following analytes.

- Total coliforms and
- *E. coli.*

Bacteria was analyzed using the IDEXX Colilert-18 methodology. Samples were run in three dilutions (1:10, 1:100 and 1:1,000) to account for the full possible range of *E. coli* and total coliform results.

Table 1. Analysis Methods and Detection Limits for Reporting.

Analyte	Responsible Organization	Analytical Method	Detection Limit for Reporting	Sample Hold Times
Nitrate as N	Creek Environmental Laboratories	EPA Method 300.0	0.1 mg/L	48 hours
Orthophosphate as P	Creek Environmental Laboratories	SM 4500-P	0.01 mg/L	48 hours
TDS	Creek Environmental Laboratories	SM 2540C	10 mg/L	7 days
TSS	Creek Environmental Laboratories	SM 2540D	5 mg/L	7 days
Oil & grease	Creek Environmental Laboratories	EPA 1664, Rev. A	5 mg/L	28 days
Dissolved metals: Ni, Pb, Cu, Zn	Creek Environmental Laboratories	EPA 200.8	Ni, Pb, Cu: 0.001 mg/L Zn: 0.005 mg/L	Filter within 15 minutes, acid preservation, and then hold for 6 months
pH	Creek Environmental Laboratories	SM 4500-H B	0.1 pH units	15 minutes
Conductivity	Creek Environmental Laboratories	SM 2510 B	1 uS/cm	48 hours
Turbidity	Creek Environmental Laboratories	SM 2130 B	0.1 NTU	48 hours
E. coli	SLO County Public Health Laboratory	IDEXX, Colilert-18	2 MPN/100 mL	6 hours preferred, 24 hours is acceptable
Total coliform	SLO County Public Health Laboratory	IDEXX, Colilert-18	2 MPN/100 mL	6 hours preferred, 24 hours is acceptable

Sample Results

The FF data has been compiled, and to provide some context for the results, the data has been compared to various applicable standards for receiving waters from sources including the CCRWQCB's Basin Plan and the CCRWQCB's Central Coast Ambient Monitoring Program (CCAMP). Please note that there are no regulatory standards for stormwater runoff itself. Rather,

the levels of various pollutants in the receiving waters must remain below the regulatory standards.

The VMP sampling effort is designed to provide data on pollutant concentrations in stormwater runoff. As there are no volumetric measurements to accompany this data, it cannot be used to estimate loading values for the Morro Bay estuary. Runoff volume measurements are not feasible for this monitoring effort and are not included in VMP FF monitoring. Further, samples are not collected from receiving waters to which beneficial use standards apply.

It is important when reviewing the data to keep in mind that the specified hold times for the dissolved metals and pH analysis were exceeded for all of the samples. The impact on the pH values is not known. In general, if samples are exposed to air prior to analysis, they absorb carbon dioxide and form carbonic acid, which lowers the pH value. Since the samples did not have prolonged exposure to air prior to analysis, the impact on pH is likely minimal. For dissolved metals, the hold time was violated because samples could not be filtered within 15 minutes of collection.

Table 2. Analytical results of the October 13, 2009 storm in Morro Bay.

Analyte	OFF	OFF2*	PCF	NTD	ROS	RMP
Oil and grease (mg/L)	2.5**	2.5	2.5	8.3	2.5	***
Zinc (mg/L)	0.12	0.12	0.15	0.071	0.16	0.073
Copper (mg/L)	0.027	0.026	0.034	0.027	0.026	0.1
Lead (mg/L)	0.002	0.002	0.002	0.001	0.002	0.001
Nickel (mg/L)	0.014	0.013	0.013	0.01	0.008	0.009
Turbidity (NTU)	70	74	63	76	67	43
pH	7.1	7.2	7.5	7.1	7.1	7.1
Conductivity (uS/cm)	410	401	433	256	271	295
Dissolved Solids (mg/L)	321	332	328	249	242	253
Suspended Solids (mg/L)	82	181	132	585	110	56
Total coliform (MPN/100 mL)	34500	34100	52100	49600	26130	18700
E. coli (MPN/100 mL)	3255	2098	3873	1670	1223	7701
Nitrates as N (mg/L)	0.94	0.92	0.71	0.73	0.55	0.56
Orthophosphates as P (mg/L)	0.64	0.48	0.47	0.57	0.43	0.39

*Results from the duplicate sample.
**Results in blue indicate a non-detect result. For results that were non-detect, we are using a value of one half of the detection limit for all reporting and calculations.
***Due to contamination introduced by the analytical lab, valid results were not obtained for this sample.

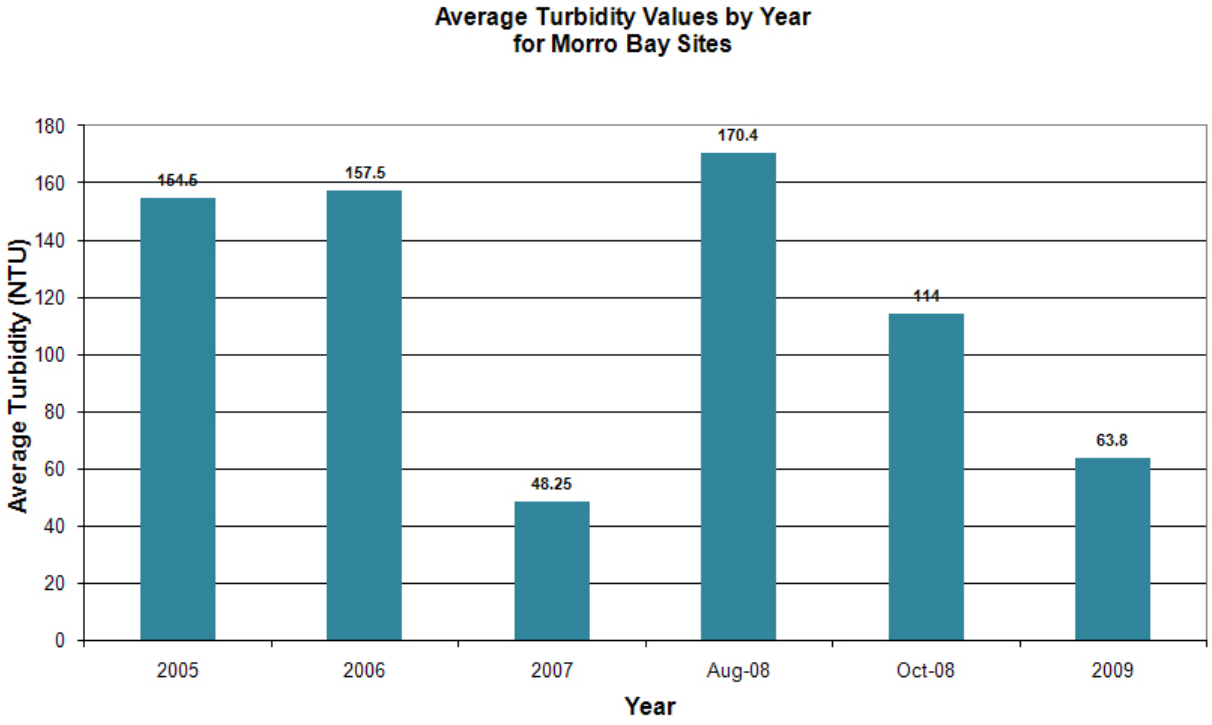
For the duplicate sample, the results showed an acceptable amount of variability, demonstrating the precision of the laboratory analysis and verifying that proper sample handling procedures were used.

In the blank sample that was analyzed along with the samples, trace amounts of dissolved copper and zinc were detected, and the turbidity reading was 0.2 NTU. The blanks submitted for bacteria analysis came back with non-detect results. These results showed no indication of contamination due to either sample handling or analysis.

Turbidity

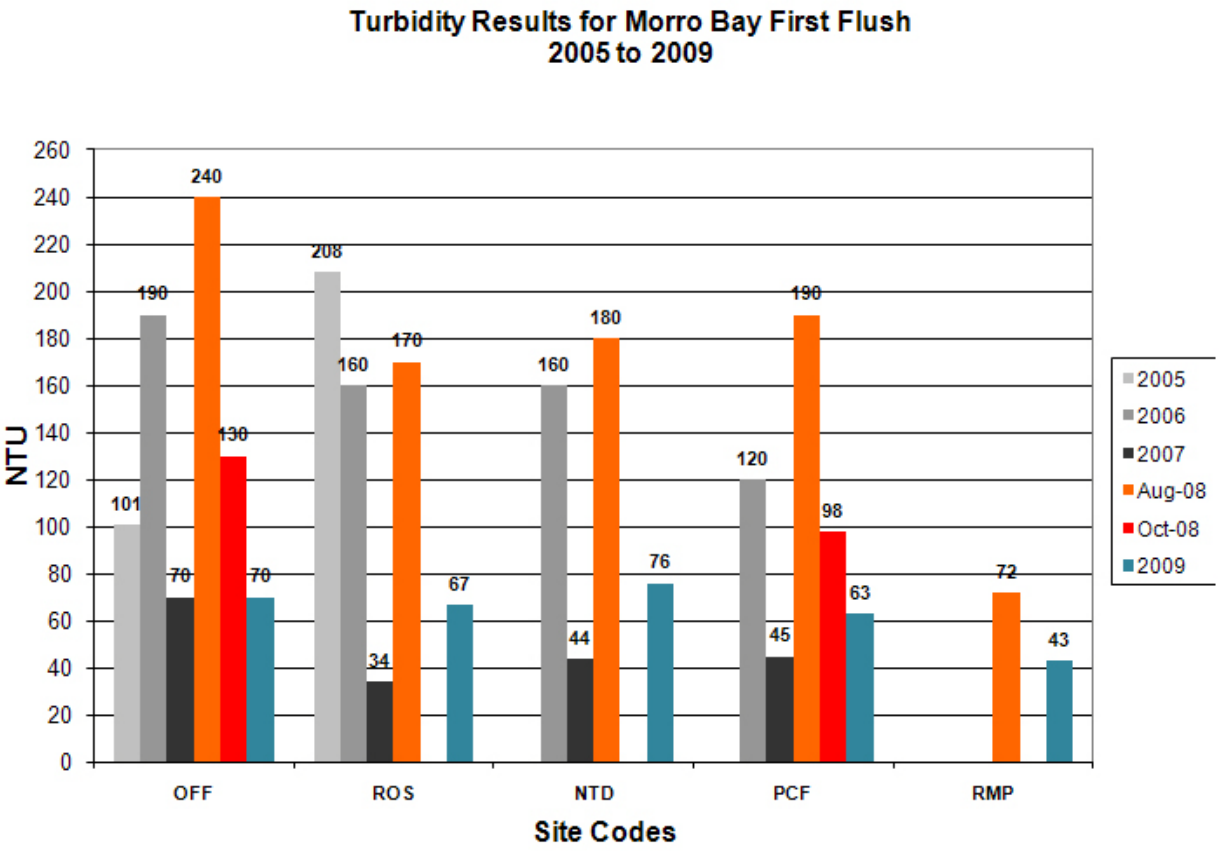
Nephelometric turbidity is a standard measurement of water clarity, specifically the light penetration through a known volume of water. The CCAMP informal attention level for turbidity in receiving waters is 10 NTU. The average value for runoff from Morro Bay sites in 2009 was 64 NTU. The average results from the previous year were 170 NTU from the August 2008 sampling event and 114 NTU for the first sample from the October 2008 time series. The lower than usual average of 48 NTU in 2007 is likely due to sampling taking place more than an hour after the start of sheet flow. The lower turbidity results for 2009 confirm that samples were collected more than an hour after the start of sheetflow during the October 13 storm.

Chart 1. Average Turbidity Values by Year for Morro Bay.



A comparison of turbidity values by year for four of the most frequently monitored Morro Bay sites are shown in Chart 2. The values from the August 2008 storm event were relatively high, possibly due to the short and intense duration of the storm which resulted in flows from the drains that were dominated by baseflow. The first sample from the October storm time series from 2008 is included for comparison. The lower than normal values in 2007 and 2009 were likely due to sampling taking place more than an hour after the start of sheet flow.

Chart 2. Turbidity Results for 2005 to 2009.

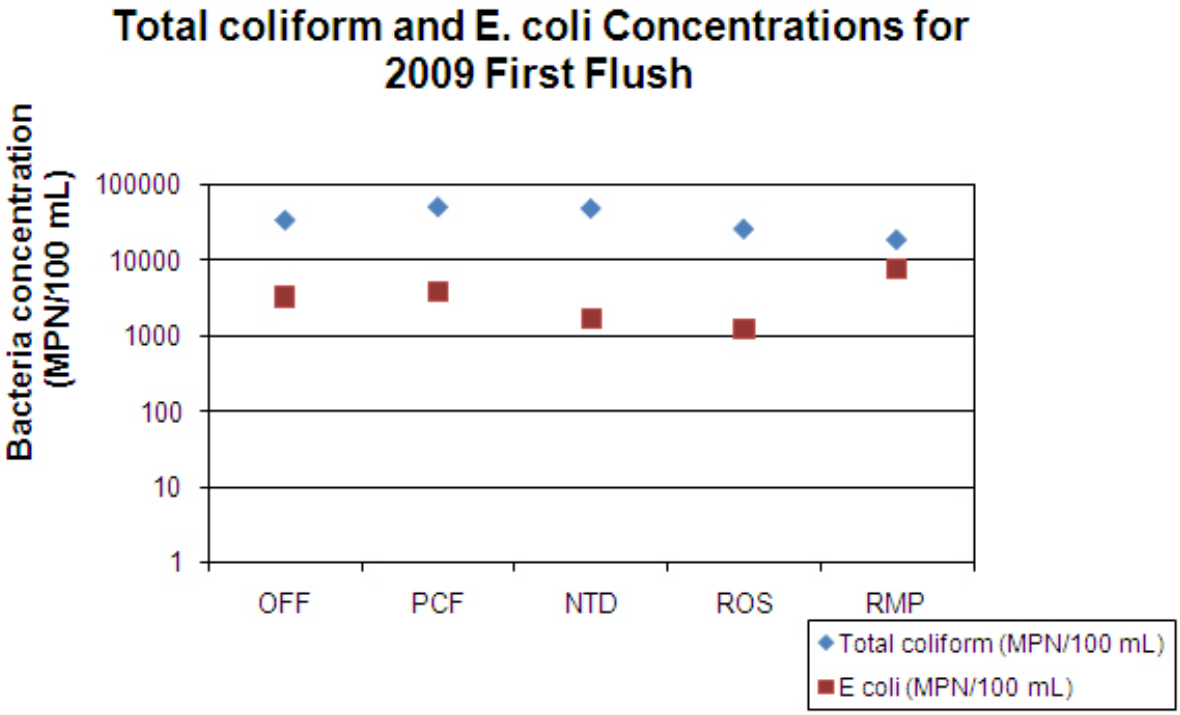


Bacteria

The EPA's recommended criteria for *E. coli* for safe recreational contact in freshwater receiving waters is 235 MPN/100 mL. Note that this is a standard applied to receiving waters rather than the stormwater runoff itself. The Basin Plan standard for total coliform is 10,000 MPN/100 mL, and the standard for fecal coliform is 400 MPN/100 mL.

