Water Quality Research and Monitoring Program

Clean Creeks
HEALTHY BEACHES
CITY OF SANTA BARBARA

Fiscal Year FY10
Annual Report

July 1 2009– June 30, 2010

City of Santa Barbara

SEAL OF THE CITY OF SANTA BARBARA CALIFORNIA

Creeks Division

9/30/2010

This report was prepared by:
Jill Murray, Ph.D., Water Resources Specialist
Jim Rumbley, Code Enforcement Officer
Stephanie Dolmat-Connel, Water Quality Intern

Additional partners:
Dr. Patricia Holden (UCSB)
Dr. Bram Sercu (UCSB)
Laurie Vandewerfhorst (UCSB)
Jessica Golman (UCSB)
Scott Reynolds (ECS)
Karen Reynolds (ECS)
Sable and Logan (ECS)

For inquiries, please contact:
Cameron Benson, Creeks Manager
Jill Murray, Water Resources Specialist
City of Santa Barbara Creeks Division
Phone: (805) 897-2508
Email: cbenson@SantaBarbaraCA.gov

The Creeks Division wishes to thank the volunteers, interns, Creeks Advisory Committee, and Creeks Division staff who often assist with sampling design, storm monitoring, creek walks, laboratory work, and data analysis. In addition, the City thanks the El Estero Wastewater Treatment Plant for processing samples and the Long Term Ecological Research Project at UCSB for running nutrient analyses free of charge. Cover invertebrate photo from California Department of Fish and Game (http://www.dfg.ca.gov/cabw/cabwhome.html).

TABLE OF CONTENTS

I. INTRODUCTION

KEY FINDINGS

Highlights from water quality sampling and data analysis in FY 2010 include:

- Sediment testing in Arroyo Burro Estuary, Mission Lagoon, Sycamore Lagoon, and Laguna Channel over three years has shown that the sediments are generally nontoxic to bottom-dwelling organisms. However, pyrethroid pesticides are an emerging constituent of concern and have been found in estuarine sediments.
- Storm monitoring also found high levels of pyrethroids in creek water samples, including high levels of Esfenvalerate and L-Cyhalothrin in Mission Creek and high levels of Cyfluthrin in Sycamore Creek.
- Toxicity testing of storm drain samples collected during a late-season storm showed no toxicity to fathead minnows.
- In very limited sampling that was conducted to investigate water quality effects from the Jesusita Fire, no increases in metals, PAHs, or toxicity were observed.
- A pilot test showed increased toxicity and foam associated with slurry sealing of road surfaces. Additional field work was conducted in summer and fall 2010; data analysis is still underway.
- Results from monitoring the Summer Urban Runoff Facility, the UV disinfection project at the Westside Drain, shows that the project continues to reduce fecal indicator bacteria to near zero levels in the effluent. However, indicator bacteria numbers rise to background levels very quickly downstream. The increase is likely due to indicator bacteria growth in Old Mission Creek rather than from new sources of input.
- Additional data analysis supports conclusions in the Fiscal Year 2009 report that there have been long-term improvements in indicator bacteria levels at Santa Barbara beaches (see below).
- High frequencies of beach warnings for indicator bacteria were seen at all beaches in Fiscal Year 2010 due to the large number of rain storms during the wet season.
- Arroyo Burro Beach exhibited a high number of beach warnings in dry weather as well, which was likely to due to indicator bacteria growth in the estuary and the open status of the estuary mouth throughout the summer (see below).
- Statistical analyses of indicator bacteria from Santa Barbara beaches showed a strong relationship between bacteria levels and rainfall, lagoon status (open or closed), and a modest influence of tide level and direction.
- Extensive field work was conducted in support of the State-funded Source Tracking Protocol Development Project, including dye testing, smoke testing, and automatic storm drain sampling.
- A Water Environment Research Foundation-funded project supported the use of canine scent tracking (sewage sniffing dogs) to investigate pollution sources (see below).

Beach Warnings at Arroyo Burro

Samples for fecal indicator bacteria (FIB) at local beaches are collected by the County of Santa Barbara, the City of Santa Barbara, and the Santa Barbara Channel Keeper. When levels exceed criteria set forth in Assembly Bill 411 (AB411), warnings are posted at the respective beaches. During the AB411 season (April 1 to October 31), Arroyo Burro Beach was posted frequently for indicator bacteria exceedances, causing curiosity and concern among Santa

Barbara beachgoers. The Creeks Division has analyzed data from past years and 2010 to investigate potential causes of the high exceedances rate.

There were 18 warnings posted at Arroyo Burro Beach during the AB411 season, six of which were due to wet weather runoff. The number of warnings was higher than in any AB411 season since testing began in 1997, but not high enough to be considered an outlier, as 16 warnings were posted in both 1998 and 2000. In 2008 there were 12 warnings, and in 2009 only five warnings. Among the warnings in 2010, there was no consistent pattern of which indicator bacteria groups (total coliform, E. coli/fecal coliform, enterococcus, or total coliform-to-fecal coliform ratio) exceeded the criteria.

Based on statistical analysis presented to the Committee in June 2010, Arroyo Burro is far likelier to have exceedances when the estuary mouth is open to the ocean. When the estuary is, exeedances are 50% more likely for enterococcus, 300% more likely for fecal coliform, and 1000% more likely for total coliform compared to rates when the estuary is closed. In 2008 and 2010, both years with high exceedance rates, the estuary was open all summer, whereas it was closed on approximately half of the sample dates in the 2009 AB411 season. Therefore, it appears that the high number of warnings in 2010 is likely due to the winter rain patterns and wave conditions leading to the pattern of an open estuary.

Given the importance of the lagoon status, creek indicator bacteria levels were also investigated. Arroyo Burro generally has lower indicator bacteria levels than Mission and Sycamore Creeks. At times total coliform levels are higher in Arroyo Burro, but not in most of 2010, and there was nothing unusual about Arroyo Burro creek indicator bacteria levels throughout the year. Based on Creeks Division sampling data, it appears that indicator bacteria grow in the estuary, due to the warm temperatures and high nutrient levels. However, such growth is not indicative of a health risk.

In addition to the supply of indicator bacteria from the creek and estuary, there is also growth of indicator bacteria on rotting kelp and sand grains. This indicator bacteria growth may stem from inoculation from bird or dog waste, or it may arise from the creek itself. It is important to note that the growth of indicator bacteria on kelp or sand does not represent a risk to swimmers – human pathogens generally require a host to replicate.

<u>Long-Term Trends in Water Quality</u>

In the Fiscal Year 2009 Annual Water Quality Report, evidence was presented to suggest that water quality has improved over the past ten years at beaches within the City. The analysis was based on Heal the Bay Beach Report Card Annual Grades, which are in turn based on complicated algorithms using data from the three indicator bacteria groups (total coliform, *E. coli*/fecal coliform, and enterococcus). Because the algorithms have been altered over time, it was not clear if indicator bacteria levels had also improved. The Creeks Division planned to examine raw FIB data provided by the County of Santa Barbara and look at long-term trends. Stephanie Dolmat-Connel, a water quality intern hired by the Creeks Division, conducted an extensive analysis of beach indicator bacteria data.

According to the analysis, which included data through 2009, levels have improved across all three FIB groups for E. Beach at Mission Creek. This result may be due to a change in beach management, i.e. there is a more often a sand berm across the estuary mouth. For other FIB groups and beaches, results are more variable. Exeedance rates have decreased for most beaches and most FIB groups. However, the spike in rainfall over the 2009-2010 winter may influence long-term trends.

Source Tracking and Illicit Discharge Detection

The Creeks Division is working with Dr. Patricia Holden (UCSB) to complete the Source Tracking Protocol Development Project, which is funded by the State Water Board's Proposition 50 Clean Beaches Initiative Grant Program. Ongoing work includes use of dye and smoke testing techniques in storm drains, along with molecular techniques for identifying areas contaminated with human waste.

In addition, the Creeks Division worked with UCSB and Environmental Canine Services to test canine scent tracking (sewage sniffing dogs) as a potential tool, with field work conducted in June 2010 and laboratory and statistical work completed in September 2010. The study was completed with funding from the Water Environment Research Foundation (WERF). The results of the study were very promising and the City submitted a Final Report to WERF in December 2010. The abstract of the report is presented here:

> Advances in microbial source tracking have enabled communities to gain more information about the specific hosts that may be responsible for elevated indicator bacteria levels in recreational waters. However, even when human-specific contamination can be traced to general areas, finding exact origins remains challenging due to sample costs and processing times. This study sought to test the use of a new qualitative tool for source tracking, canine scent tracking (sewage-sniffing dogs), to provide real-time results and low sample cost for illicit discharge detection.
>
> Canine responses were compared against traditional wastewater indicators, illicit discharge detection tracers, and emerging human-specific waste markers in storm drain locations in Santa Barbara, CA. Canine scent tracking was also tested for effectiveness in locating contaminated inputs to storm drains, addressing a specific hypothesis of contamination arising from illicit dumping from recreational vehicles, and conducting systematic outfall and storm drain reconnaissance. Based on the statistical and qualitative results presented in this pilot-scale study, canine scent tracking is a tool that should be expanded for use by researchers and stormwater managers.

A highlight of the work was uncovering a direct leak from the sanitary sewer to the Hope St. storm drain. Fortunately, this drain has been diverted to the sanitary sewer during dry weather for several years.

BACKGROUND

The goals of the monitoring program are to:

1. Quantify the levels (concentration and flux, or load) of microbial contamination and chemical pollution in watersheds throughout the city.
2. Evaluate impacts of pollution on beneficial uses of creeks and beaches, including recreation and habitat for aquatic organisms.
3. Evaluate the effectiveness of the City's restoration and water quality treatment projects, which includes collecting baseline data for future projects.
4. Identify sources of contaminants and pollution in creeks and storm drains.
5. Evaluate long-term trends in water quality.

The underlying motivation behind the monitoring program is to obtain information that the City can use to:

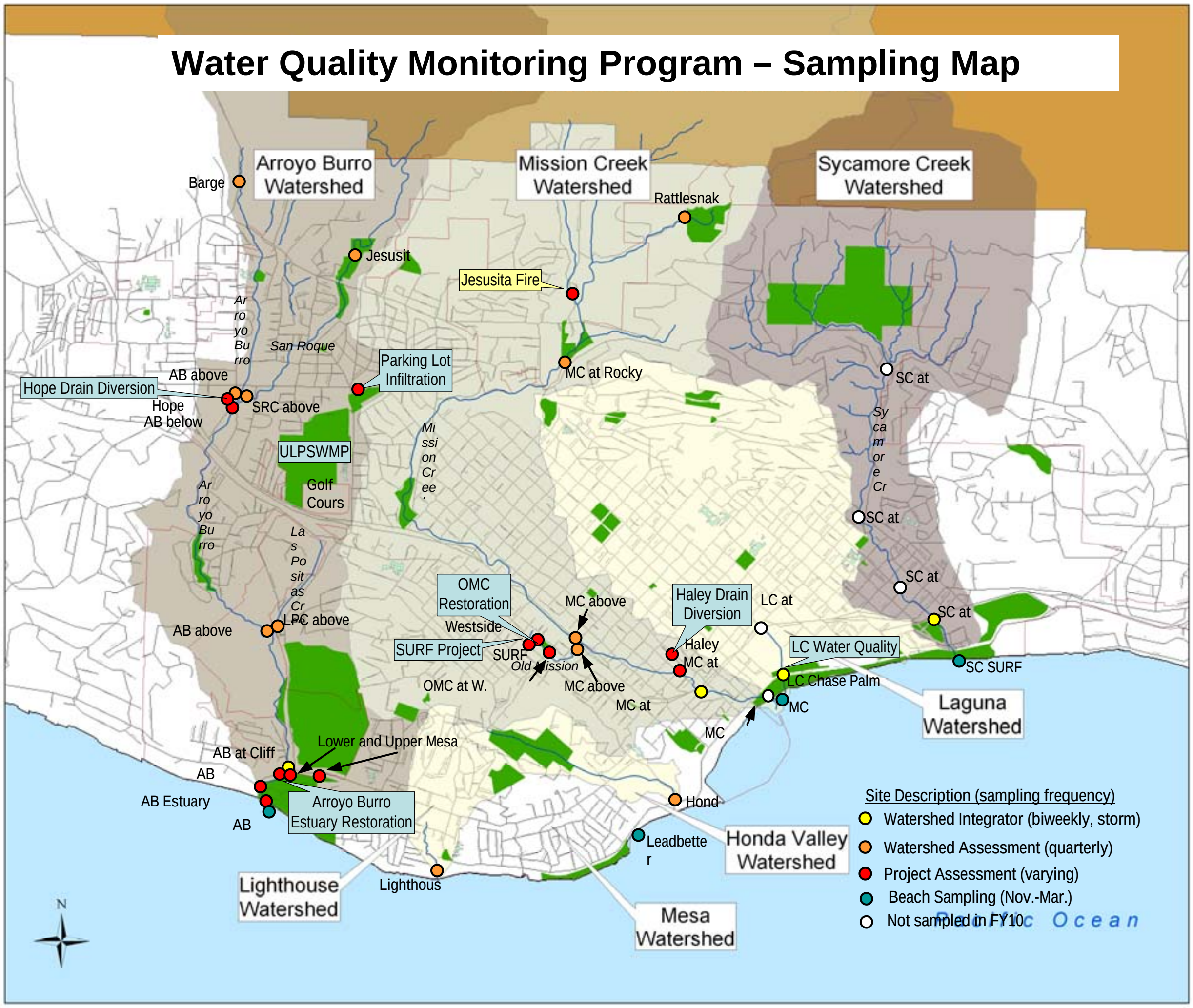
1. Develop strategies for water quality improvement, including prioritization of capital projects and outreach/education programs.
2. Communicate effectively with the public about water quality.

The following report described sampling and results that were based on the Fiscal Year 2010 Research and Monitoring Plan (Appendix A). The Research Plan is organized research questions that have been reviewed by the Creeks Advisory Committee. The Research and Monitoring Program are adaptive, and as questions are answered or modified, sampling strategies change as well.

Where possible, the report is also organized around the research questions. Many sections will be completed at the end of the Fiscal Year when yearly data sets have been compiled. Additional sections to be completed in the Annual Report include Emerging Issues and Literature Updates, Reporting, and the Recommendations for Fiscal Year 2011. ***The primary purpose of this report is to serve as an internal record of data collection and analysis. Please see the Creeks Division 2001-2006 report for a discussion of methods, information on water quality criteria, and a glossary of monitoring terms. In addition, a substantial amount of data analysis has been postponed until FY11, due to Creeks Division staff focusing on the Source Tracking Development Project, the Beach Water Quality statistical analysis, and the Slurry Seal Project.***

The monitoring program consists of eight key elements:

1. Watershed Assessment
2. Storm Monitoring
3. Restoration and Water Quality Project Assessment
4. Beach Water Quality
5. Source Tracking/Illicit Discharge Detection
6. Creeks Walks/Clean ups
7. Bioassessment
8. Methods Development



<u>Watershed Assessment</u>

Research questions:

1. Is overall water quality, in terms of indicator bacteria and field properties, getting better over time?
2. How contaminated and/or toxic is sediment at creek outfall sites?
3. What is the impact of eutrophication on Santa Barbara creeks?

<u>Storm Monitoring</u>

Research Questions:

1. What are the highest concentrations of pollutants of concern during storm events, particularly seasonal first flush storms? Do creeks and/or storm drains in Santa Barbara have problems with toxicity during storm events?
2. What are the impacts of the Jesusita Fire on water quality?
3. What are the loads of pollutants discharged from Santa Barbara creeks during storms?
4. What are the sources and routes of pollutants during storms?
    a. How do concentrations and loads vary during storms and from site to site?

    b. Fecal indicator bacteria
    c. Slurry seal/PAHs/Foam
    d. Metals
    e. Nutrients
5. How do restoration/treatment projects impact water quality during storm events?

<u>Restoration and Water Quality Project Assessment</u>

The Creeks Division has completed several restoration and water quality improvement capital projects over the past several years. Project assessment is used to determine the success of projects in lowering microbial and chemical pollution levels and improving water quality for aquatic organisms. In some cases project monitoring is grant-required, and the remaining is for internal review of project success. Additional monitoring is conducted to ensure that the facility is performing as intended.

Research Questions:
1. Do Creeks Division projects result in improved water quality, as reflected in pre- and post-project, and/or, upstream to downstream, conditions?
2. What is the baseline water quality at future restoration/treatment sites?
3. What are the mechanisms of project success?
4. Are installed projects functioning correctly?

List of Projects
1. Westside SURF and Old Mission Creek Restoration
2. Arroyo Burro Restoration, including Mesa Creek daylighting
3. Hope and Haley Diversions
4. Laguna Channel Disinfection (Source Tracking)
5. Golf Course Project (Storm)
6. San Pascual Drain (Source Tracking)
7. Parking Lot LID (Storm)
8. Debris Screens (Creek Walks)
9. Mission Creek Fish Passage (Eutrophication/Dissolved Oxygen)
10. Bird Refuge

<u>Beach water quality</u>

Research questions:
1. How to creeks and storm drains relate to beach water quality and warnings?
2. How do other factors (kelp, tides, temperature, and beach use) relate to beach warnings?
3. What are the causes of persistent beach warnings that occur?
4. What is the risk to human health from recreation in creeks and beaches in Santa Barbara?

<u>Source Tracking/Illicit Discharge Detection</u>

Research questions:
1. Which subdrainages and/or contribute the greatest loads of pollutants to creeks in Santa Barbara?
2. Where, when and how is human waste and/or sewage entering storm drains and creeks?

a. What happens to the signals of human waste and indicator bacteria levels as water moves downstream away from the source?
b. How does presence of human waste relate to beach warnings?
3. Do rotting plant material and sediment contribute to high FIB levels in storm drains?
4. What are the impacts of reservoir flushing on metals?
5. Are new hot spots emerging?
6. Specific areas of concern: Barger Canyon, Las Positas Creek, Haley Drain

Creek Walks

Research Questions:
1. Are there new problems in creeks that need to be addressed?
2. Is the amount of trash in creeks decreasing over time?
3. Were decreases in trash observed between 1999 and 2005 due to creek flow histories or the impact of City programs?
4. Will the installation of catch basin screens lead to decreased trash observed in creeks?

II. ROUTINE WATERSHED ASSESSMENT

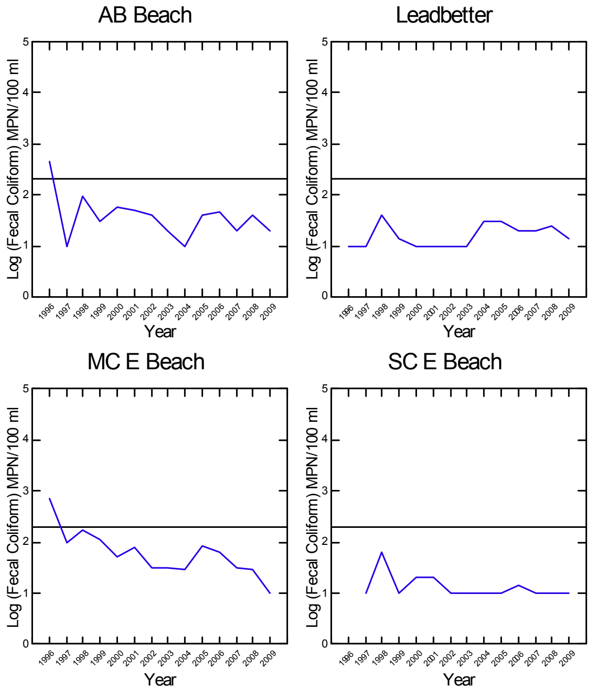
IS WATER QUALITY IMPROVING?

In the FY09 Annual WQ Report, the Creeks Division presented evidence that beach water quality had improved over the past ten years at beaches within the City. The analysis was based on Heal the Bay Beach Report Card Annual Grades, which are in turn based a complicated algorithm using data from the three indicator bacteria groups (total coliform, E. coli/fecal coliform, and enterococcus). Because the algorithms have been altered over time, it is not clear if fecal indicator bacteria (FIB) levels have also improved. he Creeks Division planned to examine raw FIB data provided by the County and look at long-term trends. Stephanie Dolmat-Connel, a water quality intern hired by the Creeks Division, conducted an extensive analysis of beach FIB data, which is included in the section below on causes of beach warnings. In addition, she provided a time series of data from each of the beaches and indicator bacteria groups, by year, as shown below.

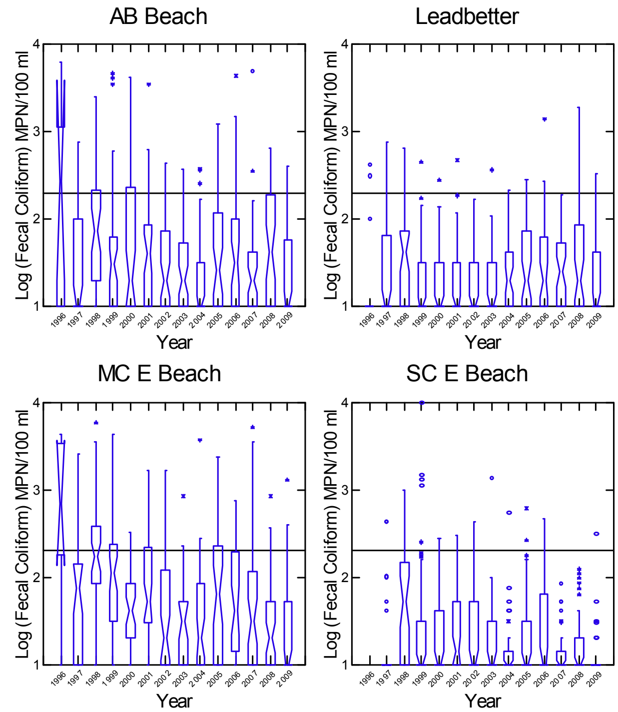
For each FIB group, the plots in the left panel show the median FIB level in the surf zone for the year. The plots in the right panel show the boxplot (including outliers, quartiles, and confidence intervals) for dry days only. Horizontal lines mark the AB411 criteria for water quality.

Beach water quality appears to have improved across all three FIB groups for E. Beach at Mission Creek. This result may be due to a change in beach management, i.e. there is a more often a sand berm across the estuary mouth (see lagoon analysis in section below). For other FIB groups and beaches, results are more variable. Additional analyses are contained in the beach warning section below. We will conduct additional investigations into creek FIB levels over time. The FY09 report does include FIB plots from Arroyo Burro and Mission Creek.

