



Morro Bay National Estuary Program's
Implementation Effectiveness Program

**Stormwater Monitoring Report
2008**

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Submitted by

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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 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 and *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 sites in Morro Bay. The high intensity, short duration storm did not generate prolonged runoff to enable time series sampling. The pollutant levels 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 drains 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.

Urban Watch (UW) is a monitoring effort to measure pollutant levels in urban runoff during the dry season. The source of flow is typically human in origin, whether from irrigation, car washing or other activities which cause 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 geographical 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 from a drain such that a sample could be collected, it was analyzed for temperature, pH, total chlorine, conductivity, ammonia, nitrates as nitrogen, orthophosphates as PO₄, turbidity and total coliform.

This report summarizes the results from Urban Watch and First Flush monitoring which took place during 2008.

First Flush

Study Design

Site Selection

The 2005, 2006, 2007 and 2008 efforts were organized and conducted by the MBNEP's Volunteer Monitoring Program (VMP). In designing the FF effort for the 2008-9 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.

For the 2008-9 rainy season, the decision was made to conduct more intensive time series monitoring in Morro Bay, a deviation from past efforts of collecting a single sample from sites in Morro Bay and Los Osos. This decision was made due to logistical concerns as well as the timing of the initial storm in the late summer of 2008.

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.

An unexpected storm occurred on Friday, August 15, 2008 with a total rainfall of 0.07 inches recorded at the gage located at Canet Road. Intense rainfall began at approximately 8:20 a.m. Sampling took place from 8:40 to 9:00 a.m. Due to the unexpected nature of this storm, a single collection of FF samples were collected at five Morro Bay sites. Due to the brevity and intensity of the storm, Los Osos was not able to be sampled during that storm event.

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.

For each site, a 60 mL sample was filtered using a syringe and a 0.45 um pore size filter for dissolved metal analysis. EPA Method 200.8 for dissolved metal analysis states that samples must be filtered within 15 minutes of collection. All dissolved metal samples were filtered shortly following collection, within approximately one hour of their collection. 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 12:25 p.m. on August 15. Thus, pH levels must be considered approximations. The bacteria samples were delivered to the county lab for analysis on August 15 at 2 p.m., and the samples were analyzed soon after. The six-hour hold time was not met, but the 24-hour hold time was met.

A duplicate sample and a blank were not analyzed for the August 15 sampling run.

The analytical results for the August 15 storm showed pollutant concentrations far higher than in typical First Flush monitoring events. However, we were concerned that due to the brief but intense duration of the August 15 storm, the rainfall was enough to generate runoff but was not enough to flush past the initial 'slug' of pollutants from the drains before samples were collected. Typical First Flush sampling allows for that initial 'slug' of water, or baseflow, to flow out of the drains before samples are collected. We hypothesized that the sampling on August 15 had captured the effect of the water in the drains that was dominated by baseflow. The decision was made to collect a time series of samples from two of the Morro Bay drains during a subsequent storm.

Nearly two months later, on Saturday, October 4, 2008, rain began falling in Morro Bay at approximately 4:30 a.m. Sampling commenced at 5:19 a.m. when the runoff was between approximately 10 to 25 gallons per minute and foam plumes were developing at the base of the outfalls. Additional samples were collected every 15 minutes for a total of four samples per site. The total rainfall for that event, per the Morro Bay Harbor Department gauge, was 0.19 inches.

A duplicate sample was collected from the site at the end of Marina Street when the second sample was pulled at approximately 5:34 a.m. The VOA for TPH-g was inadvertently omitted, so a duplicate analysis for TPH-g was not available. A blank was run for all analytes except TPH-g, conductivity, dissolved nickel and dissolved lead.

Due to the occurrence of the sampling event outside of normal business hours, samples could not be immediately delivered to analytical laboratories. Dissolved metals samples were filtered within two hours of collection. All samples were sealed and stored on ice. The samples were delivered to the county laboratory in San Luis Obispo for bacteria analysis at 10:45 a.m. on October 4. The six-hour hold time was not met, but the staff was able to process the samples on the weekend and the 24-hour hold time was met. The other samples were delivered to Creek Environmental Labs in San Luis Obispo at noon. As with the samples from the August 15 storm, the 15 minute hold time for the pH samples was not met, and the pH results should be considered to be an approximation. The lab was able to analyze the samples over the weekend so that all other hold times were met.

Sample Analysis

The analytes for First Flush monitoring were determined based on historical analytes and on advice from CCRWQCB staff.

The analysis for the following parameters was completed by Creek Environmental Laboratories and the SLO County Public Health Laboratory in San Luis Obispo.

- 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
- Turbidity
- Total coliforms
- *E. coli* and
- Total petroleum hydrocarbons – gasoline (TPH-g), for the Oct. 4 sampling event only.

Bacterial analysis was completed at the San Luis Obispo County Public Health Laboratory using the IDEXX Colilert-18 methodology. Samples were run in three dilutions (1:10, 1:100 and 1:1000) to account for the full possible range of *E. coli* and total coliform results. Analysis for the remaining analytes was conducted by Creek Environmental Laboratories.

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

Analyte	Responsible Organization	Analytical Method	Detection Limit for Reporting	Sample Hold Times
				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
Total petroleum hydrocarbons – gasoline	Creek Environmental Laboratories	EPA 8015/LUFT	0.05 mg/L	14 days, preserved
<i>E. coli</i>	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 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 should not 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 were not exposed to air prior to analysis, the impact on pH is likely minimal. For dissolved metals, samples could not be filtered within 15 minutes of collection. For bacteria, the six-hour hold time was not met, but the 24-hour hold time was met.

Table 2. Analytical results of the August 15, 2008 storm in Morro Bay.

Analyte	OFF	NTD	PCF	ROS	RMP
Oil and grease (mg/L)	36	6	10	11	2.5
Zinc (mg/L)	1.000	0.91	1.5	1.6	0.7
Copper (mg/L)	0.120	0.093	0.27	0.18	0.42
Lead (mg/L)	0.004	0.003	0.002	0.004	0.003
Nickel (mg/L)	0.056	0.055	0.072	0.087	0.043
Turbidity (NTU)	240	180	190	170	72
pH	6.6	6.2	6.6	6.6	6.6
Conductivity (uS/cm)	2,700	1,400	2,600	3,300	1,400
Dissolved Solids (mg/L)	2,100	1,400	2,300	2,900	1,400
Suspended Solids (mg/L)	820	200	300	310	68
Total coliform (MPN/100 mL)	152,900	241,961	41,400	115,300	224,770
<i>E. coli</i> (MPN/100 mL)	10,462	21,780	2,382	12,997	754
Nitrates as N (mg/L)	4.2	2.6	4	4.5	2.5
Orthophosphates as P (mg/L)	1.1	1.5	1.2	1.3	1.7

Results in blue indicate a non-detect level.

For results that were non-detect, we are using a value of one half of the detection limit for all reporting and calculations.

Table 3. Analytical results of October 4, 2008 storm in Morro Bay at OFF site.

Analyte	OFF1	OFF2	OFF2-duplicate	OFF3	OFF4
Time of sample collection	5:19 a.m.	5:34 a.m.	5:34 a.m.	5:49 a.m.	6:04 a.m.
Oil and grease (mg/L)	6	2.5	2.5	2.5	2.5
Zinc (mg/L)	0.53	0.700	0.580	0.670	0.620
Copper (mg/L)	0.077	0.050	0.049	0.049	0.034
Lead (mg/L)	0.001	0.002	0.002	0.001	0.002
Nickel (mg/L)	0.044	0.032	0.032	0.030	0.020
Turbidity (NTU)	130	140	160	110	86
pH	7.7	6.6	6.6	6.8	6.7
Conductivity (uS/cm)	3,000	1,200	1,200	1,000	690

Analyte	OFF1	OFF2	OFF2-duplicate	OFF3	OFF4
Dissolved Solids (mg/L)	2,200	1,100	1,100	860	550
Suspended Solids (mg/L)	150	510	610	210	160
Total coliform (MPN/100 mL)	44,600	172,500	110,600	69,700	65,000
<i>E. coli</i> (MPN/100 mL)	3,448	6,488	4,611	4,352	6,488
Nitrates as N (mg/L)	3	1.8	1.8	1.5	1.1
Orthophosphates as P (mg/L)	1.2	1.2	1.2	1.1	0.9
Total petroleum hydrocarbons – gasoline (mg/L)	0.0025	0.0025	0.0025	0.0025	0.0025

Results in blue indicate a non-detect level.

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.

Table 4. Analytical results of October 4, 2008 storm in Morro Bay at PCF site.

Analyte	PCF1	PCF2	PCF3	PCF4
Time of sample collection	5:20 a.m.	5:35 a.m.	5:50 a.m.	6:05 a.m.
Oil and grease (mg/L)	8	2.5	2.5	2.5
Zinc (mg/L)	1.200	0.910	0.870	0.590
Copper (mg/L)	0.160	0.072	0.069	0.043
Lead (mg/L)	0.003	0.002	0.001	0.001
Nickel (mg/L)	0.054	0.032	0.024	0.017
Turbidity (NTU)	98	60	41	50
pH	6.6	6.8	6.8	7.0
Conductivity (uS/cm)	1,800	1,000	860	590
Dissolved Solids (mg/L)	1,500	820	640	450
Suspended Solids (mg/L)	170	230	50	100
Total coliform (MPN/100 mL)	61,300	36,000	27,500	33,600
<i>E. coli</i> (MPN/100 mL)	3,873	2,755	3,873	3,255
Nitrates as N (mg/L)	2.6	1.4	1.2	0.8
Orthophosphates as P (mg/L)	1.6	1	0.8	0.6

Analyte	PCF1	PCF2	PCF3	PCF4
Total petroleum hydrocarbons – gasoline (mg/L)	0.0025	0.0025	0.0025	0.0025

Results in blue indicate a non-detect level.

In the blank sample that was analyzed along with the samples from the October 4 storm, trace amounts of dissolved copper and zinc were detected, and the turbidity reading was 1.9 NTU. 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 was 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 greater number of antecedent dry days prior to the August 2008 sampling event likely accounts for the higher values as compared to the October 2008 event.

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

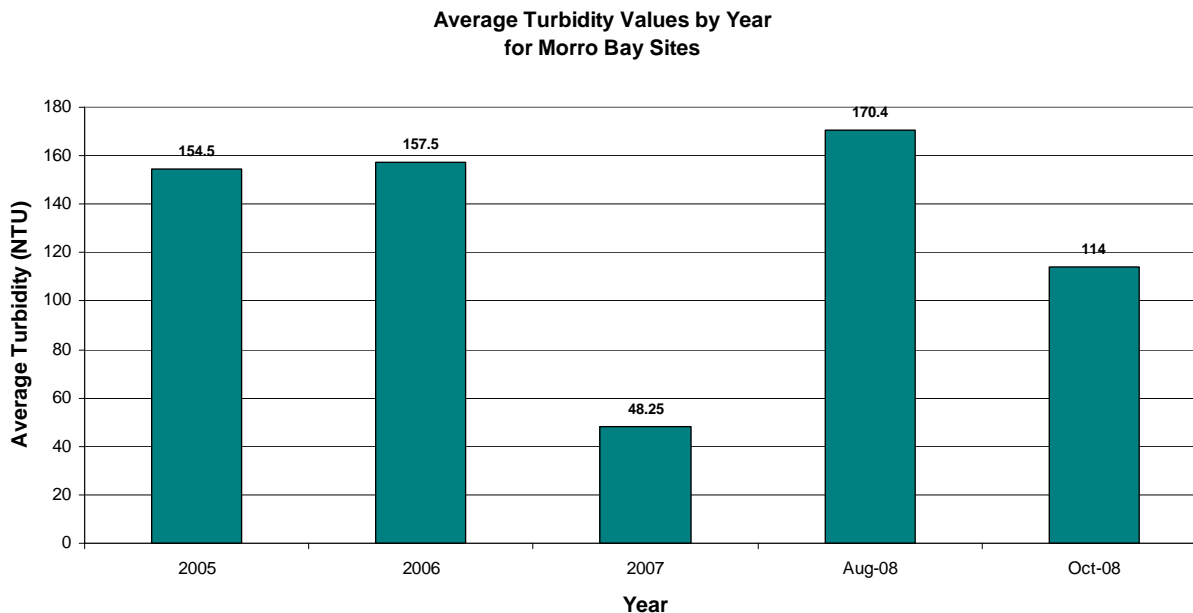
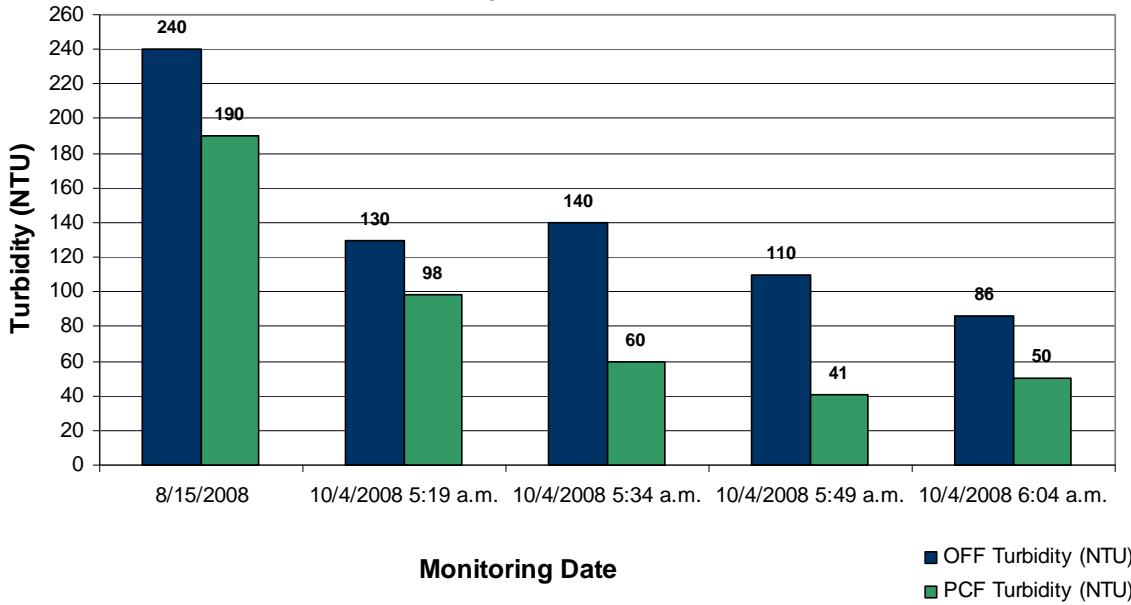


Chart 2 shows the turbidity values from the OFF and PCF site from the single sample collected during the August storm and the time series samples collected during the October event. As expected, the time series data shows a trend of decreasing turbidity throughout the storm.