Chart 3 shows the total coliform and *E. coli* results on a log scale for the five sites sampled in the October 13, 2009 event.

Chart 3. *E. coli* and total coliform values for the October 2009 sampling event.



The 2009 data can be directly compared with results from 2005, 2006, 2007 and 2008 since the same indicator species were analyzed in all three years. The historical effort (during the 1990's) analyzed for total and fecal coliform, while the more recent effort analyzed for total coliform and *E. coli*. However, the fecal coliform and *E. coli* results can still be compared to look at overall trends. The bacteria data for current and past efforts are presented in Table 3.

Table 3. Bacteria Concentrations in MPN/100 mL.

Year	ROS	OFF	NTD	PCF	RMP
Fecal coliform for 1996	-	-	9,000	-	-
Fecal coliform for 1997	-	-	22,000	-	-
***E. coli* for 2005**	1,935	4,130	-	-	-
***E. coli* for 2006**	771	862	471	934	-
***E. coli* for 2007**	12,740	4,106	4,352	3,873	-
***E. coli* for Aug 2008**	12,997	10,462	21,780	2,382	754
***E. coli* for October 2008, first sample in series**	-	3,448	-	3,873	-
***E. coli* for Oct 2009**	1,223	3,255	1,670	3,873	7,701

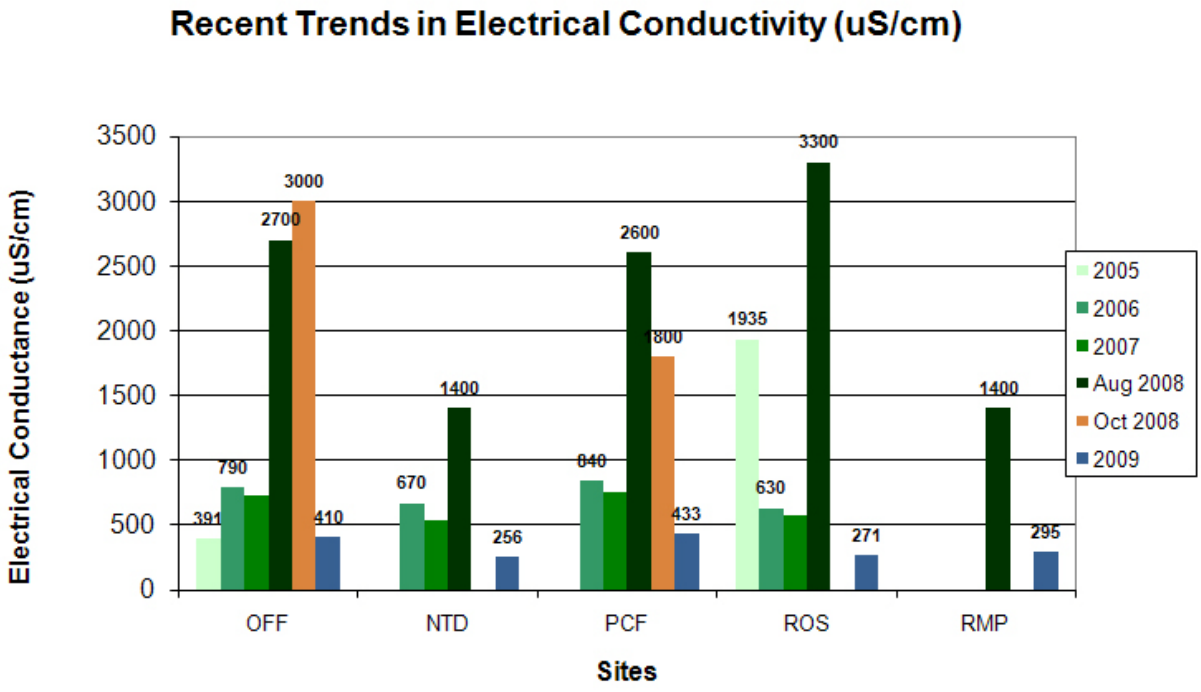
In comparing the results from year to year, it is interesting to note than in 2007, sampling likely took place more than an hour after the start of sheet flow (which typically would mean decreased results) while in the August 2008 event the sampling took place during a brief intense storm that primarily captured baseflow (which would mean increased results). Similar to the 2007 event, sampling in 2009 took place more than an hour after the start of sheet flow. However, as demonstrated in the 2008 time series sampling, the bacteria results do not follow the expected

trend of decreasing throughout the storm. While the 2009 sampling took place later in the storm, the results are not uniformly lower than in years when sampling took place earlier in the storm.

Conductivity

All of the sites sampled in October 2009 had conductivity values below 1,000 uS/cm, the value considered to be the threshold for determining whether the sample is stormwater runoff (due to dilution by rainfall which has a low conductivity value) or baseflow (which typically has high conductivity since it has not yet been substantially diluted by rainfall). This value was determined empirically by the Monterey Bay National Marine Sanctuary from their dry season runoff monitoring. Its applicability in our area has not been established.

Chart 4. Electrical conductivity values for First Flush Sampling.



For the October 2008 storm, only the results for the first sample in the time series were included in the graph. During the October 2008 time series data, the conductivity levels dropped off to less than 700 uS/cm within an hour. Based on that trend, sampling in 2009 likely occurred more than an hour after the start of the storm since the conductivity values ranged from 256 to 433 uS/cm.

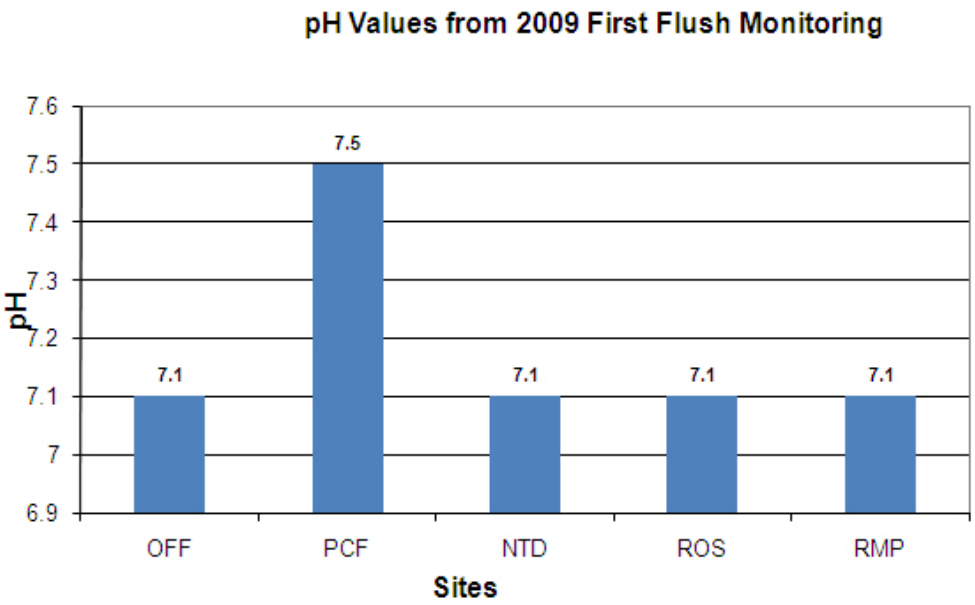
pH

The Basin Plan pH standards for the protection of marine life (MAR Beneficial Use) state that pH levels should not fall below 7.0 or rise above 8.5 units. In 2006, five of the 13 sites had pH levels below 7.0. In 2007, six of the eight sites had pH levels below 7.0. In the August 2008 storm, all of the results were below 7.0. In the October 2008 storm, two of the eight results were below 7.0. In the October 2009 storm, all pH results were between 7.1 and 7.5.

Between 2006 and 2007, the EPA method of analysis was revised to allow only a 15-minute hold time between sample collection and analysis. It is not possible to meet this hold time with this type of monitoring due to the logistics of sampling. The impact on the pH values is not known.

In general, if samples have prolonged exposure to air prior to analysis, they absorb carbon dioxide and form carbonic acid, which lowers the pH value. Since the samples are not exposed to air prior to analysis, the impact on pH is likely minimal.

Chart 5. pH units for 2009 monitoring.



Oil & Grease

Oil and grease were not detected at any of the sites in 2005, nor in the historical datasets. There were detections at two of five Morro Bay sites in 2006: OFF (6.0 mg/L) and ROS in Morro Bay (5.0 mg/L). There were no detections at the four Morro Bay sites sampled in 2007. In the August 2008 sampling, four of the five samples had detections of oil and grease. In the October 2008 time series samples, only the first sample in the series at each of the sites had detections. The subsequent three samples in the time series did not have detections of oil and grease. For 2009, only one of the four sites had a detection results (OFF, PCF and ROS). NTD had a result of 8.3 mg/L. The sample from RMP was contaminated by the lab, so those results had to be discarded.

The low incidence of detection for this parameter may be due in part to the relatively high quantitation limit for this method of testing (5.0 mg/L). It is important to note that the testing method for oil and grease does not distinguish between hydrocarbon or petroleum-based substances and biological oils such as animal fats, vegetable oils and soaps. Oil and grease concentrations shown in this report do not solely reflect petroleum-based oils.

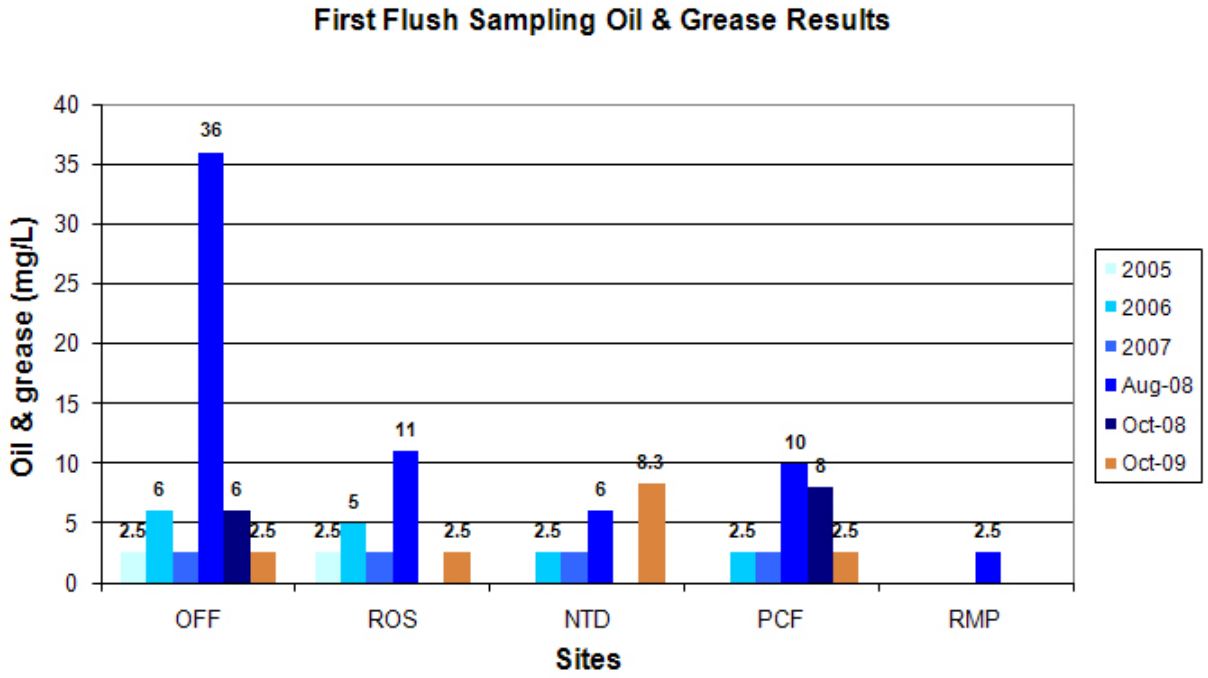
Table 4. Recent trends in oil and grease results.

Site	2005	2006	2007	Aug 2008	Oct 2008, first sample in series	October 2009
OFF	2.5	6.0	2.5	36	6	2.5
NTD	-	2.5	2.5	6	-	8.3
PCF	-	2.5	2.5	10	8	2.5
ROS	2.5	5.0	2.5	11	-	2.5
RMP	-	-	-	2.5	-	*

Values in blue denote non-detect levels.
*Sample contaminated by the lab. Valid results are not available.

In the time series data from the October 2008 sampling event, oil and grease was detected in the first sample but the concentrations dropped off to non-detect levels on all subsequent samples. Chart 6 contains only the first sample from the time series collected in the October 2008 storm.

Chart 6. Oil & Grease results.



In 2007, when samples were collected more than an hour after the start of sheet flow, the oil and grease results were all non-detects. In 2009, where sampling also took place more than an hour after the start of sheet flow, the non-detect results at OFF, ROS and PCF were expected. The elevated value at NTD is a potential area of concern, given the delayed monitoring time, and may merit further attention.

There are currently no standards set forth in the Central Coast Basin Plan for oil and grease. The EPA has an oil and grease benchmark of less than 15 mg/L for industrial NPDES permits, although this benchmark was not established to be protective of receiving waters.

Due to difficulty in sampling, no TPH-gasoline analysis was conducted in the 2009 effort.

Toxic Metals

The Basin Plan lists standards for toxic metals concentrations in marine environments with the following values: Copper 0.01 mg/L, Lead 0.01 mg/L, Nickel 0.002 mg/L, and Zinc 0.02 mg/L. These results are compared to the standards for marine receiving waters for the protection of fish and wildlife for the Marine Habitat (MAR) beneficial use. In this analysis, the concentrations in the stormwater runoff itself are being compared to the receiving water standards.

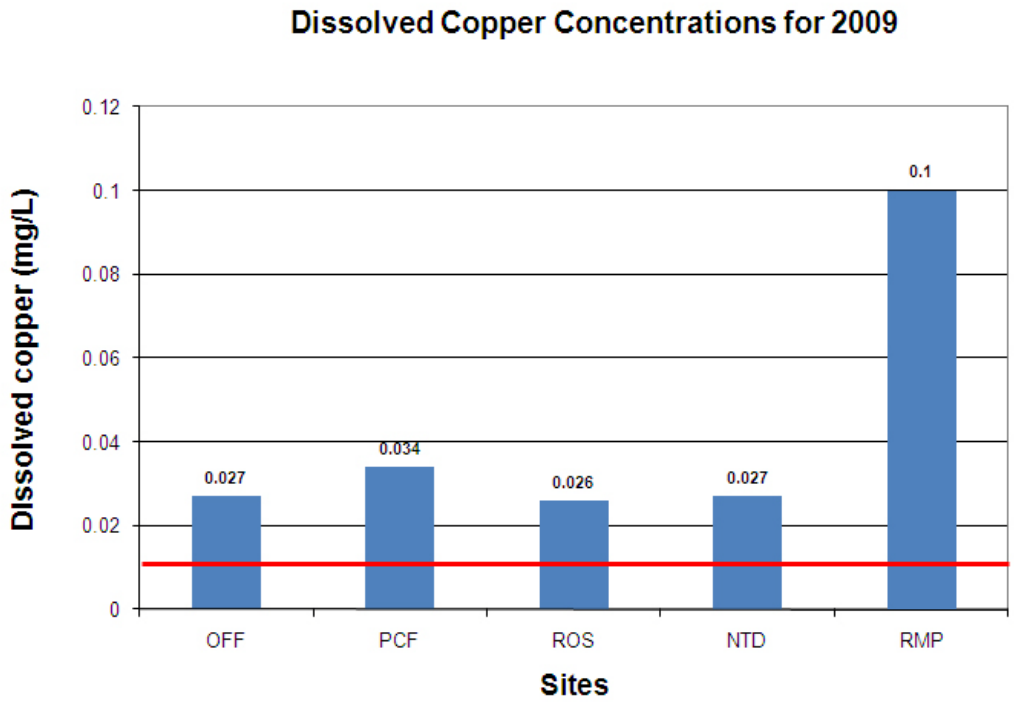
Table 5. Metals results.