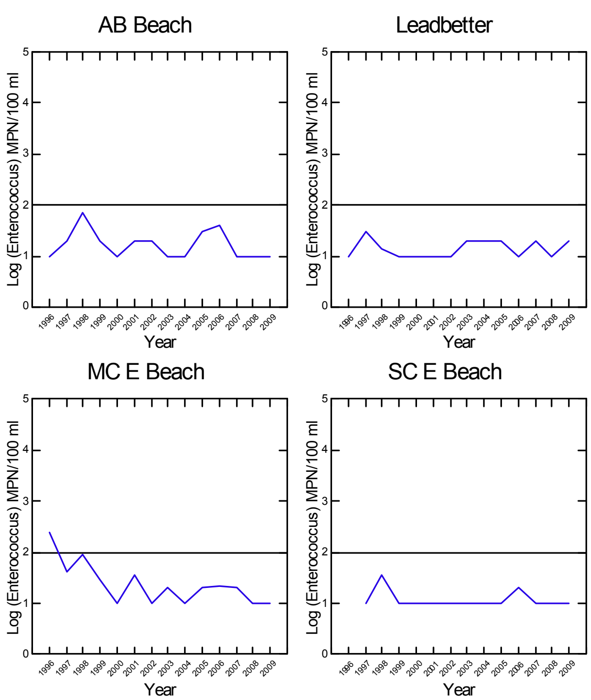
Median Fecal Coliform All Days 1996-2009



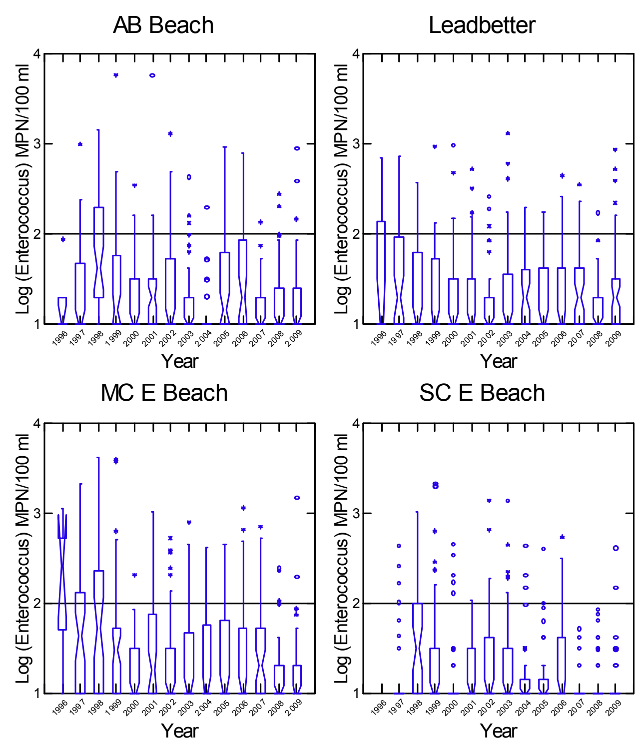
Fecal Coliform by Year (Dry Days)



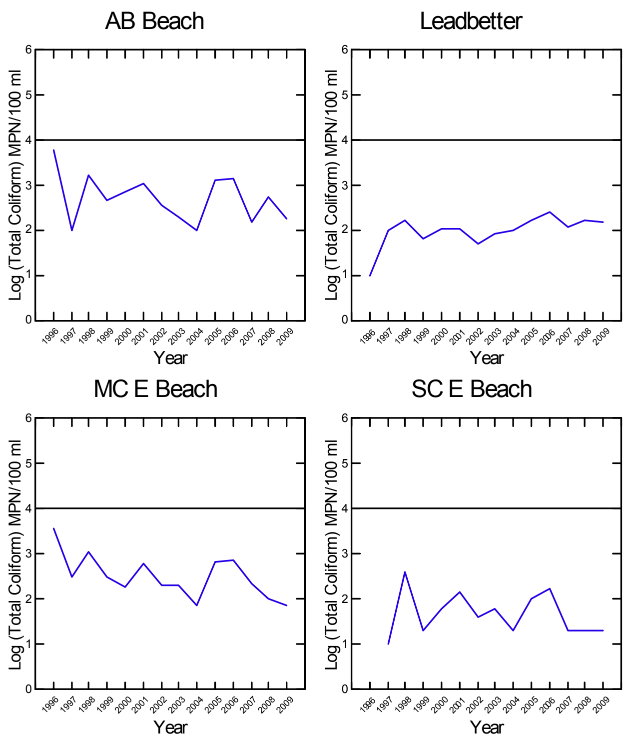
Median Enterococcus All Days 1996-2009



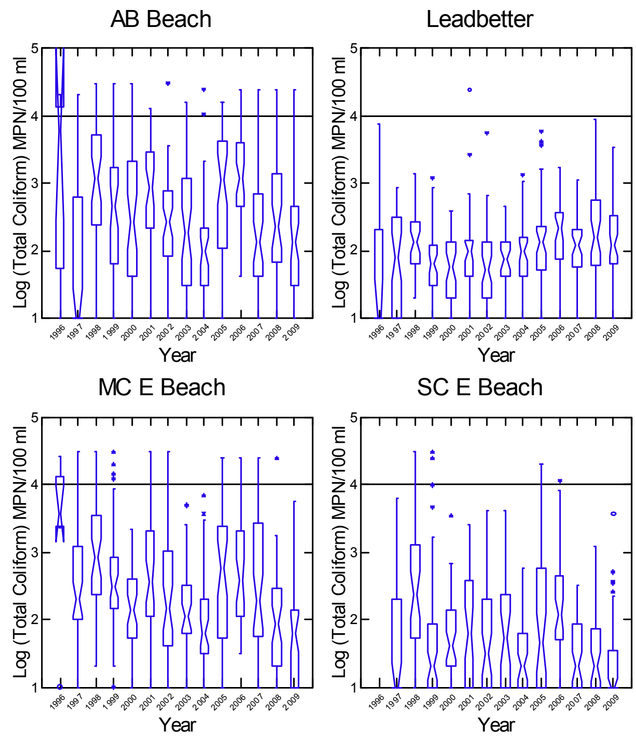
Enterococcus by Year (Dry Days)



Median Total Coliform All Days 1996-2009

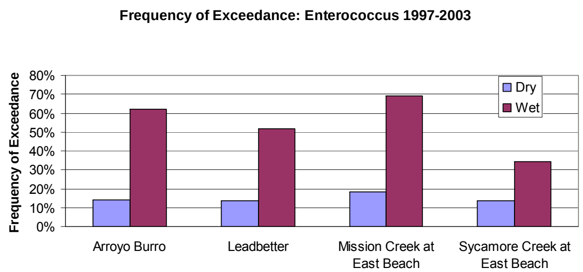


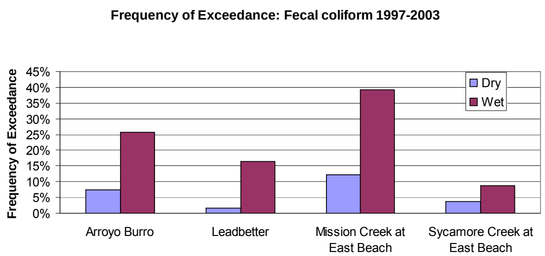
Total Coliform by Year (Dry Days)

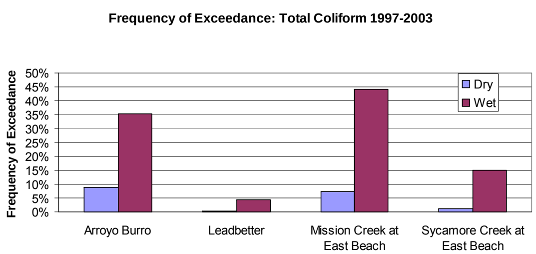


Exceedances appear to have decreased between (1997-2003) vs. (2004-2009), as shown in the plots below. However, 2010 may bring the levels and exceedances rates back up due to high levels and frequency of rainstorms.

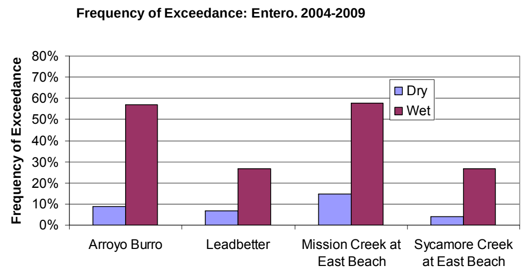
Average Exeedances 1997-2003

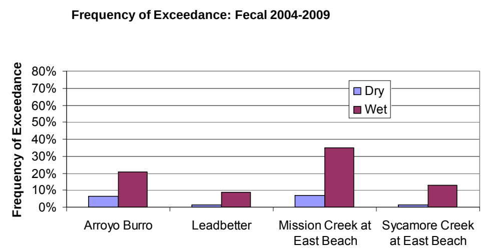


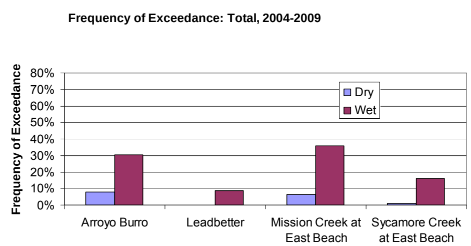




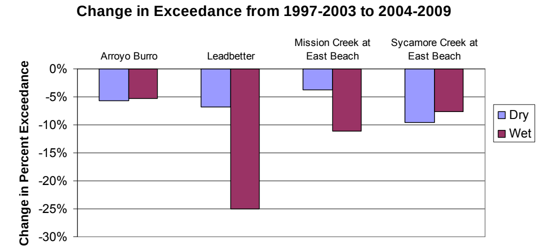
Average Exceedances 2004-2009

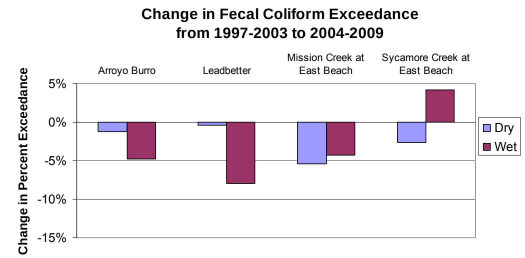


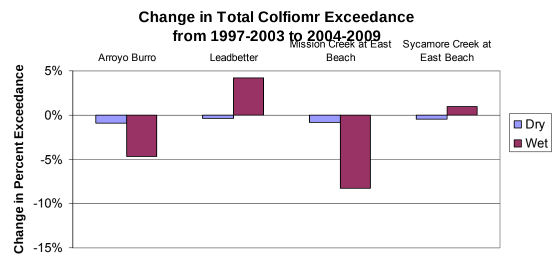




Change in Average Exceedances

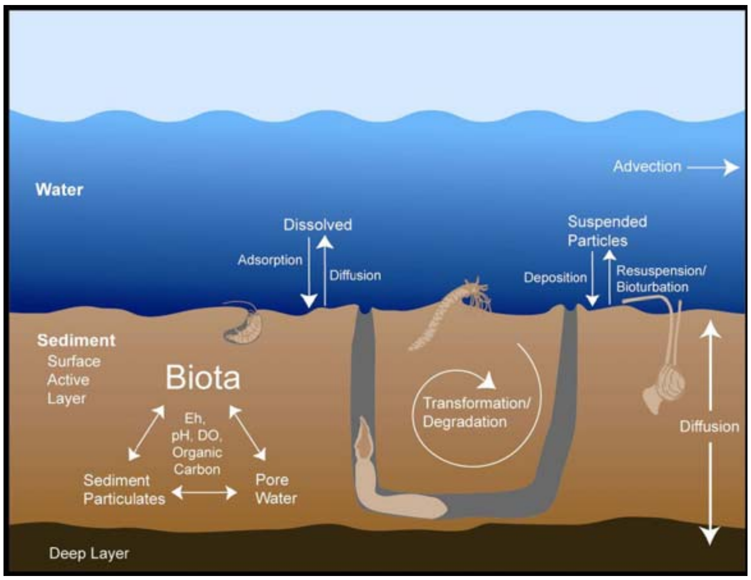






HOW CONTAMINATED AND/OR TOXIC IS SEDIMENT AT CREEK OUTFALL SITES?

Many pollutants are known to adhere to sediments and persist for a much longer time than they do in the water column, causing harm to sediment biota. However, assessing the impact of pollutants in sediments is more difficult compared to the water column, because the bioavailability of pollutants in sediments depends on many factors, as shown in the following figure.



Sediment processes affecting the distribution and form of contaminants (in: SWRCB, Draft Staff Report for Water Quality in Enclosed Bays and Estuaries, 2008).

Based on recommendations from the Creeks Advisory Committee, the Creeks Division FY08 Research Plan called for quarterly sediment sampling to assess the condition of sediment downstream the integrator stations, i.e. in the estuarine portion of Mission Creek, Arroyo Burro, and Sycamore, and the lower section in Laguna Channel. However, due to the unexpected high cost of processing these samples, the decision was made to sample sediment annually. Three years of sediment data have been collected, comprised of sampling in November 2007, September 2008, and August 2009. The Andre Clark Bird Refuge (ACBR) was sampled in 2008. Based on the results from the ACBR, limited testing was also conducted there 2009.

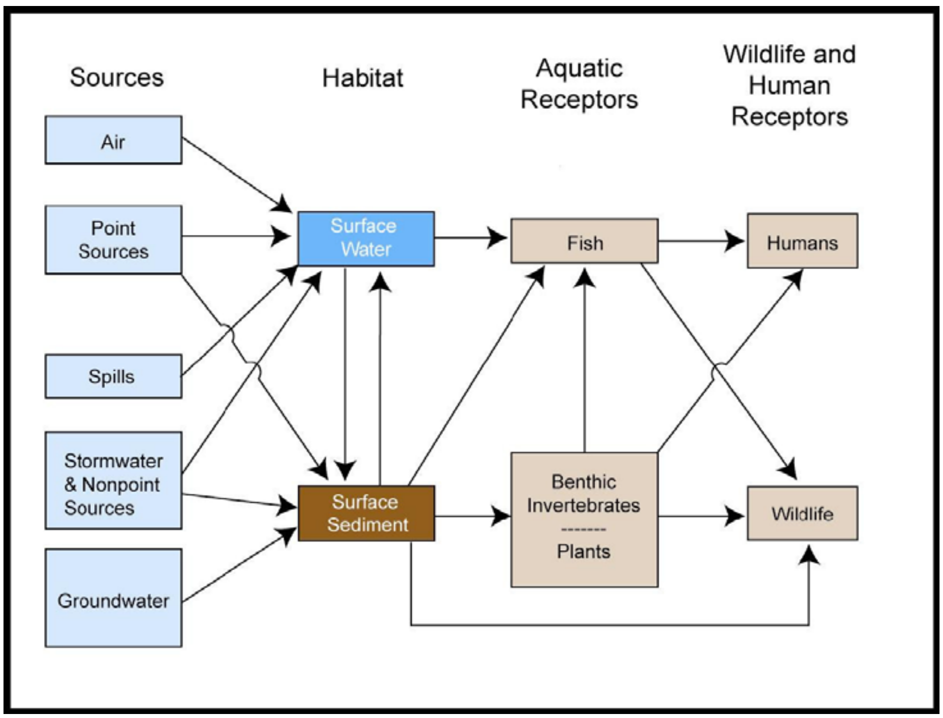
The following section uses the data collected over three years to analyze the condition of sediment in Arroyo Burro Estuary, Mission Lagoon, Laguna Channel, Sycamore Lagoon, and ACBR. Until recently, there were very few objectives or standards available to use when interpreting sediment chemistry data. The Creeks Division used the California State Water Resources Control Board (State Water Board) draft Sediment Quality Objectives (SQOs) in order to guide the sediment assessment in the 2008 Water Quality Report. The SQOs were signed into law in September 2009, and will apply to enclosed bays, estuaries, and coastal lagoons throughout California. Arroyo Burro Estuary, Mission Lagoon, and Sycamore Lagoon fit the definition of coastal lagoons and estuaries. In recent years, the outfall of Laguna Channel has merged with Mission Lagoon prior to discharge to the ocean, preventing a separate sampling effort for Laguna Lagoon. Lower Laguna Channel and the Bird Refuge, which do not receive saline water, do not fit within the definition of a coastal lagoon. In addition, Santa

Barbara Harbor fits the definition of an enclosed bay; however, the Creeks Division does not sample harbor sediments. \

The SQOs integrate chemical and biological measures to determine if sediment-dependent biota are protected or degraded as a result of exposure to toxic pollutants. The SQOs are also used to determine the risk to human health from consumption of sediment-associated seafood. The approach includes the following narrative objectives and associated beneficial uses:

Beneficial Uses	Target Receptors	Narrative Objective
Estuarine Habitat Marine Habitat	Benthic Community	Pollutants in sediments shall not be present in quantities that, alone or in combination, are toxic to benthic communities in bays and estuaries of California.
Commercial and Sport Fishing Aquaculture Shellfish Harvesting	Human Health	Pollutants shall not be present in sediments at levels that will bioaccumulate in aquatic life to levels that are harmful to human health.

The Sediment Quality Objective Control Plan includes a program of implementation, using multiple lines of evidence (MLOE), including chemistry, toxicity, and bioassessment, to determine if the narrative objective for benthic community protection is met. The human health objective will be addressed in future years. The following figure illustrates the relationship among pollutant sources, habitats, and receptors.



Principal sources, fates, and effects of sediment contaminants in enclosed bays and estuaries. Adapted from Brides et al. 2005 (in: SWRCB, Draft Staff Report for Water Quality in Enclosed Bays and Estuaries, 2008).

Methodology- Where possible, the SQO Implementation Plan was used to determine the sampling, chemistry, and toxicity methods. The ecological component, using bioassessment, has not been implemented by the Creeks Division.

Staff used a short section of wide PVC pipe, along with a flat shovel, for collecting lagoon sediment samples. The PVC pipe was pushed down into the sediment, approximately 5 cm deep. The flat shovel was slid underneath the pipe to hold the sediment inside the pipe as it was pulled toward the surface. The sediment from this first “scoop” was emptied into a bucket. A total of two scoops were collected at four different areas in each lagoon, ranging from lower to upper lagoon (for a total of 8 scoops). Once all the samples were in the bucket, the sediment was mixed thoroughly and poured into sample bottles provided by the laboratory. In 2008, sediment was collected from the Bird Refuge by Richarde Forde, from several locations throughout the lake. Sediment samples were outsourced to Calscience laboratory for sediment chemistry, ABC Labs for toxicity, and CRG for pyrethroids.

The following table shows the chemical tests required by the SQO to conduct chemistry assessment. All of the chemicals were measured in at least one year for each site. In addition, a second type of analysis that was presented in a recent SCCWRP report (taken from Macdonald et al., 2000) is also presented below. **In order to make the most conservative assessment of sediment quality, the highest values observed for each compound over the years sample, at each site, were used in the analyses.**

Chemical tests required to conduct the SQO Sediment Chemistry Assessment

Pollutant of Concern	Detection Limit, Units
Cadmium	n/a, mg/kg
Copper	52.8 mg/kg
Lead	26.4 mg/kg
Mercury	0.09 mg/kg
Zinc	112 mg/kg
Chlordane, alpha	µg/kg
Chlordane, gamma	µg/kg
DDDs	µg/kg
DDEs	µg/kg
DDTs	µg/kg
Dieldrin	µg/kg
p,p' DDT (4,4, DDT)	µg/kg
PAHs, high molecular weight	µg/kg
PAHs, low molecular weight	µg/kg
PCBs	µg/kg
trans nonachlor	µg/kg

For freshwater sites (Laguna Channel and the Bird Refuge), an integration of chemistry data was also conducted, based on a 2008 report by SCCWRP. The SCCWRP report was based on MacDonald (2006). Additional tests required for this are shown in the table below.

Additional Tests Required to Conduct SCCWRP Freshwater Analysis

Pollutant of Concern
Arsenic
Chromium
Nickel
Dieldrin
Endrin
Helptachlor Epoxide

Lindane
Pyrethroid Pesticides

Results and Analysis

The following table reports the raw data and thresholds used in the analyses presented below. Highlighting indicates values that exceeded the most conservative thresholds available.

Sediment Chemistry Results 2007-2009

Shading represents cases where concentrations exceeded relevant sediment criteria.

			Estuarine Sites SWRCB SQO Analysis				**Freshwater Sites SCCWRP Analysis**		
Constituent **2007** **2008** **2009**	**Units**	**Minimum Detection Level, for ND (MDL)**	**Arroyo Burro**	**Mission**	**Sycamore**	**CSI and CALRM Criteria**	**Lagun a**	**Bird Refuge**	**PEC**
Metals, mg/kg									
Cadmium	mg/kg		0.513 0.405 0.75	0.179 0.173 0.16	0.349 0.708 0.09	NA/0.49	0.998 0.629 0.65	0.446 0.42	4.98
Copper	mg/kg		13.5 8.58 13.3	7.98 8 5.7	13.2 15.6 8.8	52.8/77	19.5 21 16.8	57.9 19.9	149
Lead	mg/kg		4.39 7.15 7.3	5.41 13.9 6.4	4.96 6.84 7.3	26/26.4	37.1 26.4 19.8	18 10.2	128
Mercury	mg/kg	0.013 0.013 0.01	ND ND 0.038	ND 0.0317 ND	ND 0.0215 ND	0.09/0.58	0.0387 0.0329 0.046	0.0291 0.032	1.06
Zinc	mg/kg		39 35.1 56.5	29.7 31.4 24.6	21.8 57 32.2	112/66	109 81.3 113	33.7 36.9	459
Arsenic (Arsenic and the following metals were not tested in 2009)	mg/kg		2.42 3.45	2.03 2.59	2.66 4.44	n/a	3.82 3.9	2.51	33
Chromium	mg/kg		16 20.2	14.9 11.8	10.5 29.2	n/a	13.4 11.5	9.15	111
Nickel	mg/kg		24 21.4	13.1 11.4	12.7 32.5	n/a	13.7 10.8	12.2	48.6
Selenium	mg/kg	0.308 0.328	ND 1.9	ND 1.58	ND 3.95	n/a	ND 2.85	ND	n/a
Silver	mg/kg	0.015 0.009	ND ND	ND ND	ND ND	n/a	0.229 0.33	ND	n/a
PAHs 2007 **2008** **(Not tested in '09)**	**Units**	**MDL**	**Arroyo Burro**	**Mission**	**Sycamore**	**CSI and CALRM Criteria**	**Lagun a**	**Bird Refuge**	**PEC**
Total LMW PAHs	µg/kg	<15 for all PAHs	ND 171	ND 223	ND 129	85.4/1700	909 384	77	n/a
Naphthalene	µg/kg		ND 130	ND 80	ND 96		20 160	ND	561
Acenaphthylene	µg/kg		ND ND	ND ND	ND ND		ND ND	ND	n/a
Acenaphthene	µg/kg		ND ND	ND ND	ND ND		140 ND	ND	n/a
Fluorene	µg/kg		ND ND	ND ND	ND 11		ND ND	ND	536
Phenanthrene	µg/kg		ND ND	ND 23	ND ND		39 32	ND	1170
Anthracene	µg/kg		ND ND	ND ND	ND ND		50 ND	ND	845
Fluoranthene	µg/kg		ND ND	ND 67	ND ND		410 72	33	2230
Pyrene	µg/kg		ND 41	ND 53	ND 22		250 120	44	1520
Total HMW PAHs	µg/kg		ND 71	ND 169	ND 404	312/5500	328 1165	ND	n/a
Benzo (a) Anthracene	µg/kg		ND 18	ND 29	ND ND		54 40	ND	1050
Chrysene	µg/kg		ND 27	ND 49	ND 14		72 78	ND	1290
Benzo (b) Fluoranthene	µg/kg		ND ND	ND ND	ND ND		54 ND	ND	n/a