Chart 2. Nephelometric turbidity for 2008 for two Morro Bay sites.

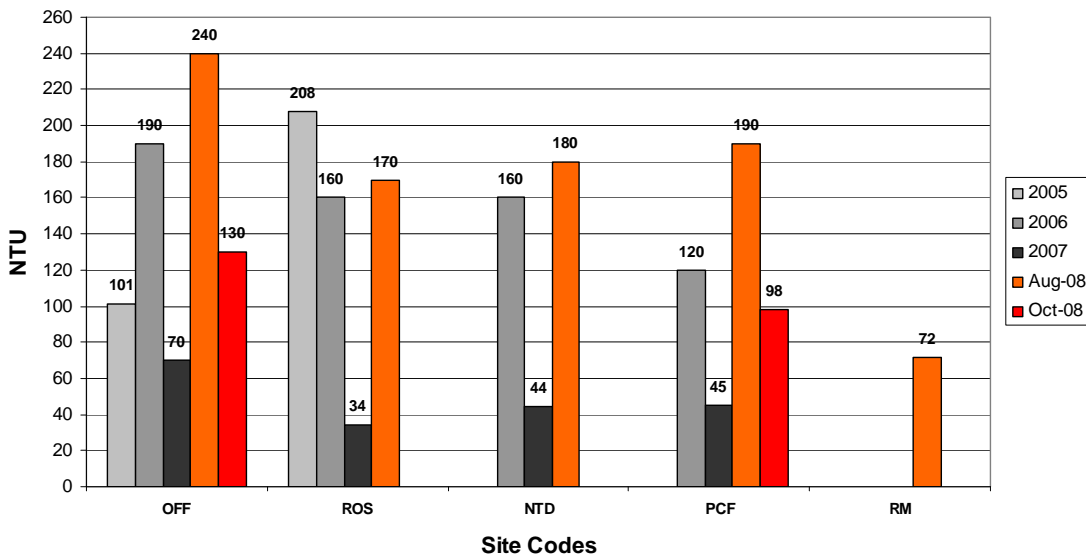
Turbidity for First Flush Sites



A comparison of turbidity values by year for four of the most frequently monitored Morro Bay sites are shown in Chart 3. 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 is included for comparison. The lower than normal values in 2007 were likely due to sampling taking place more than an hour after the start of sheet flow.

Chart 3. Turbidity Results for August 2008 storm and first sample from October 2008 storm.

Turbidity Results for Morro Bay First Flush 2005 to 2008



Bacteria

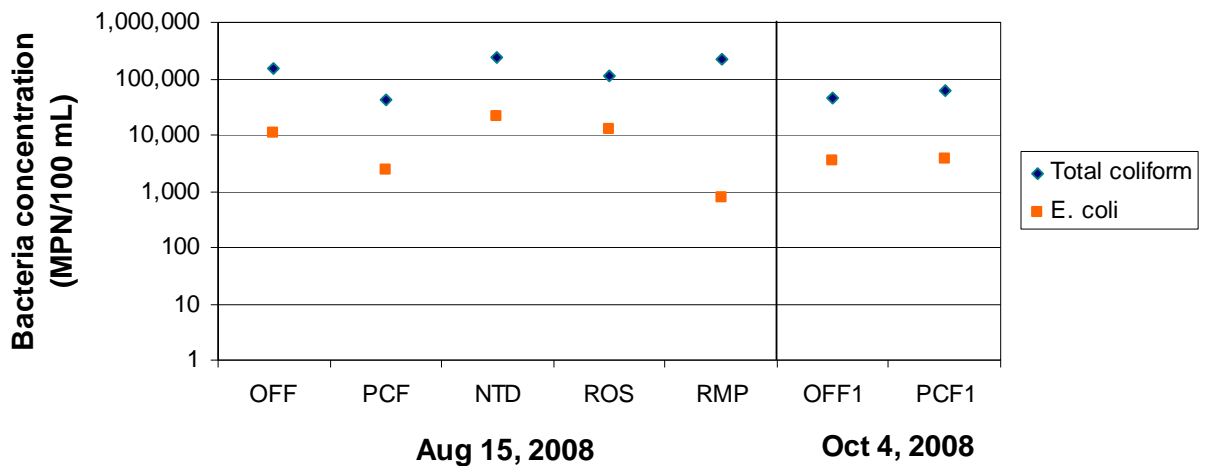
The EPA’s recommended criteria for *E. coli* for safe recreational contact in freshwater receiving waters is 235 MPN/100 mL. Note that this is a standard applied to receiving waters rather than the stormwater runoff itself. The Basin Plan standard for total coliform is 10,000 MPN/100 mL,

and the standard for fecal coliform is 400 MPN/100 mL. As noted before, the six-hour hold time for bacteria samples was exceeded which may have resulted in bacteria die-off, however results still significantly exceeded the level for safe recreational contact.

Chart 4 shows the total coliform and *E. coli* results on a log scale for the five sites sampled in the August 15 event and the first sample from the time series collected during the October 4 event.

Chart 4. *E. coli* and total coliform values for August 2008 and the first sample from the October 2008 sampling event.

Total coliform and *E. coli* Concentrations for 2008 First Flush Sites



The 2008 data can be directly compared with results from 2005, 2006 and 2007 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 4.

Table 5. Bacteria Concentrations in MPN/100 mL.

Site	Fecal coliform for 1996-7	Fecal coliform for 1997-8	<i>E. coli</i> for 2005	<i>E. coli</i> for 2006	<i>E. coli</i> for 2007	<i>E. coli</i> for Aug 2008	<i>E. coli</i> for October 2008, first sample in series
ROS	-	-	1,935	771	12,740	12,997	-
OFF	-	-	4,130	862	4,106	10,462	3,448
NTD	9,000	22,000	-	471	4,352	21,780	-
PCF	-	-	-	934	3,873	2,382	3,873
RMP	-	-	-	-	-	754	-

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 typically would mean increased results). However, the bacteria results do not follow the expected trend. PCF and ROS had elevated bacteria concentrations in both the 2007 and the August 2008 monitoring events.

Table 6. Bacteria Concentrations for Time Series Samples on October 4, 2008.

Site and Time Sampled on October 4, 1008	Total coliform (MPN/100 mL)	<i>E. coli</i> (MPN/100 mL)
OFF (5:19 a.m.)	44,600	3,448
OFF (5:34 a.m.)	172,500	6,488
OFF (5:49 a.m.)	69,700	4,352
OFF (6:04 a.m.)	65,000	6,488
PCF (5:20 a.m.)	61,300	3,873
PCF (5:35 a.m.)	36,000	2,755
PCF (5:50 a.m.)	27,500	3,873
PCF (6:05 a.m.)	33,600	3,255

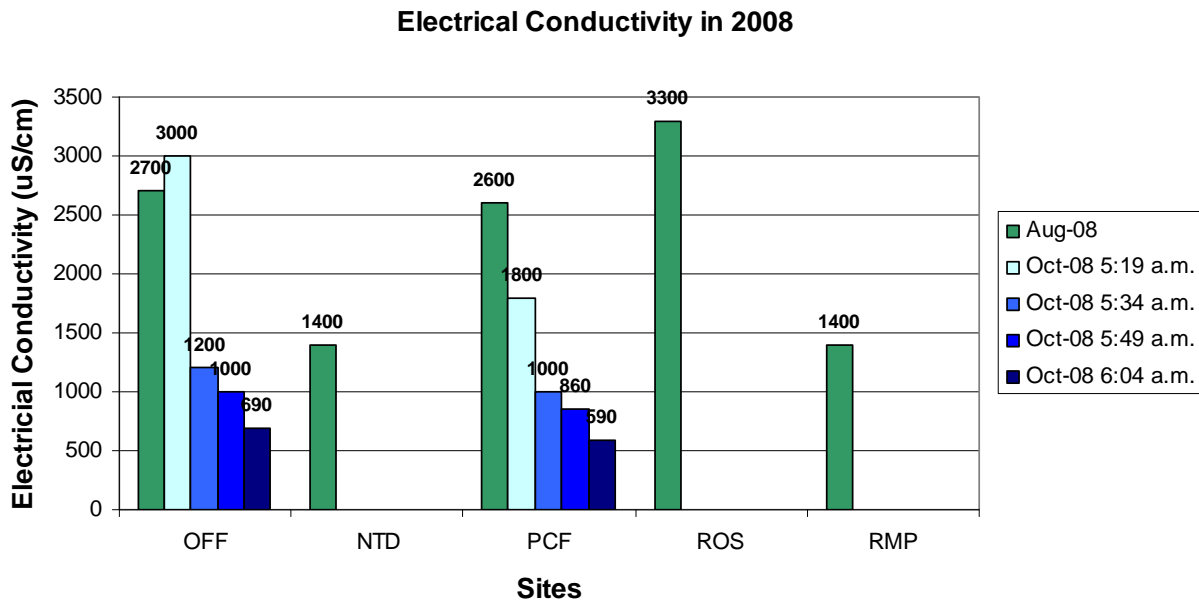
In conducting time series sampling for First Flush, we had expected to see a decrease in bacteria levels throughout the storm. As shown in Table 5, the results did not follow this expected trend, with bacteria concentrations rising and falling throughout the sampling series.

Conductivity

All of the sites sampled in August 2008 had conductivity values above 1,000 uS/cm. This value is considered the threshold for determining whether the sample is stormwater runoff (which has a low conductivity 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. These elevated conductivity values confirm our initial conclusion that the August 2008 sampling event is a characterization of baseflow with some storm water influence, rather than a typical First Flush event.

During the October 4 storm, the time series results showed a decrease in conductivity values throughout the storm. At the OFF site, the values dropped from 3,000 to 690 uS/cm. At the PCF site, the values dropped from 1,500 to 450 uS/cm during the course of the sampling series. This follows the expected trend that more rainfall, with its low conductivity values, dilutes the effect of the baseflow.

Chart 5. Electrical conductivity values for August and October 2008 First Flush Sampling



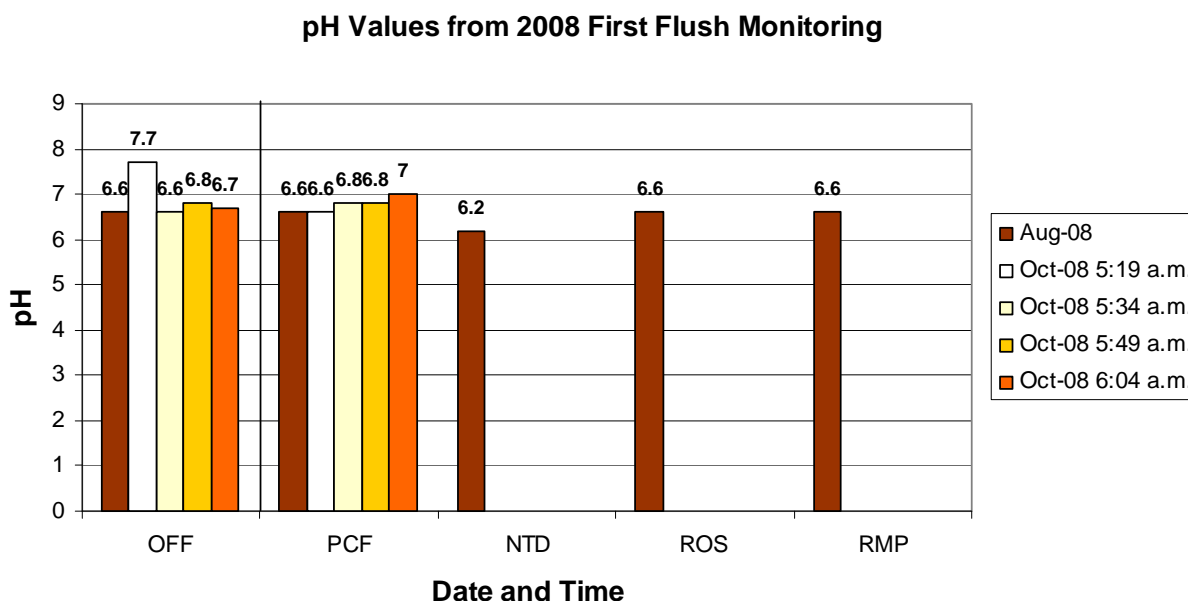
pH

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.