Analyte	Site	1995	1996	1997	2005	2006	2007	Aug 2008	Oct 2008, first in series	Oct 2009
Copper (mg/L)	ROS	-	-	-	0.052	0.056	0.067	0.18	-	0.026
	NTD	0.025	0.036	0.016	-	0.051	0.065	0.093	-	0.027
	OFF	-	-	-	0.029	0.044	0.044	0.120	0.077	0.027
	PCF	-	-	-	-	0.079	0.06	0.27	0.160	0.034
	RMP	-	-	-	-	-	-	0.42	-	0.1
Lead (mg/L)	ROS	-	-	-	0.004	0.005	0.004	0.004	-	0.002
	NTD	0.011	0.018	0.019	-	0.003	0.002	0.003	-	0.001
	OFF	-	-	-	0.002	0.004	0.002	0.004	0.001	0.002
	PCF	-	-	-	-	0.004	0.003	0.002	0.003	0.002
	RMP	-	-	-	-	-	-	0.003	-	0.001
Nickel (mg/L)	ROS	-	-	-	0.021	0.026	0.024	0.087	-	0.008
	NTD	0.025	0.025	0.025	-	0.032	0.026	0.055	-	0.01
	OFF	-	-	-	0.016	0.029	0.027	0.056	0.044	0.014
	PCF	-	-	-	-	0.036	0.025	0.072	0.054	0.013
	RMP	-	-	-	-	-	-	0.043	-	0.009
Zinc (mg/L)	ROS	-	-	-	0.380	0.470	0.6	1.6	-	0.16
	NTD	0.101	0.265	0.139	-	0.35	0.35	0.91	-	0.071
	OFF	-	-	-	0.160	0.400	0.39	1.0	0.530	0.12
	PCF	-	-	-	-	0.65	0.58	1.5	1.200	0.15
	RMP	-	-	-	-	-	-	0.70	-	0.073

The metals concentrations were consistently lower in the 2009 sampling event than in previous years, likely due to sampling occurring more than an hour after the start of sheet flow. As demonstrated in the October 2008 time series sampling event, metals concentrations dropped off over the hour when sampling occurred for all metals except lead.

Dissolved copper ions in stormwater can be generated from a variety of sources. Increased use of copper as an architectural material in some areas has been linked to elevations in dissolved copper ions in stormwater runoff. Copper is also a major component of automobile brake pads and is released into the environment as brake pads wear down. Copper exhibits both chronic and acute toxicity in many species of marine invertebrates including varieties of mussels, oysters, sea urchins and sand dollars. The Basin Plan standard to protect marine life is detection of less than 0.01 mg/L of copper in marine waters (indicated by the red line in the charts).

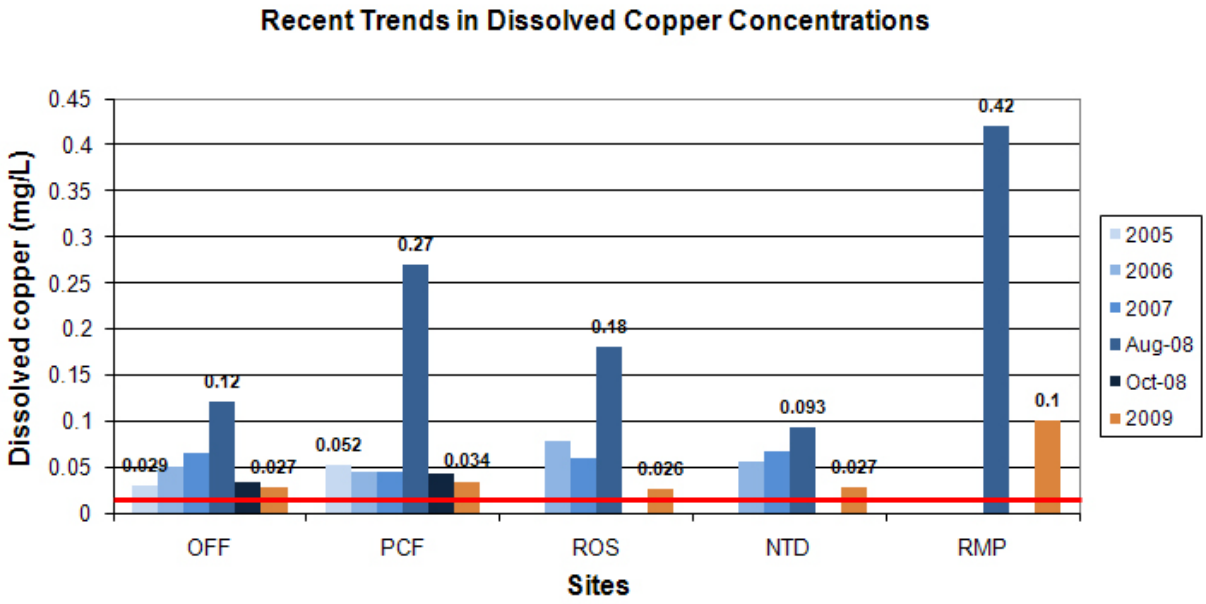
Chart 7. Dissolved copper concentrations for 2009.



Dissolved copper concentrations detected in 2009 were lower than historical data except for two samples from NTD in the mid-1990s. This is likely due to sampling occurring more than an hour after the start of sheet flow. However, copper concentrations far exceeded the Basin Plan standard protective of aquatic life. Of note, the copper concentration at RMP is considerably higher than at other sites monitored, a trend which was also followed in the samples collected in August of 2008. The RMP site drains areas with a residential land use type. Marine paint and architectural use of copper are two suspected sources.

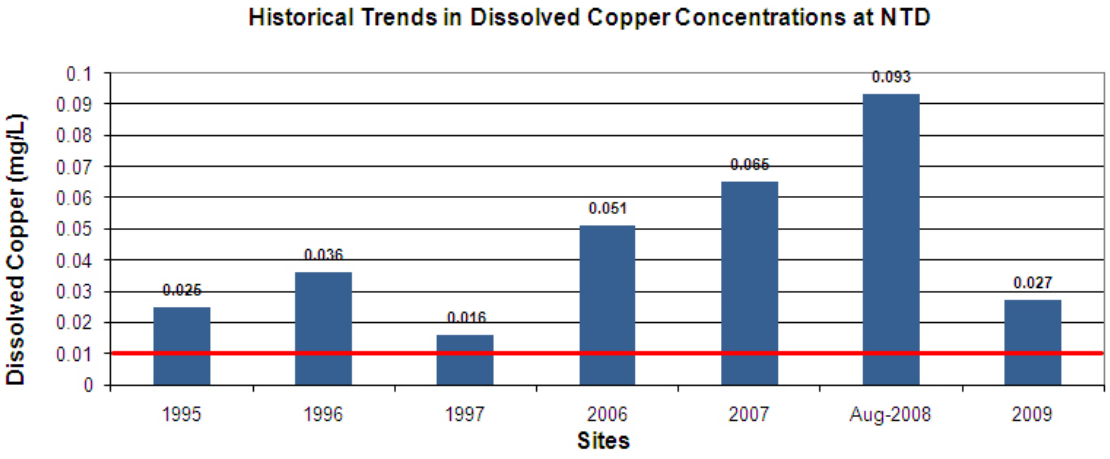
For sites where monitoring historically took place, the following two charts show the trends in dissolved copper concentrations in recent monitoring efforts (2005 through 2009) and historical monitoring efforts (1995, 1996, 1997, 2006, 2007, 2008 and 2009). For the October 2008 data, only the first sample in the series was included. The copper concentrations from the August 2008 storm are considerably higher than previous years, indicating the sampling of baseflow rather than runoff. The elevated value at RMP from 2009 is of note because it exceeds all historical data at all sites, other than the samples from August 2008.

Chart 8. Recent trends in dissolved copper concentrations.



The following chart shows results for NTD, where monitoring has consistently taken place over the years. A review of historic dissolved copper concentrations (1990's) indicates that dissolved copper concentrations have increased at this site.

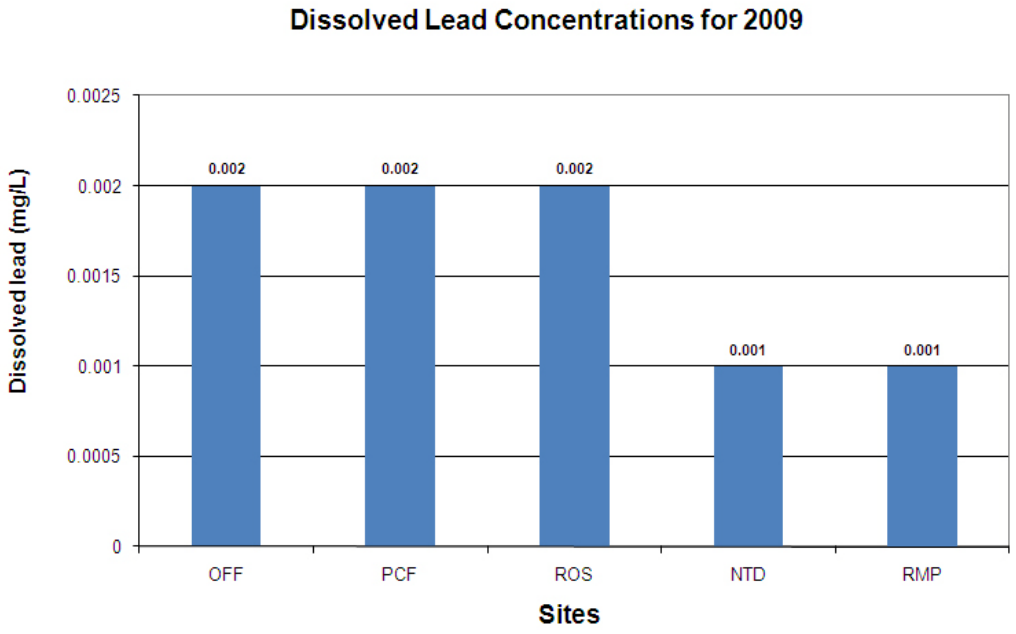
Chart 9. Historic trends in dissolved copper concentrations.



Dissolved lead remains a contaminant of concern in urban stormwater runoff. Although lead is no longer used as a gasoline additive, remnant lead contamination has been detected in soils near highways and in drainages for highway stormwater. Lead remains present in gasoline today at lower 'natural' concentrations. The Central Coast Basin Plan states the criteria of 0.01 mg/L dissolved lead should not be exceeded for protection of marine life.

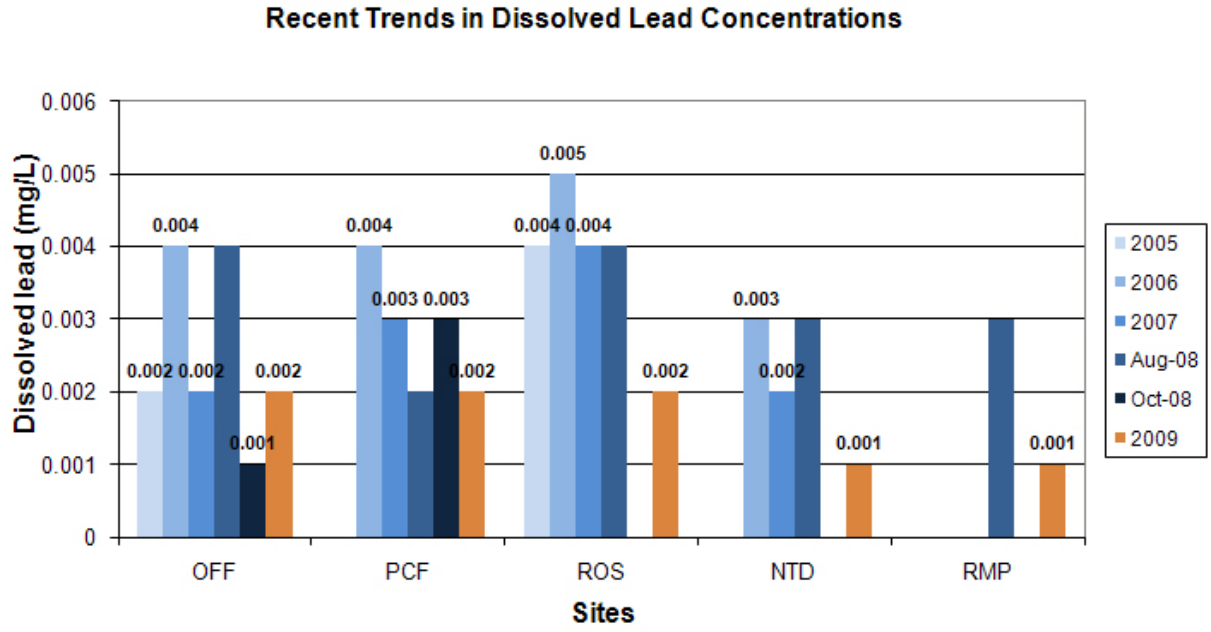
In the 2009 samples, lead was detected at all five of the Morro Bay sites. The analytical detection limit for dissolved lead is 0.001 mg/L. None of the sites exceeded the Basin Plan standard of 0.01 mg/L.

Chart 10. Dissolved lead concentrations for 2009.