Benzo (k) Fluoranthene	µg/kg		ND 60	ND 16	ND 390		40 1000	ND	n/a
Benzo (a) Pyrene	µg/kg		ND ND	ND 27	ND ND		41 ND	ND	1450
Dibenz (a,h) Anthracene	µg/kg		ND ND	ND ND	ND ND		ND ND	ND	n/a
Benzo (g,h,i) Perylene	µg/kg		ND 11	ND 17	ND ND		35 ND	ND	n/a
Indeno (1,2,3-c,d) Pyrene	µg/kg		ND ND	ND 31	ND ND		32 47	ND	n/a
1-Methylnapthalene	µg/kg		ND	ND	ND		ND	ND	n/a
2-Methylnapthalene	µg/kg		ND	ND	ND		ND	ND	n/a
Total PAHs	µg/kg		ND 242	ND 392	ND 533		1237 1549	77	22800
Chlorinated Pesticides 2007 2008 2009	**Units**	**MDL**	**Arroyo Burro**	**Mission**	**Sycamore**	**CSI and CALRM Criteria**	**Laguna**	**Bird Refuge**	**PEC**
Chlordane, alpha	µg/kg	4 1 0.15	ND ND 1.5	ND ND 0.45	ND ND ND	0.5/4	ND ND 1.3	ND	17.6
Chlordane, gamma	µg/kg	4 4 0.14	ND ND 2.7	ND ND 0.86	ND ND 0.32	0.54/n/a	12 9.7* 4.8	ND	17.6
DDDs, total	µg/kg	<0.68 <0.68 <0.2	ND ND 1.31	ND ND 0.16	0.37 ND ND	0.5	3.39 ND 2.9	0.33	28
DDEs, total	µg/kg	<.68 <0.68 <0.2	ND ND 1.9	ND ND 0.4	0.55 ND 0.28	0.5	2.6 1.2 2.3	0.98	31.3
DDTs, total	µg/kg	<0.68 <0.68 <0.1	ND ND 0.51	ND ND 0.18	ND ND 0.16	0.5	0.73 ND 2.1	ND	62.9
Total DDT	µg/kg		ND ND 3.72	ND ND 0.74	0.92 ND 0.76	n/a	6.72 1.2 7.3	1.31	572
Dieldrin	µg/kg		ND ND 2.1	ND ND 0.29	ND ND ND	na/2.7	ND ND 2.2	ND	61.8
trans-Nonachlor (2009)	µg/kg		2.3	0.64	0.29	4.7	2.5		n/a
Endrin	µg/kg		ND ND	ND ND	ND ND	n/a	0.25 ND	ND	207
Heptoclor epoxide	µg/kg		ND ND	ND ND	ND ND	n/a	ND ND	ND	16
Lindane	µg/kg		ND ND	ND ND	ND ND	n/a	ND ND	ND	4.99
All other EPA 8081A (Chlorinated Pesticides)	µg/kg		ND ND	ND ND	ND ND	n/a	ND ND	ND	n/a
Pyrethroids (EPA 8270CmNCI)	**Units**		**Arroyo Burro**	**Mission**	**Sycamore**	**CSI and CALRM Criteria**	**Laguna**	**Bird Refuge**	**SCCWRP LC 50**
Bifenthrin	ng/g dry		ND ND 6.7	ND ND 2.4	ND ND ND	n/a	ND ND 7.1	3 ND	4.5
Cyfluthrin	ng/g dry		ND ND ND	ND ND ND	ND ND ND	n/a	ND ND ND	ND ND	13.7
Deltamethrin	ng/g dry		ND ND ND	ND ND ND	ND ND ND	n/a	ND ND ND	ND ND	9.9
Esfenvalerate	ng/g dry		ND ND ND	ND ND ND	ND ND ND	n/a	ND ND ND	ND ND	24

Lambda-cyhalothrin	ng/g dry		ND ND ND	ND ND ND	ND ND ND	n/a	ND ND ND	ND ND	5.6
Permethrin	ng/g dry		ND ND ND	ND ND ND	ND ND ND	n/a	ND ND ND	ND ND	90
All other EPA 8270	ng/g dry		ND ND ND	ND ND ND	ND ND ND	n/a	ND ND ND	ND ND	n/a
Other Pesticides and Herbicides	**Units**		**Arroyo Burro**	**Mission**	**Sycamore**	**CSI and CALRM Criteria**	**Lagun a**	**Bird Refuge**	**SCCWRP LC 50**
EPA 8141A (Organophosphorus Pesticides) Not sampled in 2009.	µg /kg		ND ND	ND ND	ND ND	n/a	ND ND	ND	n/a
EPA 8151A (Chlorinated Herbicides) Not sampled in 2009	µg/kg		ND ND	ND ND	ND ND	n/a	ND ND	ND	n/a
Fipronil (phenylpyrazole insecticide) . Only tested in 2009	µg/kg		ND	ND	ND	n/a	ND	ND	n/a
PCBs	µg/kg		ND ND 1.13	ND ND 0.70	ND ND 1.16	11.9/325	36 ND 6.92	ND	676

-"Probable Effects Concentration" (PEC) refers to the concentration above which probable toxic effects would be predicted (Macdonald, et al., 2006).
-SCCWRP LC50 are described below and taken from the Habitat Value of Urban Streams (SCCWRP, 2008).
-"n/a" means that the compound was not included in the analysis and that no guidelines have been identified.
-Chlorinated pesticides: Alpha-BHC; Gamma-BHC; Beta-BHC; Heptachlor; Delta-BHC; Aldrin; Heptachlor Epoxide; Endosulfan I; Dieldrin; 4,4'-DDE; Endrin; Endrin Aldehyde; 4,4'-DDD; Endosulfan II; 4,4'DDT; Endosulfan Sulfate; Methoxychlor; Chlordane; Toxaphene; Endrin Ketone
-Pyrethroids (8270): Allethrin, Bifenthrin, Cyfluthrin, Cypermethrin, Danitol, Deltamethrin, Esfenvalerate, Fenvalerate, Fluvalinate, L-Cyhalothrin, Permethrin, Prallethrin, Resmethrin
Organophosphorus pesticides: Azinphos Methyl; Bolstar; Chlorpyrifos; Coumaphos; Demeton-o; Demeton-s; Diazinon; Dichlorvos; Disulfoton; Ethoprop; Fensulfothion; Fenthion; Malathion; Merphos; Methyl Parathion; Mevinphos; Naled; Phorate; Ronnel; Stirophos; Tokuthion; Trichloronate

SWRCB Sediment Quality Objective Analysis

Chemistry Line of Evidence- The data (including some that is not shown), were used to follow the steps outlined in the SQO to determine the sediment condition based on chemistry and toxicity. The chemistry LOE is used to assess the potential risk to benthic organisms from toxic pollutants in surficial sediments. The sediment chemistry LOE is intended only to evaluate overall exposure risk from chemical pollutants. This LOE does not establish causality associated with specific chemicals. The following table presents results of the sediment sampling in 2007, 2008, and 2009, including constituents that were not used in the analyses. Highlighted values denote constituents that were above thresholds for "minimal disturbance" in the analysis.
For each constituent, exposure categories are described in the following table:

Exposure Level	**Score**	**Predicted Effect on Biota**
Minimal	1	Sediment-associated contamination may be present, but exposure is unlikely to result in effects.
Low	2	Small increase in pollutant exposure that may be associated with increased effects, but magnitude or frequency of occurrence of biological impacts is low.
Moderate	3	Clear evidence of sediment pollutant exposure that is likely to result in biological effects; an intermediate category.
High	4	Pollutant exposure highly likely to result in possibly severe biological effects; generally present in a small percentage of the samples.

1. The Chemical Score Index (CSI), which predicts the degree of benthic community disturbance, was computed for each estuarine site and constituent. Maximum scores observed over three years were used in the analysis. Scores above 1 indicate constituents of concern, and are highlighted in the table below. A weighted score each constituent is calculated, and then averaged to result in a weighted average for each site. The weighted average is used to determine the overall disturbance category, based on the SQO.

Chemical Score Index (Based on SQO)

	AB	MC	SC
Copper	1	1	1
Lead	1	1	1
Mercury	1	1	1
Zinc	1	1	1
PAHs low	2	2	2
PAHs high	1	1	2
Chlordane, alpha	3	1	1
Chlordane, gamma	3	2	2
DDDs	2	1	2
DDEs	2	1	2
DDTs	2	1	1
PCBs	1	1	1
Weighted Average	1.56	1.12	1.26
Category Assigned	Minimal	Minimal	Minimal
Score Assigned	1	1	1

2. The California Logistic Regression Model (CALRM) was used to predict the probability of sediment toxicity based on concentrations of each constituent. The maximum probability for each site is calculated, and used to identify a category of response. The maximum observed concentration observed over the three years of sampling was used for each compound and site. Probabilities of ≥ 0.33 are considered indicative of probable toxicity, and are highlighted in the table below. Again, the greatest number of constituents exceeding the threshold was seen in Laguna Channel. Cadmium was the most comment constituent to exceed.

CA Logistic Regression Model

Constituent	AB	MC	SC
Cadmium	0.47	0.11	0.45
Copper	0.07	0.04	0.08
Lead	0.09	0.19	0.09
Mercury	0.02	0.02	0.01
Zinc	0.16	0.18	0.29
PAHs, high	0.01	0.02	0.05
PAHs, low	0.07	0.08	0.06
Chlordane, alpha	0.07	0.01	0.00
Dieldrin	0.27	0.04	0.00
trans-Nonachlor	0.09	0.01	0.00
PCBs	0.01	0.01	0.01
p,p' DDT	0.01	0.00	0.00
Maximum P	**0.47**	**0.19**	**0.45**
Score	2	1	2
Category Assigned	Low	Minimal	Low

3. An integration of sediment chemistry categories is conducted by averaging the score using the two methods, and rounding up to the nearest integer.

Integration of Sediment Chemistry

Site	Chemical Score Index	California Logistic Regression Model	Average, Rounded to Nearest Integer	Integration of Sediment Chemistry Guidelines, Disturbance Category
Arroyo Burro	1	2	2	Low
Mission	1	1	1	Minimal
Sycamore	1	2	2	Low

Toxicity- In 2007 and 2008 acute toxicity was tested using a ten-day survival test with *Euhaustoriaus*. In 2009 a sublethal, or chronic, test was conducted using *Mytilus galloprovincialis*. The percent survival or growth was scaled to the control, and the SQO was used to identify the toxicity category.

Sediment Toxicity Data (All Data Scaled to Control)

	Arroyo Burro	**Mission**	**Laguna**	**Sycamore**	**Andre Clark Bird Refuge**	**Toxicity Category**
2008 % Survival	90	92	95	95		Nontoxic
2007 % Survival	98	98	100	99	93	Nontoxic
2009 % Normal	90.5	90	99	95		Nontoxic

At all sites in all years, the responses were considered nontoxic. Therefore, it is possible that chemicals contained in the sediment at levels of concern are not bioavailable.

Potential for Chemically Mediated Effects - The SQO was used to combine the chemistry and toxicity data to determine the potential for chemically mediated effects at each site.

Potential for Chemically Mediated Effects, Determined by Chemistry and Toxicity

Site	**Potential for Chemically Mediated Effects**
Arroyo Burro	Minimal Potential
Mission	Minimal Potential
Sycamore	Minimal Potential

<u>SCCWRP Analysis</u>

An integration of chemistry data, per SCCWRP, was also conducted for freshwater sites. First, PEC quotients were calculated by dividing the result by the PEC. PEC quotients are considered problematic when they are greater than 1, i.e. when the result exceeds the PEC. The average PEC quotient is calculated for As, Cd, Cr, Cu, Pb, Ni, Zn, total PAHs, PCBs, and sum of DDEs. Samples with a mean PEC quotient for all constituents of >0.5 are considered toxic. As shown in the table below, no sites exceeded single or grouped constituent Probable Effect Concentrations (PECs), nor did the mean PECqs exceed the threshold of 0.5.

Probable Effects Concentration Quotients (PECq)

Constituent PECq (PECq determined with maximum concentration observed)	**Laguna**	**Bird Refuge**
Cadmium	0.20	0.09
Copper	0.14	0.39
Lead	0.29	0.14
Zinc	0.25	0.08
Arsenic	0.12	0.08
Chromium	0.12	0.08
Nickel	0.28	0.25
Total PAHs	0.07	0.00
DDEs, total	0.08	0.03
PCBs	0.05	0.00
Mean PECq	**0.16**	**0.11**

For pyrethroids, the LC50 quotients are calculated for the constituents that have LC50s, and the mean pyrethroid LC50 quotient is calculated. There is no guideline for predicting toxicity. The mean LC50 quotients for each site, using the maximum concentration observed, is shown in the following table. There were no identified toxicity problems using this averaging method; however, the levels of bifenthrin are concerning. It is important to note that this is an analysis designed for freshwater sites.

LC50 Quotients Pyrethroids

Pyrethroid	**Laguna**	**Bird Refuge**
Bifenthrin	1.58	0.67
Cyfluthrin	0	0
Deltamethrin	0	0
Esfenvalerate	0	0
Lambda-cyhalothrin	0	0
Permethrin	0	0
Mean LC50 Quotient	**0.26**	**0.11**

Conclusions

Site Assessment - According to the analysis conducted here, Arroyo Burro Estuary, Mission Lagoon, Sycamore Lagoon have "minimal potential for a chemically mediated effect on the benthic community" the Bird Refuge and Laguna Channel are "unlikely to cause toxicity." Laguna Channel, which is almost entirely developed, has the highest concentrations of most constituents. Toxicity tests from each site had "nontoxic" results. A bioassessment study would be required to determine if the sites are truly not impacted at a biological level. It is important to reiterate that this conclusion is based on the conservative decision to use the maximum constituent values observed over three years of sampling. In addition, the Laguna Channel and Bioassessment would be required to determine whether the Laguna site is, in fact, impacted. However, bioassessment method in the SQO is very specifically designed for an estuarine site, and would not be appropriate for the Laguna Channel.

Constituents of concern – Compounds which exceeded the most conservative sediment quality criteria include: low molecular weight PAHs, chlorinated pesticides (chlordane, DDDs, DDEs, DDTs), cadmium, and pyrethroid pesticides (bifenthrin). These compounds have been tested in storm water runoff but with the exception of cadmium, have not been detected, likely because they are sequestered in sediments. Because most of the compounds are very insoluble in water, they can partition onto sediments and can remain there for long periods of time. The chlorinated pesticides detected are all legacy compounds, meaning they have been banned for some time and are no longer discharged to the environment. DDT was banned from use in the United States in 1972 and chlordane was banned in 1988. DDE and DDD are breakdown products of DDT. Pyrethroids have grown in use in recent years, primarily to control termites, and are highly toxic to aquatic invertebrates. Bifenthrin was detected in all sites, but criteria only exist for the freshwater sites. Polycyclic aromatic hydrocarbons (PAHs) and cadmium are likely from transportation sources, including fossil-fuel exhaust, runoff from road and parking lot seal coats, and wear of break linings.

References:

SWRCB SQO:
http://www.swrcb.ca.gov/water_issues/programs/bptcp/docs/sediment/sed_qlty_part1.pdf

SCCWRP Analysis:
Habitat Value and Treatment Effectiveness of Freshwater Urban Wetlands, 2008.
ftp://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/559_HabValFreshwaterUrban.pdf

Macdonald, D.D., Ingersoll, C.G., and T.A. Berger. 2000. Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems. Arch. Environ. Contam. Toxicol. 39, 20-31.

Recommendations for FY11

- Extend testing for pyrethroids to additional sites
- Testing for toxicity only at sites to be determined, including where pyrethroid samples are taken. Investigate the organisms to use which are most sensitive to pyrethroids.
- Test for effects of fire-related sediment deposition by testing select compounds at integrator sites.

Update

The State Waterboard has discussed updating its assessment of toxicity and some of the nontoxic results we report here may be considered as toxic in future 303(d) assessments.

III. STORM MONITORING

Table of storm events sampled in FY10. Detailed results for each storm will be presented in the Annual report.

Sampling Event(s)	Date
Slurry Seal Pilot Test (Runoff simulation)	October 6, 2009
First Flush, Parking Lot Infiltration, Jesusita Fire, Slurry Seal Runoff	October 13, 2009
Parking Lot Infiltration, Slurry Seal Runoff	December 7, 2009
Pollutant Loads	April 11, 2010
Storm Drain Toxicity	April 20, 2010

WHAT ARE THE HIGHEST CONCENTRATIONS OF POLLUTANTS DURING FIRST FLUSH STORM EVENTS?

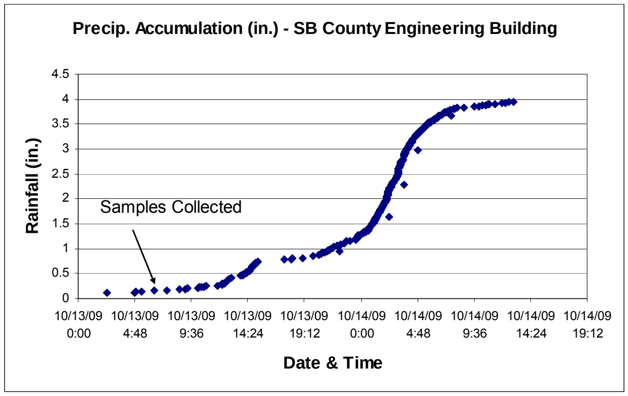
Introduction

The goal of this sampling event was to catch the "first flush" storm of the 2009-2010 water year: the first storm of the season to cause substantial runoff to the creeks. A first flush event such as this should typically produce the highest concentrations of polluted runoff of the year, as the first substantial rain washes away pollutants that have been collecting since the previous rainy season.

An early-season storm was predicted to hit the Santa Barbara area early Tuesday, October 13th. Rainfall was expected to reach 1 to 3 inches in most coastal areas, with as much as 6 inches in the coastal mountains.

Light rain fell Monday afternoon on the 12th, with continued cloud cover throughout the day and not much if any rain. At approximately 4:30 AM, when the significant rainfall was imminent, the decision was made by Jill Murray and Jim Rumbley to meet at the office and begin sampling.

Three teams of two staff members (1) Liz Smith and Tim Burgess, (2) Jill Murray and Julie Kahrnoff, and (3) Jim Rumbley and Casey Smith participated in the sampling. Once in the field, runoff and flow were sufficient for sampling at City Parking Lot 4, Laguna Channel at Chase Palm Park, Mission Creek at Montecito Street, Palermo at Arroyo Burro, and Arroyo Burro at Cliff Drive. These sites were sampled between 6:30 AM and 7:30 AM. Mission Creek at Mission Canyon and Sycamore Creek at the railroad bridge, were sampled between 1:00 PM and 2:00 PM.



Cumulative rainfall through the duration of the storm, using rainfall amounts recorded at the City of Santa Barbra Engineering Building.

Methods

At each site, samples were collected from the stream using either a) a plastic bucket and rope lowered off of a bridge or b) a plastic beaker dipped directly into the stream. The bucket and/or beaker were rinsed thoroughly at each site before use. Sample bottles were filled directly from the bucket and/or beaker in the field. In-stream parameters were measured using the Creeks multi-meters.

After sampling was completed, coolers were packed with ice and brought back to the office for pickup by the Test America courier on Tuesday at 5:00 PM.

The next week, rainfall totals for the October 13th storm showed that a total of 3.86 inches had fallen over the course of the storm at the County of Santa Barbara Engineering Building. The total was checked on the County of Santa Barbara Public Works website: http://contrail.onerain.com. Results from this storm study are summarized in a table below.

Results

The following table summarizes the results from the laboratory analysis. Constituents that exceeded water quality criteria are highlighted in yellow. Note that criteria used for total metals are outdated (no current criteria exist). However these outdated criteria help to illustrate the relative impacts of these pollutants. "ND" means that a constituent was not detected. Also, results for Parking Lot 4, Palermo at Arroyo Burro, and Mission Creek at Mission Canyon are included in different sections of this report (Low Impact Development section and Jesusita Fire section respectively).

Constituent	SC Railroa (Sycamore Creek at the railroad bridge)	LC CPP (Laguna Channel at Chase Palm Park)	MC Monteci (Mission Creek at Montecito Street)	AB Cliff (Arroyo Burro at Cliff Drive)	Criteria in mg/L unless otherwise noted (source)
Metals (mg/L)					
Arsenic, total	ND	ND	ND	ND	0.15 (EPA CCC, old)
Cadmium, total	ND	ND	ND	ND	.00027 (EPA CCC, old)
Chromium, total	ND	ND	ND	ND	.086 (EPA CCC, old)
Copper, total	0.022	0.0033	0.019	0.0033	.0094 (EPA CCC, old)
Copper, dissolved	0.021	0.0021	0.014	0.0035	0.17, 0.079, 0.112, 0.061 for these sites (EPA CCC, based on BLM)
Lead, total	0.0054	ND	ND	ND	.0053 (EPA CCC, old)
Mercury, total	ND	ND	ND	ND	.00091 (EPA CCC, old)
Nickel, total	ND	0.0061	0.0088	0.0093	.052 (EPA CCC, old)
Zinc, total	0.064	0.01	0.05	0.022	.12 (EPA CCC, old)
Pesticides and Herbicides					
Chlorinated herbicides, EPA 8151A[1] (µg/L)	ND	ND	ND	ND	no criteria
Chlorinated pesticides, EPA 8081A[2] (µg/L)	ND	ND	ND	ND	no criteria
Organophosphorus Pesticides, EPA 8141A[3] (µg/L)	ND	ND	ND	ND	limited criteria[4]
Synthetic Pyrethroid Insecticides, EPA 625 mNCI[5] (ng/L)	ND (except Cyfluthrin - 36.1 ng/L)	ND	ND (except Esfenvalerate - 1.6 ng/L & L-Cyhalothrin - 7 ng/L)	ND	Results are highlighted when any pyrethroids are detected. No official criteria. LC50 or EC50 values taken from Weston 2010: Bifenthrin: 3.3; Cyfluthrin 1.9; Cypermethrin 1.7;L-cyhalothrin 2.3; Permethrin 21.1; Chlorpyrifos 96.
Glyphosate (µg/L)	ND	ND	ND	ND	0.7 (BP)
Other					
Total suspended solids (mg/L)	43	10	26	8	no criteria
Oil and grease (mg/L)	ND	ND	ND	ND	Visible sheen (BP)
MBAS (mg/L)	1.2	10	1.2	0.23	0.2 (BP)
Toxicity - % Survival (TUa)	100% (0)	100% (0)	100% (0)	100% (0)	0.3 (OP)
Dissolved Organic Carbon (mg/L)	34	4.6	26	10	no criteria
Chloride (mg/L)	36	220	71	290	142 (BP)
Alkalinity (mg/L)	40	350	250	370	>20 if there are not natural sources of $CaCO_3$
Hardness (mg/L)	140	540	450	750	no criteria
Sodium, total	28	180	90	180	69 (BP)

[1] Chlorinated herbicides (8151 A): Dalapon; Dicamba; MCPP; MCPA; Dichlorprop; 2,4-D; 2,4,5-TP; 2,4,5-T; 2,4-DB; Dinoseb, 4-Nitrophenol, Pentachlorophenol, Picloram

[2] Chlorinated pesticides (8081 A): Alpha-BHC; Gamma-BHC; Beta-BHC; Heptachlor; Delta-BHC; Aldrin; Heptachlor Epoxide; Endosulfan I; Dieldrin; 4,4'-DDE; Endrin (0.2 ug/L); Endrin Aldehyde; 4,4'-DDD; Endosulfan II; 4,4'DDT; Endosulfan Sulfate; Methoxychlor; Chlordane; Toxaphene; Endrin Ketone. These are in the EPA method, but results were not provided by Test America:
Chlorobenzilate, DBCP, Diallate, Hexachlorobenzene, Hexachlorocyclopentadiene, Isodrin, Alpha-Chlordane, Gamma-Chlordane

[3] Organophosphorus pesticides (8141 A): Azinphos Methyl; Bolstar (Sulprofos); Chlorpyrifos; Coumaphos; Demeton, Total (Qualitative only); Diazinon; Dichlorvos; Dimethoate, Disulfoton; EPN, Ethoprop; Fensulfothion; Fenthion; Malathion; Parathion-methyl, Parathion-ethyl; Mevinphos; Phorate; Ronnel; Stirophos (Tetrachlorvinphos); Tokuthion; Trichloronate (Prothiofos). These are in the EPA method, but results were not given:
Azinphos Ethyl, Carbophenothion, Chlorfenvinphos, Chlorpyrifos Methyl, Crotoxyphos, Dichlorofenthion, Dichrotophos, Dioxathion, Ethion, Famphur, Fenitrothion, Fonophos, Leptophos, Merphos, Monocrotophos, Naled, Phosmet, Phosphamidon, Sulfotepp, TEPP, Terbufos, Thionazin, Trichlorfon

[4] Criteria are limited. Criteria do not exist for some constituents. Criterion for Malathion (.0001 mg/L) is less than the minimum detection limit (.0012 mg/L) therefore it is unknown if criteria was exceeded. Criterion for Parathion (.000013 mg/L) was not exceeded. Criterion for Chlorpyrifos (.000041 mg/L) is less than the minimum detection limit (.0024 mg/L) therefore it is unknown if the criterion was exceeded.