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. 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 are not exposed to air prior to analysis, the impact on pH is likely minimal.

The time series data from the October 4 storm showed relatively stable pH levels throughout the storm.

Chart 6. pH units for 2008 monitoring.



Oil & Grease and TPH-g

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 detects of oil and grease. In the October 2008 time series samples, only the first sample in the series at each of the sites had detects. The remaining samples in the time series did not have detections of oil and grease.

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.

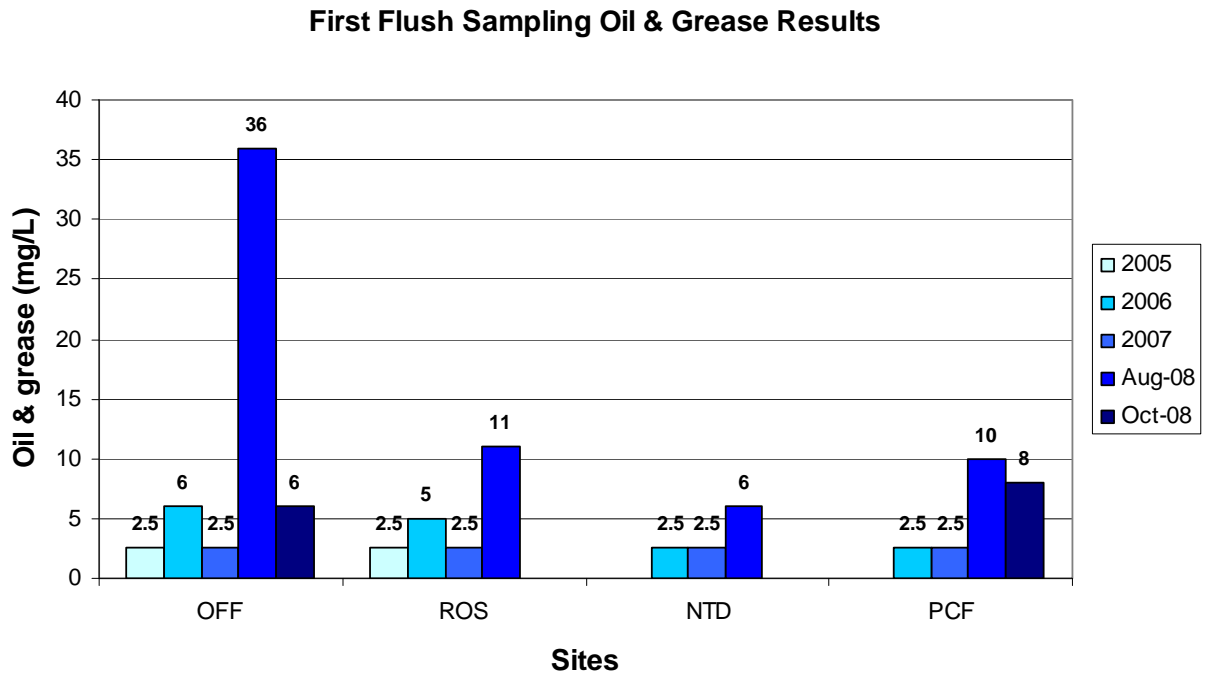
Table 7. Recent trends in oil and grease results.

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

Values in blue denote non-detect levels.

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 7. Oil & Grease results.



As with the results from other analytes, the oil and grease results confirm that the 2007 sampling likely took place more than an hour after the start of sheet flow (hence the lower than expected values) and in the August 2008 event, the sampling likely captured the baseflow rather than the stormflow runoff, resulting in historically unprecedented elevated values.

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 the concentration of oil and grease detected in the August 2008 sampling event, the decision was made to analyze for TPH-gasoline for the time series sampling on the subsequent storm. The purpose was to try to determine whether the source was hydrocarbon/petroleum-based or biological oil-based (i.e., animal fats, vegetables oils, soaps). The results were non-detect for all samples in the series at both sites, likely indicating that the oil and grease detected in the October 2008 event were not due to petroleum hydrocarbon-based sources.

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.

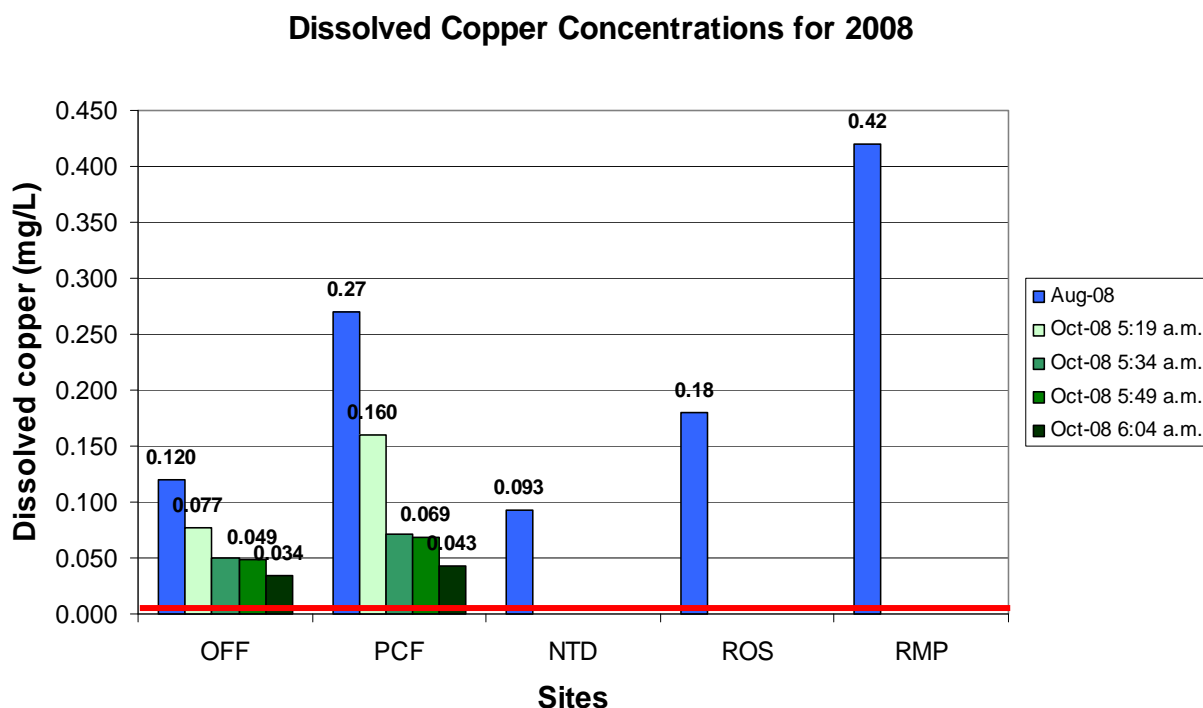
Table 8. Metals results.

Analyte	Site	1995	1996	1997	2005	2006	2007	Aug 2008	Oct 2008, first sample in series
Copper (mg/L)	ROS	0.341	0.157	-	0.052	0.056	0.067	0.18	-
	NTD	0.025	0.036	0.016	-	0.051	0.065	0.093	-
	OFF	-	-	-	0.029	0.044	0.044	0.120	0.077
	PCF	-	-	-	-	0.079	0.06	0.27	0.160
	RMP	-	-	-	-	-	-	0.42	-
Lead (mg/L)	ROS	0.034	0.013	-	0.004	0.005	0.004	0.004	-
	NTD	0.011	0.018	0.019	-	0.003	0.002	0.003	-
	OFF	-	-	-	0.002	0.004	0.002	0.004	0.001
	PCF	-	-	-	-	0.004	0.003	0.002	0.003
	RMP	-	-	-	-	-	-	0.003	-
Nickel (mg/L)	ROS	0.025	0.025	-	0.021	0.026	0.024	0.087	-
	NTD	0.025	0.025	0.025	-	0.032	0.026	0.055	-
	OFF	-	-	-	0.016	0.029	0.027	0.056	0.044
	PCF	-	-	-	-	0.036	0.025	0.072	0.054
	RMP	-	-	-	-	-	-	0.043	-
Zinc (mg/L)	ROS	0.693	0.578	-	0.380	0.470	0.6	1.6	-
	NTD	0.101	0.265	0.139	-	0.35	0.35	0.91	-
	OFF	-	-	-	0.160	0.400	0.39	1.0	0.530
	PCF	-	-	-	-	0.65	0.58	1.5	1.200
	RMP	-	-	-	-	-	-	0.70	-

The metals concentrations were relatively stable as compared to recent years. Zinc concentrations at all four sites were substantially elevated above previous years in the August 2008 sampling event, and moderately elevated in the October 2008 sampling event.

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 (Boiler, 1997; Odnevall Wallinder and Leygraf, 1997; Mason et al, 1999; Odnevall Wallinder and Leygraf, 1999). 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).

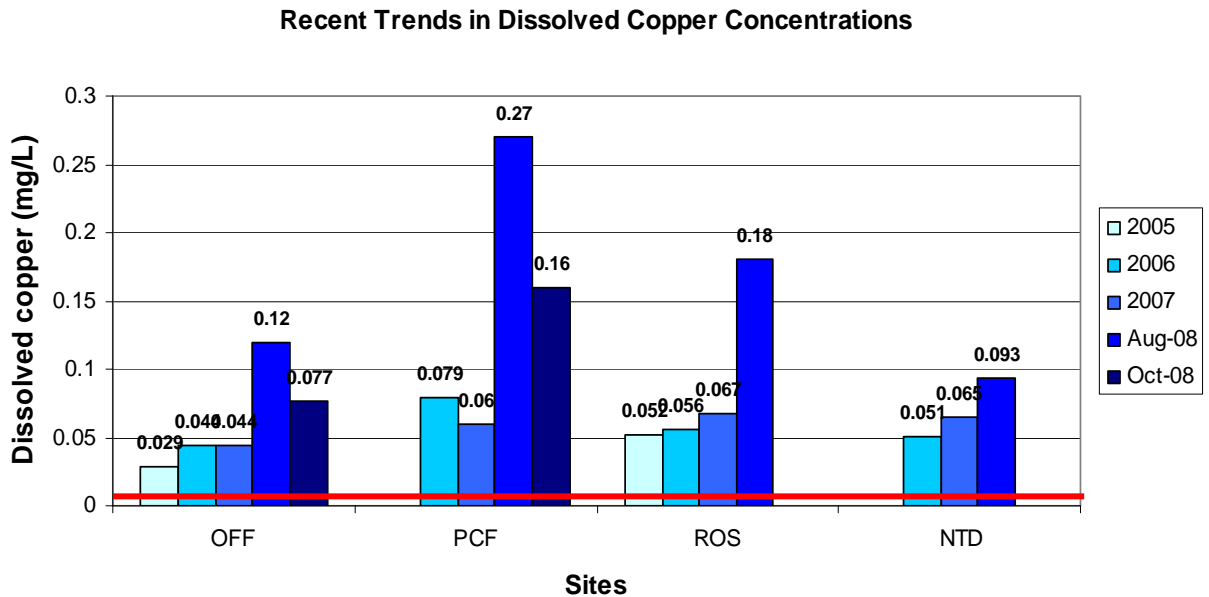
Chart 8. Dissolved copper concentrations for 2008.



The time series data from the October storm exhibits the expected trend of a decrease in dissolved copper concentrations as the storm progressed. At both sites in the October monitoring, the initial reading was far less than the August monitoring results. This is either due to the nature of each of the storms or the significantly smaller number of antecedent dry days for the October storm versus the August storm. The RMP site was sampled for the first time in August, and the dissolved copper concentration was elevated above the results at any other site. In looking back at historical data, the RMP value was the highest ever detected, other than two results from the mid-1990s from a boatyard along the Embarcadero. The RMP site drains areas with a residential land use type. Marine paint is a suspected source of the copper.

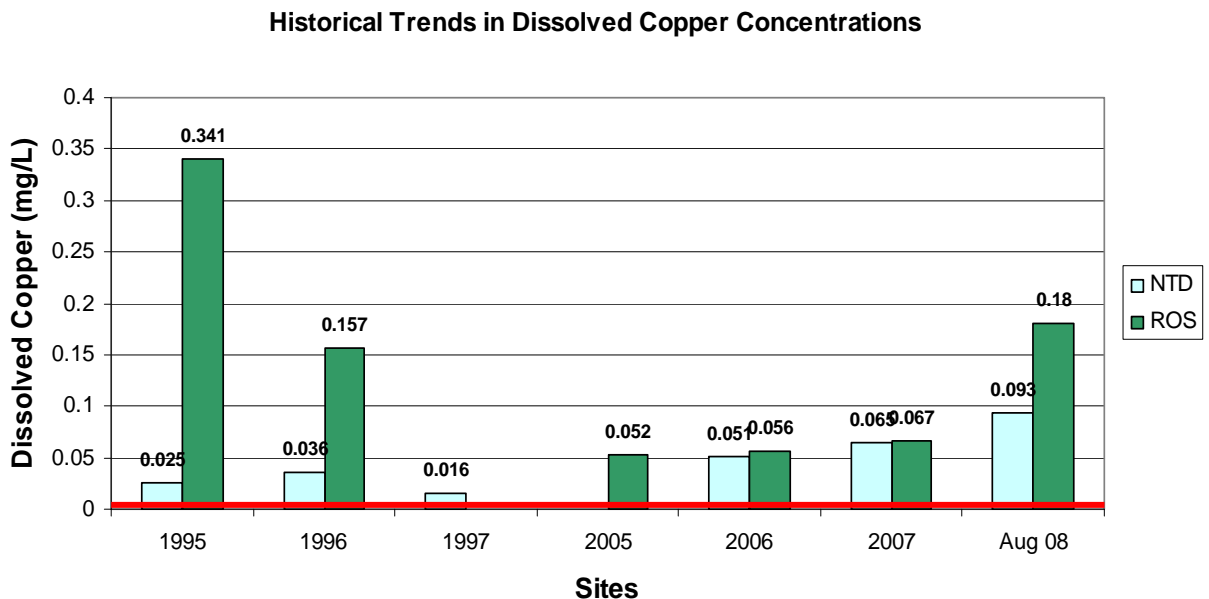
For sites where monitoring historically took place, the following two charts show the trends in dissolved copper concentrations in recent monitoring efforts (2005 through 2008) and historical monitoring efforts (1995, 1996, 1997, 2006, 2007 and 2008). For the October 2008 data, only the first sample 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.