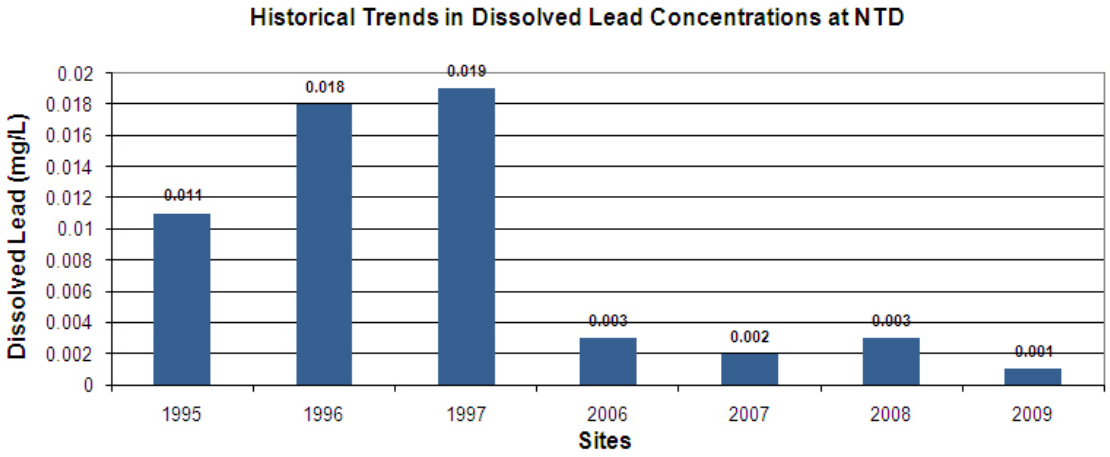
For sites where monitoring historically took place, the following chart shows the trend in dissolved lead concentrations in recent monitoring efforts (2005 through 2009).

Chart 11. Recent trends in dissolved lead concentrations.



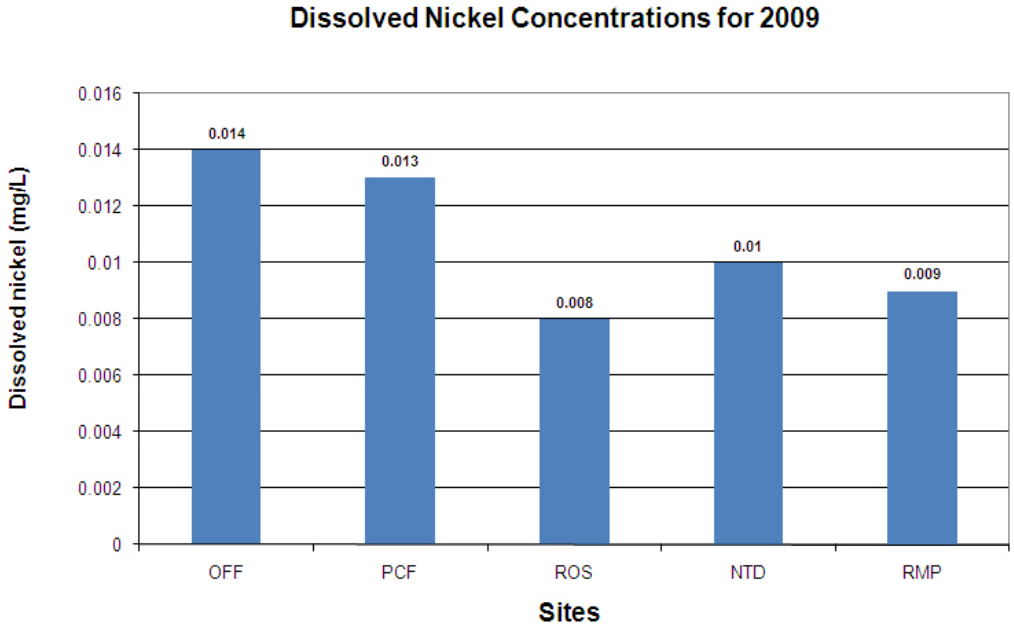
A review of historic data (1990's) indicates that lead concentrations have been reduced at the NTD site. The unusually low detection of 0.001 mg/L in 2009 is likely due to sampling taking place more than an hour after the start of sheet flow.

Chart 12. Historic trends in dissolved lead concentrations.



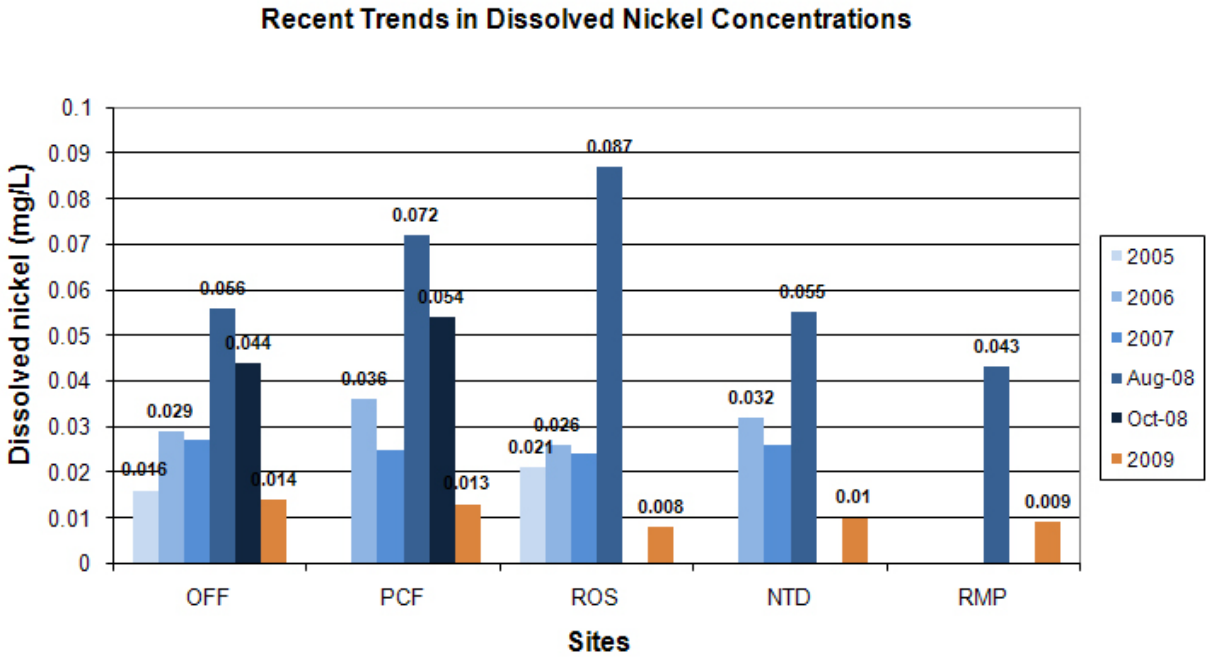
There are a variety of urban sources that can contribute to dissolved nickel in stormwater. Nickel is produced in gasoline and diesel fuel combustion and is a major component of nickel-metal hydride (NiMH) batteries. The Basin Plan standard is listed for nickel salts, while FF analysis was conducted for dissolved nickel.

Chart 13. Dissolved nickel concentrations for 2009.



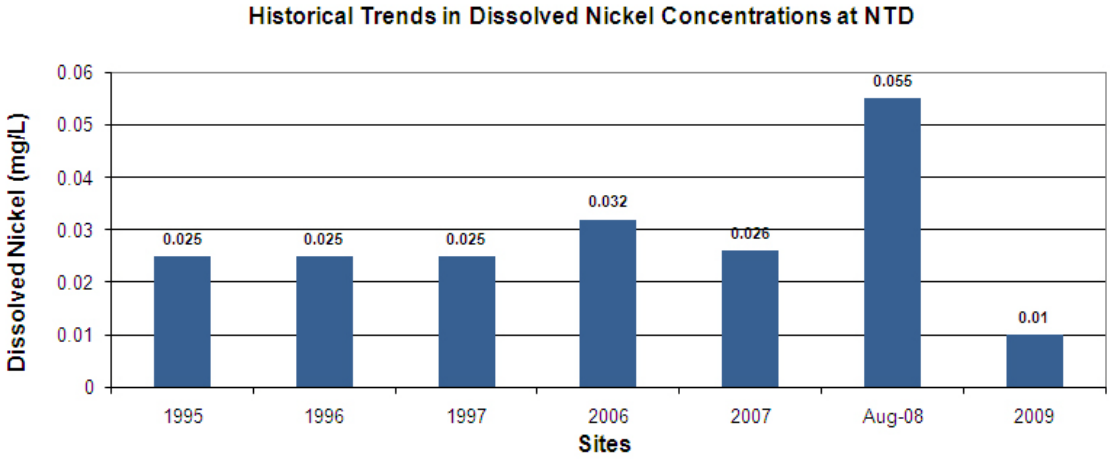
For sites where monitoring historically took place, the following two charts show the trends in dissolved nickel concentrations in recent monitoring efforts (2005 through 2009) and historical monitoring efforts (1995 through 2009). Only the first sample from the time series in the October 2008 storm was included.

Chart 14. Recent trends in dissolved nickel concentrations.



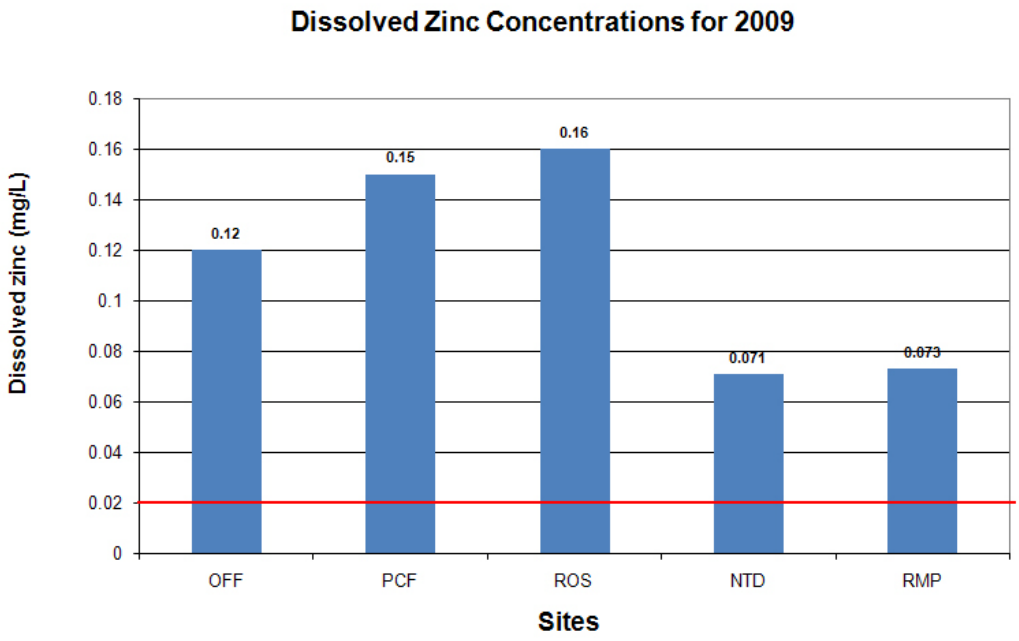
As NTD is the site monitored the most consistently for dissolved nickel throughout the historical and recent monitoring efforts, it is the only site depicted in the following graph. Although historical lab reports are not available for confirmation, it is likely that a level of 0.025 mg/L indicates a non-detect result for the method of analysis at that time. Other than the August 2008 results, which are believed to be elevated due to the effect of baseflow, the dissolved nickel concentrations at these sites appear to be relatively stable.

Chart 15. Historic trends in dissolved nickel concentrations.



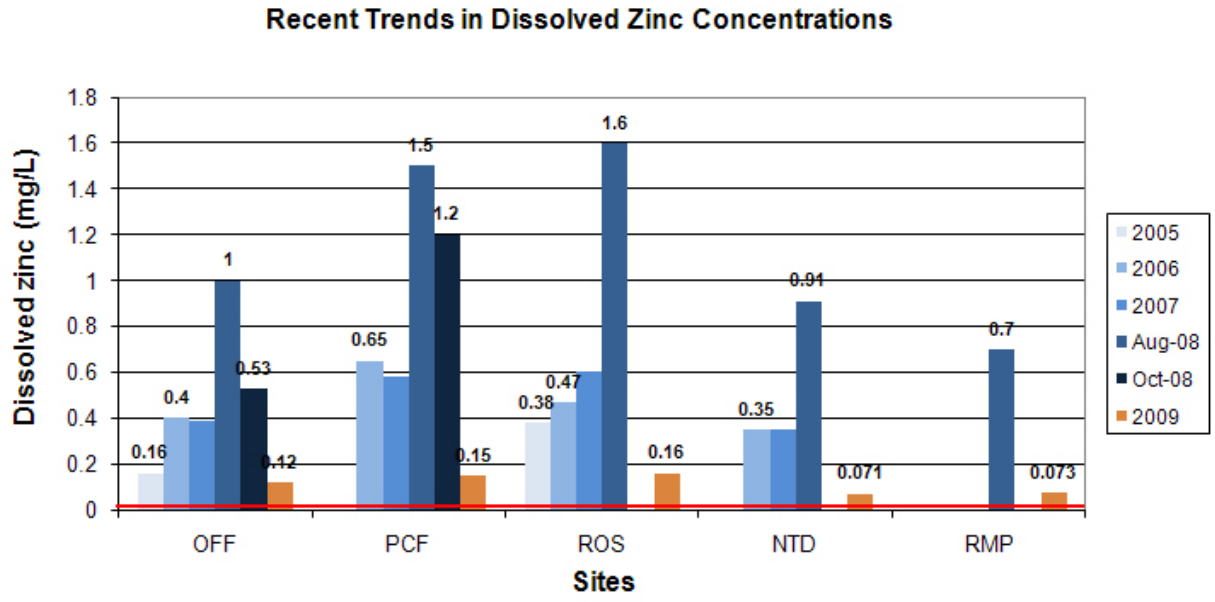
Zinc is a major component of automobile tires and is deposited on roadways as tires wear down. Zinc can also be deposited directly onto roadways through leaked hydraulic fluid or motor oil. Industrial areas with high volumes of heavy machinery in operation are considered an important 'source' of zinc in urban runoff. Residential sources of zinc include galvanized roofing materials or zinc paints used to prevent rusting or corrosion. Zinc becomes toxic at low levels in the environment, with lethal effects on plankton and marine fouling organisms. The Basin Plan standard for zinc is 0.02 mg/L for the protection of marine life.

Chart 16. Dissolved zinc concentrations for 2009.



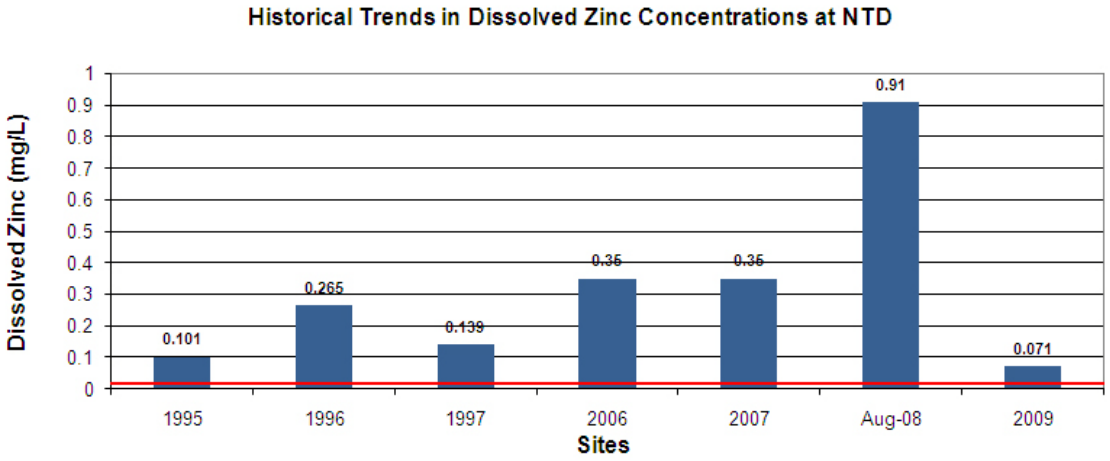
For sites where monitoring historically took place, the following two charts show the trends in dissolved zinc concentrations in recent monitoring efforts (2005 through 2009) and historical monitoring efforts (1995 through 2009).