[5] Synthetic Pyrethroid Insecticides (625 mNCI): Allethrin, Bifenthrin, Cyfluthrin, Cypermethrin, Danitol, Deltamethrin, Esfenvalerate, Fenvalerate, Fluvalinate, L-Cyhalothrin, Permethrin, Prallethrin, Resmethrin

Acronyms used:
EPA- USEPA's Current National Recommended Water Quality Criteria (US EPA, 2005)
EPA old – The EPA no longer provides criteria for total metals, due to effect of other water quality parameters on metal speciation and toxicity.
CTR- California Toxics Rule (US EPA, 2000). Does not supply criteria for total metals.
BP- RWQCB's Basin Plan (CA EPA, 1994). Does not distinguish between CCC and CMC.
CCC- Continuous Concentration Criteria
CMC- Continuous Maximum Concentration
OP- California Ocean Plan (CA EPA, 2005).

Discussion

As observed during the first flush last year, total copper exceeded the older criteria for total copper during this storm at Mission Creek at Montecito St. The only other metals that exceeded criteria this year were total copper and total lead at Sycamore Creek at the railroad bridge. Criteria for dissolved copper, which takes into account the effects of other water quality parameters on copper toxicity, were not exceeded. Samples were not taken at Sycamore during the first flush last year so comparisons are not possible for this site. Arsenic, chromium, cadmium, and mercury were the only metals not detected at all during this storm.

Similar to last year's first flush sampling, Methylene-Blue active Substances (MBAS) exceeded criteria at all sites that were sampled.

Alkalinity was the only other constituent that exceeded levels allowed by the criteria at all integrator sites tested. Chloride exceeded criteria at Arroyo Burro at Cliff Dr and Laguna Channel. Last year, chloride at Arroyo Burro was close to the cutoff threshold, but it did not exceed the criteria. Sycamore Creek was recently listed as an impaired water body for chloride, and the Creeks Division will investigate whether the salinity is natural or arriving from runoff over irrigated surfaces.

Herbicide and pesticide criteria and detection limits will be reviewed and updated in the Annual Report.

Synthetic Pyrethroid Insecticides results were mostly non-detects. However, three Pyrethroids were found at elevated levels. High levels of Esfenvalerate and L-Cyhalothrin were found in Mission Creek at Montecito St and high levels of Cyfluthrin were found in Sycamore Creek at the railroad bridge. No other significant levels of Pyrethroids were detected.

DO CREEKS AND/OR STORM DRAINS IN SANTA BARBARA HAVE PROBLEMS WITH TOXICITY DURING STORM EVENTS?

As shown in the table below, creek samples during first flush sampling events have shown low toxicity, with the exception of the sample collected in Fall 2008 from Laguna Channel at Chase Palm Park. Storm drain samples have been more variable, with three highly toxic results from the Hope Drain, Haley Drain, and McKenzie Park parking lot runoff.

Toxicity Results from Integrator Sites during Storm Monitoring 2007-2009
All tests are 5-Day Survival of Fathead Minnows

All results presented as % survival (over control) and toxicity units. All samples 100% dilution.	Mission Creek at Montecito St.	Arroyo Burro at Cliff Dr.	Laguna at Chase Palm Park	Sycamore at Railroad Br.
November 2006			100%, 0 TU(a)	
First Flush Fall 2007	100%, 0 TU(a)	95%, .41 TU(a)	100%, 0 TU(a)	not sampled- dry
First Flush Fall 2008	100%, 0 TU(a)	95%, .41 TU(a)	25%, > 1 TU(a)	not sampled – lab error
First Flush Fall 2009	100%, 0 TU(a)	100%, 0 TU(a)	100%, 0 TU(a)	100%, 0 TU(a)

Additional Wet Weather Creek, Drain, and Gutter Samples

Site	Date	Test Organism	Result
Hope Drain	Fall 2008	Fathead Minnow	0% Survival
Haley Drain	11/27/2006	Fathead Minnow	55% Survival
Palermo AB	10/13/2009	Ceriodaphnia	90% Survival
Parking Lot 4	10/13/2009	Fathead Minnow	100% Survival
Mission Creek at Mission Canyon	10/14/2009	Fathead Minnow	100% Survival
Laguna and Ortega (recycled rubber slurry)	12/7/2009	Ceriodaphnia	100% Survival
McKenzie Park Parking Lot	12/7/2009	Fathead Minnow	100% Survival
Serena Drain at Mission Creek	4/20/2010	Fathead Minnow	100% Survival
Stanley Gutter	4/20/2010	Fathead Minnow	100% Survival
Westside Drain	4/20/2010	Fathead Minnow	100% Survival
Drain from Hwy 101 to MC at Montecito	4/20/2010	Fathead Minnow	100% Survival

Copper results will be summarized in the next Annual Report.

WHAT ARE THE IMPACTS OF THE JESUSITA FIRE ON WATER QUALITY?

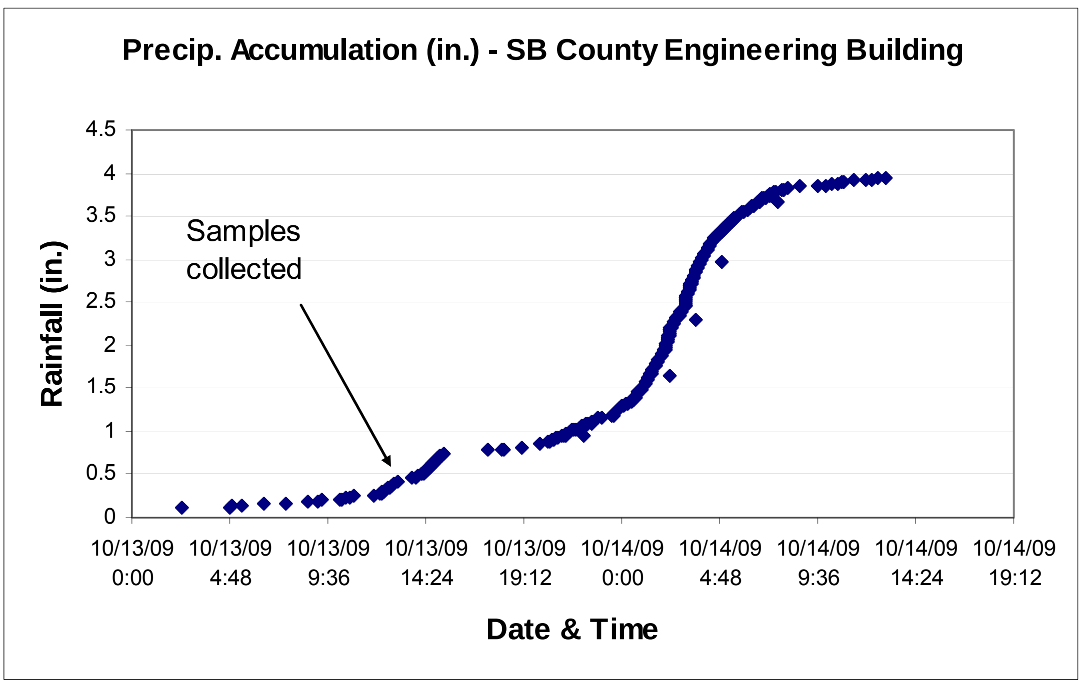
Introduction

The goal of this sampling event was to test a post-burn area for total metals, toxicity, suspended sediment, and PAHs to test against pre-fire data. Pre-fire data will be added in the next report.

An early-season storm was predicted to hit the Santa Barbara area early Tuesday, October 13th. Rainfall was expected to reach 1 to 3 inches in most coastal areas, with as much as 6 inches in the coastal mountains.

Light rain fell Monday afternoon on the 12th, with continued cloud cover throughout the day and not much if any rain. At approximately 4:30 AM, when the significant rainfall was imminent, the decision was made by Jill Murray and Jim Rumbley to meet at the office and begin sampling.

The Mission Creek at Mission Canyon site was not sampled until around 1:00 PM when flows were deemed sufficient to begin sampling.



Cumulative rainfall through the duration of the storm, using rainfall amounts recorded at the City of Santa Barbra Engineering Building.

Methods

At each site, samples were collected from the stream using a plastic beaker dipped directly into the stream. The beaker was rinsed thoroughly at each site before use. Sample bottles were filled directly from the beaker in the field. In-stream parameters were measured using the Creeks multi-meters.

After sampling was completed, coolers were packed with ice and brought back to the office for pickup by the Test America courier on Tuesday at 5:00 PM.

The next week, rainfall totals for the October 13th storm showed that a total of 3.86 inches had fallen over the course of the storm at the County of Santa Barbara Engineering Building. The total was checked on the County of Santa Barbara Public Works website: http://contrail.onerain.com. Results from this storm study are summarized in a table below.

Results

The following table summarizes the results from the laboratory analysis. Constituents that exceeded water quality criteria are highlighted in yellow. Note that criteria used for total metals are outdated (no current criteria exist). However these outdated criteria help to illustrate the relative impacts of these pollutants. "ND" means that a constituent was not detected. Please refer to first flush results for more information about criteria acronyms.

Constituent	Pre Fire	Post Fire (Mission Creek at Mission Canyon)
Metals (mg/L)		
Arsenic, total	ND	ND
Cadmium, total	ND	ND
Chromium, total	ND	ND
Copper, total	ND	0.0027
Copper, dissolved	0.0017	0.0034
Lead, total	ND	ND
Mercury, total	ns	ND
Nickel, total	ND	0.0043
Iron, total	ns	0.066
Zinc, total	ND	ND
Other		
Total suspended solids (mg/L)	ND	ND
Oil and grease (mg/L)	ns	ND
MBAS (mg/L)	ns	ND
Toxicity - % Survival (TUa)	ns	100% (0)
Dissolved Organic Carbon (mg/L)	ns	11
Polycyclic aromatic hydrocarbons (PAH), EPA 8270 C SIM[1] (µg/L)	ND	ND

[1] Polycyclic aromatic hydrocarbons (8270 C SIM): Acenaphthene, Acenaphthylene, Anthracene, Benzo(a)anthracene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(g,h,i)perylene, Benzo(a)pyrene, Chrysene, Dibenzo(a,h)anthracene, Fluoranthene, Fluorene, Indeno(1,2,3-c,d)pyrene, Naphthalene, Phenanthrene, Pyrene

These are in the EPA method, but results were not given: Dibenzo(a,j)acridine, Dibenzo(a,e)pyrene, 7,12-Dimethylbenz(a)anthracene, , 1-Methylnaphthalene, 2-Methylnaphthalene

Discussion

No total metal result exceeded criteria at the Mission Canyon burn area site. Arsenic, Chromium, Lead, Cadmium, Zinc and Mercury were all non-detects. All other metals returned results above the detection limit threshold but did not exceed the established "high" criteria limit. Total copper and dissolved copper were higher in the post-fire sample, but we do not have enough data to determine whether it is due to the fire, or if it due to the variability of water quality data during a storm.

No Polycyclic Aromatic Hydrocarbons (PAHs) were found at either site. All PAH results were non-detects.

All other constituent results for the Mission Canyon site were either at or below acceptable levels or criteria have not been established.

WHAT ARE THE LOADS OF POLLUTANTS DISCHARGED FROM SANTA BARBARA CREEKS DURING STORMS?

This section will be completed in the next Annual Report. A storm was tested in December for runoff from a test plot of slurry seal, applied by the Streets Division. In addition, a storm was tested on April 11, 2010 for bacteria and metals throughout a storm. Results for both will be included in the next Annual report. In addition, a pilot study was conducted to simulate a runoff event in an area with fresh slurry seal, as described in the following section.

IS THERE A PROBLEM ASSOCIATED WITH SLURRY SEALING?

Slurry Seal Pilot Study

The Creeks Division suspects that slurry sealing of streets may lead to pollution in creeks, due to rain runoff over surfaces and excess sediment material reaching creeks. The Creeks Division conducted a pilot test, using a simulated runoff event, to begin gathering information about this hypothesis. The following is the sampling plan for the pilot study conducted on October 6, 2009.

Slurry Seal Sampling Plan October 2009

Goals:

1. Test recently sealed vs. older/nonsealed [new pavement, old slurry sealed (>5 yrs), old pavement], for toxicity and contaminants in a simulated rainfall event.
2. Assess whether recently sealed streets contribute greater amount of foam than the other types.

Sites

1. One treated site
2. One control site

Contaminants:

Water: PAHs, suite of total metals, total suspended solids, toxicity
Swept Sediment: PAHs, metals

Field Plan (Tuesday 10/6/09):

1. Each site, cone off an area.
2. Wet it down with one liter of de-chlorinated tap water.
3. Scrub it lightly in a systematic way.
4. Pour remaining water on.
5. Collect runoff at catch basin in amber bottles
6. Swirl then pour into sample bottles and foam bottle.
7. Shake for 1 minute, photograph and record depth/color of foam.
8. Let it sit, check every minute.
9. From adjacent area, sweep until enough material collected to fill sediment jar
10. Record how large the swept area was.

Sampling Photos

Control Site, Corporate Yard

Fresh Slurry Site, Portofino

Results, Water

Runoff from the freshly sealed site:

- Contained *lower concentrations of metals* than runoff from the control site.
- Had similar levels of suspended sediment to the control site.
- Had no detectable PAHs.
- Resulted in higher toxicity than the control site.

Constituent	Runoff (water samples) Control (Corporate Yard)	Fresh Slurry Seal (Portofino)
Metals, Total (mg/L)		
Arsenic	.01	ND
Cadmium	ND	ND
Chromium	0.021	0.017
Copper	0.140	0.13
Lead	0.04	0.03
Mercury	ND	ND
Nickel	.062	0.072
Zinc	1.4	0.68
PAHs (ug/kg)		
Total LMW PAHs	ns	ND
Naphthalene	ns	ND
Acenaphthylene	ns	ND
Acenaphthene	ns	ND
Fluorene	ns	ND
Phenanthrene	ns	ND
Anthracene	ns	ND
Fluoranthene	ns	ND
Pyrene	ns	ND
Total HMW PAHs	ns	**ND**
Benzo (a) Anthracene	ns	ND
Chrysene	ns	ND
Benzo (b) Fluoranthene	ns	ND
Benzo (k) Fluoranthene	ns	ND
Benzo (a) Pyrene	ns	ND
Dibenz (a,h) Anthracene	ns	ND
Benzo (g,h,i) Perylene	ns	ND
Indeno (1,2,3-c,d) Pyrene	ns	ND
1-Methylnapthalene	ns	ND
2-Methylnapthalene	ns	ND
Total PAHs	ns	**ND**
Other		
Total suspended solids (mg/L)	210	220
Toxicity, Percent Survival	60%	0%
Toxicity, offspring produced as a percent of the control sample	11.4	0

Note: PAHs were not tested in the control runoff due to the sample bottle breaking in transit. Chronic toxicity (10-day) was tested using the organism *Ceriodaphnia*.

Results, Swept Sediment

Sediment swept off of the freshly sealed street:

- Had slightly lower concentrations of metals than sediment from the control site.
- Had five times higher concentrations of low and high molecular weight PAHs compared to the control site.

Constituent	**Control (Corporate Yard)**	**Fresh Slurry Seal (Portofino)**
Metals, Total (mg/L)		
Arsenic	0.84	0.062
Cadmium	0.22	0.013
Chromium	5.3	4.5
Copper	8.6	6.3
Lead	3.1	1.4
Mercury	0.033	0.033
Nickel	4.7	4.7
Zinc	93.6	25.6
Acenaphthene	ND	34
Acenaphthylene	ND	34
Anthracene	6.9	34
Fluoranthene	13	8.9
Fluorene	ND	34
Naphthalene	ND	34
Phenanthrene	18	22
Pyrene	9.3	13
Total Low Molecular Weight PAHs	**47.2**	**213.9**
1-Methylnapthalene	ND	ND
2-Methylnapthalene	ND	ND
Benzo (a) Anthracene	25	84
Benzo (a) Pyrene	ND	34
Benzo (b) Fluoranthene	9.2	40
Benzo (g,h,i) Perylene	18	34
Benzo (k) Fluoranthene	ND	34
Chrysene	ND	34
Dibenz (a,h) Anthracene	ND	34
Indeno (1,2,3-c,d) Pyrene	ND	34
Total High Molecular Weight PAHs	**52.2**	**328**
Total PAHs	**99.4**	**541.9**

Results, Foam

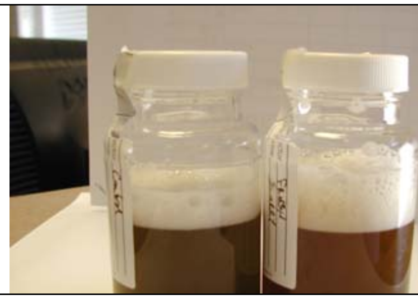
Runoff from the freshly sealed site had:

- twice as high of a foam head after one minute of shaking, compared to runoff from the control site.
- foam that dissipated much more slowly than that from the control site.

Rapidly disappearing foam is a sign that it is from natural proteins, whereas foam from synthetic sources is typically long lasting (Pitt, 2004).

Photos were taken after shaking the bottles from each site for one minute:

Time	Control on Left, Fresh Slurry Seal on Right
0 minutes, after shaking for one minute	
After one minute	
5 minutes	
5 hours	
40 hrs	

48 hours after sampling, shaken again for 1 minute	

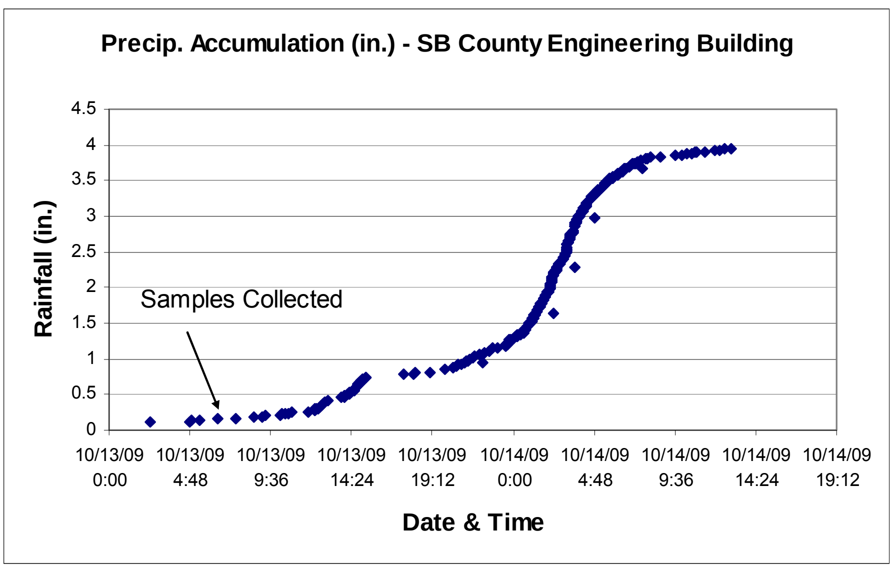
Slurry Seal Storm Samples (October 13, 2009 & December 7, 2009)

Introduction

The goal of these sampling events was to collect the first rainfall runoff from streets recently resurfaced with slurry seal. The goal of sampling the first 0.25" is to collect data on the highest concentrations that might be seen in the effluent.

October 13th Storm – Sampling at Palermo Dr.:
An early-season storm was predicted to hit the Santa Barbara area early Tuesday, October 13th. Rainfall was expected to reach 1 to 3 inches in most coastal areas, with as much as 6 inches in the coastal mountains.

Light rain fell Monday afternoon on the 12th, with continued cloud cover throughout the day and not much if any rain. At approximately 4:30 AM, when the significant rainfall was imminent, the decision was made by Jill Murray and Jim Rumbley to meet at the office and begin sampling.

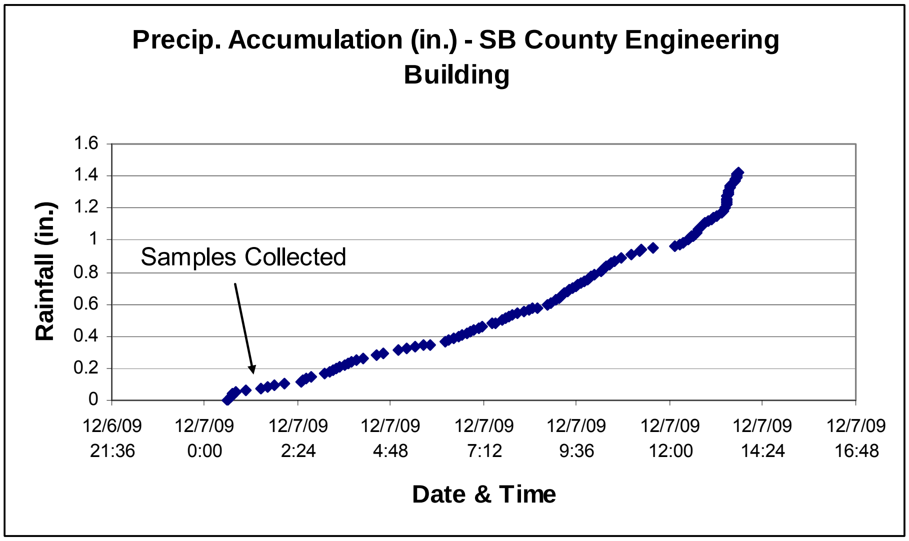


Cumulative rainfall through the duration of the Oct. 13th storm, using rainfall amounts recorded at the City of Santa Barbra Engineering Building.

December 7th Storm – Sampling at Laguna St/Ortega St. Intersection:

A mid-season storm was predicted to hit the Santa Barbara area early Monday, December 7th. Rainfall was expected to reach over 1 inch in most coastal areas, with as much as 3 inches in the coastal mountains.

At approximately 12:00 AM, when the significant rainfall was imminent, the decision was made by Jill Murray and Jim Rumbley to meet at the office and begin sampling.



Cumulative rainfall through the duration of the Dec. 7th storm, using rainfall amounts recorded at the City of Santa Barbra Engineering Building.

Methods

One team of composed of two staff members (Tim Burgess & Liz Smith) collected the samples during the Oct. 13th storm from the gutter near the storm drain where Palermo Dr. dead ends. During the Dec. 7th storm, one team composed of two staff members (Jill Murray & Jim Rumbley) collected samples from the gutter at the Laguna St./Ortega St. intersection.

At both sites samples were collected from the runoff using a plastic beaker dipped directly into the gutter. The beaker was rinsed thoroughly before use. Sample bottles were filled directly from the beaker in the field. In-flow parameters were measured using the Creeks multi-meters.

After sampling was completed, coolers were packed with ice and brought back to the Creeks office. The same day the samples were sent via Courier or FedEx to the Test America lab in Irvine, CA.