Chart 9. Recent trends in dissolved copper concentrations.



The following chart shows results for two sites where more consistent monitoring has taken place: NTD and ROS. At NTD, the data from the 1990s as a whole is less than the results from the 2000s. At ROS, the trend appears to be in the opposite direction with the exception of the August 2008 sample which likely captured the effect of baseflow rather than stormflow.

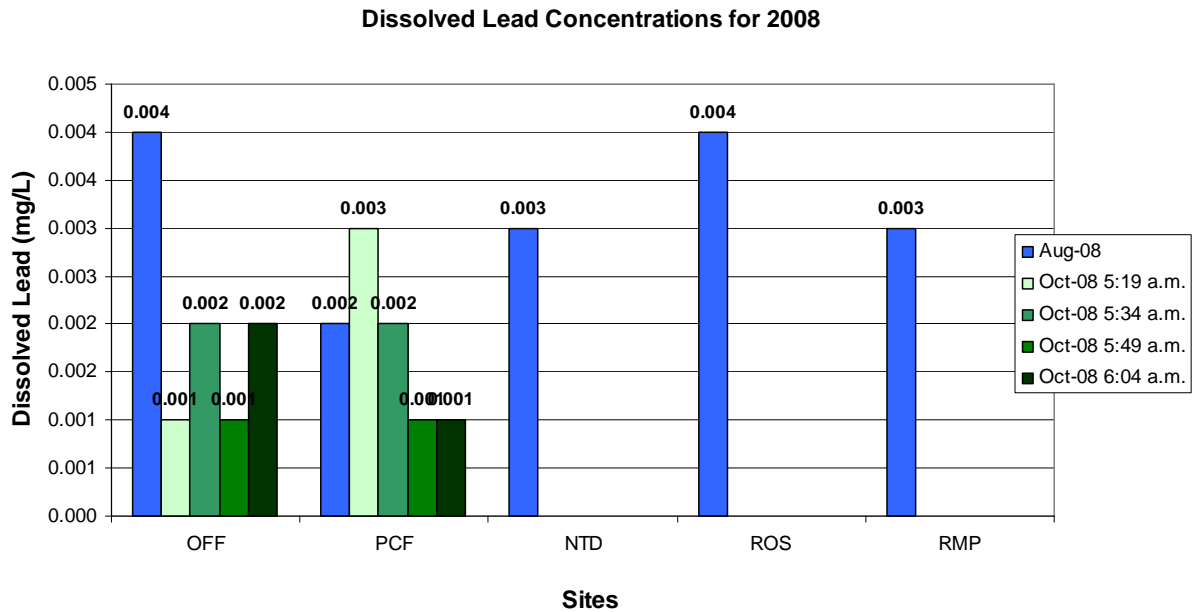
Chart 10. Historic trends in dissolved copper concentrations.



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 (G.F. Lee, A. Jones-Lee, Stormwater). The Central Coast Basin Plan states the criteria of 0.01 mg/L dissolved lead should not be exceeded for protection of marine life.

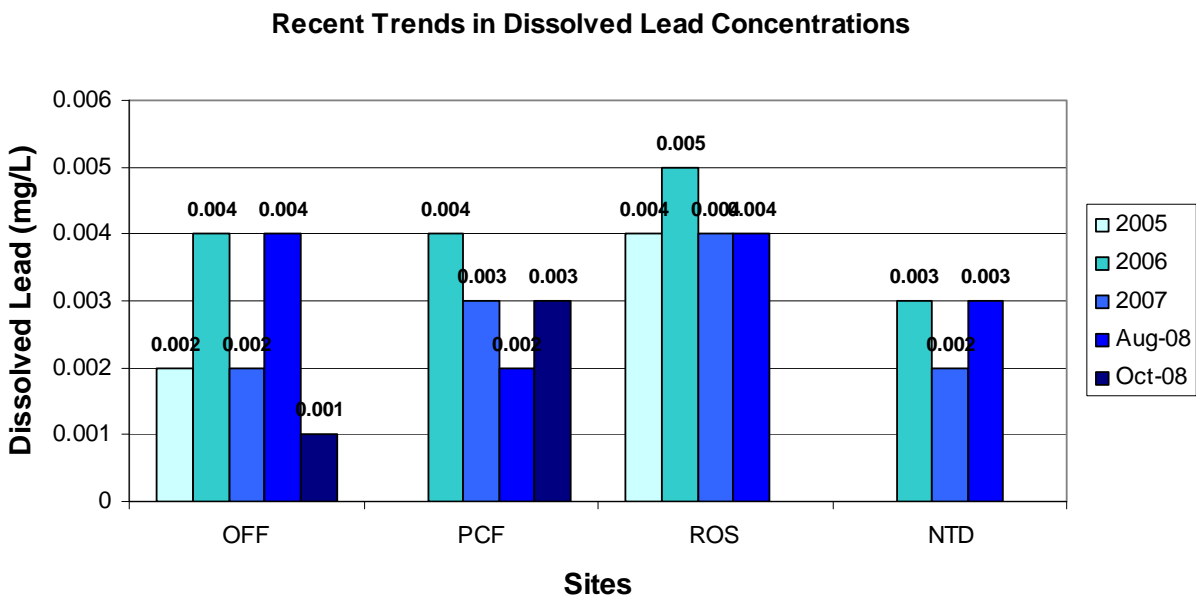
In the August 2008 samples, lead was detected at all four of the Morro Bay sites. The analytical detection limit for dissolved lead is 0.001 mg/L. None of the sites exceeded the Basin Plan standard of 0.01 mg/L. Even the highest concentrations detected were less than half of the Basin Plan standard.

Chart 11. Dissolved lead concentrations for 2008.



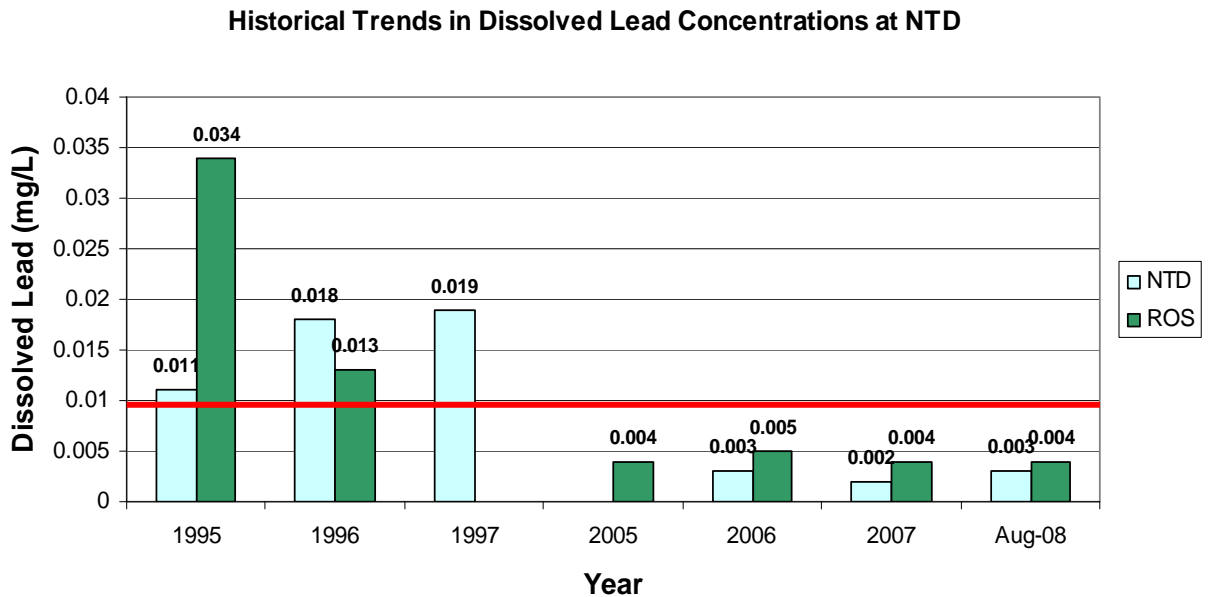
For sites where monitoring historically took place, the following two charts show the trends in dissolved lead concentrations in recent monitoring efforts (2005 through 2008) and historical monitoring efforts (1995, 1996, 1997, 2006, 2007 and 2008).

Chart 12. Recent trends in dissolved lead concentrations.



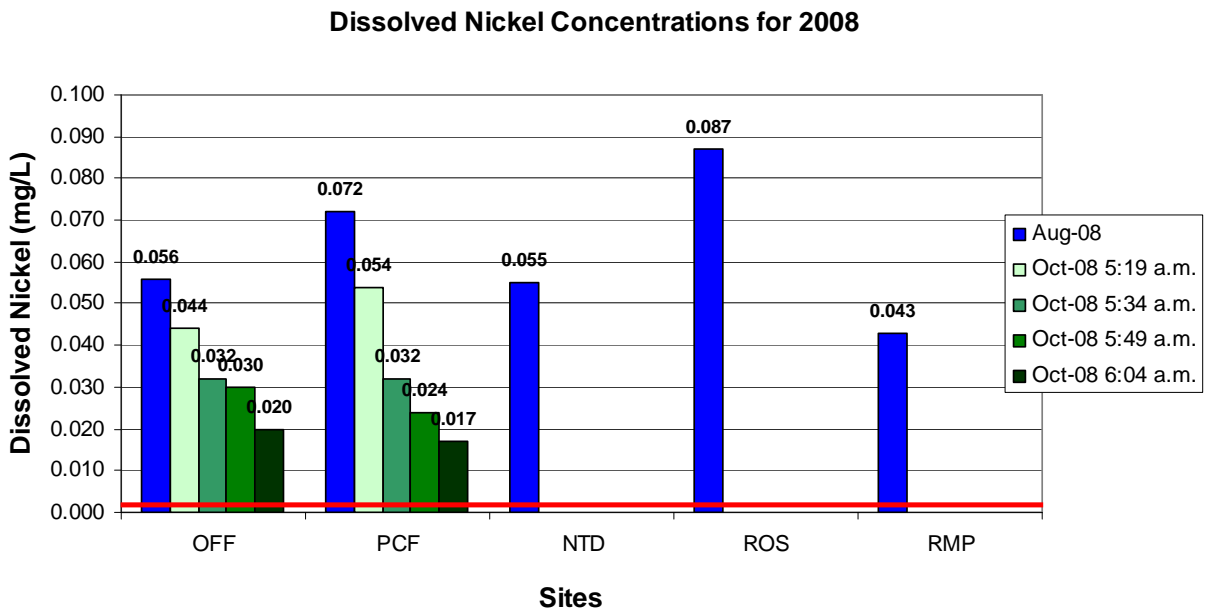
Consistent with previous years' data, the historical trend for both sites continues of far lower dissolved lead concentrations in the 2000s as compared to the 1990s.

Chart 13. Historic trends in dissolved lead concentrations.



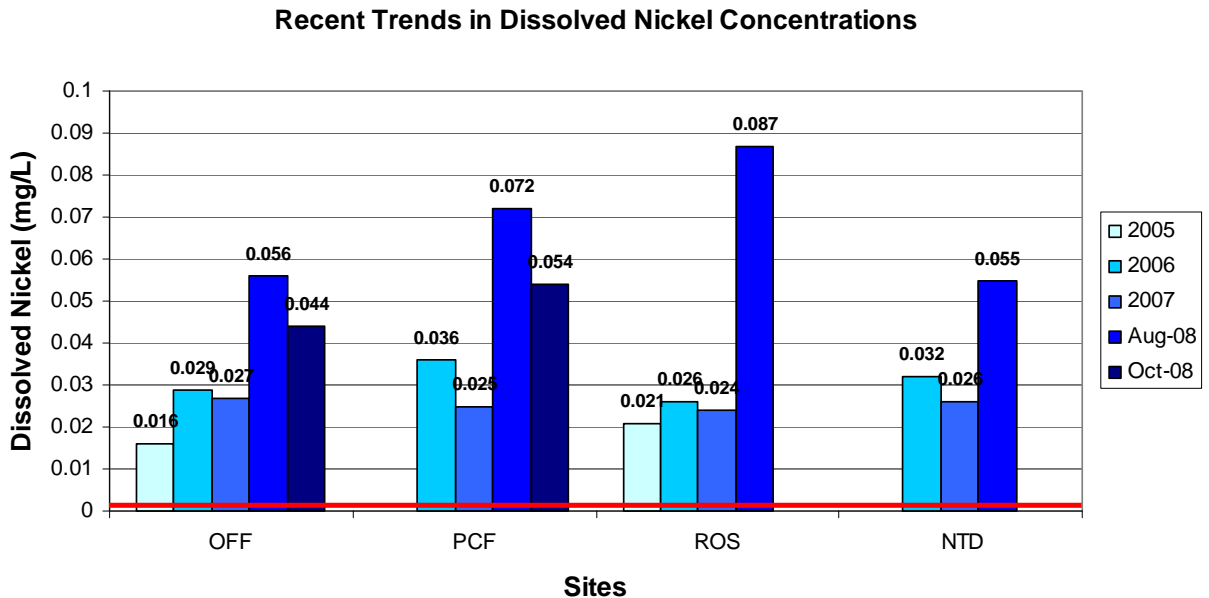
There are a variety of urban sources that can contribute to dissolved nickel in stormwater. Nickel is produced in gasoline and diesel fuel combustion and is a major component of nickel-metal hydride (NiMH) batteries. The Basin Plan standard is listed for nickel salts, while FF analysis was conducted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

Chart 14. Dissolved nickel concentrations for 2008.