Chart 17. Recent trends in dissolved zinc concentrations.



As with dissolved nickel, NTD was the site monitored the most consistently for dissolved zinc throughout the historical and recent monitoring efforts. Because the August 2008 sampling was not in conditions consistent with previous monitoring efforts, the elevated concentration should not necessarily be interpreted as a reason for concern. Dissolved nickel concentrations appear to be relatively stable at this site between the 1990s and the 2000s.

Chart18. Historic trends in dissolved zinc concentrations.

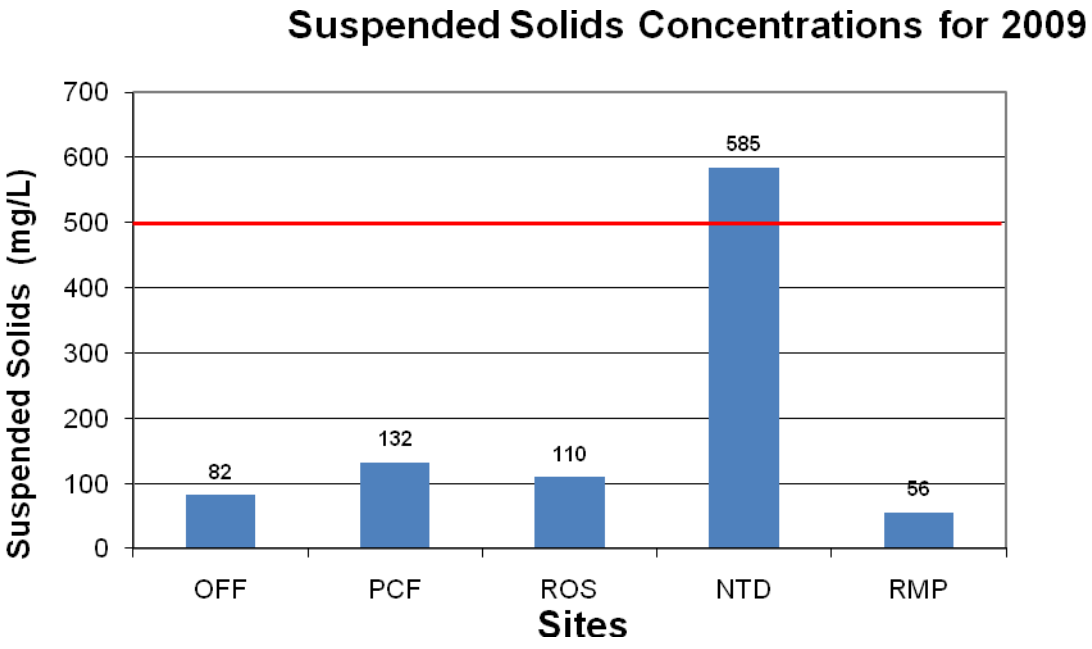


Dissolved and Suspended Solids

The CCAMP informal attention level for total suspended solids and total dissolved solids is 500 mg/L. These action levels are not regulatory standards but rather levels where previous data have shown a potential negative impact on aquatic life. Suspended solids are an important constituent as they can affect water clarity and also provide substrate for sediment-bound pollutants such as toxic metals.

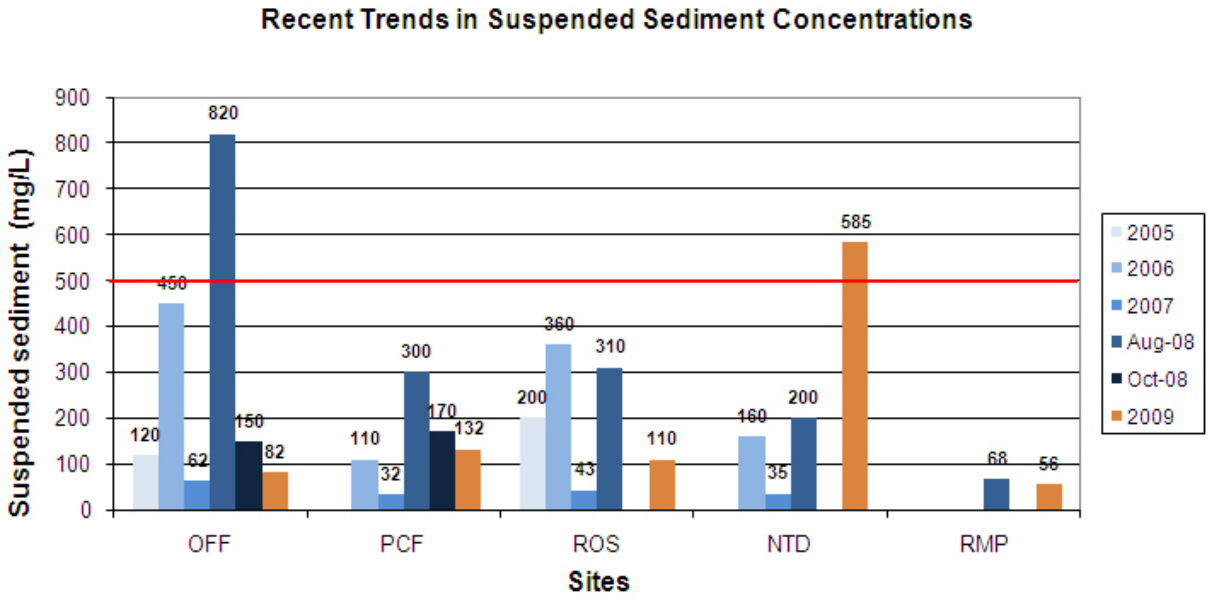
The NTD site was the only one in 2009 with concentrations above 500 mg/L.

Chart 19. Total suspended solids concentrations for 2009.



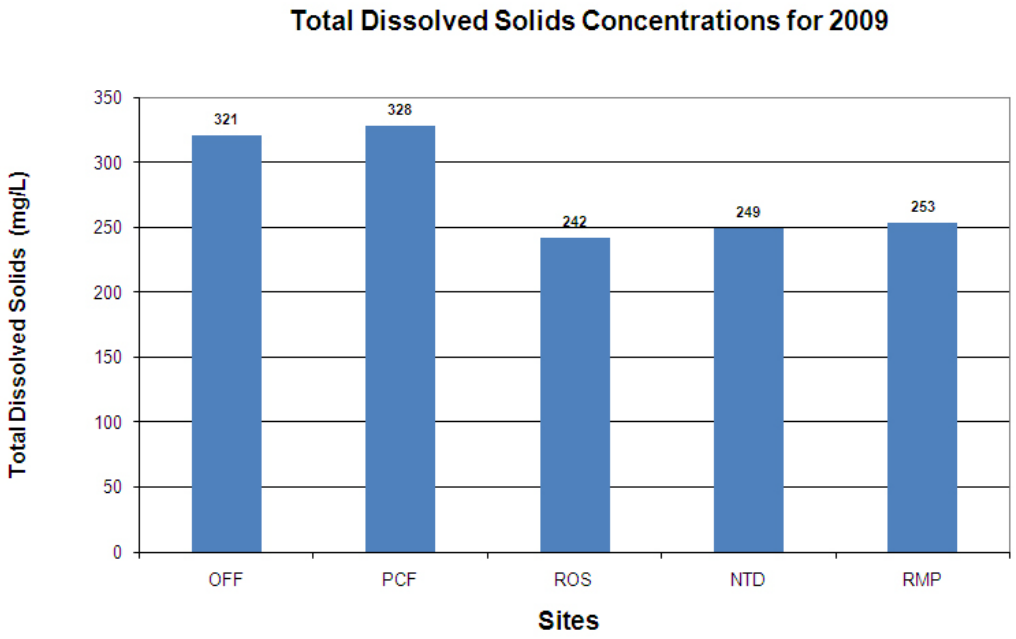
In the 2009 data, TDS was low at all sites except for NTD, which had the highest reading detected at that site since 2005.

Chart 20. Recent trends in suspended solids for Morro Bay.



Total dissolved solids (TDS) can be made up of ions, nutrients and pesticides and represent the substances in the water that cannot be removed by a 2 um filter. Results in 2009 for all sites were less than the 500 mg/L level of concern

Chart 21. Total dissolved solids concentrations for 2009.

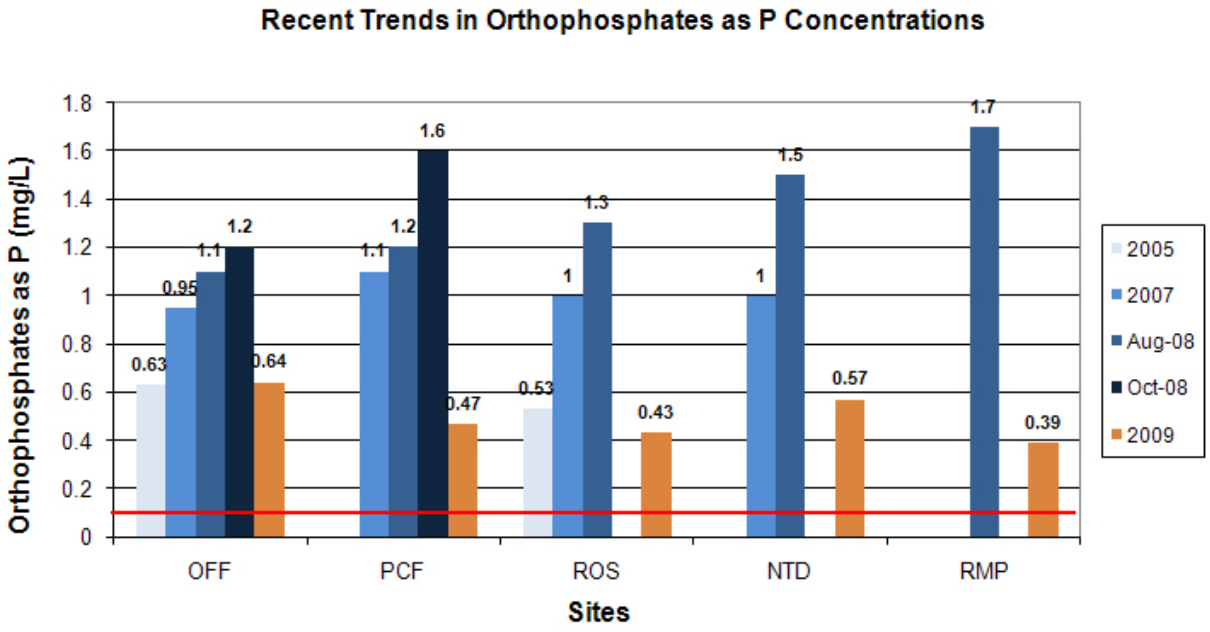


Nutrients

Starting in 2005, samples were analyzed for nitrates as N and orthophosphates as P. These recent results are not comparable to data from historical FF efforts because different constituents were analyzed.

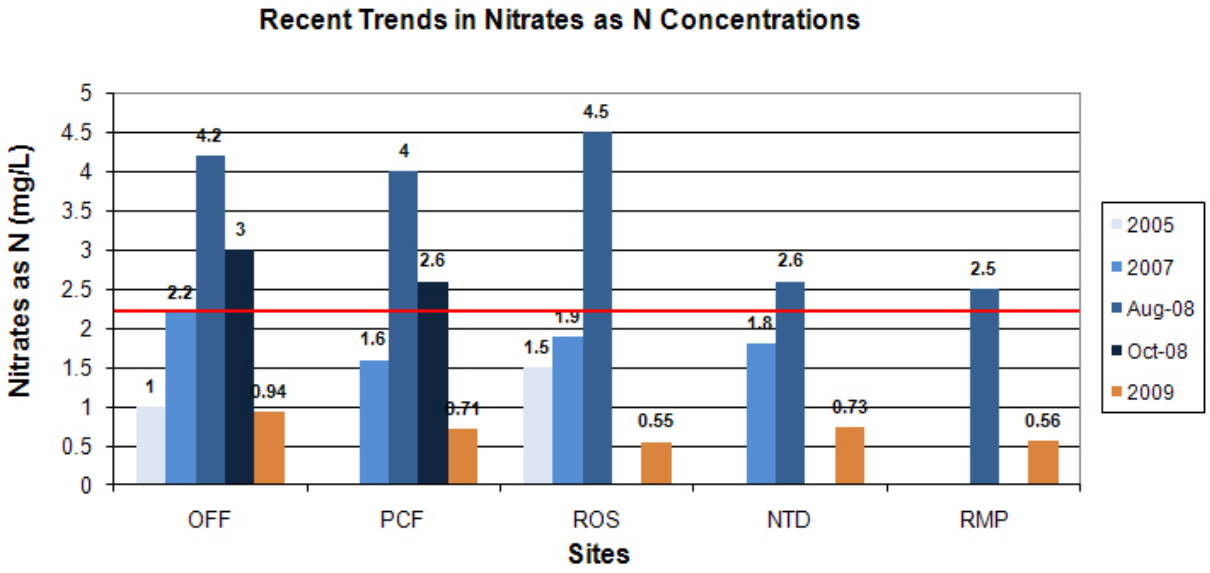
The CCAMP informal attention level of concern for orthophosphates as P is 0.12 mg/L. In 2009, results were relatively low compared to historical sampling, likely due to sampling taking place more than an hour after the start of the storm.

Chart 22. Recent trends in Orthophosphate as P concentrations.



The CCAMP informal attention level of concern for nitrates as N is 2.25 mg/L. The 2009 nitrate data followed the same trend as the orthophosphate data, with concentrations lower than historically measured levels.

Chart 23. Recent trends in Nitrate as N concentrations.



Overview of Results

The results from the 2009 FF effort highlighted the elevated levels of most pollutants which are typically present in stormwater.

The following results are especially notable and may merit further attention.

E. coli

- The *E. coli* levels were above EPA's recommended safe recreational contact level for freshwater of 235 MPN/100 mL at all sites, varying from 1,223 to 7,701 MPN/100 mL. This despite the fact that sampling took place more than four hours into the storm.

Turbidity

- Turbidity readings exceeded 10 NTU, the CCAMP attention level, at all sites. Readings varied from 43 to 76 NTU in the samples from the October 13, 2009 storm event.
- The overall average turbidity over all sites was lower in 2009 than in previous years, and similar to the average for 2007, a year when sampling also took place more than an hour after the start of the storm.