The next week, rainfall totals for the storms occurring on October 13th and December 7th showed that a total of 3.86 inches and 1.42 inches respectively had fallen over the course of the storms at the County of Santa Barbara Engineering Building. The total was checked on the County of Santa Barbara Public Works website: http://contrail.onerain.com. Results from this storm study are summarized in a table below.

Results

The following table summarizes the results from the laboratory analysis. Constituents that exceeded water quality criteria are highlighted in yellow. Note that criteria used for total metals are outdated (no current criteria exist). However these outdated criteria help to illustrate the relative impacts of these pollutants. "ND" means that a constituent was not detected. "N/A" indicates that that constituent was not tested for. Please refer to first flush results for more information about criteria acronyms.

Constituent	**Palermo AB (Storm Drain at Palermo Rd Dead End)**	**LC LagOrt (Intersection of Laguna & Ortega)**	**Criteria in mg/L unless otherwise noted (source)**
Metals (mg/L)			
Arsenic, total	ND	ND	.15 (EPA CCC, old)
Cadmium, total	ND	ND	.00027 (EPA CCC, old)
Calcium, total	230	170	no criteria
Chromium, total	ND	0.044	.086 (EPA CCC, old)
Copper, total	0.043	0.038	.0094 (EPA CCC, old)
Copper, dissolved	0.036	0.027	0.044, 0.091, 0.031 for these sites (EPA CCC, based on BLM)
Lead, total	ND	ND	.0053 (EPA CCC, old)
Mercury, total	ND	ND	.00091 (EPA CCC, old)
Nickel, total	0.022	0.016	.052 (EPA CCC, old)
Iron, total	0.56	1.1	no criteria
Magnesium, total	17	5.9	no criteria
Manganese, total	0.78	0.12	no criteria
Potassium, total	33	9.6	no criteria
Sodium, total	57	54	no criteria
Zinc, total	0.17	0.28	.12 (EPA CCC, old)
Other			
Total suspended solids (mg/L)	66	N/A	no criteria
Oil and grease (mg/L)	ND	N/A	Visible sheen (BP)
MBAS (mg/L)	1.2	2.6	.2 (BP)
Toxicity - % Survival (TUc)	90% (1)	100% (1)	no criteria
Toxicity - Offspring prod. as % of control (TUc)	62.3% (>2)	99% (1)	no criteria
Dissolved Organic Carbon (mg/L)	160	N/A	no criteria
Chloride (mg/L)	290	N/A	142 (BP)
Sulfate (mg/L)	240	N/A	no criteria
Polycyclic aromatic hydrocarbons (PAH), EPA 8270 C SIM[1] (µg/L)	ND	ND	no criteria

[1]Polycyclic aromatic hydrocarbons (8270 C SIM): Acenaphthene, Acenaphthylene, Anthracene, Benzo(a)anthracene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(g,h,i)perylene, Benzo(a)pyrene, Chrysene, Dibenzo(a,h)anthracene, Fluoranthene, Fluorene, Indeno(1,2,3-c,d)pyrene, Naphthalene, Phenanthrene, Pyrene

These are in the EPA method, but results were not given: Dibenzo(a,j)acridine, Dibenzo(a,e)pyrene, 7,12-Dimethylbenz(a)anthracene, , 1-Methylnaphthalene, 2-Methylnaphthalene

Discussion

Total copper and total zinc were the only metals that exceeded criteria at both sites, and arsenic, lead, cadmium, and mercury were the only metals to return “Non Detect” results at both sites. Methylene-Blue active Substances (MBAS) exceeded criteria at both sites as well. More Ceriodaphnia dubia (test organism) died during toxicity testing of the Palermo Rd. storm drain samples than during the testing of the samples for the intersection at Laguna & Ortega. Similarly, fewer Ceriodaphnia dubia offspring were produced from the samples from Palermo Rd. No Polycyclic Aromatic Hydrocarbons (PAHs) were found at either site. All PAH results were non-detects. All other constituent results for these sites were either at or below acceptable levels or criteria have not been established.

IV. PROJECT SITE ASSESSMENT

Additional projects besides the Westside SURF will be analyzed in the FY11 Annual Report.

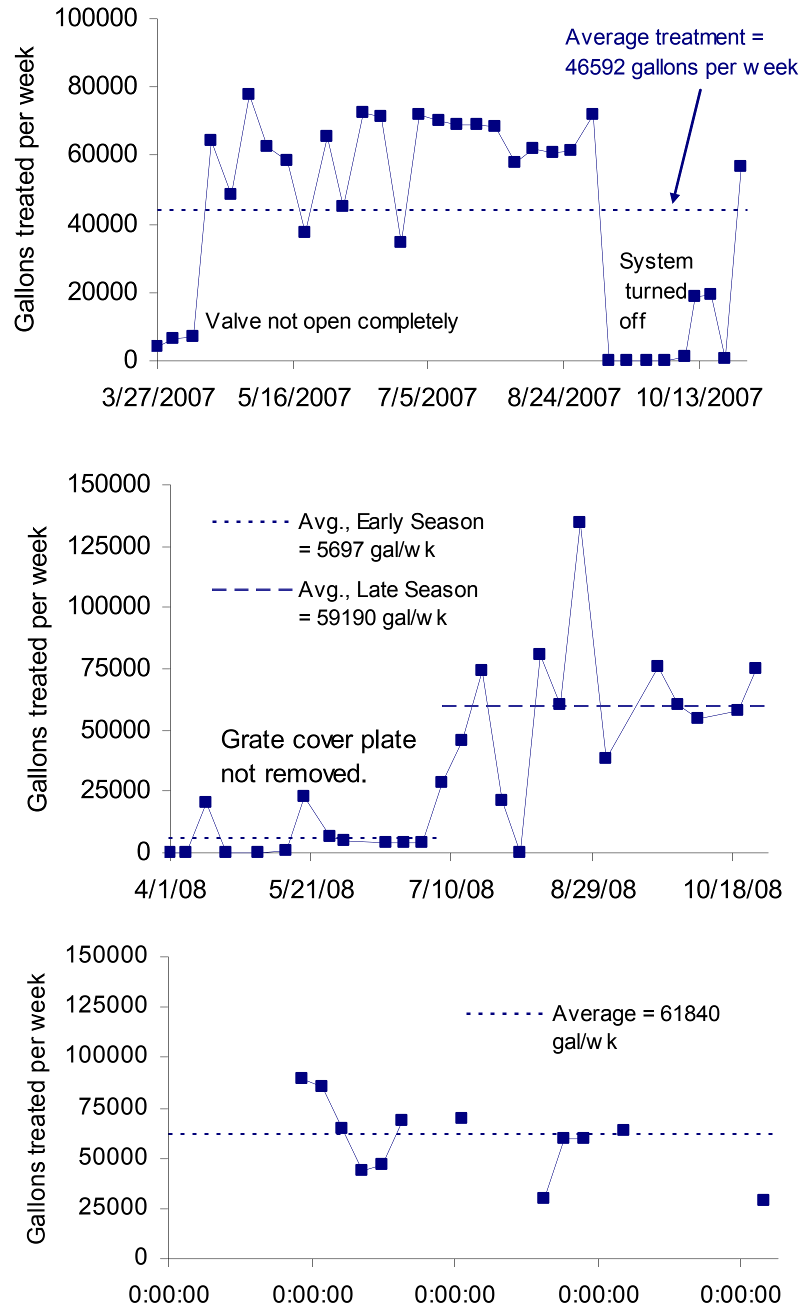
<u>WESTSIDE SURF PROJECT</u>

Results from quarterly intensives will be completed in the FY11 Annual Report.

Effectiveness of Project components

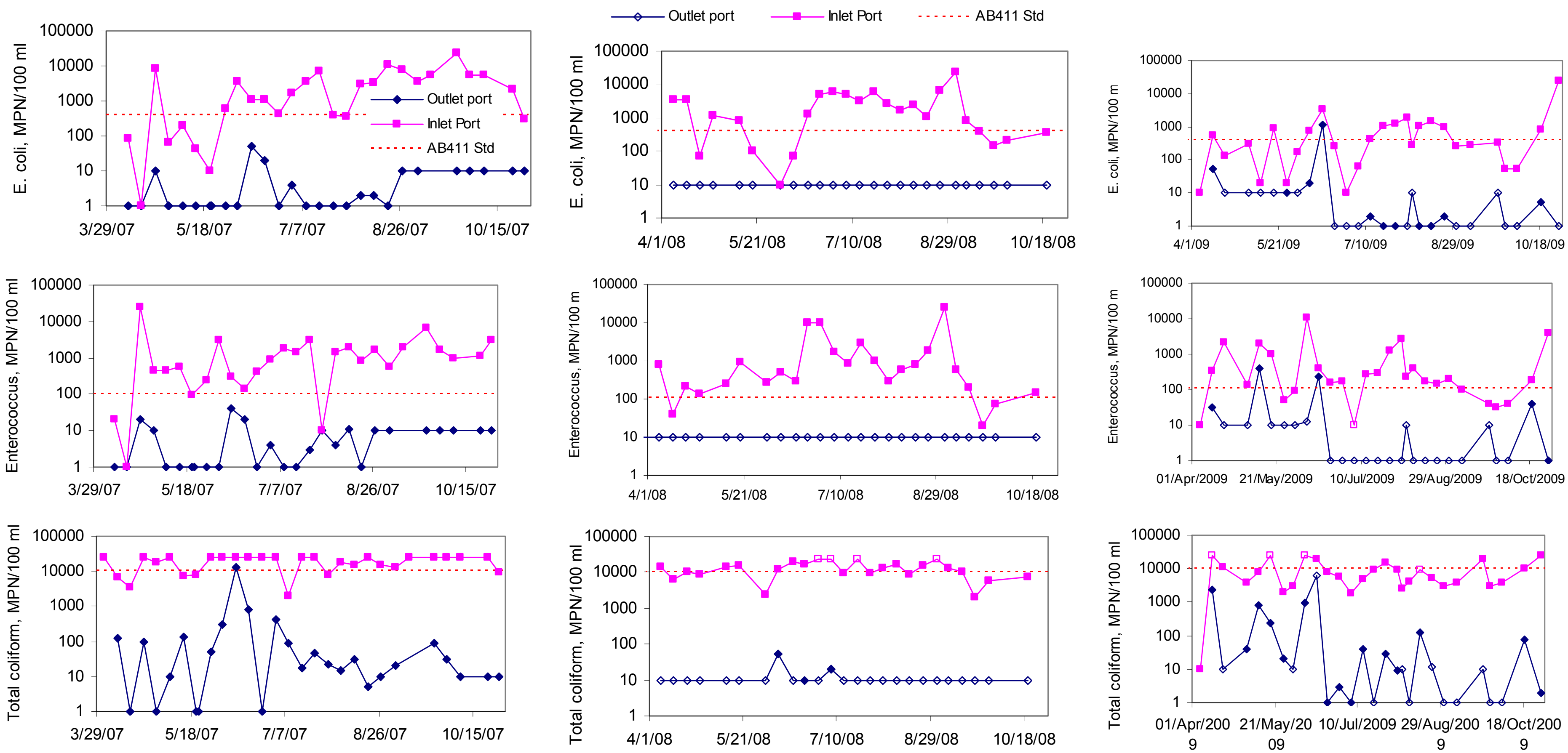
The Westside SURF Project began treating water from the Westside storm drain on March 27, 2007. The figures below show the operation of the SURF facility during its first, second, and third seasons of operation. The first season of monitoring was required by the grant that funded the project, as described in the Monitoring Plan. The second and third seasons were completed in order to continue assessing the project performance. In reviewing the data, it is clear that most of the monitoring should continue as long as the facility is in operation, in order to determine if it is functioning properly.

The following charts show the volume of water discharged by the system per week. When the system appears to be performing correctly, approximately 70,000 gallons are discharged per week. When divided by the number of minutes in a week, the average discharge rate is 7 gpm, far lower than the 100 gpm the system was designed for and that flow measurements from the Westside Drain have shown in the past. One of the reasons for the discrepancies is that the flow meter does not record flow that is discharged to the sanitary sewer during backwash operations. This discrepancy indicates a major issue that must be resolved in future operations.



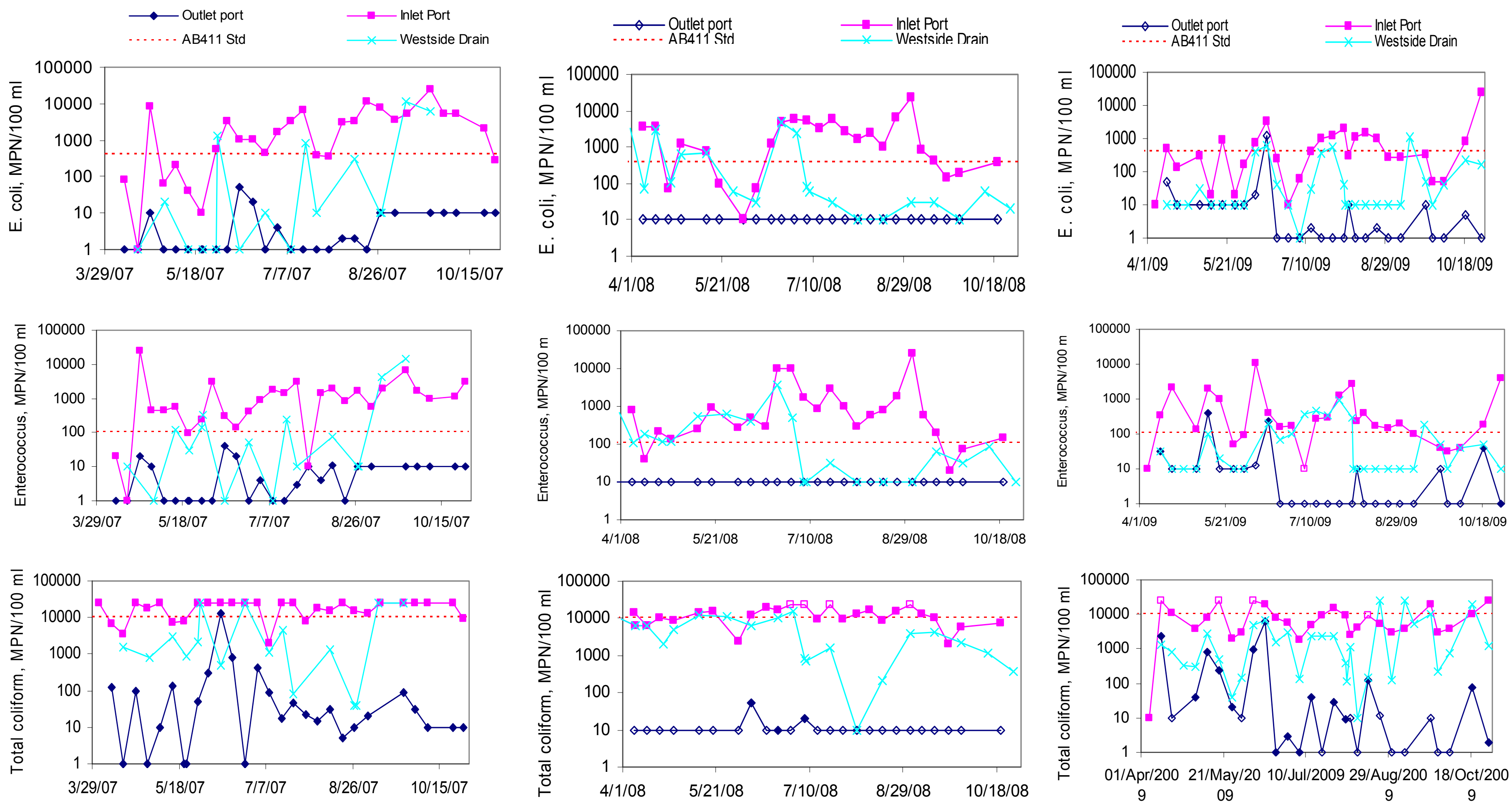
Gallons treated per week at the Westside SURF Project, AB411 Seasons 2007-2009.

A comparison of indicator bacteria data, collected weekly, shows the dramatic reduction in concentrations between the inlet port of the SURF Project (downstream of pump station, upstream of media filters), and the outlet port (just downstream of UV bulbs). For all *E. coli* and Enterococcus, values were usually reduced from ~100-1000 MPN/100, to < 10 MPN/100 ml (see figures below). Total coliform was generally reduced to <10 MPN/100 ml. It was recommended for Fiscal Year 2009 that the dilution be increased for the outlet samples, so that the lower limit is <1, rather tan <10 MPN/100 ml.



Weekly data demonstrating effectiveness of Westside SURF Project in reducing indicator bacteria concentrations. For Enterococcus, open symbols respresent data less than 10 MPN/100 ml.

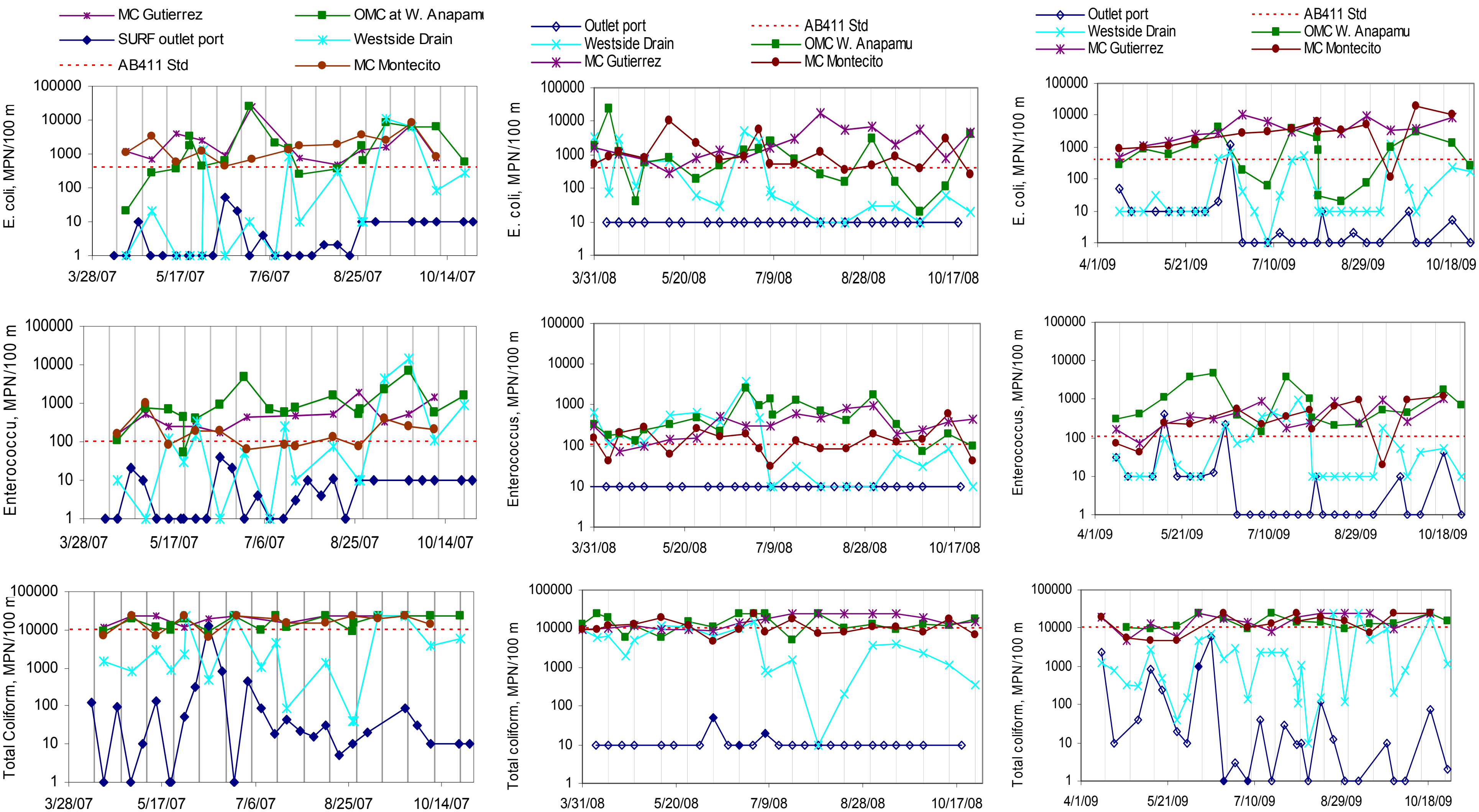
A comparison of indicator bacteria data between the inlet port and the Westside Drain shows that often, the facility has not treated the entire flow. When the system is fully functional, the Westside Drain numbers should be equal or slightly higher than the outlet numbers for E. coli and Enterococcus, and definitely below the AB411 stds. However, sampling methods may led to collection of water that had mixed with water in the pool below the discharge of the Westside Drain. Starting in late July 2009, sampling methods were changed so that water is always collected 2-3' upstream of the grate, and only when the SURF facility has been discharging for two minutes. This will improve the likelihood that the bacteria levels reflect the proportion of storm drain flow that has been treated by the SURF facility.



Downstream Impacts

The downstream impact of the SURF project is of chief interest to the Creeks Division and the local community. When the system if functioning properly, bacteria levels at the Westside Drain outlet, immediately downstream of the Project, are variable but lower than the background levels at W. Anapamu. At the next downstream site, Old Mission Creek at W. Anapamu, indicator bacteria levels are consistently at typical background levels seen in Mission Creek, as shown by the results from Mission Creek at Gutierrez. Even further downstream, i.e., at Mission Creek at Montecito Street, indicator bacteria concentrations did not appear to relate with the results from Westside SURF Project (see figure below). These results are not surprising, given similar results at other UV disinfection facilities and the mounting evidence for indicator bacteria survival and growth in sediments and decaying plant material.