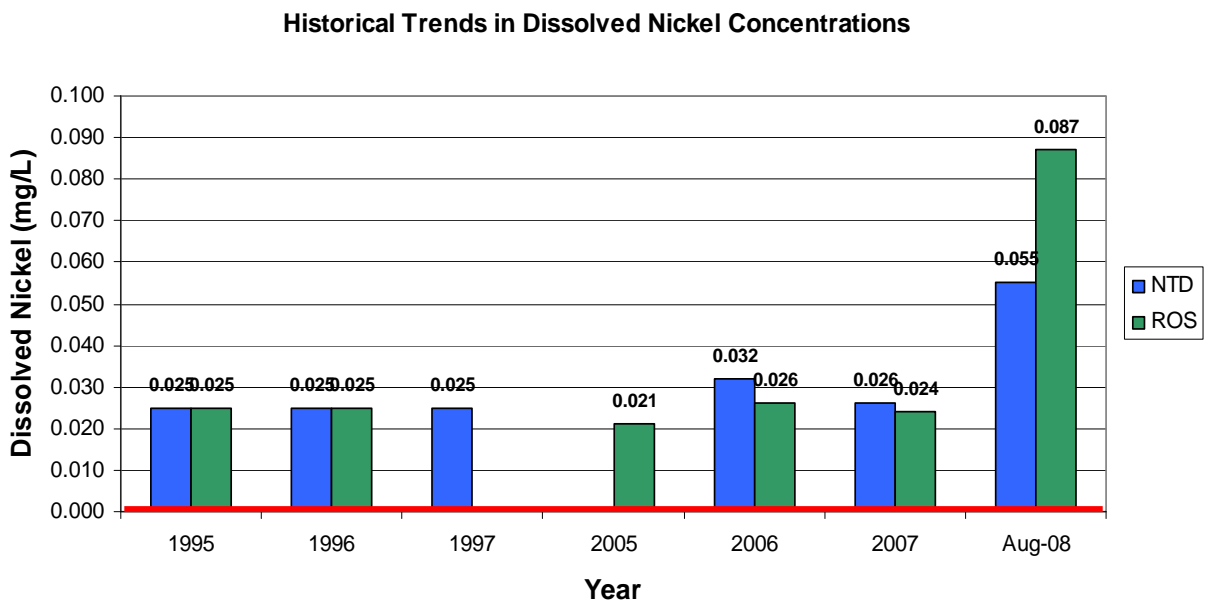
For sites where monitoring historically took place, the following two charts show the trends in dissolved nickel concentrations in recent monitoring efforts (2005 through 2008) and historical monitoring efforts (1995, 1996, 1997, 2005, 2006, 2007 and 2008). As with previous trend graphs, only the first sample from the series in the October 2008 storm was included.

Chart 15. Recent trends in dissolved nickel concentrations.



As NTD and ROS were the sites monitored the most consistently for dissolved nickel throughout the historical and recent monitoring efforts, they are the only sites 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 was 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.

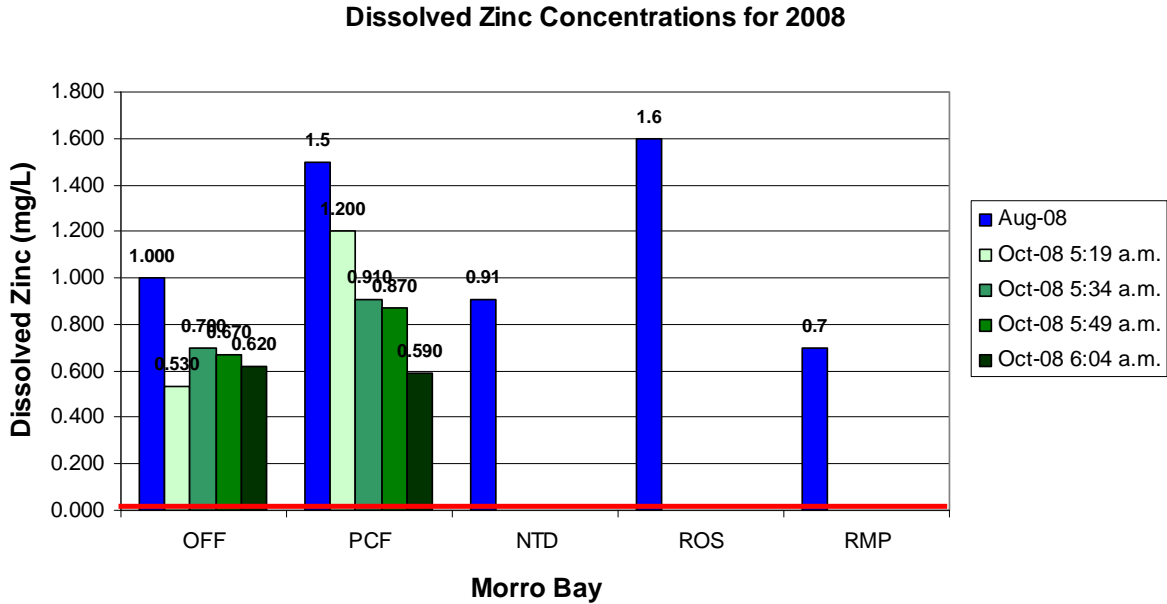
Chart 16. Historic trends in dissolved nickel concentrations.



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 trucks and forklifts in operation are considered an important 'source' of zinc in urban runoff. Residential sources of zinc include galvanized roofing

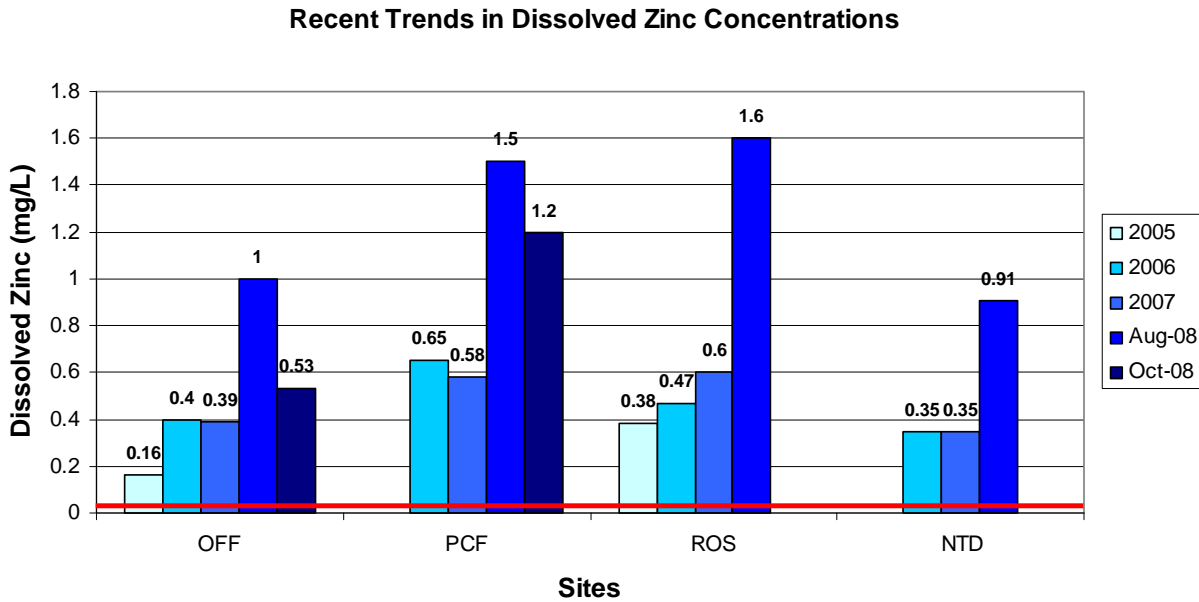
materials or zinc paints used to prevent rusting or corrosion. Zinc becomes toxic at low levels in the environment, with lethal effects on plankton and marine fouling organisms. The Basin Plan standard for zinc is 0.02 mg/L for the protection of marine life. As with the other dissolved metals, the time series data from the October storm at these two sites shows primarily a decreasing trend throughout the storm.

Chart 17. Dissolved zinc concentrations for 2008.



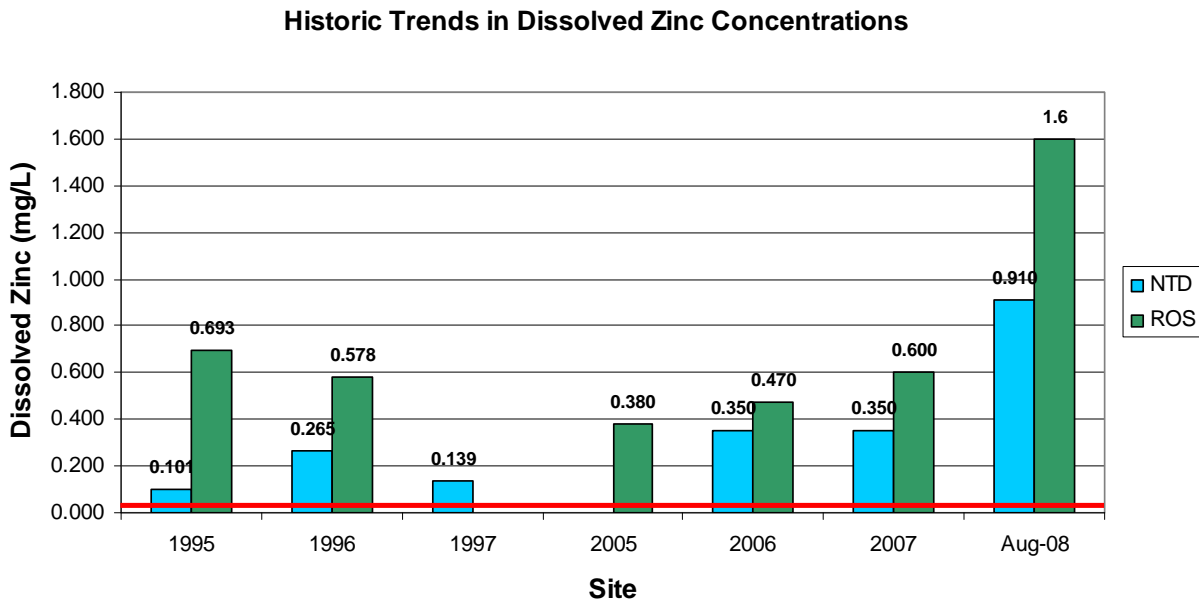
For sites where monitoring historically took place, the following two charts show the trends in dissolved zinc concentrations in recent monitoring efforts (2005 through 2008) and historical monitoring efforts (1995, 1996, 1997, 2005, 2006, 2007 and 2008).

Chart 18. Recent trends in dissolved zinc concentrations.



As with dissolved nickel, NTD and ROS were the sites 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, this data should not be included when assessing trends. Dissolved nickel concentrations appear to be relatively stable at these two sites between the 1990s and the 2000s.

Chart 19. Historic trends in dissolved zinc concentrations.

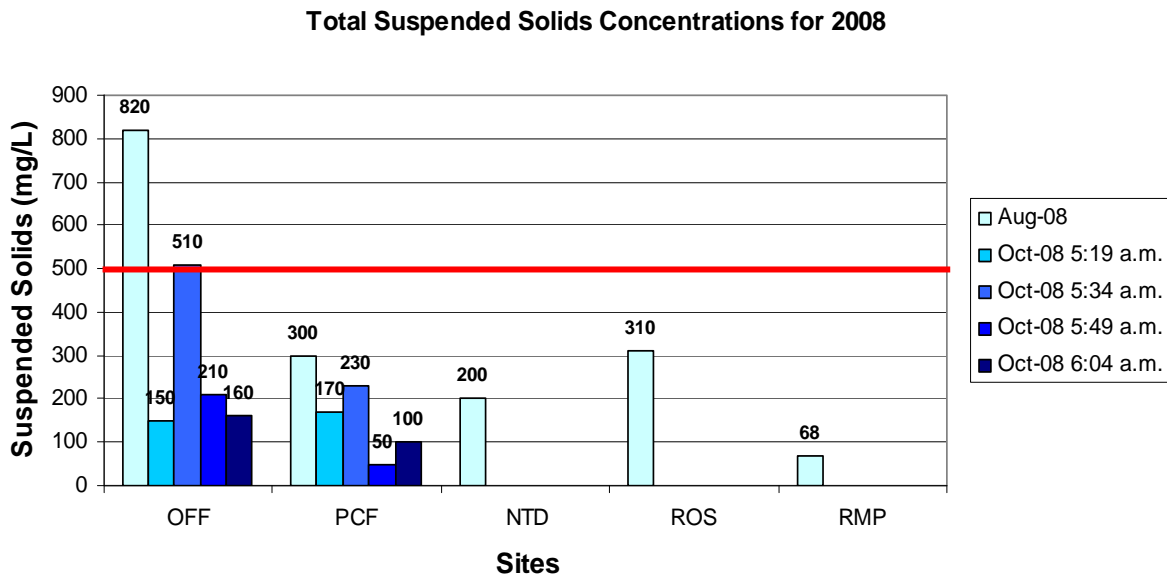


Dissolved and Suspended Solids

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 are levels where previous data have shown a potential negative impact on aquatic life. Suspended solids are an important analyte as they can affect water clarity and also provide substrate for sediment-bound pollutants such as toxic metals.