Orthophosphates as P

- Orthophosphates as P were detected at levels significantly above the CCAMP recommended attention level of 0.12 mg/L at all sites, and ranged from 0.39 to 0.64 mg/L.
- *All sites sampled since 2005* have had orthophosphate as P concentrations that exceeded the CCAMP recommended attention level, with concentrations ranging from 0.39 to 1.7 mg/L.

Oil and Grease

- Oil and grease results were non-detect at three of the five sites (OFF, ROS and NTD) and 8.3 mg/L at NTD. The sample for RMP was contaminated by the lab. None of the results had an oil and grease concentration that exceeded the 15 mg/L benchmark for industrial NPDES permits, although this level was not established to be protective of receiving waters.

Dissolved Zinc

- Zinc was detected at levels above the Basin Plan standard for receiving waters of 0.02 mg/L at all sites, with concentrations varying from 0.071 to 0.16 mg/L.
- As metals tend to decrease in time throughout a storm, the lower than usual values are expected since the sampling in 2009 occurred more than an hour after the start of the storm.

Dissolved Copper

- Copper was detected at all sites in both 2009 storms at levels above the Basin Plan standard for receiving waters of 0.01 mg/L. Concentrations ranged from 0.027 to 0.1 mg/L
- In the October 2009 storm, as in the August 2008 storm, RMP had the highest dissolved copper concentration detected in the event.

Dissolved Nickel

- Nickel was detected at all sites at levels exceeding the Basin Plan standard of 0.002 mg/L for receiving waters, with concentrations varying from 0.008 to 0.014 mg/L.
- Looking at NTD, which has monitoring data in the mid-1990s and the 2000s, the nickel concentrations detected appear to be relatively stable.

Parameters with detected levels below the regulatory or attention level were as follows:

Nitrates as N

- None of the results from the 2009 storm exceeded the CCAMP recommended attention level of 2.25 mg/L, with concentrations ranging from 0.55 to 0.94 mg/L.

pH

- pH values ranged from 7.1 to 7.5, all within the range of 7.0 to 8.5 that is protective of marine beneficial uses.

Dissolved Lead

- Lead levels at all sites in both storms were below the 0.01 mg/L regulatory standard.
- As a whole, lead concentrations detected in the mid-1990s were higher than the values detected during monitoring conducted ten years later.

Conductivity

- Conductivity levels ranged from 256 to 410 uS/cm. These readings were lower than what we normally detect, since sampling in 2009 took place more than an hour after the start of the storm. Typically once the drains are flushed of the baseflow, the conductivity readings drop, so a decreasing trend is expected throughout the storm.

TDS

- TDS concentrations ranged from 242 to 332 mg/L in the October 13, 2009 event. The CCAMP informal attention level is 500 mg/L.
- In the October 2008 storm, concentrations at OFF during the time series of data decreased from 2,200 to 550 mg/L through the time series, while the concentrations at PCF decreased from 1,500 to 450 mg/L. Thus, the lower TDS values from the 2009 monitoring is not indicative of an overall decreasing trend in TDS but rather due to sampling occurring more than an hour after the start of the storm.

TSS

- Suspended solids levels were below 500 mg/L, the CCAMP informal attention level, at all sites except NTD (585 mg/L). Looking at historical data, OFF was the only site with TSS levels exceeding the 500 mg/L attention level.

All sites had exceedances of regulatory standards and informal attention levels. However, elevated levels of a few of the analytes stood out:

- The OFF site had the highest detected concentrations of all of the sites for dissolved nickel (0.014 mg/L), and the highest nutrient concentrations (nitrate as N of 0.94 mg/L and orthophosphate as P of 0.64 mg/L).
- The PCF site had the second to highest detected concentration of zinc (0.15 mg/L).

- The NTD site had the only oil & grease detection (8.3 mg/L), the highest turbidity (76 NTU), and the highest TSS concentration (585 mg/L). It also had the second highest levels of nutrients (nitrate as N of 0.73 mg/L and orthophosphate as P of 0.57 mg/L).
- The ROS site had the highest dissolved zinc concentration (0.16 mg/L).
- RMP had the highest *E. coli* concentration of all of the sites (7,701 mg/L) and the highest dissolved copper concentration (0.1 mg/L). Of note, elevated copper concentrations were also detected at this site in the August 2008 sampling event, when the highest copper concentration ever was detected (0.42 mg/L) other than two results from a boat yard detected during sampling in the mid-1990s.

In general, a few observations can be made from the historical and current data sets.

- Samples from NTD, the only long-term Morro Bay site, shows that lead has decreased since the mid-1990s. Nickel levels have remained relatively stable. Zinc and copper concentrations at the site show an overall increasing trend.
- Copper concentrations at RMP have been notably high in two recent storms, possibly meriting further attention.
- Bacteria values continued to be mixed, with no clear trend from year to year. Bacteria concentrations do not decrease throughout a storm as do other analytical parameters, as shown by the time series data from 2008 and the elevated concentrations detected in 2009 more than four hours after the start of the storm.
- Oil and grease appear to be flushed fairly quickly, as it was primarily detected in the runoff at the beginning of a storm from the time series monitoring conducted in 2008. Because sampling in 2009 took place so long after the start of the storm, the elevated reading at NTD in 2009 (8.3 mg/L) could be of concern.
- For the nutrients, both orthophosphate as P and nitrates as N concentrations appear to decrease throughout a storm. All orthophosphate concentrations have exceeded the attention level in all samples collected since 2005.

Future Efforts

With the conclusion of the 2009 monitoring season, the VMP is halting its on-going stormwater monitoring effort. Monitoring has taken place during the first major storm of the season since 2005, and five years of data have demonstrated that the idiosyncracies of each storm make year-to-year data difficult to interpret. Each storm and subsequent sampling event is unique due to unseasonably early storms and intermittent rains, making analysis of trends over time extremely challenging. In the Monterey Bay National Marine Sanctuary's First Flush effort, data is always collected in a time series, and their data set has proven to be statistically sound. A much broader and more expensive effort would be required in Morro Bay to obtain similar results.

Appendices
FF 2009 Site Descriptions
FF Field Instructions
FF 2009 Datasheet

Urban Watch

Study Design

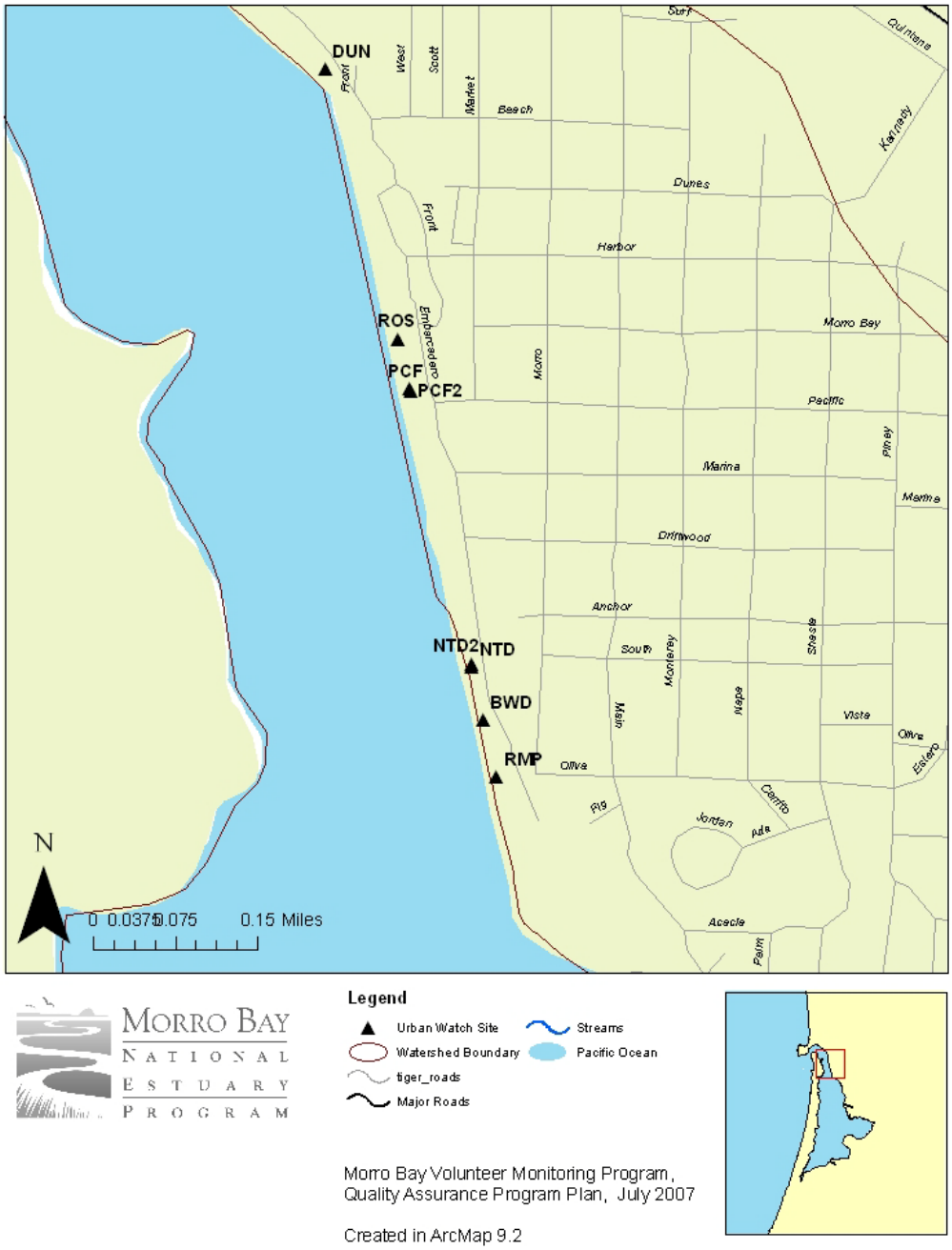
Site Selection
The 2009 effort was organized by the MBNEP's Volunteer Monitoring Program. The following considerations were weighed when selecting sites for UW monitoring:

- Which sites had safe access?
- Has there been a history of dry season flows at the site?
- Is the site also monitored for First Flush?
- Which sites are of interest to local agencies and regulators?

Based on these considerations, eight sites in Morro Bay and six sites in Los Osos were selected for UW monitoring. The site locations for 2009 were unchanged from the 2007 and 2008 monitoring seasons.

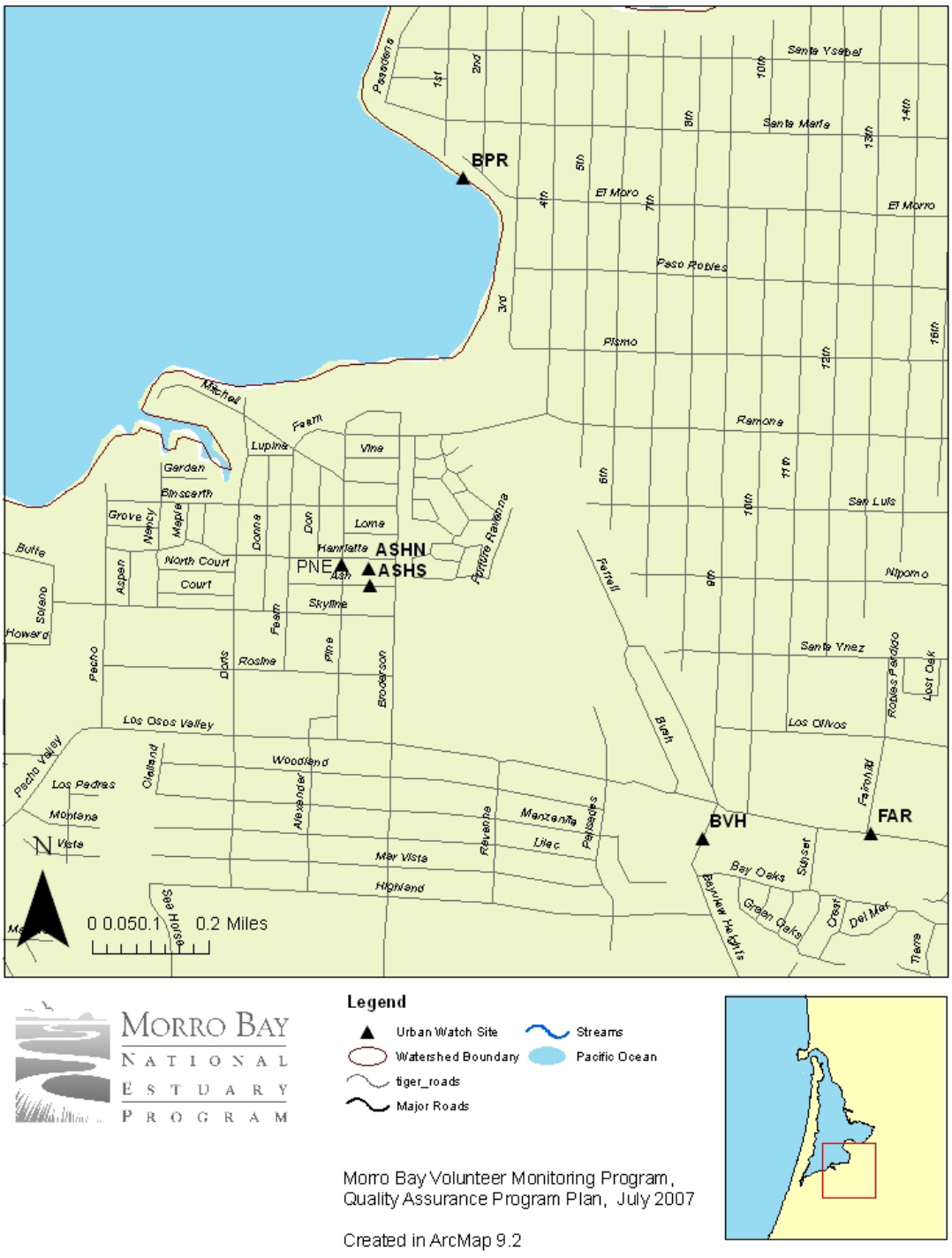
The eight Morro Bay sites were as follows:

- Culvert beneath the ramp to the public dock at north Tidelands Park. (RMP)
- Culvert that drains the boat wash station in north Tidelands Park. (BWD)
- Large black HDPE culvert near 451 Embarcadero. (NTD)
- Smaller black HDPE culvert located next to NTD. (NTD2)
- Culvert draining into the bay at the end of Pacific St. on the Embarcadero. (PCF)
- Set of two PVC drains for the parking lot at the end of Pacific St. (PCF2)
- Large concrete culvert near the public access dock between Rose's Landing and Embarcadero Grill Restaurants on the Embarcadero. (ROS)
- Culvert at the concrete ramp down to the dock, just south of the south T-pier, at the end of Dune St. (DUN)



The six Los Osos sites were as follows:

- Drain inlet on the south side of Ash St. between Pine and Broderson Streets, at the low point in the street. (ASHS)
- Drain inlet on the north side of Ash St. between Pine and Broderson Streets, at the low point in the street. (ASHN)
- Drain inlet in Pine St. between Ash and Henrietta Streets, on east side of street. (PNE)
- Culvert immediately south of Baywood Pier in Baywood. (BPR)
- Drain outlet into gutter on west side of Bayview Heights Drive, below the fire station, next to the former Taylor and Syfan office building parking lot driveway. (BVH)
- Drain inlet on Los Osos Valley Rd. at the corner of Fairchild St. (FAR)



Sample Collection

The UW program established in Monterey Bay was used as a model for our monitoring effort. In planning the effort, VMP staff met with personnel from the CCRWQCB, the city of Morro Bay, SLO County stormwater management, and the Los Osos Community Services District. They provided advice on selection of sites and monitoring parameters and let us know which data was of interest for their own NPS management needs. Based on this information, sites were selected for monitoring.