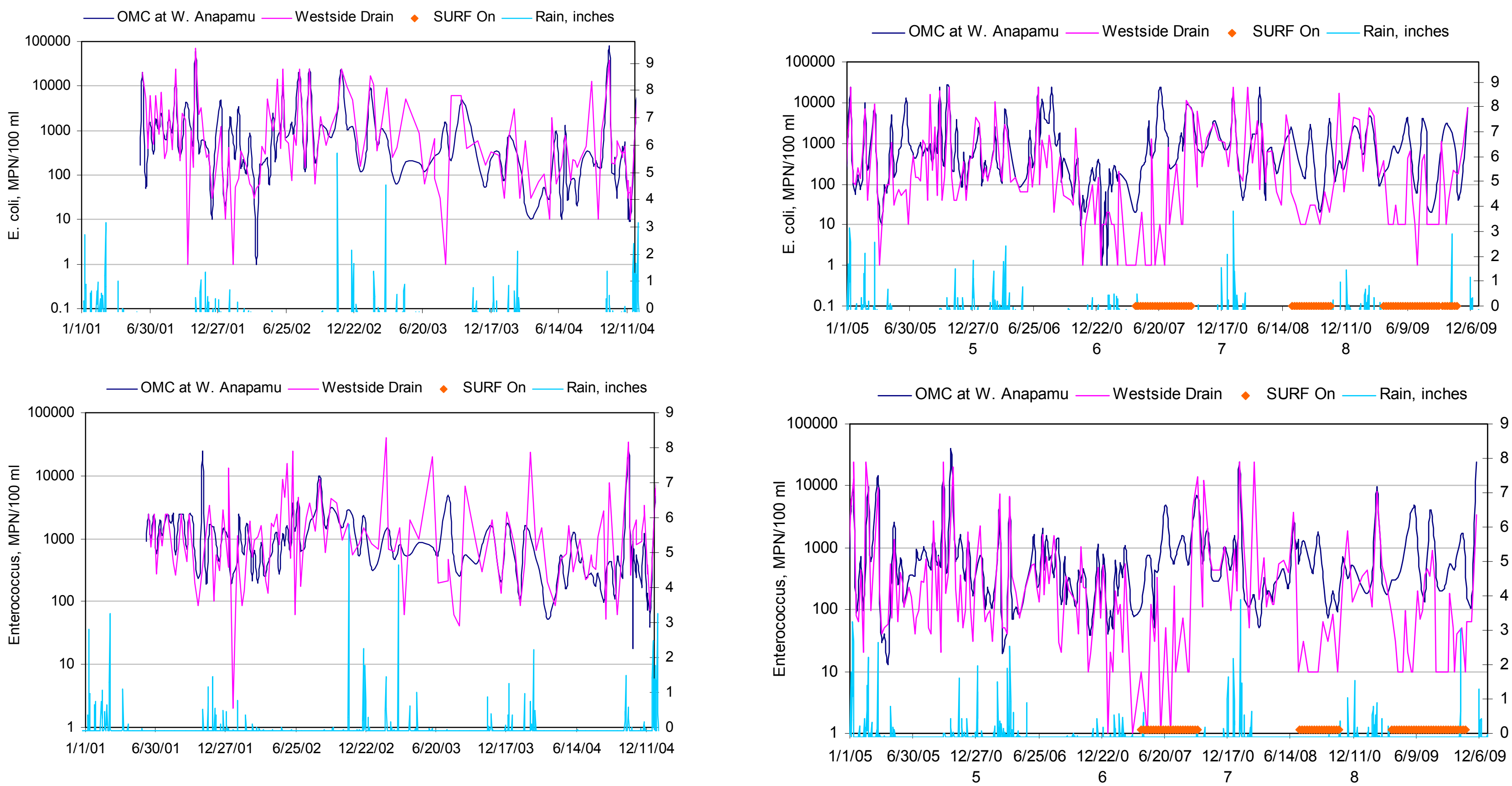
It is important to note however, that whether or not the Project impacts downstream indicator bacteria concentrations, the creek and ocean certainly have fewer pathogens than prior to Project installation. The importance of the SURF Project in keeping water safe for swimming is highlighted by results from the City's research with Dr. Patricia Holden, which has identified signals of human waste at the Westside Storm Drain, as discussed below in Additional Benefits.



Downstream impacts of Westside SURF Project on Mission Creek.

Long Term Changes

And additional topic analyzed this year was that of long-term changes in E. coli and Enterococcus levels. The following figures show long term data from the Westside Drain and OMC at W. Anapamu. The top panels show the raw data, including rainfall and when the SURF facility was in operation. In general, the two stations track each other well. The SURF project dos not appear to have an impact on the water quality at W. Anapamu. Interestingly, the values at the Westside Drain were among their lower ever prior the initiation of operation – this is possibly due to the very low rainfall during the previous winter and the fact that coffer dams were in place during construction.



Long term indicator bacteria levels downstream of the SURF Project

V. BEACH WATER QUALITY

Both Arroyo Burro Beach and East Beach at Mission Creek exhibited high frequencies of beach warnings based on indicator bacteria levels in the second and third quarter of FY10. High indicator bacteria levels are likely due to increased sediment runoff from the Jesusita Fire and the continuous status of both lagoons being open. Data from the first quarter and turbidity values from the creeks will be included in the Annual Report.

AB411 Beach Water Quality Criteria

Total Coliform (TC)	Fecal coliform (FC)	Enterococcus (ENT)	TC:FC, when TC>1000
10,000 MPN/100 ml	400 MPN/100 ml	104 MPN/100 ml	0.1

Beach Sampling Results

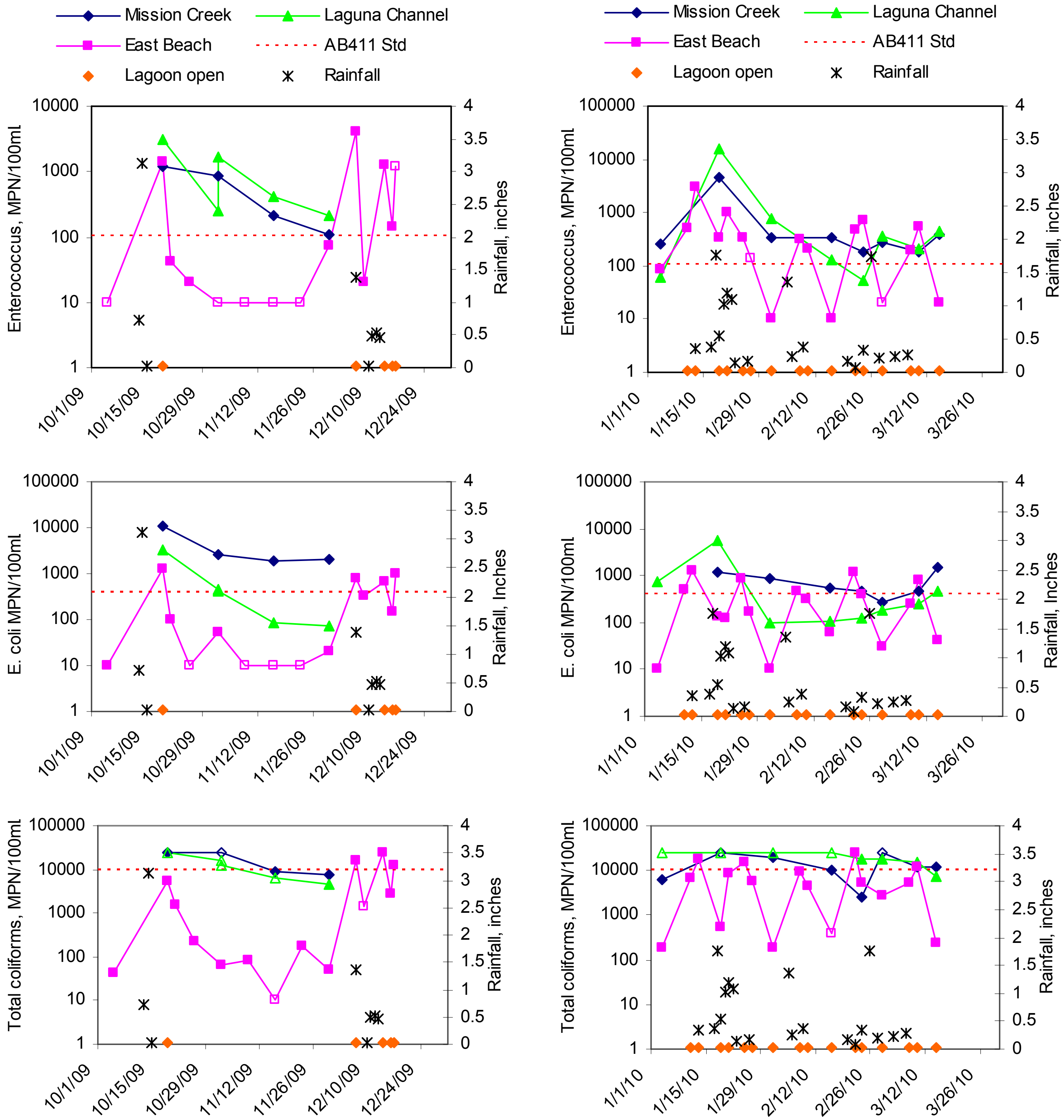
Date	Arroyo Burro Beach	East Beach-Mission Creek	East Beach-Sycamore Creek	Leadbetter Beach	Comments
07/06/09					
07/13/09					
07/20/09					
07/27/09					
08/03/09					
08/10/09	Warning				
08/17/09					
08/24/09	Warning	Warning			
08/26/09			ns	ns	
08/31/09					
09/08/09			Warning	Warning	
09/10/09	ns	ns			
09/14/09					
09/22/09					
09/28/09					
10/05/09					
10/12/09		ns			
10/19/09	Warning	Warning		Warning	over 3.5 inches of rain on Oct. 14
10/21/09			ns		
10/26/09					
11/02/09					
11/09/09					
11/16/09					
11/23/09					
11/30/09				Warning	
12/02/09	ns	ns	ns		
12/07/09	Warning	Warning	0	0	.5 inches of rain on this date
12/09/09	Warning	Warning	ns	ns	over .75 inches of rain on Dec. 8th
12/10/09	Warning	ns	ns	ns	

12/14/09	Warning	Warning		Warning	sewage spill in Mesa Creek & over one inch of rain from Dec. 11-13
12/16/09	Warning	Warning	ns		
12/17/09	Warning	Warning	ns	ns	
01/04/10					
01/11/10		Warning			
01/13/10	ns	Warning	ns	ns	
01/19/10	Warning	Warning	Warning	Warning	Approx. 6 inches of rain from Jan 18-23
01/21/10	Warning	Warning	Warning	Warning	Approx. 6 inches of rain from Jan 18-23
01/25/10	Warning	Warning	Warning	Warning	Approx. 6 inches of rain from Jan 18-23
01/27/10	Warning	Warning	Warning		.20 inches of rain on Jan 27th
02/01/10	Warning				
02/03/10	Warning	ns	ns	ns	
02/08/10	Warning	Warning			storm over weekend
02/10/10	Warning	Warning	ns	ns	.3 inches of rain on Feb. 10th
02/16/10					
02/22/10	Warning	Warning			.17 inches of rain on Feb 20th
02/24/10	Warning	Warning	ns	ns	
03/01/10	Warning				approx. 2 inches of rain on Feb 27th and 28th combined
03/03/10	Warning	ns	ns	ns	
03/08/10	Warning	Warning			.45 inches of rain on March 7th
03/10/10	Warning	Warning	ns	ns	
03/15/10					
03/22/10	Warning	Warning			
03/24/10		Warning	ns	ns	
03/29/10					
03/29/10					
4/5/2010	Warning	Warning	Warning		.38 inches of rain on April 5th
4/7/2010				ns	
4/12/2010	Warning	Warning	Warning	0	.9 inches of rain on April 12th
4/14/2010	Warning	Warning	Warning	ns	
4/19/2010		Warning			
4/21/2010	ns	Warning	ns	ns	.56 on April 21st
4/26/2010					
5/3/2010					
5/10/2010					
5/17/2010				Warning	
5/19/2010	ns	ns	ns		
5/24/2010					
5/31/2010	Warning				
6/2/2010		ns	ns	ns	
6/7/2010					

6/14/2010					
6/21/2010	Warning				
6/23/2010		ns	ns	ns	
6/28/2010					

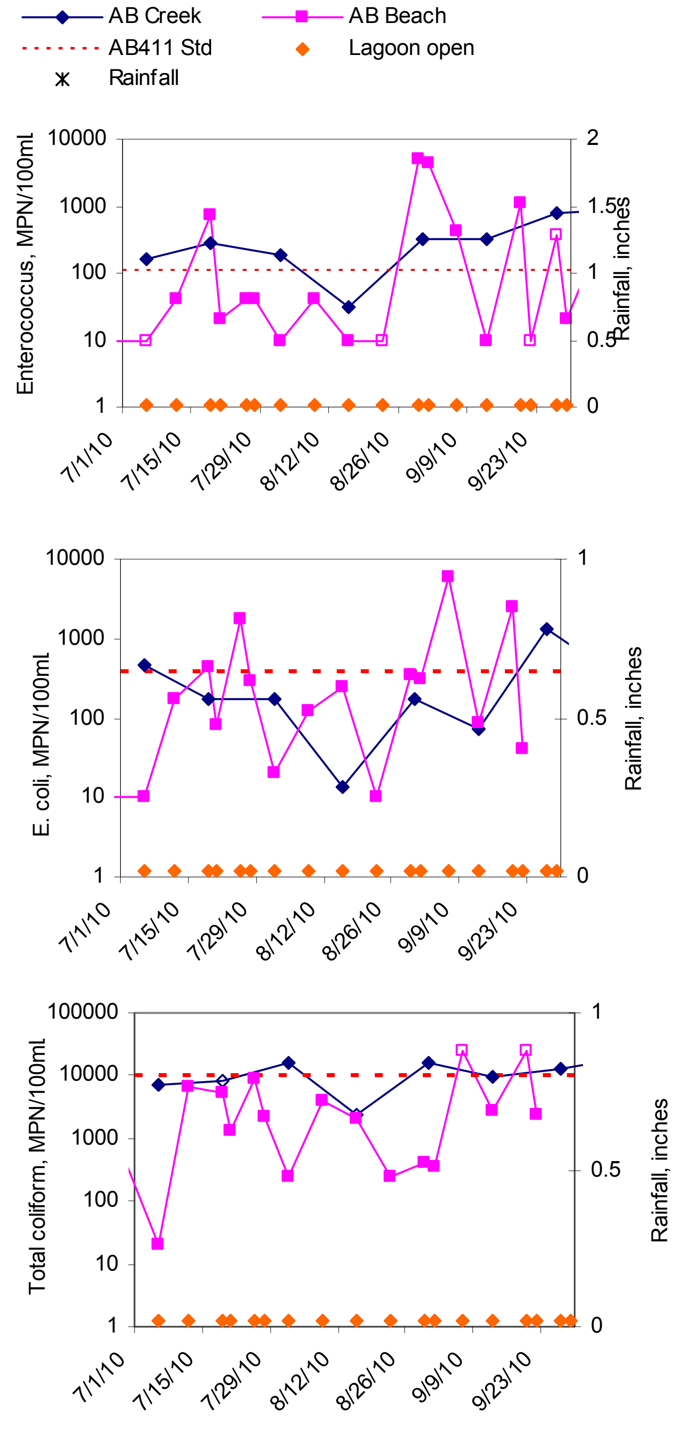
ns = not sampled. Beaches are sampled on Monday, and only those that have a Warning posted are re-sampled on Wednesday.

MISSION CREEK AND LAGUNA CHANNEL

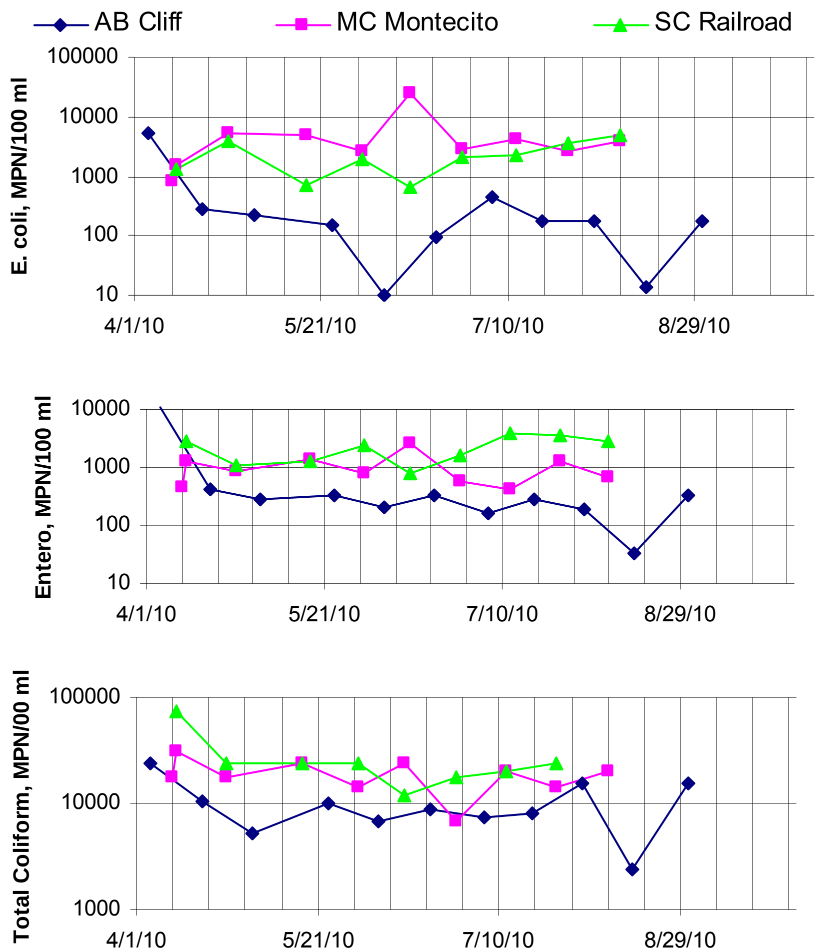


Summer 2010 Beach Warnings:

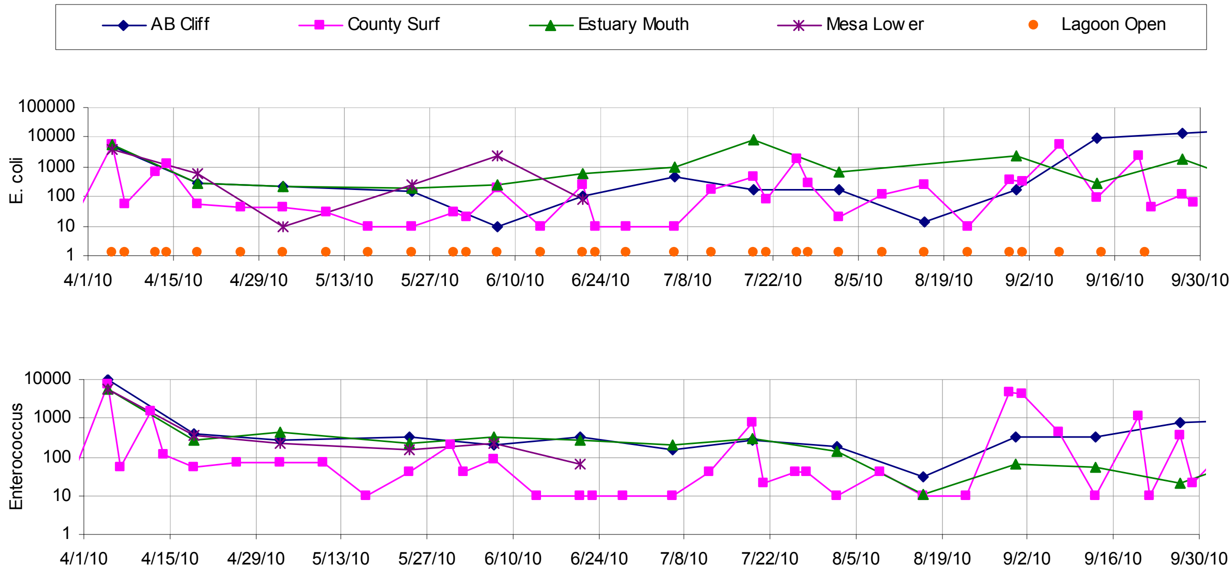
Entero really shot up above creek and estuary:



Arroyo Burro was not more elevated in indicator bacteria than other integrator sites:



The estuary appears to be a source of E. coli, especially in warmer months, but not Enterococcus:



In addition, the Creeks Division hired an intern, Stephanie Dolmat-Connel to conduct a statistical investigation into causes of beach water quality. The preliminary report follows:

Santa Barbara County Beaches, 1996-2009:
A Statistical Analysis of Factors Affecting Beach Water Quality

Abstract

Marine beach water sampling for fecal indicator bacteria (FIB) has occurred weekly at four different beaches within the City of Santa Barbara from 1996 to 2009. This study investigated different factors, such as tidal influences, lagoon influences, creek load of FIB, and rainfall and their influence on FIB levels, probability of detection, and probability of exceedance of state standards at each of the beaches tested for enterococcus, fecal coliform, and total coliform. The results of logistic regressions showed that rainfall in the prior 72 hours and when nearby lagoons that flow into the ocean are open are the two most important predictors of the probability of detection of FIBs and the probability of state standard exceedance of FIBs. Tidal influences such as spring tides and ebbing tides play a part in predicting the detection of FIBs but not the exceedance of FIBs. Further research into the effect of creeks and lagoons on the detection and exceedance of FIBs at the beaches in Santa Barbara is warranted to understand this important source of pollution at the beaches and the interconnectedness of the water system.

Introduction

The County of Santa Barbara must post a warning at the beach when threshold fecal indicator bacteria (FIB) levels are exceeded, per US EPA and State of California legislation, Assembly Bill 411. AB 411 went into effect in July 1999 and mandates that in Santa Barbara, weekly testing for FIB at certain beaches must occur between April 1st and October 31st. The City of Santa Barbara and the County of Santa Barbara have collaborated to test the beaches year-round, and Santa Barbara Channelkeeper has helped to test FIB levels as well. The single daily sample standards, which in Santa Barbara are tested weekly, are: Enterococcus (104 organisms/100 ml), Fecal Coliform (400 organisms/100 ml), Total Coliform (10,000 organisms/100 ml), and the Fecal:Total Coliform Ratio where if the ratio exceeds 0.1, then Total Coliform single-sample standard is 1,000 organisms/100ml.

Prior research has suggested that a number of factors may contribute to FIB densities at beaches, such as stormwater discharge, rainfall (both actual and lagged), ocean temperature, upwelling index, wind velocity, wave height and direction, visitor number, atmospheric pressure, solar insolation, sampling time, and tide level and range (Hou et al. 2006, Boehm et al. 2005). High levels of enterococcus have shown a higher correlation to human sickness than fecal coliform or total coliform (Haile et al. 1999, Wade et al. 2003). Therefore, in order to address FIB sources and possible mitigation issues, the Creeks Division sought to investigate the linkage between FIBs, external factors, and beach warnings. Our research focused on all three indicator bacteria, to look at the difference in factors that contributed to higher levels of detection and exceedance.

Methods:

We compiled a data set that shows weekly and biweekly bacteria levels at four beaches in the City of Santa Barbara from 1996-2009. The beaches we looked at were: Arroyo Burro, Leadbetter, Mission Creek at East Beach, and Sycamore Creek at East Beach. We looked at three FIBs: enterococcus, fecal coliform, and total coliform. During testing, if standards are exceeded, a resample is taken two days later. Here, we omitted the resample data due to autocorrelation for detection and exceedance. Laboratory results of FIB testing show the data as most probable number (MPN) per 100 ml of sample water. The data were censored, meaning that laboratory results do not reflect bacteria levels at or below 10 MPN/100 mL or above 24,192MPN/100 mL, since detection is not possible below/above these levels. All data points at or below 10 MPN/100 mL were included as 10 MPN/100 mL and all data points at or above 24,192 MPN/100 mL were included as 24,192 MN/100 mL.