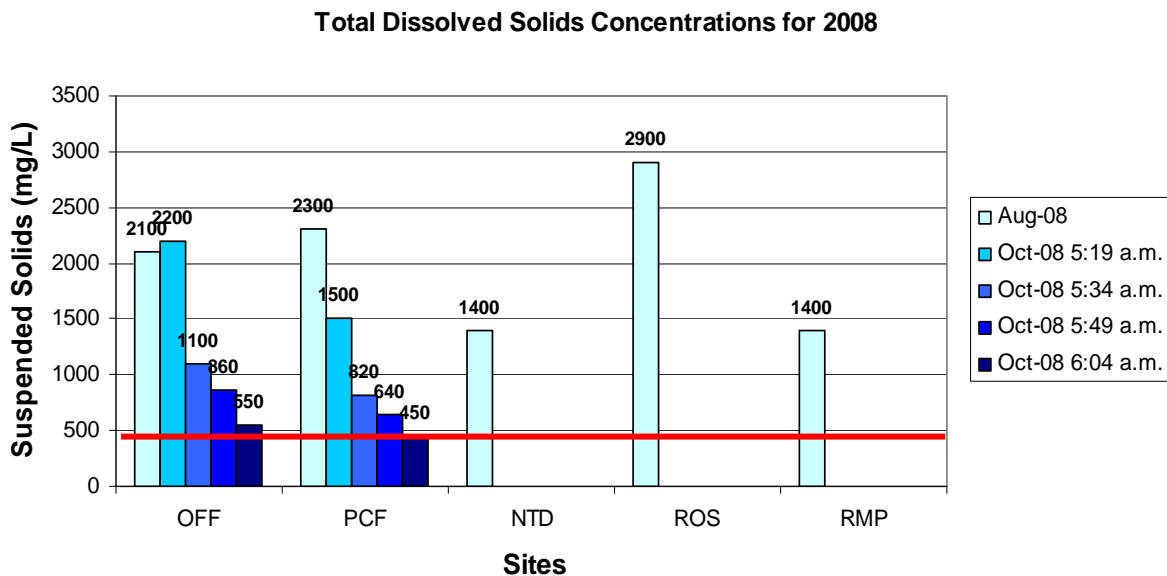
The OFF site is the only one with concentrations that were not consistently below 500 mg/L.

Chart 20. Total suspended solids concentrations for 2008.



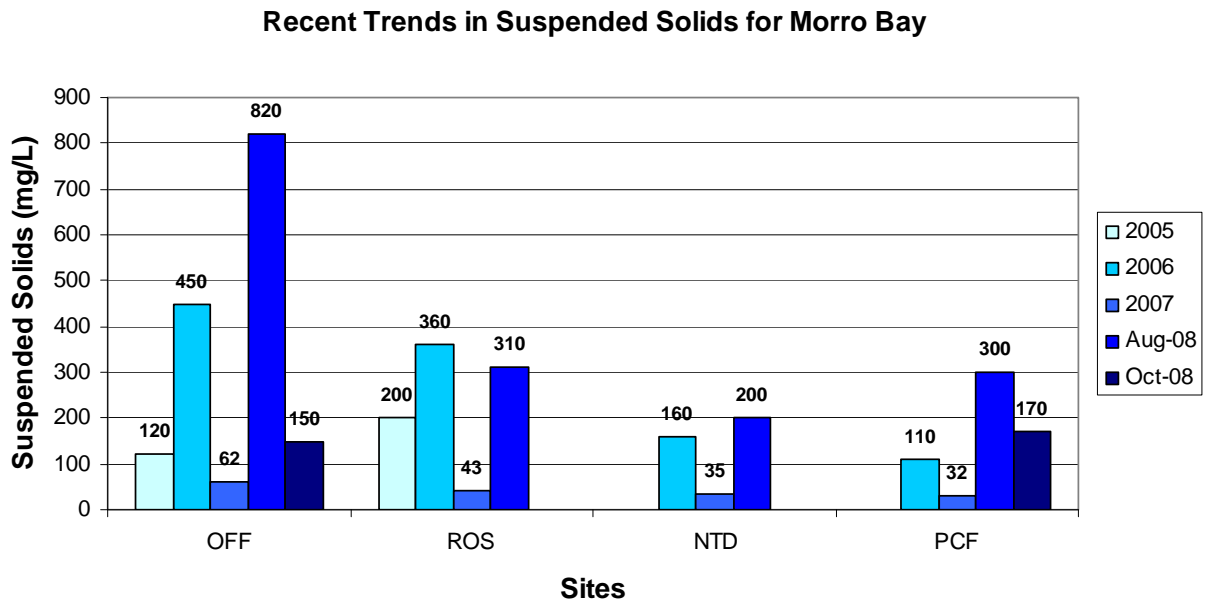
Total dissolved solids (TDS) can be made up of ions, nutrients and pesticides and represent the substances in the water that cannot be removed by a 2 um filter. The time series data shows a decreasing trend throughout the October 4 storm.

Chart 21. Total dissolved solids concentrations for 2008.



When looking at suspended solid concentrations for the Morro Bay sites, it does appear that the concentrations in 2007 were considerably lower than what was detected in 2006, although the 2005 reading at OFF is more in line with the 2007 values. Again, this could indicate that in 2007 sampling occurred after the first hour of the beginning of sheet flow. As with other analytes, results from the August 2008 storm were considerably higher than other recent data.

Chart 22. Recent trends in suspended solids for Morro Bay.



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 analytes were used.

The CCAMP informal attention level of concern for nitrates as N is 2.25 mg/L. The informal attention level of concern for orthophosphates as P is 0.12 mg/L. In August 2008, all of the sites had nitrate levels that exceeded the attention level. In October 2008, only the initial sample in the series was elevated. All of the samples in 2008 had orthophosphate levels that exceeded the informal attention level.

Chart 23. Recent trends in Orthophosphate as P concentrations.

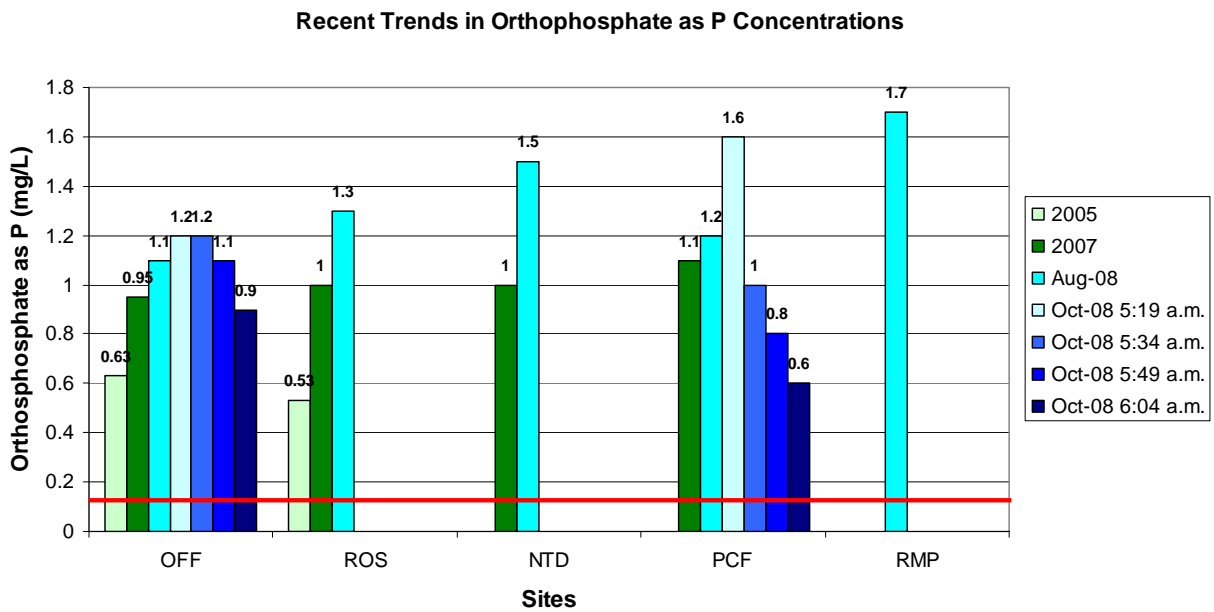
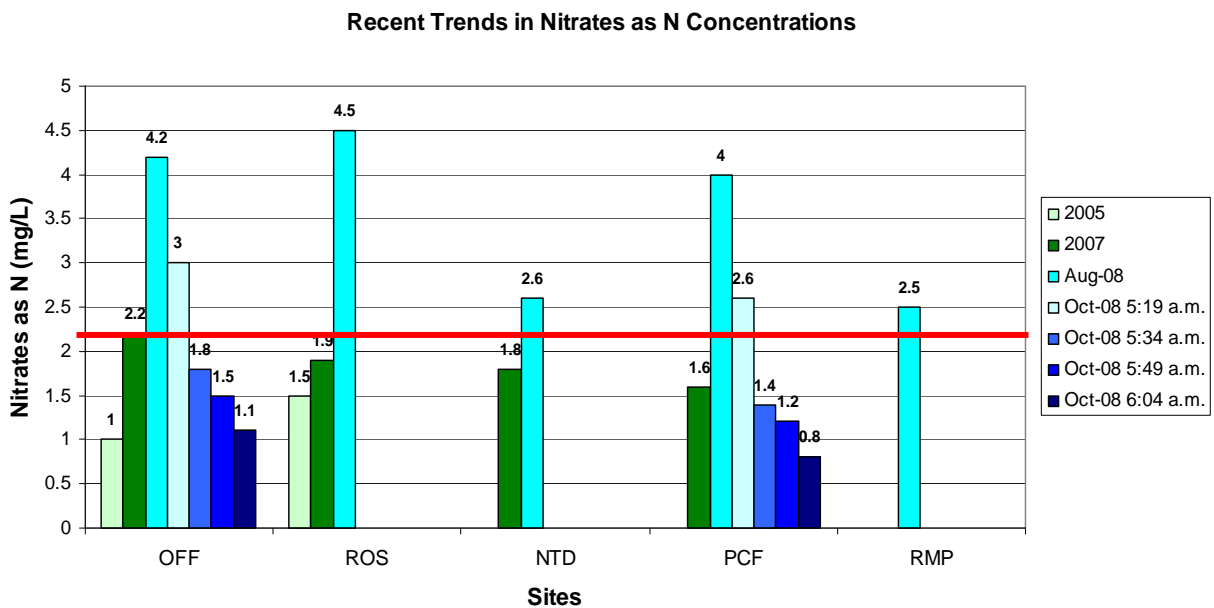


Chart 24. Recent trends in Nitrate as N concentrations.



Overview of Results

The results from the 2008 FF effort highlighted the elevated levels of most pollutants which were 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.
- Levels were especially high at ROS (12,997 MPN/100 mL) and NTD (21,780 MPN/100 mL) during the August 15 storm.

Turbidity

- Turbidity readings exceeded 10 NTU, the CCAMP attention level, at all sites.
- Readings varied from 72 to 240 NTU in the August 15 storm. Readings decreased from 130 to 86 NTU throughout the time series of samples at OFF and from 98 to 41 NTU throughout the time series of samples at PCF during the October 4 storm.

Orthophosphates as P

- Orthophosphates as P were detected at levels above the CCAMP recommended attention level of 0.12 mg/L for all samples at all sites.
- Especially high values were detected at NTD (1.5 mg/L) during the August 15 event and PCF (1.6 mg/L) during the October 4 time series samples.
- In 2005, 2006 and 2007, all sites had orthophosphate as P concentrations that exceeded the CCAMP recommended attention level.

Nitrates as N

- Nitrates as nitrogen levels exceeded the CCAMP recommended attention level of 2.25 mg/L for all of the samples at all of the sites in the August 15 storm.
- In the October 4 storm event, only the first sample in the series exceeded the attention level (OFF = 3 mg/L, PCF = 2.6 mg/L).
- In 2005, 2006 and 2007, none of the sites had nitrate as N concentrations that exceeded this 2.25 mg/L attention level.

pH

- pH values for all five of the sites during the August 2008 storm were less than 7, which is outside of the range of 7.0 to 8.5 that is protective of marine beneficial uses.
- pH values for two of the four samples in the time series at OFF and three of the four samples in the series at PCF were less than 7.0.
- In 2007, the pH values were less than 7.0 for all four sites. In 2006, pH values for all of the five Morro Bay sites were outside of the range of 7.0 to 8.5.