The monitoring program was designed so that the drains in each community would be monitored approximately once a week throughout the dry season. The monitoring season would end with the first major rains when FF monitoring was conducted.

Monitoring commenced on June 2, 2009 in Los Osos and on May 28, 2009 in Morro Bay. The sites in Los Osos were monitored approximately every other week, and the sites in Morro Bay were monitored approximately weekly. Monitoring ended in Los Osos in late September and in Morro Bay in early October in anticipation of the October 2009 FF monitoring.

Each volunteer visited the sites in their route (either Los Osos or Morro Bay) and filled out a checklist indicating the date and time of the observation and whether a site was flowing, dry, ponded or tidally-influenced. If the site had flow, then the volunteer conducted some field analysis, collected a sample for further analysis back at the office, and made observations on the color, odor, etc. of the flow. The volunteer completed a flow datasheet containing the results of their analysis and observations.

Sample Analysis

The analytes for UW were selected based on interest of regulators and agencies, as well as the technical feasibility of conducting the monitoring. All samples were analyzed by the volunteers using either meters or inexpensive test kits. Some analytes must be measured immediately upon collection, whereas others could be conducted later on samples collected with Whirl-Pak bags and stored either in a cooler with icepacks or in the refrigerator. The table below indicates if analysis takes place immediately in the field or later on in the lab, and describes the method of analysis.

Table 6. Urban Watch analytes.

Analyte	Where Analysis Conducted	Method of analysis	Detection Limit for Reporting
Water temperature	Field	Hanna HI 98312 conductivity meter	0.5°C
Conductivity	Field	Hanna HI 98312 conductivity meter	10 uS/cm
pH	Field	pH paper	0.5 pH units
Ammonia-Nitrogen	Field	HACH test strips	0.25 mg/L
Total chlorine	Field	LaMotte test kit	0.2 mg/L
Turbidity	Lab	HACH 2100P turbidimeter	0.01 NTU
Orthophosphate as PO_4	Lab	Hanna meter with HACH reagent	0.02 mg/L
Nitrate as N	Lab	LaMotte test kit	1 mg/L
Total coliform	Lab	HACH paddle testers	< 100 CFU

While there was great interest among the regulators in data on detergents, we could not identify a simple, low-cost method of conducting the analysis. Chemical analysis uses toxic reagents. We considered other methods that involved placing filters in storm drains and then using UV light to detect brighteners added to most detergents. However, while low tech and inexpensive, this method required a great deal of labor. Other groups are beginning to use a bench top meter for

fluorimetric detection. If this method proves to be reliable, we may consider adding it to the monitoring effort in the future. The state's Clean Water Team has a unit that we may be able to borrow in future seasons.

Sample Results

The 2009 UW results were compiled in an Access database. Although standards do not exist for the urban runoff itself, the data has been compared to various relevant standards from sources including the Basin Plan and CCAMP.

The following table summarizes the number of visits to each site during the monitoring season and indicates how often the site was flowing, had ponded water, was tidally-inundated or was dry. Note that the sum of the number of these four categories may not add up to the total number of site observations because volunteers were instructed to check-off as many categories as applied during a single site visit.

Table 7. Summary of observations of UW site visits.

City	Site Code	# observations with site flowing	# observations with site ponded	# observations with site dry	# observations with site tidally inundated	Total # observations
Morro Bay	BWD	1	5	13	0	19
	DUN	0	2	17	0	19
	NTD	2	10	2	6	19
	NTD2	0	3	16	0	19
	PCF	0	2	16	1	19
	PCF2	0	1	18	0	19
	RMP	9	3	7	0	19
	ROS	18	1	0	0	19
Los Osos	ASHN	0	5	3	0	8
	ASHS	0	5	3	0	8
	BPR	2	3	0	6	8
	BVH	3	5	0	0	8
	FAR	0	0	8	0	8
	PNE	0	1	7	0	8

In 2008, BVH in Los Osos had either flow or signs of recent flow in 11 out of 13 observations. In 2009, flow or signs of recent flow were detected in all eight observations. In Morro Bay in 2008, there was either flow or signs of flow in 11 of 18 observations at RMP, 13 of 17 observations at NTD, and 15 of 17 observations at ROS. In 2009, ROS had flow in all 19 observations, in 12 of 19 at NTD, and in 12 of 19 at RMP.

The following table provides a summary of the mean values from the analysis conducted on samples collected from Morro Bay sites. Flow was analyzed from 33 samples in 2009.

Table 8. Mean values of flow collected from Morro Bay sites.

Site	NTD	RMP	ROS
Number of samples	2	9	17
Water Temperature (°C)	17.6	15.2	18.8
Conductivity (uS/cm)	3,265	762	1,068
pH	7.25	7	7
Ammonia Nitrogen (mg/L)	0.25	0.33	0.21
Total Chlorine (mg/L)	0.15	0.11	0.27
Turbidity (NTU)	11.8	7.3	47.5
Orthophosphates as PO_4 (mg/L)	3.39	0.98	0.70
Nitrates as N (mg/L)	4.5	0.67	0.56
Total coliform (CFU)	75	194	702,100

The following table provides the average of results on samples collected from Los Osos sites.

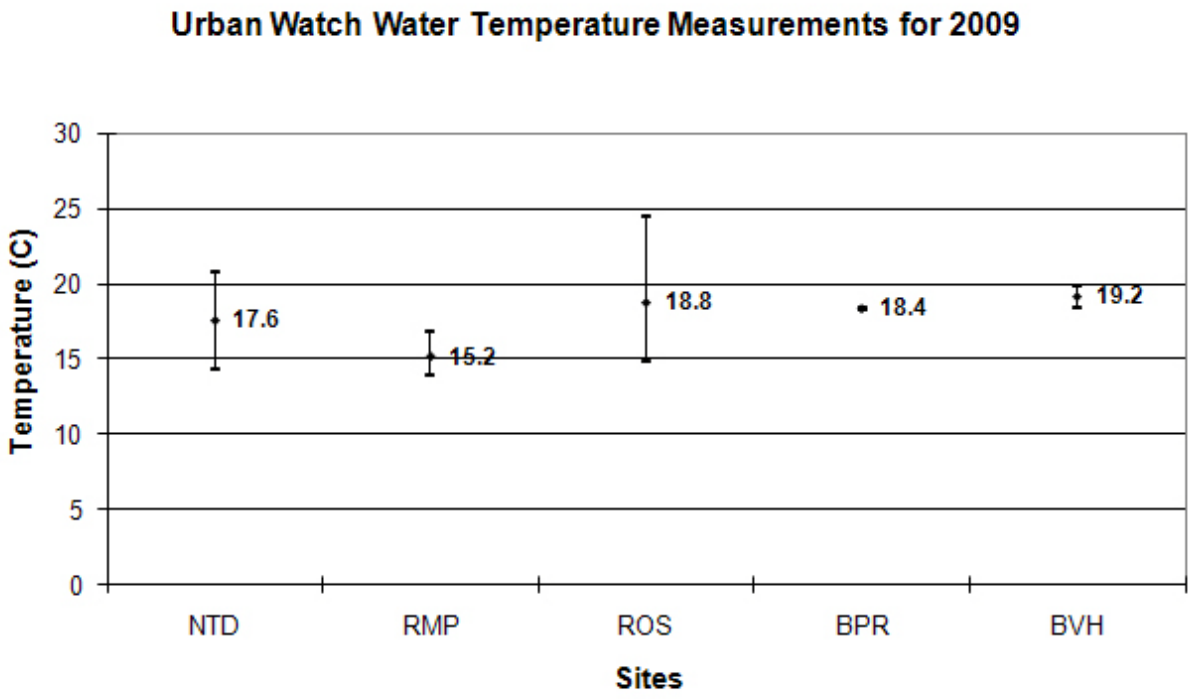
Table 9. Mean values of flow collected from Los Osos sites.

Analyte	BPR	BVH
Number of Samples	2	3
Water Temperature (°C)	18.4	19.2
Conductivity (uS/cm)	21,945	590
pH	7.5	7.17
Ammonia-N (mg/L)	0.38	0.08
Total Chlorine (mg/L)	0.1	0.1
Turbidity (NTU)	31.5	15.8
Orthophosphates as PO_4 (mg/L)	1.44	0.55
Nitrates as N (mg/L)	1.5	0.67
Total coliform (CFU)	100	1,000

Water Temperature

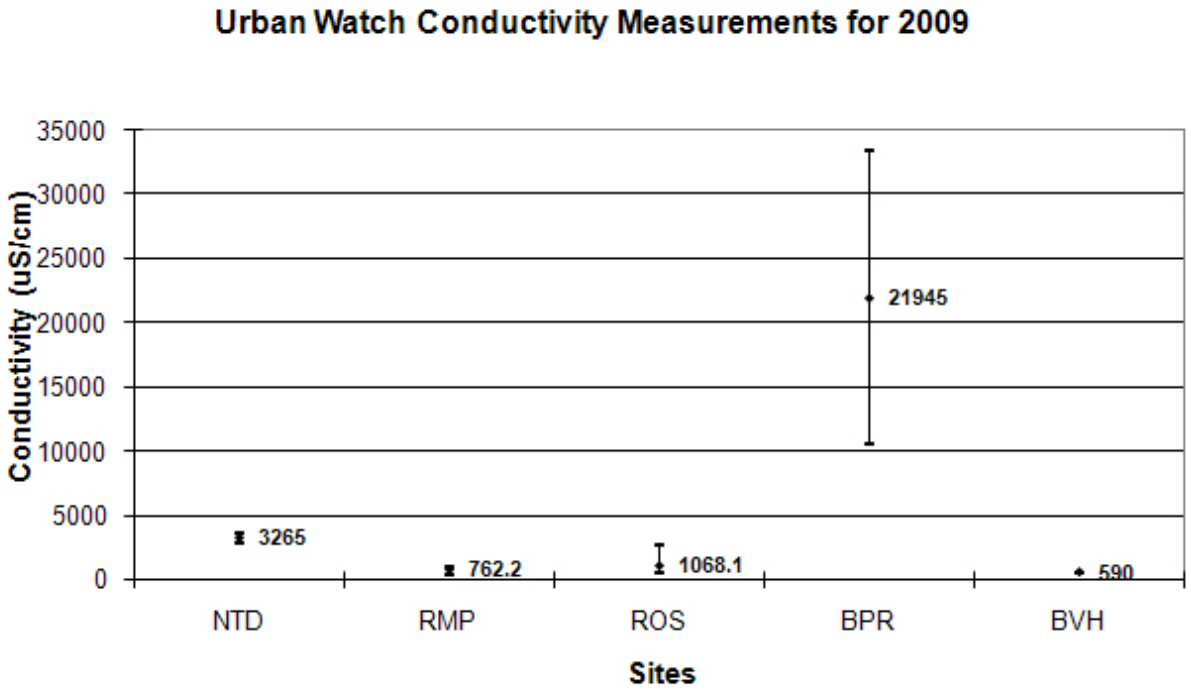
Temperature measurements were taken of the water collected from the storm drains. The maximum, minimum and average water temperatures are illustrated in the following graph.

Chart 24. Urban Watch temperature measurements.



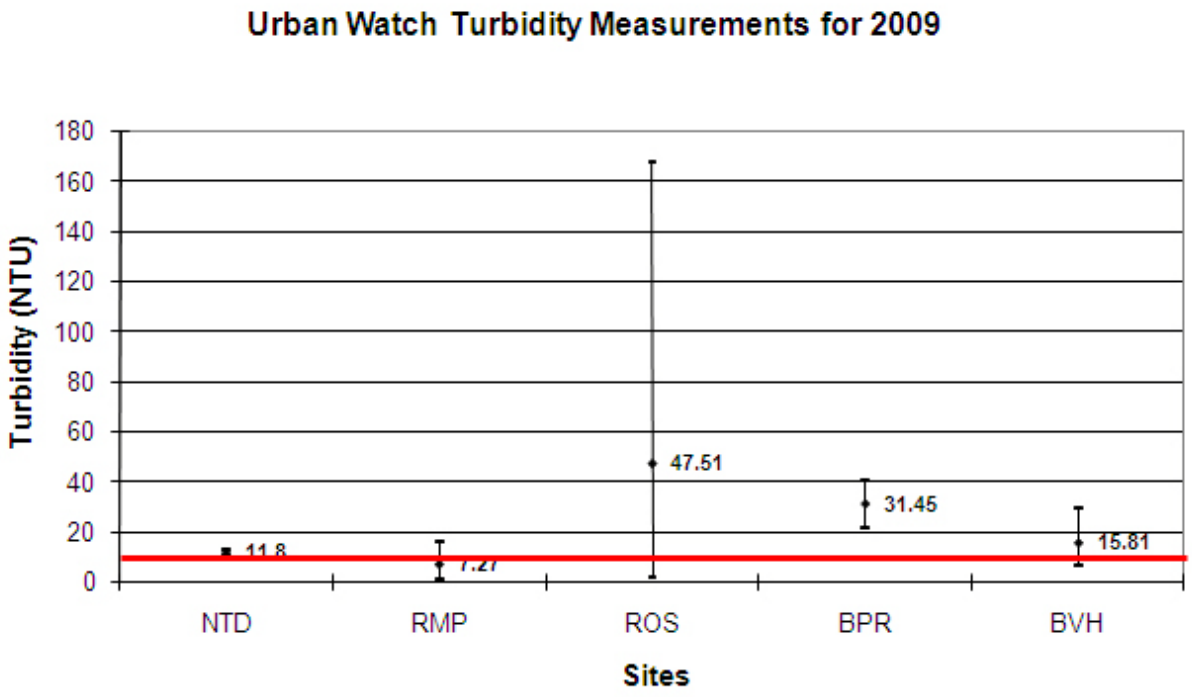
Conductivity
Specific conductance measurements were taken from the water collected from the storm drains.

Chart 26. Urban Watch conductivity measurements.



Turbidity
Turbidity readings were taken using a field turbidimeter for measurements in NTU. The water collected from the ROS site was often milky white and cloudy, resulting in the elevated turbidity values. The CCAMP informal attention level for the receiving water is 10 NTU. The average exceeded this value at all sites except for RMP.