We then considered a number of independent variables that could have an effect on bacteria levels. The variables we found most important to look at are:

- Whether it has rained in the last 72 hours—"wet" defined as a day in which it rained either more than 0.05" in the previous 24 hours or more than 0.1" in the prior 48 or 72 hours, "dry" otherwise (categorical, binary)
- Amount of rain in the last 72 hours, measured at the rain gauge at El Estero, Santa Barbara (numerical, continuous)
- Ocean surface temperature (numerical, continuous)—measured using City of Santa Barbara-collected data from 1996-2004. From 2005 to 2009, used NOAA data from Goleta Point, which averages approximately 1°C colder than Santa Barbara Harbor; used corrected data (-1°C) for temperature differential.
- Whether it is a spring or neap tide—"spring" defined as Days 0-3, 12-18, and 26-28 following the full moon, with all other tides defined as "neap" (categorical, binary) (following Boehm & Weisberg, 2005)
- Tide height (numerical, continuous). Defined as 11:00 on the day of sampling.
- Whether the tide is flooding, ebbing, at slack-low or at slack-high. Used 2 hr tidal height difference from 11:00 to 13:00. Flooding defined as 2hr change in tide height > 0.5 feet, ebbing defined as 2hr change in tide height < -0.5 feet. If 2 hr change in tide height is between -0.5 ft and 0.5 ft, then slack-low if tide height at 11:00 is in the lowest 25th percentile of tide heights, slack-high if not.
- Tide height was categorized into four categories: very high, high, low, and very low, to look at the effect. Very low tides were classified as the lowest 25th percentile of tide height over the period of 1996-2009, low tides as the 25-50th percentile of tide heights, high tides as the 50th-75th percentile of tide heights, and very high tides as the 75th percentile and above of tide heights.
- Creek load of the number of bacteria discharged from the creek per unit of time (numerical, continuous)—creek load information was only available for Arroyo Burro and Mission Creek at East Beach from 2001 to 2009.
- Whether the lagoon is open or closed (categorical, binary)—lagoon information was only available for Arroyo Burro, Mission Creek at East Beach, and Sycamore Creek and East Beach from 2001 to 2009. The information available was a notation of whether the lagoon was flowing to the ocean (connected) or not.
- Year in which the sampling occurred (categorical, to take a look at the effect of environmental fluctuations such as ENSO)
- Month in which the sampling occurred

We first produced box plots for all of the beach, bacteria, and variable combinations. The bacteria levels were log-transformed due to the large range in bacteria numbers (several orders of magnitude). 95% confidence intervals on the median (based on interquartile ranges) are included in the plots to assess significant differences. Because rain was such a strong variable, and rain had been coded into "wet" and "dry" (wet meaning >0.1" of rain during the previous 72 hours), the boxplots were also produced without wet data. Scatterplots of certain of the continuous variables were also produced. Kruskal-Wallis tests of statistical significance were conducted on each of the categorical variables to determine their significance to the differences in bacteria levels.

In order to determine the variables that contributed to the likelihood of exceedance of each of the bacteria, we ran a logistic regression for each beach and for each indicator bacteria. A logistic regression analysis is appropriate for looking at the prediction of the probability of the occurrence of an event—here, the occurrence is whether a FIB will exceed or not given the predictor variables (both numerical and categorical) inputted into the model. We used only the data from 2001 to 2009 for the logistic regression models, in order to include the effects of the lagoon and the creek load number, where available. We included interaction terms to take into account the potential effect one variable has on another variable to explain FIB levels, for example, the effect of rainfall on whether or not the lagoon is open or closed, or the effect of spring/neap tides to affect tide height. To determine the significance of each of the variables, we then ran an ANOVA on the regression model, and used a p-value of 0.1 as the limit for significance. Any variables that were then found to be significant under the ANOVA test were then looked at in the model to determine their effects through the parameter estimates in the logistic regression. To determine the effects for variables in which the standard deviation was too large to find a significant parameter estimate, we either looked at the boxplots for variables or, in certain cases, we conducted a backward stepwise regression in order to better isolate the parameter values, and eliminated variables in an iterative process.

We used the same process as above to conduct a logistic regression on the probability of detection of each of the FIBs at each beach. All samplings equal to or below 10 MPN/100 mL were coded as undetected, and all samples above 10 MPN/100 mL were coded as detected. Conducting two different logistic regressions allows a better look at how the factors that contribute to absolute levels of FIB (detection) differ from the factors that contribute to exceedance of state standards (exceedance), if any. In addition, the detection logistic regression gives a bigger sample size of probability of the even occurring, since more data points are detected than exceed.

Results:

<u>Boxplots</u>

Overall levels of FIB by month of enterococcus, fecal coliform, and total coliform can be seen in Appendix A, Figure 1. Limit lines of AB 411 exceedance standards are included in the graphs. Boxplots of wet/dry variable by beach showed that wet/dry conditions were significant predictors of bacteria levels (see Appendix A, Figure 2), with the most significant effects contributing to exceedance seen at both Arroyo Burro and Mission Creek at East Beach for all three bacteria, and at Leadbetter and Sycamore Creek at East Beach for enterococcus. Given these significant effects of wet/dry on levels of bacteria, the effects of other variables were analyzed using "dry" data only in order to minimize the masking effect of rain on the other variables. However, it should be noted that the use of boxplots only explains the significance of a variable on its own and does not take into account the interactions between variables or the influence of one variable on another.

The following variables were looked at using dry data only:

Spring tides had a higher median level of enterococcus than neap tides at both Leadbetter and at Mission Creek at East Beach (see Appendix A, Figure 3). Spring tides had a higher median level of fecal coliform than neap tides at both Arroyo Burro and Leadbetter, but had no effect on either Mission Creek or Sycamore Creek. Total coliform did not seem to be affected by spring/neap tides at any beach.

Ebbing tides produced higher median levels of enterococcus at Arroyo Burro and at Leadbetter, and ebbing tides and slack-low tides produced higher median levels of enterococcus at Mission Creek (see Appendix A, Figure 4). Ebbing tides and slack-high tides produced higher median levels of fecal coliform at Leadbetter, but fecal coliform was not influenced by flooding or ebbing tides at any other beach. Flooding tides yielded higher median levels of total coliform at Arroyo Burro, whereas ebbing tides yielded higher median levels of TC at Sycamore Creek.

Very low tides at Arroyo Burro contributed to higher levels of enterococcus (see Appendix A, Figure 5). Very high and very low tides at Mission Creek contributed to higher levels of enterococcus. Very high tides at Arroyo Burro contributed to higher levels of fecal coliform, whereas very low tides contributed to higher levels of both fecal and total coliform at Mission Creek.

Tides classified as both Spring and Ebb tides yielded higher levels of enterococcus at Arroyo Burro, Leadbetter, and Mission Creek (see Appendix A, Figure 6).

An open lagoon contributed significantly to higher levels of all three bacteria at the three beaches where there was lagoon information available (from 2001-2009 at Arroyo Burro, Mission Creek, and Sycamore Creek; see Appendix A, Figure 7).

Table 1 on the following page explains the percent exceedance of AB 411 standards at each of the beaches during dry days when the lagoon is open and when the lagoon is closed. Mission Creek shows a significantly higher percentage of exceedance for enterococcus when the lagoon is open (25.57%) compared to when it is closed (5.31%), exceeding almost four times as often when it is open. Sycamore showed the same significant difference, with 20.31% exceedance when the lagoon is open, compared to 3.77% when the lagoon is closed, exceeding 4.4 times more when the lagoon is open. Total coliform exceeds almost exclusively when the lagoon is open.

Exceedance tables for other variables can be seen in Appendix B.

Table 1:

Lagoon Open and Closed (Dry Days) 2001-2009					
		All Beaches	**AB**	**MC E Beach**	**SC E Beach**
Enterococcus	**Open**	Median: 20, n=522 % exc. 15.90	Median: ≤10, n=282 % exc. 8.87	Median: 31, n=176 % exc. 25.57	Median: 30, n=64 % exc. 20.31
		***	**	***	***
	Closed	Median: ≤10, n=627 % exc. 4.63	Median: ≤10, n=102 % exc. 5.88	Median: ≤10, n=207 % exc. 5.31	Median: ≤10, n=318 % exc. 3.77
Fecal Coliform	**Open**	Median: 41, n=518 % exc. 8.88	Median: 31, n=282 % exc. 6.03	Median: 74, n=173 % exc. 14.45	Median: 41, n=63 % exc. 6.35
		***	***	***	***
	Closed	Median: ≤10, n=603 % exc. 1.00	Median: ≤10, n=102 % exc. 1.96	Median: 20, n=196 % exc. 1.53	Median: ≤10, n=305 % exc. 0.33
Total Coliform	**Open**	Median: 591, n=518 % exc. 9.65	Median: 666, n=282 % exc. 9.57	Median: 714, n=173 % exc. 12.72	Median: 350, n=63 % exc. 1.59
		***	***	***	***
	Closed	Median: 41, n=603 % exc. 0.33	Median: 57, n=102 % exc. 0.00	Median: 74, n=196 % exc. 0.51	Median: 20, n=305 % exc. 0.33
Note: Medians are in MPN/100ml					
* <0.05 **<0.01 ***<0.001 from the Kruskall-Wallis Test					
Note: No information available for Leadbetter beach					

<u>Logistic Regressions: Detection and Exceedance</u>

Overall percent detection rates and exceedances for each bacteria level 2001 to 2009 can be found in Table 2. Total Coliform has the highest detection rate out of any FIB; Sycamore Creek at East Beach had the lowest detection rates of FIB. Mission Creek at East Beach and Arroyo Burro had on average the highest percentage of exceedances of state standards, and enterococcus had the highest percentage of exceedances of the three FIBs.

Table 2:

	Number of Samples (2001-2009)	**Percent Detection (2001-2009)**			**Percent Exceedance (2001-2009)**		
		ENT	**FC**	**TC**	**ENT**	**FC**	**TC**
Arroyo Burro	452	46.0%	63.3%	91.4%	15.5%	7.4%	11.4%
Leadbetter	440	48.8%	54.5%	92.7%	11.4%	2.4%	1.3%
Mission Creek at East Beach	439	49.6%	70.6%	91.3%	21.1%	11.6%	11.2%
Sycamore Creek at East Beach	438	34.5%	40.0%	69.6%	9.9%	2.9%	3.1%
Overall: All Beaches	1769	47.4%	57.7%	85.0%	14.5%	6.1%	6.7%

The results of the logistic regression and ANOVA tests for each FIB by beach are summarized in the paragraphs and the tables below. Certain parameter estimates had a standard deviation too high to draw an appropriate conclusion, but where parameter estimates offered instructive information on detection or exceedance levels, we have discussed them below.

Arroyo Burro Beach:

<u>Enterococcus (ENT)</u>: Rain, the lagoon open or closed, and spring/neap tides play a significant role in the probability of ENT detection and in the probability of ENT exceedance at Arroyo Burro. For detection, the odds that ENT will be detected increases by a factor of 2.41 (+/- 1.44) when the lagoon is open compared to when it is closed. When we take into account the effect of tide height, spring tides increase the probability of detection by 4.4 times compared to neap tides. For exceedance, the odds that ENT will exceed increase by 364 times (+/- 20.9) for each additional inch of rainfall in the past 24 hours, increase by a factor of 7.1 (+/- 1.9) when the lagoon is open compared to when it is closed, and increase by a factor of 3.43 (+/- 2.7) when it

is a spring tide compared to when it is a neap tide. Yearly influences on probabilities of detection and exceedance were found to be significant, whereas monthly influences were only found important for probability of exceedance.

Fecal Coliform (FC): The odds that FC will exceed standards increase by a factor of 1.68 (+/- 1.21) for each degree the ocean temperature rises. This effect was also seen for FC at Mission Creek at East Beach and at Sycamore Creek at East Beach, but not at Leadbetter. An open lagoon only influenced detection and not exceedance (an open lagoon increases the probability of detection 4.6 times (+/-1.4) than when it is closed), whereas the creek load of FC influenced exceedance only. A spring/neap influence was found in detection only.

Total Coliform (TC): TC stands out from the other FIB for Arroyo Burro because it does not have a spring/neap influence, but rather a flooding/ebbing influence for the probability of detection. Total coliform also has a lagoon influence and a rain influence for probabilities of detection and exceedance. However, the creek load of TC influences exceedance only.

Leadbetter Beach

Leadbetter is the only beach in the study that does not have a significant outfall of water from the shore, either in a creek or lagoon form. Therefore, compared to the three other beaches studies, Leadbetter did not have as many independent variables for regression models.

ENT: Rain was the most important factor for both detection and exceedance, with the odds that ENT will exceed increasing by a factor of 7.5 (+/- 1.5) for each additional inch of rainfall in the past 72 hours. Flood/ebb was found to be significant in exceedance, and was almost significant (p=0.102) in detection as well. A monthly influence was also found for detection.

FC: For detection, year, month, rain, and spring/neap and the interaction term of spring/neap and tide height were found to be important. Month and rain were similarly important for exceedance, but tide height and flooding and ebbing were found to important for exceedance rather than spring and neap. The odds of FC detection increase by a factor of 5.5 when it is a spring tide compared to when it is a neap tide.

TC: Month and rain were both significant factors for detection and exceedance, and tide height played a factor in both detection and exceedance but in different ways. Flood/ebb interaction with tide height was only significant for detection and tide height was only significant for exceedance.

East Beach at Mission Creek

ENT: The factors that influenced detection and exceedance were largely the same and included month, rain, creek load, and the lagoon being open. The only differences were that in detection, yearly influences played a role and spring/neap was found to influence probability of detection as well. For exceedance, the odds that ENT will exceed increase by a factor of 3.6 (+/- 1.1) when the lagoon is open compared to when it is closed. The odds that ENT will exceed increase by a factor of 8.1 (+/- 2.0) for each additional inch of rainfall in the past 72 hours.

FC: FC had a number of significant factors that increase the likelihood of detection and exceedance. Year, month, rain, and lagoon were significant factors for both detection and exceedance. The odds that ENT will exceed increase by a factor of 4.8 (+/- 2.5) when the lagoon is open compared to when it is closed.

TC: Both detection and exceedance had yearly and monthly influences. However, rain was only significant for exceedance, as well as creek load of TC and lagoon open. The interaction term between spring/neap and tide height was important for detection, where spring tides increase the likelihood of detection compared with neap tides.

East Beach at Sycamore Creek

ENT: Rain, year, and lagoon were significant predictors of both detection and exceedance. The odds that ENT will exceed increase 6.33 times (+/- 2.0) for each additional inch of rainfall in the past 72 hours. The odds that ENT will exceed increase by a factor of 13 (+/- 1.9) when the lagoon is open compared to when it is closed. Month and flood/ebb:tide height were also important for detection.

FC: Rain and lagoon were the two factors that were important in both detection and exceedance. In detection, we add year, month, ocean temperature, and flood/ebb:tide height as factors, whereas for exceedance, we see spring/neap:tide height and flood/ebb as predictors. For exceedance, taking into account the effect of tide height, the odds the FC will exceed increase when there is a spring tide compared to when there is a neap tide. Compared with ebbing tides, flooding and slack-low tides increase the likelihood of exceedance, whereas a slack-high tide decreases the likelihood of exceedance as compared with ebbing.

TC: Year, month, and rain were important for both detection and exceedance. Lagoon was important for detection, whereas ocean temperature was important for exceedance. The odds that TC will exceed increase by a factor of 5.29 (+/- 2.69) for each degree increase in ocean temperature.

Arroyo Burro 2001-2009

		Boxplot Interpretation (Dry Days)	Logistic Regression Detection			Logistic Regression Exceedance		
	Variable:		Percent Detection Rate	Significance	ANOVA P-Value	Percent Exceedance Rate	Significance	ANOVA P-Value
ENT	Year	2001, 2005, 2006 highest medians	46% of the time ENT was detectable at Arroyo Burro	***	0.001	15.5% of the time, ENT at Arroyo Burro exceeded standards.	**	0.006
	Month	Highest absolute levels in June & July					*	0.031
	Rain	Median above exceedance level on wet days		**	0.001		***	6.19E-11
	Ocean Temp							
	Tide Height	Very low tides yield higher median						
	Spring/Neap	No difference in medians		.	0.084		*	0.02
	Spring/Neap: Tide Height			*	0.011			
	Flood/Ebb	Ebbing yields higher median						
	Flood/Ebb:Tide Height							
	Creekload							
	Rain:Creekload							
	Lagoon	Signif. higher median when open		**	0.002		*	0.019
	Rain:Lagoon							
Fecal Coliform	Year	2001, 2005, 2006 and 2008 highest medians	63% of the time Fecal Coliform was detectable at Arroyo Burro.			7.4% of the time, Fecal Coliform at Arroyo Burro exceeded standards.	.	0.074
	Month	July and November highest					***	0.0003
	Rain	Wet days significantly higher		***	0.000		***	7.76E-06
	Ocean Temp						**	0.00096
	Tide Height	Very high tides yield higher median						
	Spring/Neap	Spring tides yield higher median		**	0.003			
	Spring/Neap: Tide Height							
	Flood/Ebb	No difference in medians						
	Flood/Ebb:Tide Height							
	Creekload							
	Rain:Creekload			*	0.048		**	0.00012
	Lagoon	Signif. higher median when open		***	3.25E-06			
	Rain:Lagoon							
Total Coliform	Year	2001, 2005, and 2006 highest medians	91% of the time, Total Coliform was detectable at Arroyo Burro.			11.4% of the time, Total Coliform at Arroyo Burro exceeded standards.		
	Month	Summer months yield highest medians						
	Rain	Wet days significantly higher		*	0.033		***	8.75E-14
	Ocean Temp							
	Tide Height	No difference in medians						
	Spring/Neap	No signif. difference in medians						
	Spring/Neap: Tide Height							
	Flood/Ebb	Flooding tides yield higher median						
	Flood/Ebb:Tide Height			*	0.017			
	Creekload						***	0.00049
	Rain:Creekload							
	Lagoon	Signif. higher median when open		***	2.51E-06		***	2.81E-05
	Rain:Lagoon							

Leadbetter Beach 2001-2009

		Boxplot Interpretation (Dry Days)	Logistic Regression Detection			Logistic Regression Exceedance		
	Variable:		Percent Detection Rate	Significance	ANOVA P-Value	Percent Exceedance Rate	Significance	ANOVA P-Value
ENT	Year	2004, 2007, and 2009 had the highest medians	49% of the time ENT was detectable at Leadbetter			11.4% of the time, ENT at Leadbetter exceeded standards.		
	Month	July had the highest median		***	3.94E-04			
	Rain	Wet days significantly higher		***	6.43E-09		***	1.73E-10
	Ocean Temp							
	Tide Height							
	Spring/Neap	Spring tides yield higher median						
	Spring/Neap: Tide Height							
	Flood/Ebb	Ebbing tides yield higher median					*	0.024
	Flood/Ebb:Tide Height			Almost signif.	0.102			
Fecal Coliform	Year		55% of the time Fecal Coliform was detectable at Leadbetter.	*	0.029	2.4% of the time, Fecal Coliform at Leadbetter exceeded standards.		
	Month	July had the highest median		**	0.005		***	0.00026
	Rain	Wet days significantly higher		***	7.69E-05		***	3.41E-06
	Ocean Temp							
	Tide Height	Very high and low tides yield higher medians					.	0.098
	Spring/Neap	Spring tides yield higher median		**	0.002			
	Spring/Neap: Tide Height			*	0.034			
	Flood/Ebb							
	Flood/Ebb:Tide Height						.	0.095
Total Coliform	Year	2006, 2008, and 2009 had higher medians	93% of the time, Total Coliform was detectable at Leadbetter.			1.3% of the time, Total Coliform at Leadbetter exceeded standards.		
	Month	July had the highest median		*	0.049		.	0.076
	Rain	Wet days significantly higher		**	0.009		***	9.00E-04
	Ocean Temp							
	Tide Height						.	0.096
	Spring/Neap	Spring tides yield higher median						
	Spring/Neap: Tide Height							
	Flood/Ebb							
	Flood/Ebb:Tide Height			*	0.013			

East Beach at Mission Creek 2001-2009

		Boxplot Interpretation (Dry Days)	Logistic Regression Detection			Logistic Regression Exceedance		
	Variable:		Percent Detection Rate	Significance	ANOVA P-Value	Percent Exceedance Rate	Significance	ANOVA P-Value
ENT	Year	2001 and 2007 had the highest medians	50% of the time ENT was detectable at East Beach at Mission Creek	*	0.020	21.1% of the time, ENT at East Beach at Mission Creek exceeded standards.		
	Month	The winter months had the highest medians		*	0.048		**	0.002
	Rain	Median above exceedance level on wet days		**	0.001		***	2.97E-06
	Ocean Temp							
	Tide Height							
	Spring/Neap	Spring tides yield higher median		.	0.051			
	Spring/Neap: Tide Height							
	Flood/Ebb	Ebbing and slack-low tides yield higher median						
	Flood/Ebb:Tide Height							
	Creekload			**	0.001		.	0.073
	Rain:Creekload							
	Lagoon	Signif. higher median when open		***	2.34E-06		***	6.89E-07
	Rain:Lagoon							
Fecal Coliform	Year	2005 had a higher median	71% of the time Fecal Coliform was detectable at East Beach at Mission Creek.	.	0.084	11.6% of the time, Fecal Coliform at East Beach at Mission Creek exceeded standards.	.	0.073
	Month	February and March had the highest medians		*	0.018		**	0.0018
	Rain	Wet days significantly higher		*	0.018		**	3.00E-03
	Ocean Temp			**	0.009			
	Tide Height	Very high and very low tides yield higher medians		***	0.001			
	Spring/Neap							
	Spring/Neap: Tide Height			.	0.054			
	Flood/Ebb	Ebbing and slack-high tides yield higher median						
	Flood/Ebb:Tide Height							
	Creekload						.	0.063
	Rain:Creekload						**	0.006
	Lagoon	Signif. higher median when open		***	9.25E-04		***	9.04E-07
	Rain:Lagoon							
Total Coliform	Year	2001 and 2005 had higher medians	91% of the time, Total Coliform was detectable at East Beach at Mission Creek.	*	0.018	11.2% of the time, Total Coliform at East Beach at Mission Creek exceeded standards.	**	0.0052
	Month	February had the highest median		*	0.016		*	0.025
	Rain	Wet days significantly higher					***	1.10E-05
	Ocean Temp							
	Tide Height							
	Spring/Neap							
	Spring/Neap: Tide Height			.	0.067			
	Flood/Ebb							
	Flood/Ebb:Tide Height							
	Creekload						.	0.046
	Rain:Creekload							
	Lagoon	Signif. higher median when open					***	1.59E-05
	Rain:Lagoon							

East Beach at Sycamore Creek 2001-2009

	Variable:	Boxplot Interpretation (Dry Days)	Logistic Regression Detection: Percent Detection Rate	Logistic Regression Detection: Significance	Logistic Regression Detection: ANOVA P-Value	Logistic Regression Exceedance: Percent Exceedance Rate	Logistic Regression Exceedance: Significance	Logistic Regression Exceedance: ANOVA P-Value
ENT	Year		35% of the time ENT was detectable at East Beach at Sycamore Creek	***	1.03E-04	9.9% of the time, ENT at East Beach at Sycamore Creek exceeded standards.	*	0.027
	Month	Nov., Dec., and Jan. had the highest medians		**	0.006			
	Rain	Wet days significantly higher		**	0.002		***	6.55E-07
	Ocean Temp							
	Tide Height							
	Spring/Neap							
	Spring/Neap: Tide Height							
	Flood/Ebb							
	Flood/Ebb:Tide Height			*	0.017			
	Lagoon	Signif. higher median when open		***	1.99E-07		***	4.23E-06
	Rain:Lagoon							
Fecal Coliform	Year	2001 had a higher median than the rest	40% of the time Fecal Coliform was detectable at East Beach at Sycamore Creek.	.	0.070	2.9% of the time, Fecal Coliform at East Beach at Sycamore Creek exceeded standards.		
	Month	Nov., Dec., and Jan. had the highest medians		***	4.54E-05			
	Rain	Wet days significantly higher		*	0.015		**	4.12E-09
	Ocean Temp			*	0.025			
	Tide Height							
	Spring/Neap							
	Spring/Neap: Tide Height						***	<2.2E-16
	Flood/Ebb						**	0.007
	Flood/Ebb:Tide Height			**	0.002			
	Lagoon	Signif. higher median when open		***	2.92E-06		***	3.39E-12
	Rain:Lagoon							
Total Coliform	Year	2006 had the highest median	70% of the time, Total Coliform was detectable at East Beach at Sycamore Creek.	***	3.97E-04	3.1% of the time, Total Coliform at East Beach at Sycamore Creek exceeded standards.	.	0.062
	Month	The winter months had the highest medians		**	0.007		.	0.097
	Rain	Wet days significantly higher		*	0.049		***	1.72E-07
	Ocean Temp						*	0.029
	Tide Height							
	Spring/Neap							
	Spring/Neap: Tide Height							
	Flood/Ebb							
	Flood/Ebb:Tide Height							
	Lagoon	Signif. higher median when open		***	1.90E-07			
	Rain:Lagoon							

Discussion:

It is not known whether the FIB discharges during storm events are harmful to humans, as epidemiological studies have not reached a consensus on the effects of the FIBs on human sickness. Regardless of the health effects of FIBs at the beach, the overall number of beach warnings still may affect local tourism, public perception of water quality, and could have an effect on other aquatic animals.