Oil and Grease and TPH-g

- Oil and grease was detected at all five sites in the August 15 storm with values ranging from non-detect (reported as 2.5 mg/L which is half of the detection limit) to 36 mg/L.
- Only the OFF site in the August 15 storm 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.
- In the October 4 storm, oil and grease was detected in only the first sample of the series (OFF = 6 mg/L, PCF = 8 mg/L) and were non-detect in all other samples. TPH-g was not detected in any of the samples from the October storm.

TDS

- TDS concentrations ranged from 1,400 to 2,900 mg/L in the August 15 event. In the October 4 storm, concentrations at OFF decreased from 2,200 to 550 mg/L through the time series, while the concentrations at PCF went from 1,500 to 450 mg/L. The CCAMP informal attention level is 500 mg/L.

Dissolved Zinc

- Zinc was detected at levels above the Basin Plan standard for receiving waters of 0.02 mg/L at all samples at all sites in both storms.
- The highest levels were 1.5 mg/L at PCF and 1.60 mg/L at ROS during the August 15 storm.
- In the October 4 storm, the values ranged from 0.7 to 0.53 mg/L at OFF and from 1.2 to 0.59 mg/L at PCF.
- Looking at both the data collected during the mid-1990s as well as more recent data, information is available for two sites: NTD and ROS. The trend for NTD has been an increase over time, while the trend at ROS has been a decrease over time.

Dissolved Copper

- Copper was detected at all sites in both storms at levels above the Basin Plan standard for receiving waters of 0.01 mg/L.
- In the August 15 storm, RMP had a concentration of 0.42 mg/L, the highest level detected in that event.
- In the October 4 storm, concentrations varied from 0.077 to 0.034 mg/L at OFF and 0.16 to 0.043 mg/L at PCF.
- As with zinc, the trend appears to be toward an increase in copper concentrations at NTD over time and a decrease at ROS.

Dissolved Nickel

- Nickel was detected at all sites in both storms at levels exceeding the Basin Plan standard of 0.002 mg/L for receiving waters.
- The highest concentration was at ROS (0.087 mg/L) in the August 15 storm.
- In the October 4 storm, values decreased from 0.044 to 0.020 mg/L at OFF and from 0.054 to 0.017 mg/L at PCF.
- Looking at NTD and ROS, 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:

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 3,300 uS/cm (ROS) to 1,400 (RMP and NTD) in the August 4 storm. These readings were higher than what we normally detect, likely due to the sampling of baseflow rather than storm runoff. Typically once the drains are flushed of the baseflow, the conductivity readings drop.
- In the October 4 storm, the time series results varied from 3,000 to 690 uS/cm at OFF and from 1,800 to 590 uS/cm at PCF.

Suspended Solids

- Suspended solids levels were below 500 mg/L, the CCAMP informal attention level, at all sites except OFF (820 mg/L in the August 4 event, and 510 mg/L in the October 4 event).

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 oil and grease (36 mg/L) and turbidity (240 NTU). The site also had the second highest nitrate as nitrogen concentration (3.0 mg/L).
- The PCF site had the highest detected concentration of zinc (1.5 mg/L), and the second highest orthophosphate concentration of the sites (1.6 mg/L).
- The NTD site had the highest detected *E. coli* concentration (21,780 MPN/100 mL) of all of the sites, and the lowest pH value (6.2).
- The ROS site had the second highest *E. coli* value (12,997 MPN/100 mL) and the highest nitrate as nitrogen concentration (4.5 mg/L).
- RMP had the highest orthophosphate concentration of all of the sites (1.7 mg/L) and the highest copper concentration ever 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.

- Lead has decreased since the mid-1990s. Nickel levels have remained relatively stable. The trend for zinc and copper concentrations was mixed, with an increase at some sites and a decrease at others.
- Bacteria values continued to be mixed, with no clear trend from year to year. Bacteria concentrations do not decrease throughout a storm, as shown by the time series data, as do other analytical parameters.
- Oil and grease appeared to be flushed fairly quickly, as it was primarily detected in the runoff at the beginning of a storm. In our time series data from the October storm, oil and grease was only detected in the initial sample of the series. TPH-g was not detected in any of the samples during that storm.
- For the nutrients, orthophosphate as P concentrations regularly exceeded the attention level throughout a storm, as the time series data illustrated. Nitrate as nitrogen appeared to be flushed more quickly during a storm, with concentrations quickly dropping to below the attention level of concern.

Future Efforts

The VMP is currently operating under a State Revolving Fund Project overseen by the California State Water Resources Control Board. The scope for the funding agreement includes monitoring of nonpoint source pollution related to stormwater and dry season runoff. A storm runoff monitoring effort is planned for fall of 2009.

Appendices

FF 2008 Site Descriptions

FF Field Instructions

FF 2008 Datasheet

Urban Watch

Study Design

Site Selection

The 2008 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 2008 were unchanged from the 2007 monitoring effort.

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)



Legend

- ▲ Urban Watch Site
- Watershed Boundary
- tiger_roads
- Major Roads
- ~ Streams
- Pacific Ocean

Morro Bay Volunteer Monitoring Program,
Quality Assurance Program Plan, July 2007

Created in ArcMap 9.2



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)



- Legend**
- ▲ Urban Watch Site
 - Watershed Boundary
 - ~ tiger_roads
 - ~ Major Roads
 - ~ Streams
 - Pacific Ocean



Morro Bay Volunteer Monitoring Program,
Quality Assurance Program Plan, July 2007

Created in ArcMap 9.2

Sample Collection

The UW program established in Monterey Bay was used as a model for our monitoring effort. In planning the effort, we met with personnel from the CCRWQCB, the city of Morro Bay, the county of SLO 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 26, 2008 in Los Osos and on June 12, 2008 in Morro Bay. Monitoring ended in both communities on September 30, 2008 in anticipation of the October 2008 FF monitoring. During the 2008 UW season, an unusual storm passed through the area on August 15. Sampling was not conducted within 72 hours of the storm event, and then UW monitoring recommenced through the end of September. Due to the unseasonable nature of the storm and the expectation that further FF monitoring would be conducted, the UW monitoring season continued beyond this August 15 storm event.

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 their results of analysis and observations.

Sample Analysis

The analytes for UW were selected both 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 with icepacks in a cooler 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 9. 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 some 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.

Sample Results

The 2008 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 times the site was flowing, ponded, tidally-inundated or dry does not add up to the total number of site observations because volunteers were instructed to check-off all categories that applied and so sometimes selected more than one of these categories on their datasheet.

Table 10. Summary of observations of UW site visits.

City	Site Code	# observations with site flowing	# observations with site ponded	# observations with site tidally inundated	# observations with site dry	Total # observations
Los Osos	BVH	3	8	NA	2	13
	ASHS	0	8	NA	5	13
	ASHN	0	6	NA	7	13
	FAR	0	2	NA	11	13
	PNE	0	1	NA	12	13
	BPR	0	5	9	1	12
Morro Bay	RMP	6	5	0	7	18
	BWD	0	6	1	11	17
	NTD	4	9	6	0	17
	NTD2	0	7	2	10	17
	PCF	2	4	1	11	17
	PCF2	0	0	0	17	17
	ROS	6	9	1	1	17
	DUN	0	1	0	15	16

Of note, BVH in Los Osos had either flow or signs of recent flow in 11 out of 13 observations. In Morro Bay, 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.

The following table provides a summary of the mean values from the analysis conducted on samples collected from Morro Bay sites.

Table 11. Mean values of flow collected from Morro Bay sites

Analyte	NTD	PCF	RMP	ROS
---------	-----	-----	-----	-----

Analyte	NTD	PCF	RMP	ROS
Number of Samples	2	2	6	4
Water Temperature (°C)	19.1	18.8	16.7	19.3
Conductivity (uS/cm)	415.0	1500.5	713.8	1089.3
pH	7.5	7.5	6.5	7.0
Ammonia-N (mg/L)	0.25	0.25	0.63	0.22
Total Chlorine (mg/L)	0.30	0.20	0.23	0.20
Turbidity (NTU)	81.0	31.5	15.8	75.4
Orthophosphates as PO₄ (mg/L)	1.74	2.96	1.31	0.57
Nitrates as N (mg/L)	1.15	2.75	0.83	0.50
Total coliform (CFU)	5,050	1,000,000	260	300,250

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

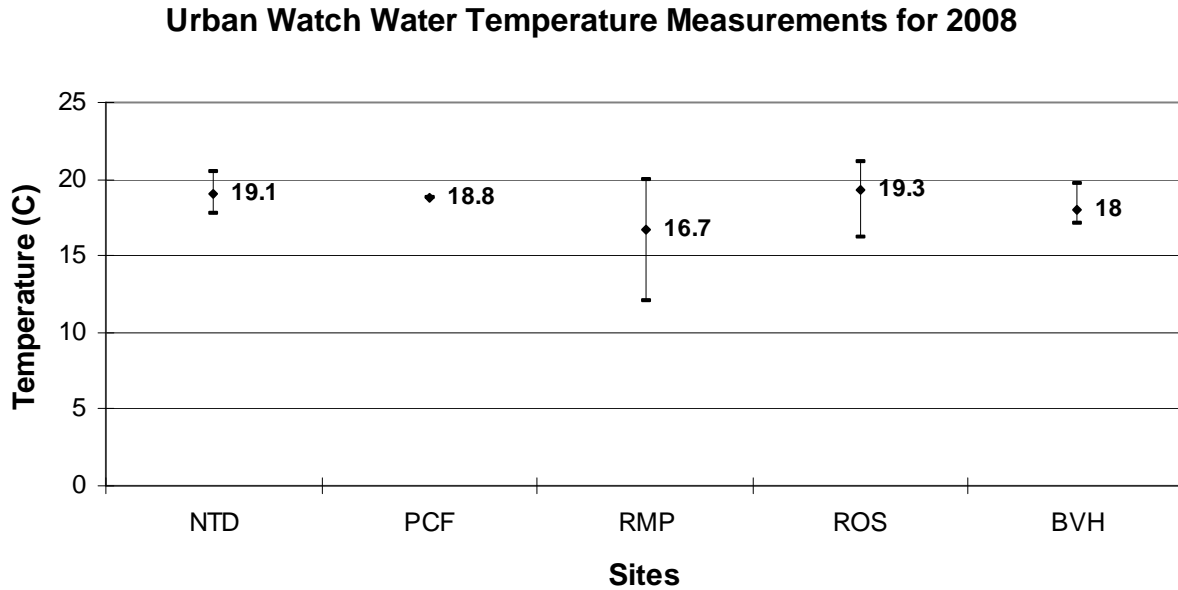
Table 12. Mean value of flow collected from Los Osos sites.

Analyte	BVH
Number of Samples	4
Water Temperature (°C)	18.0
Conductivity (uS/cm)	600.0
pH	6.8
Ammonia-N (mg/L)	1.63
Total Chlorine (mg/L)	0.20
Turbidity (NTU)	18.5
Orthophosphates as PO₄ (mg/L)	4.12
Nitrates as N (mg/L)	0.50
Total coliform (CFU)	334,000

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.

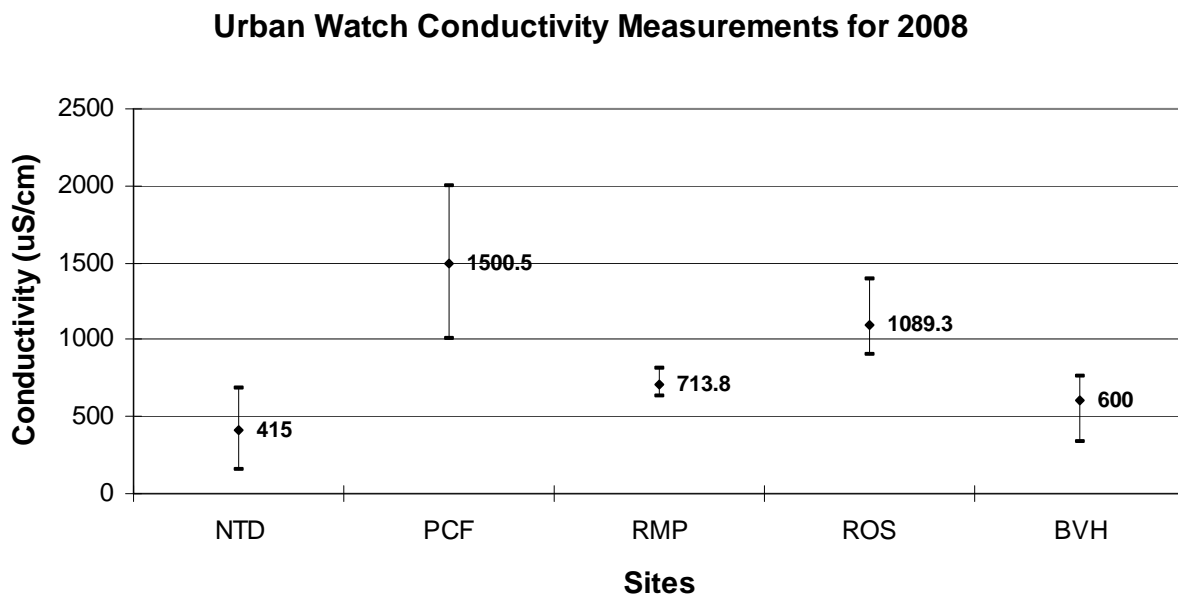
Chart 25. Urban Watch temperature measurements.