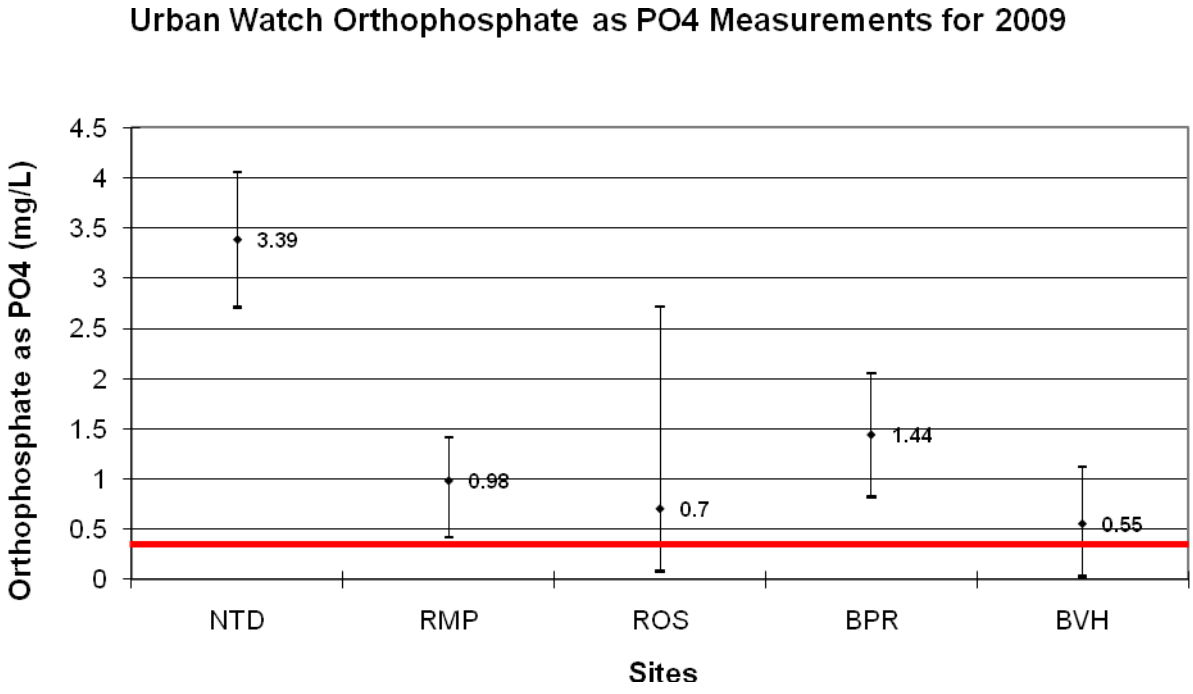
Chart 26. Urban Watch turbidity measurements.



Orthophosphates

The samples were analyzed for orthophosphates as PO_4 using a field colorimeter. The CCAMP informal attention level for receiving waters is 0.36 mg/L as PO_4.

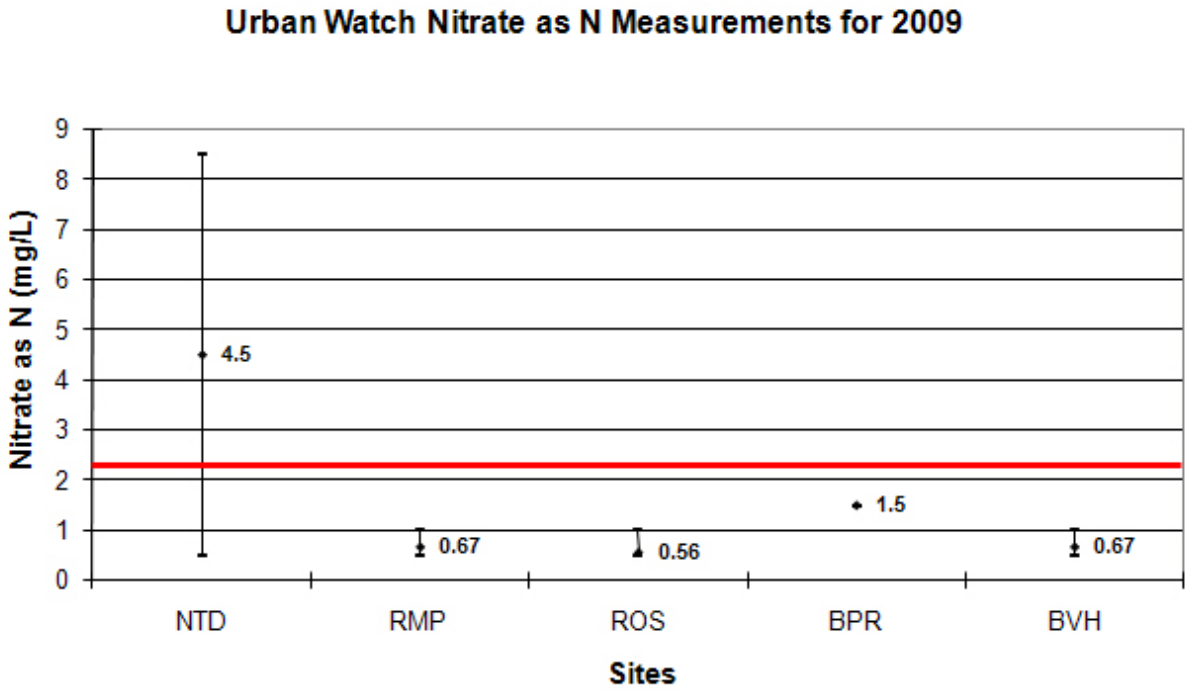
Chart 27. Urban Watch orthophosphate measurements.



Nitrates

The samples were analyzed for nitrates as nitrogen using a LaMotte test kit. The majority of readings varied from non-detect to 1 mg/L. A concentration of 8.5 mg/L at NTD was the only result that exceeded 2.25 mg/L, the CCAMP informal attention level for this analyte.

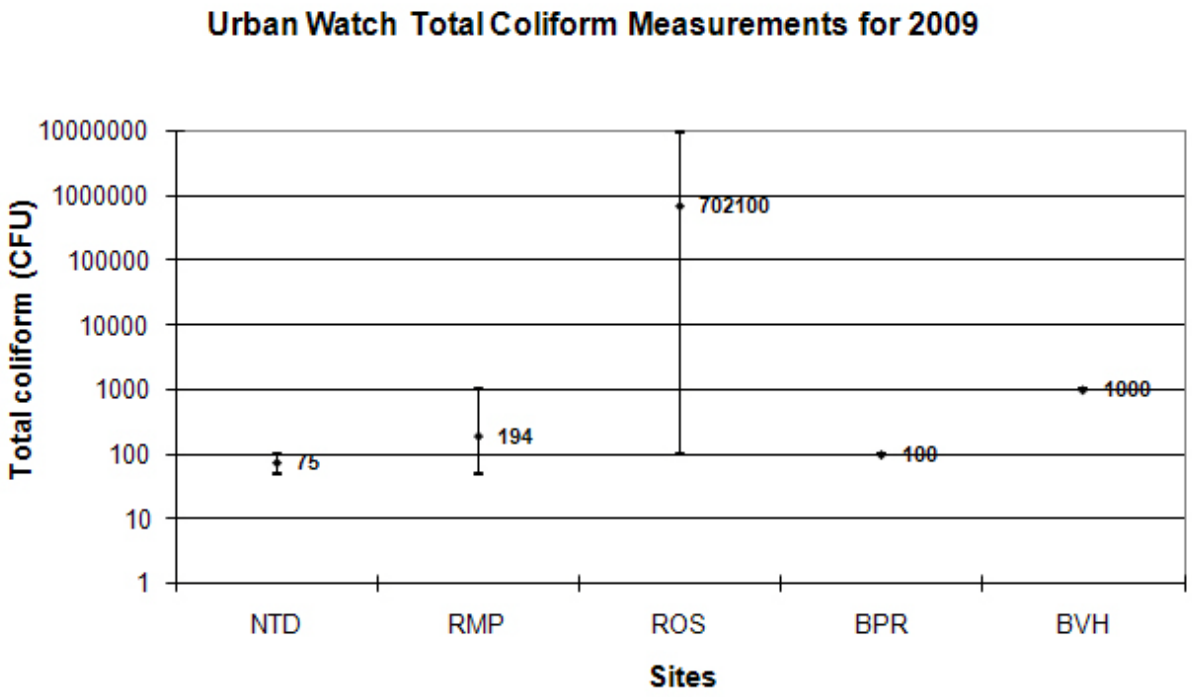
Chart 28. Urban Watch nitrate measurements.



Total Coliforms

In designing the UW monitoring effort, it would have been preferable to obtain total coliform and *E. coli* data using the same method as for First Flush samples, which is the Colilert-18 method by IDEXX. Unfortunately, due to the amount of training and the time required for this type of monitoring, it was not feasible. Instead, paddle testers designed by HACH were used to give an estimate of total coliforms present in the samples. Runoff samples were collected in Whirl-Pak bags containing sodium thiosulfate. The paddles, which are coated in growth media, were dipped into the sample and then incubated at 35° C for 24 to 48 hours. The paddles were then read by counting the number of magenta or pink colonies that had formed. This is matched to a chart provided by the manufacturer to estimate the number of colony forming units (CFU) of total coliforms. Occasionally a runoff sample could not be analyzed for total coliforms because no one was available to read the results after 24 to 48 hours. The non-detect value for the test was less than 100 CFU, which was recorded as a value of 50 for the purposes of analysis.

Chart 29. Urban Watch total coliform measurements.



Chlorine and Ammonia-Nitrogen
The results for chlorine and ammonia-nitrogen were primarily non-detects, with the exception of ammonia readings of 3 mg/L at ROS and at RMP on June 25, 2009 and a chlorine reading of 2 mg/L at ROS on July 7, 2009.

Observations
If a drain was flowing enough for a sample to be collected for analysis, the volunteer would also make several observations about the flow and the drain pipe or outlet. The categories analyzed were odor, color, clarity, floatables, deposits, amount of water flow, if the flow was reaching the receiving water, and the source of the flow. A total of 33 samples were collected during the 2009 monitoring season, and the results were as follows:

For odor, of the 33 samples, 11 had a detectable odor. Six samples were described as musty, four were described as rotten egg, and two were described as having a sewage odor.

For color, of the 33 samples, 29 had color discernible to the naked eye.

For clarity, of the 33 samples, 11 were slightly cloudy and two were rated as opaque.

For floatables, trash was observed once, oil once, and bubbles and foam twice. Algae was observed three times.

For deposits in the pipe/drain, sediment was observed three times, particulates once, and oil once.

For water flow, the flow was rated as a trickle (< 1 qt/min) in 18 samples and as moderate (< 1 gal/min) in 13 samples. The flow was rated as high (> 1 gal/min) once at ROS on July 7, 2009.

In noting whether the flow reached the receiving waters, this was a 'yes' for 30 samples and 'no' for three samples.

The source of the flow could not be identified for any of the samples. Volunteers were instructed to note the source if it was apparent from the vicinity of the drain. They were instructed not to follow the flow 'upstream' to its source.

Overview of Results

Water Temperature

- Water temperature averages ranged from a low of 14.0 to a high of 24.5° C, which far exceeds typical day-time temperatures in the bay.

pH

- The range of pH values varied among the sites, with a typical range of 6.5 to 7.5.
- For FF, values ranged from 7.1 to 7.5, although the analysis was not conducted within 15 minutes of sample collection.

Conductivity

- Conductivity values were widely variable, with values ranging from 380 uS/cm (typical of a freshwater stream) to a high of 33,330 uS/cm (at a tidally-inundated site).
- For FF values, the results varied from 256 to 410 uS/cm.

Turbidity

- Turbidity values ranged from low (1.53 NTU) to fairly high (168 NTU).
- Of the 33 samples collected from all sites, 18 of them had turbidity values greater than 10 NTU, the CCAMP attention level for receiving waters.
- In comparison, stormwater turbidity values from FF monitoring varied from 43 to 76 NTU.

Orthophosphates

- Orthophosphates as PO_4 were elevated above the CCAMP informal attention level of 0.36 mg/L in 24 of the 32 samples analyzed for orthophosphates during the monitoring season.
- The highest values were detected at NTD, with readings of 4.06 and 2.71 mg/L.
- In comparison, FF values varied from 0.39 to 0.64 mg/L as PO_4.

Nitrates

- Nitrates as N values were below the CCAMP informal attention level of 2.25 mg/L for all readings except for a concentration of 8.5 mg/L from NTD on May 28, 2009.
- In comparison, FF values varied from 0.55 to 0.94 mg/L.

Total coliforms

- Total coliform values were variable, ranging from non-detect to 10,000,000 CFU.
- The FF results for total coliforms are not directly comparable to the UW results because a different method of analysis was used. Of note, the results from FF were consistently

elevated, with total coliform values ranging from 18,700 to 52,100 MPN/100 mL. In comparison, UW results had occasional non-detect levels.

Ammonia as nitrogen was detected at a concentration of 3 mg/L at RMP and ROS during the 2009 monitoring season. Nine low readings for total chlorine were detected throughout the season. A reading of 2.0 mg/L for total chlorine was detected at ROS on June 25, 2009.

As with the 2007 and 2008 seasons, the most significant findings of the 2009 UW monitoring season was how often flow or signs of recent flow were found in the storm drains.

In Los Osos, flow was observed at BVH at all eight visits during the 2009 monitoring season, and was so frequent that algal growth could often be observed in the gutter downstream from the drain outlet. The Ash St. inlets (ASHN and ASHS) had signs of recent flow in 63% of site visits, although there was never sufficient flow for collecting samples. In the vicinity, there were signs of over-irrigation on private property. BPR was inundated with tidal bay water during nearly all of the visits.

In Morro Bay, flow was observed at RMP in 53% of the site visits, at BWD in 32% of the site visits, at NTD in 63% of the visits, at PCF in 11% of the visits, and at ROS in 100% of the visits. While the volumes observed to be flowing in the drains were often minimal, the high frequency of these dry season flows was apparent, even in the limited monitoring conducted during the season.

The following table provides an overview of the percent of times the drains had flow in 2007, 2008 and 2009.

Over three seasons of monitoring, trends are becoming apparent. Flows are fairly consistently detected at BVH, ASHS and ASHN in Los Osos and at RMP, NTD and ROS in Morro Bay.

Table 10. Overview of observations from 2007, 2008 and 2009 UW monitoring.

City	Site Code	% of Observations with Flow in 2007	% of Observations with Flow in 2008	% of observations with Flow in 2009
Los Osos	BVH	92%	85%	100%
	ASHS	50%	62%	63%
	ASHN	25%	62%	63%
	FAR	0%	15%	0%
	PNE	0%	8%	13%
	BPR	8%	50%	46%
Morro Bay	RMP	30%	61%	63%
	BWD	58%	33%	32%
	NTD	53%	76%	63%
	NTD2	0%	41%	16%
	PCF	53%	35%	11%
	PCF2	0%	0%	5%
	ROS	89%	88%	100%
	DUN	0%	6%	11%

Future Efforts

The VMP is planning to conduct UW monitoring during the 2010 season. Monitoring will take place between June and the first major storm of the season in the fall of 2010.

Appendices
UW 2009 Site Descriptions
UW Field instructions
UW 2009 Datasheet