Conductivity

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

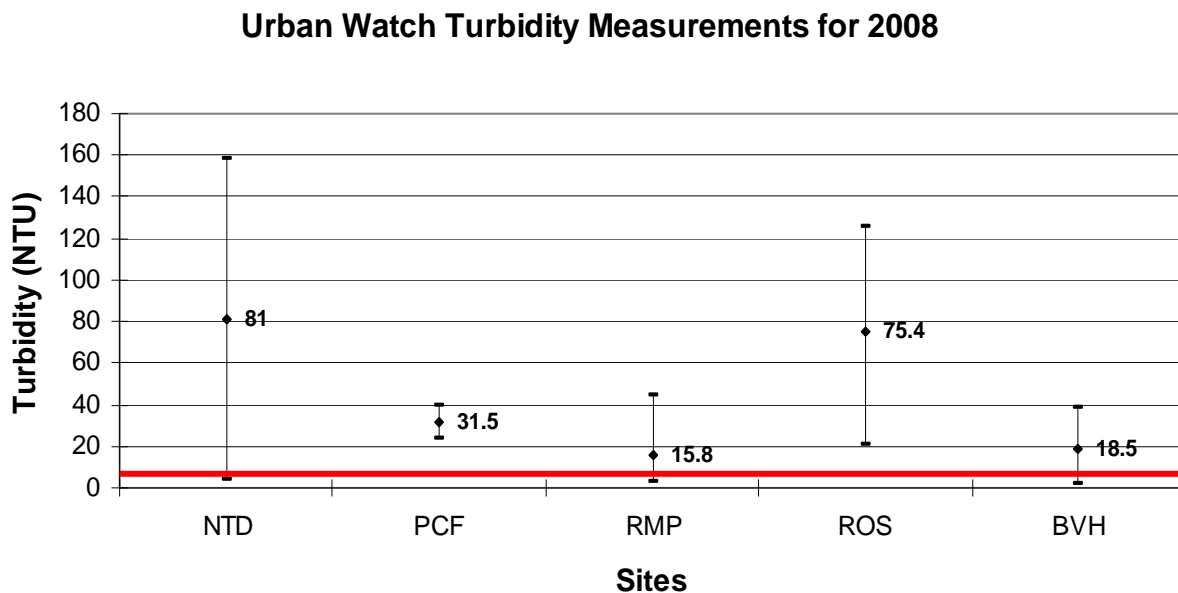
Chart 26. Urban Watch conductivity measurements.



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 opaque, 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.

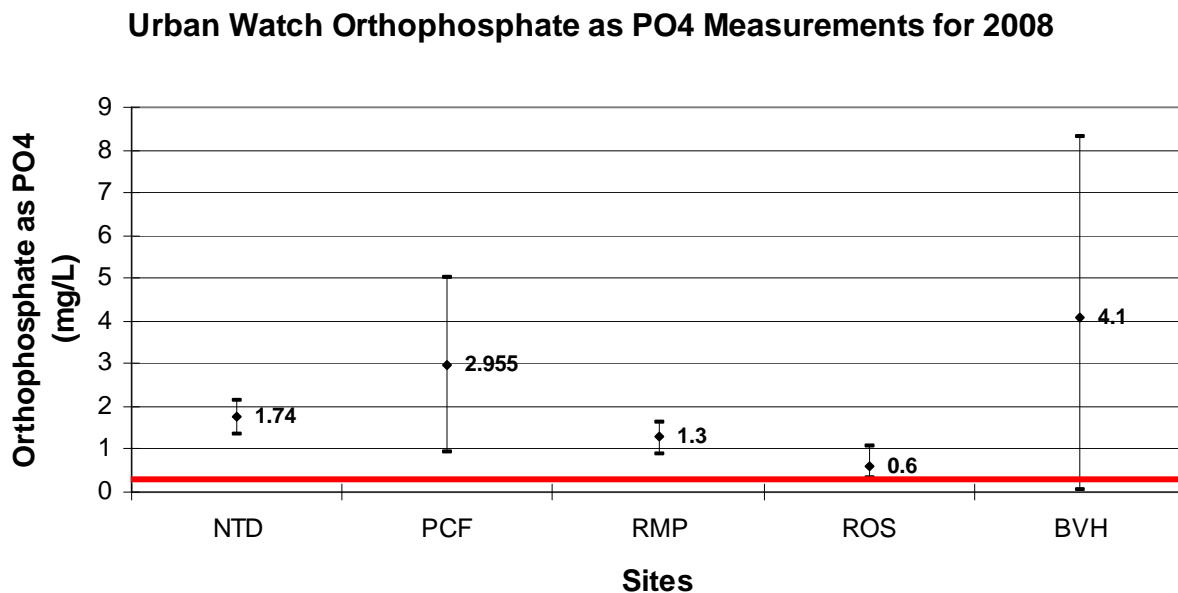
Chart 27. Urban Watch turbidity measurements.



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 28. Urban Watch orthophosphate measurements.

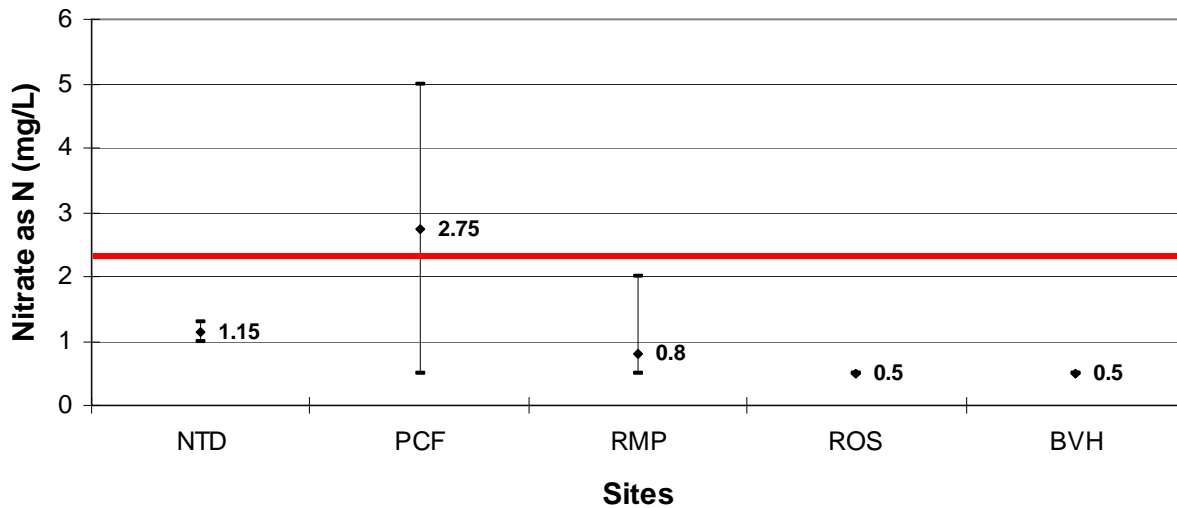


Nitrates

The samples were analyzed for nitrates as nitrogen using a LaMotte test kit. A value of 0.50 mg/L is the lower detection limit for our test kit. All readings from ROS and BVH were non-detect for nitrates. A concentration of 5 mg/L at PCF was the only result that exceeded 2.25 mg/L, the CCAMP informal attention level for this analyte.

Chart 29. Urban Watch nitrate measurements.

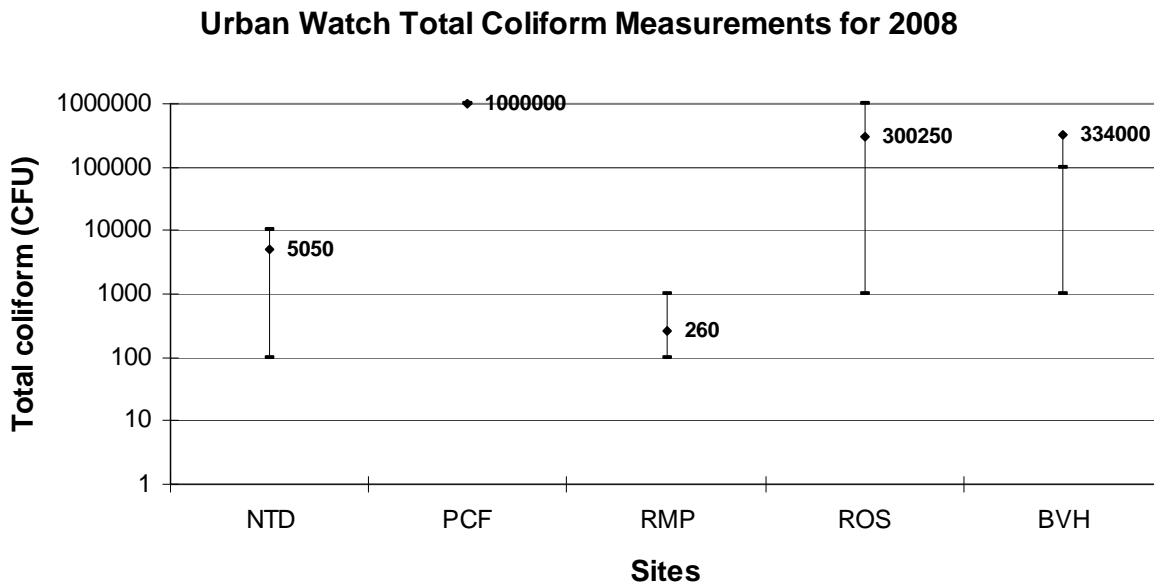
Urban Watch Nitrate as N Measurements for 2008



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 deemed infeasible. 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.

Chart 30. Urban Watch total coliform measurements.



Chlorine and Ammonia-Nitrogen

The results for chlorine and ammonia-nitrogen were primarily non-detects, with the exception of two ammonia readings of 3 mg/L at RMP on August 22, 2008 and 6 mg/L at BVH on September 9, 2008.

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 18 samples were collected during the 2008 monitoring season, and the results were as follows:

For odor, of the 18 samples, seven had a detectable odor. One sample was described as musty, one was described as rotten egg, and one was described as having a sewage odor.

For color, of the 18 samples, 14 had color discernible to the naked eye.

For clarity, of the 18 samples, six were slightly cloudy and none were rated as opaque.

For floatables, trash was observed three times, oil once, cigarette butts twice and food wrappers once.

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

For water flow, the flow was rated as a trickle (< 1 qt/min) in 11 samples and as moderate (< 1 gal/min) in three samples.

In noting whether the flow reached the receiving waters, this was a 'yes' for 14 samples and 'no' for four samples.

The source of the flow could only be identified for two 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 16.7 to a high of 19.3° C, which is above typical day-time temperatures detected in the front bay.

pH

- The range of pH values varied among the sites, with a typical range of 5.5 to 7.5.
- For FF, values ranged from 6.2 to 7.7, although the analysis was not conducted within 15 minutes of sample collection.

Conductivity

- Conductivity values were widely variable, with values ranging from 152 to a high of 1,392 uS/cm.
- For FF values, the results varied from 590 to 3,300 uS/cm.

Turbidity

- Turbidity values ranged from fairly low (4.05 NTU) to fairly high (158 NTU).
- Of the 18 samples collected from all sites, 12 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 41 to 240 NTU.

Orthophosphates

- Orthophosphates as PO₄ were elevated above the CCAMP informal attention level of 0.36 mg/L in all samples collected during the monitoring season except for two.
- The highest values were detected at BVH and varied from 0.05 to 8.3 mg/L.
- In comparison, FF values varied from 2.4 to 5.1 mg/L as PO₄.

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 5 mg/L from PCF.
- In comparison, FF values varied from 1.1 to 4.5 mg/L.

Total coliforms

- Total coliform values were variable, ranging from non-detect to 1,000,000 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 27,500 to 241,961 MPN/100 mL. In comparison, UW results had occasional non-detect levels.

Ammonia as nitrogen was detected at concentrations of 3 mg/L at RMP and 6 mg/L at BVH during the 2008 monitoring season. Total chlorine had no detections during the monitoring season.

As with the 2007 season, the most significant findings of the 2008 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 both early in the morning and late in the evening and was so frequent that algal growth could often be observed in the gutter downstream from the drain outlet. Flow or signs of recent flow were present in 85% of the visits to the site. The Ash St. inlets (ASHN and ASHS) frequently had signs of recent flow in 62% 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 33% of the site visits, at BWD in 61% of the site visits, at NTD in 76% of the visits, at PCF in 35% of the visits, and at ROS in 88% 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 and 2008.

Table 13. Overview of observations from 2007 and 2008 UW monitoring.

City	Site Code	% of Observations with Flow in 2007	% of Observations with Flow in 2008
Los Osos	BVH	92%	85%
	ASHS	50%	62%
	ASHN	25%	62%
	FAR	0%	15%
	PNE	0%	7.6%
	BPR	8.3%	50%
Morro Bay	RMP	30%	61%
	BWD	58%	33%
	NTD	53%	76%
	NTD2	0%	41%
	PCF	53%	35%
	PCF2	0%	0%
	ROS	89%	88%
	DUN	0%	6%

Future Efforts

The VMP is planning to conduct UW monitoring during the 2009 season. Monitoring will take place between June and the first major storm of the season in the fall of 2009.

Appendices

UW 2008 Site Descriptions

UW Field instructions

UW 2008 Datasheet