For enterococcus, rain and whether the lagoon was open or closed had the largest influence on the likelihood of detection and exceedance across all beaches, except for at Leadbetter Beach (lagoon information is N/A), where rainfall and flooding/ebbing tides had the largest influence. Tidal influences seemed to be more predictors of detection rather than exceedance. Fecal coliform did not show any uniform trends across beaches, although rain was an important factor at all beaches for both detection and exceedance. The lagoon was an important factor in fecal coliform detection and exceedance at both Mission Creek and Sycamore Creek. Creek load was more important for exceedance than detection. For total coliform, rain was a significant predictor of detection across all beaches except East Beach at Mission Creek. All beaches except for East Beach at Sycamore Creek showed some sort of tidal influence on detection, such as spring/neap or flood/ebb. Lagoon was important for detection at both Arroyo Burro and East Beach at Sycamore Creek. Like enterococcus, rain had the largest influence on the likelihood of exceedance across all beaches. Creek load of TC was important at Mission Creek and Arroyo Burro for exceedance. However, for exceedance, no tidal influences seemed to play a part.

Rainfall in the prior 72 hours was shown to be a significant influence on all three FIBs for detection and exceedance across beaches. Guidance for California beach managers issued by the California Department of Public Health recommends that beach warnings after a storm should remain in effect 72 hours after the storm in order for bathers to avoid microbial contamination (CDHS 2006). This guidance corresponds with this research by showing that higher levels of FIB are indeed correlated with rainfall 72 hours after the storm, producing higher likelihoods of exceedance of FIB.

For beaches with available lagoon information, an open lagoon was found to be an extremely large predictor on whether enterococcus would be detected and whether it would exceed. The same is true for total coliform and held true for both wet and dry days. Creek load of bacteria, studied at both Arroyo Burro and at East Beach at Mission Creek, was also important across FIBs. Lagoons and creeks could be an important source of FIB from either human sewage or animal waste; therefore, when the lagoon is flowing, the source of FIBs flows into the water at a higher concentration. The Creeks Division has worked to keep the lagoons closed to improve the habitat for the federally endangered tidewater goby; these findings further stress the importance of keeping the lagoons closed absent natural rainfall events.

The finding that lagoons have such a strong influence on the likelihood of exceedance could have important significance for further study. For example, how far across the beach a FIB spreads from its lagoon/creek source is not known; FIB levels could be important only within a certain range of the lagoon/creek outflow. However, immediate best management practices could include stressing the importance to lagoon ‘gatekeepers’ about the linkage between the lagoon openings and beach closures, and exploring the extent to which FIB levels mix across the width of the beach. This could warrant only a certain portion of the beach being subject to a warning rather than the whole beach, especially during high tourism season.

Tidal influences were found to be an important source for prediction of detection among FIBs, although they were not found to be among the larger influencers on exceedances (except for fecal coliform at Sycamore Creek and flooding/ebbing at Leadbetter Beach). Prior research shows that:

> There are numerous mechanisms whereby tides might influence shoreline FIB concentrations. Flooding tides can dilute nearshore FIB sources and reduce bacterial concentrations. Ebbing tides allow water to drain from land to sea from tidally influenced wetlands and beach aquifers. Higher than average spring tides provide a hydrologic connection between the sea and fecal sources at the high water line and upper reaches of the tidal prism in tidal wetlands and subterranean estuaries within the beach aquifer. Tidally modulated nearshore currents are capable of moving FIB from a source to a distant beach. (Boehm and Weisberg 2005)

Tidal functions such as spring/neap and flood/ebb were important for detection of the FIBs in this study, but it was not found across all beaches that tidal functions play a role in exceedance at all beaches.

Ocean temperature for detection was found to be important for fecal coliform at East Beach at Mission Creek and East Beach at Sycamore Creek. For exceedance, ocean temperature was found to be significant at Arroyo Burro for fecal coliform and at Sycamore Creek for total coliform. Ocean temperature could play a role at these beaches due to current effects and since higher temperatures could increase survival rates of the bacteria. However, ocean temperature did not play a role across all beaches, suggesting that it is not an important factor for ENT and TC, but could be an important factor for detection in fecal coliform.

Prior to this study, rainfall was known to be an indicator of exceedances across the County of Santa Barbara. However, it was not known prior to this study about the effect of lagoon openings on bacteria levels in beaches. This finding could promote the further investigation of lagoons and creeks as a bacterial source. Lagoons play an important part in predicting both detection and exceedance of FIBs; in order to better understand the input of creeks and lagoons to the system, in the future, an integrator site analysis could include rainfall into the creeks, dissolved oxygen, conductivity, water temperature, air temperature, and insolation from the creeks and how they influence bacteria levels at the beaches.

References:

Boehm, A.B., et al. (2002). Decadal and shorter period variability of surf zone water quality at Huntington Beach, California. Environ. Sci. & Tech.: 36, 3885—3892.

Boehm, A.B. and Weisberg, S.B. (2005). Tidal forcing of enterococci at marine recreational beaches at fortnightly and semidiurnal frequencies. *Environ. Sci. Technol*.: 39, 5575-5583.

California Department of Public Health, Division of Drinking Water and Environmental Management (2006). Draft Guidance for Salt Water Beaches. Accessed at: < http://www.cdph.ca.gov/HealthInfo/environhealth/water/Documents/Beaches/DraftGuidanceforSaltWaterBeaches.pdf>

Haile, R.W., et al. (1999). The health effects of swimming in ocean water contaminated by storm drain runoff. *Epidemiology*: 10, 355-363.

Hou, D. et al (2006). *Enterococci Predictions from Partial Least Squares Regression Models in Conjunction with a Single-Sample Standard Improve the Efficacy of Beach Management Advisories*. Environ. Sci. & Tech.: 40, 6, 1737- 1743.

Wade, T.J., et al. (2003). Do US Environmental Protection Agency water quality guidelines for recreational waters prevent gastrointestinal illness? A systematic review and meta-analysis. *Environ. Health Perspect.*: 111, 1102-1109.

Appendix A

The following boxplots should be read as follows: The median bacteria level falls at the most notched part in the box. The notches in the box represent the 95th confidence interval around the median. The box itself represents the middle 50% of the data, with the 75th percentile represented at the top of the box and the 25th percentile represented at the bottom of the box. The spread of the data is represented by the whiskers, or the combination of lines and dots around the box.

Figure 1:

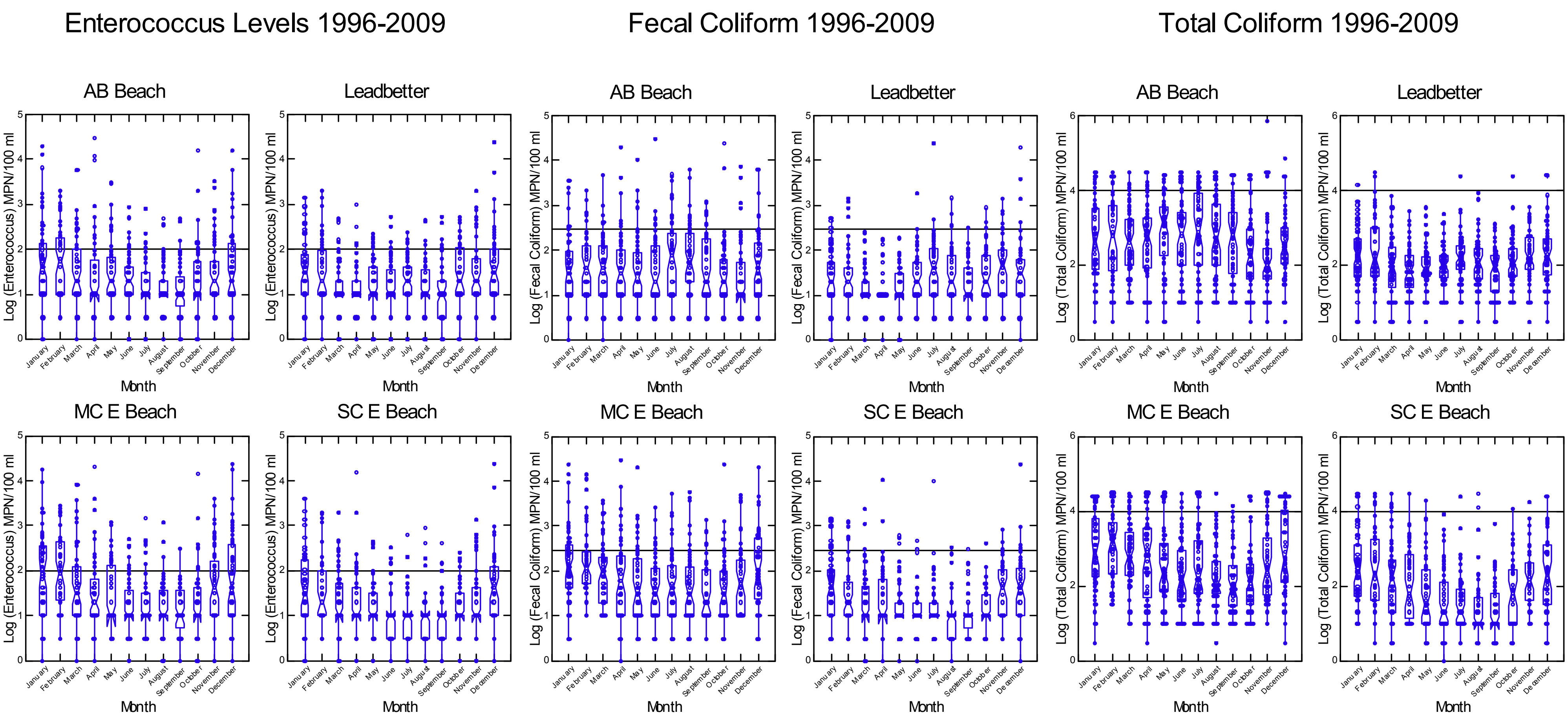


Figure 2:

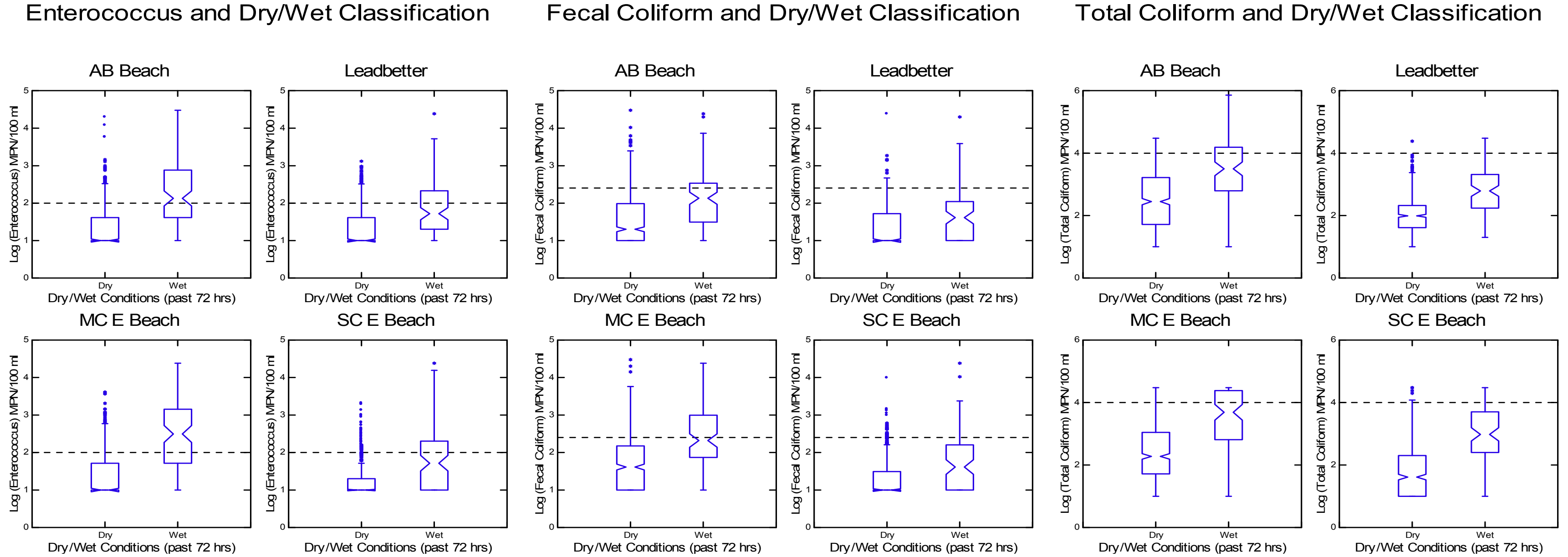


Figure 3:

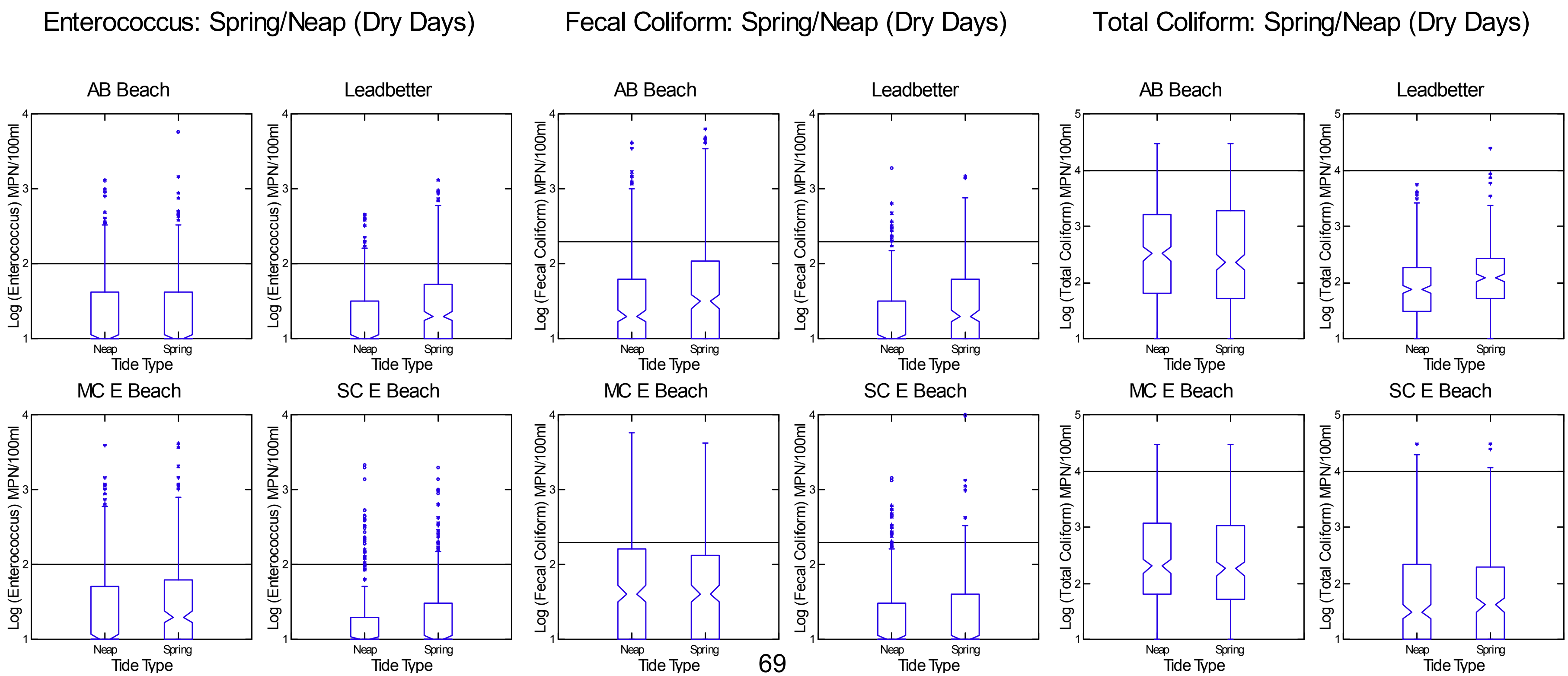


Figure 4:

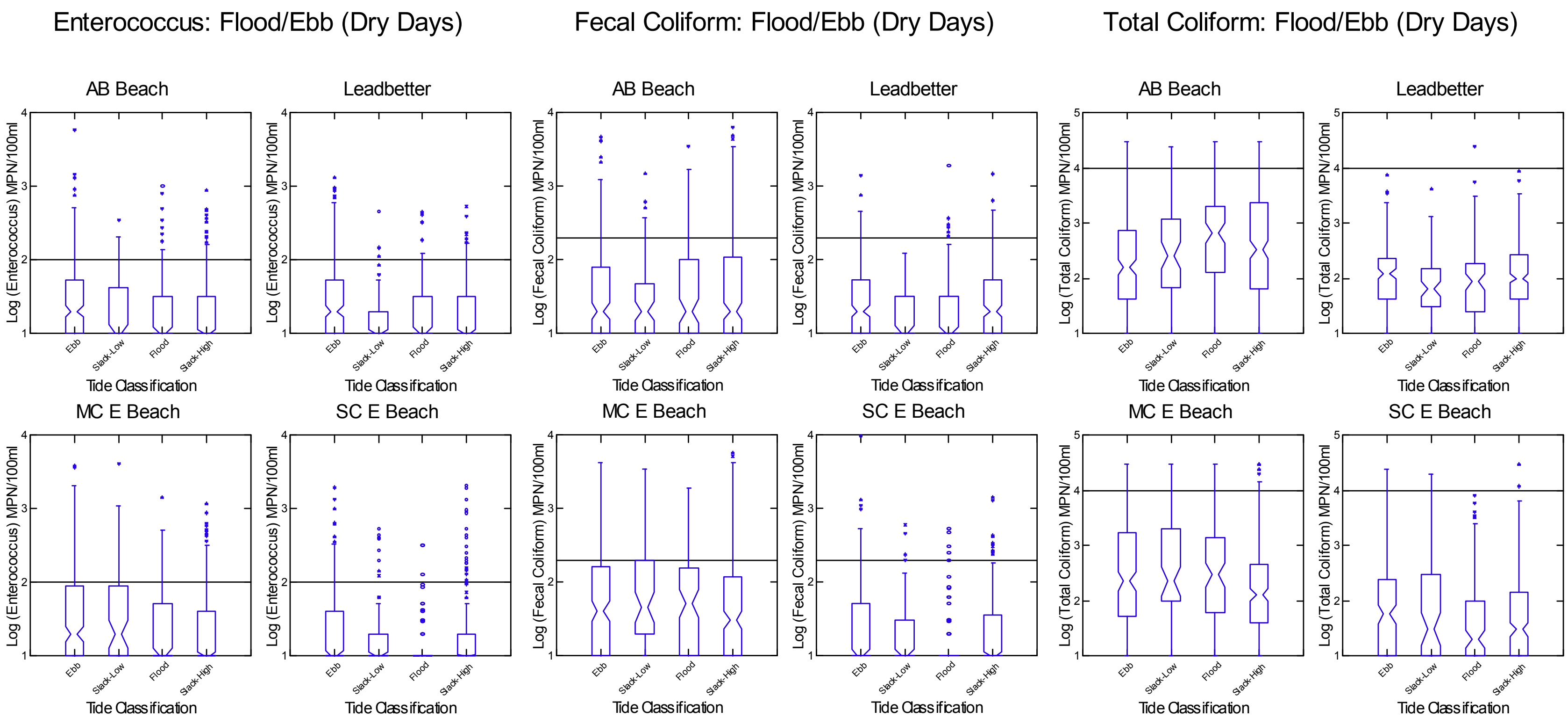
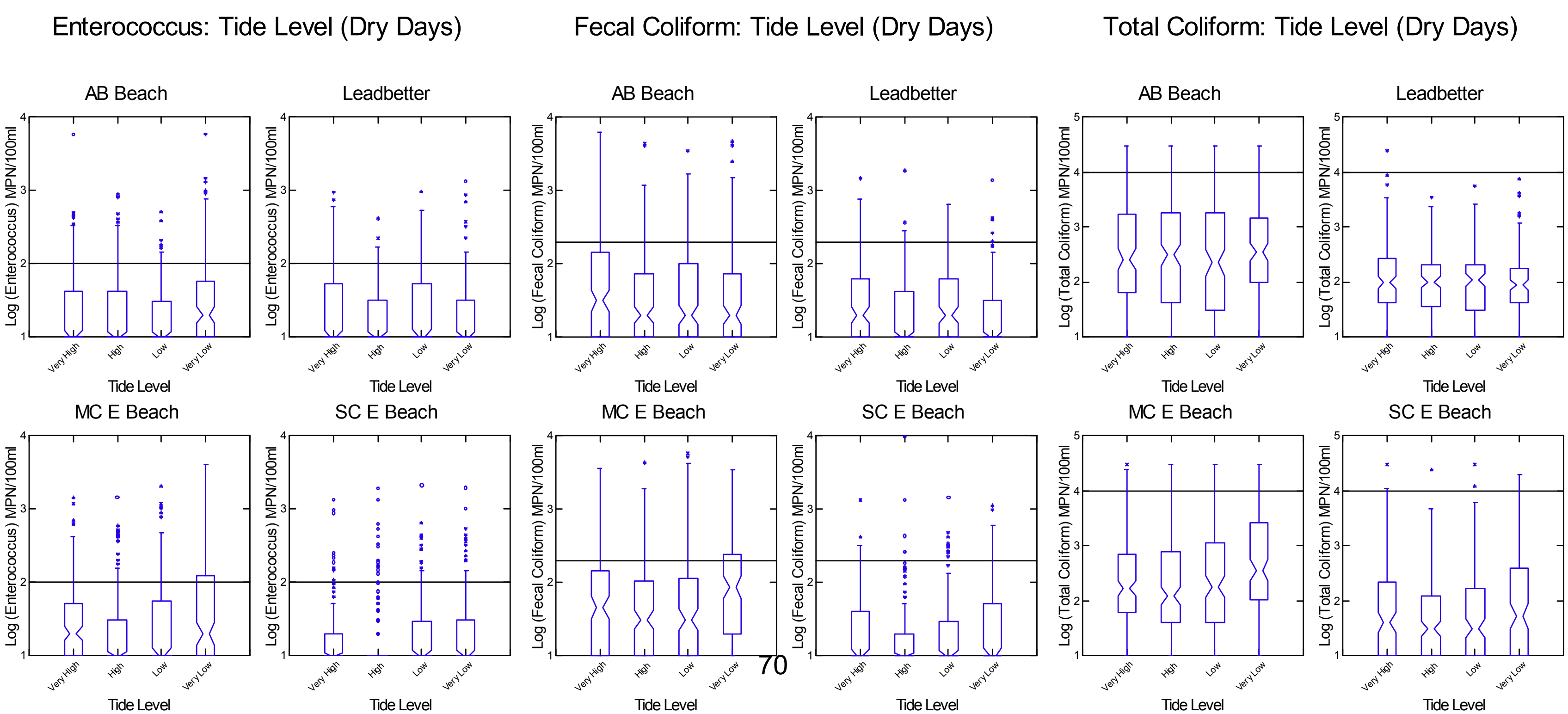
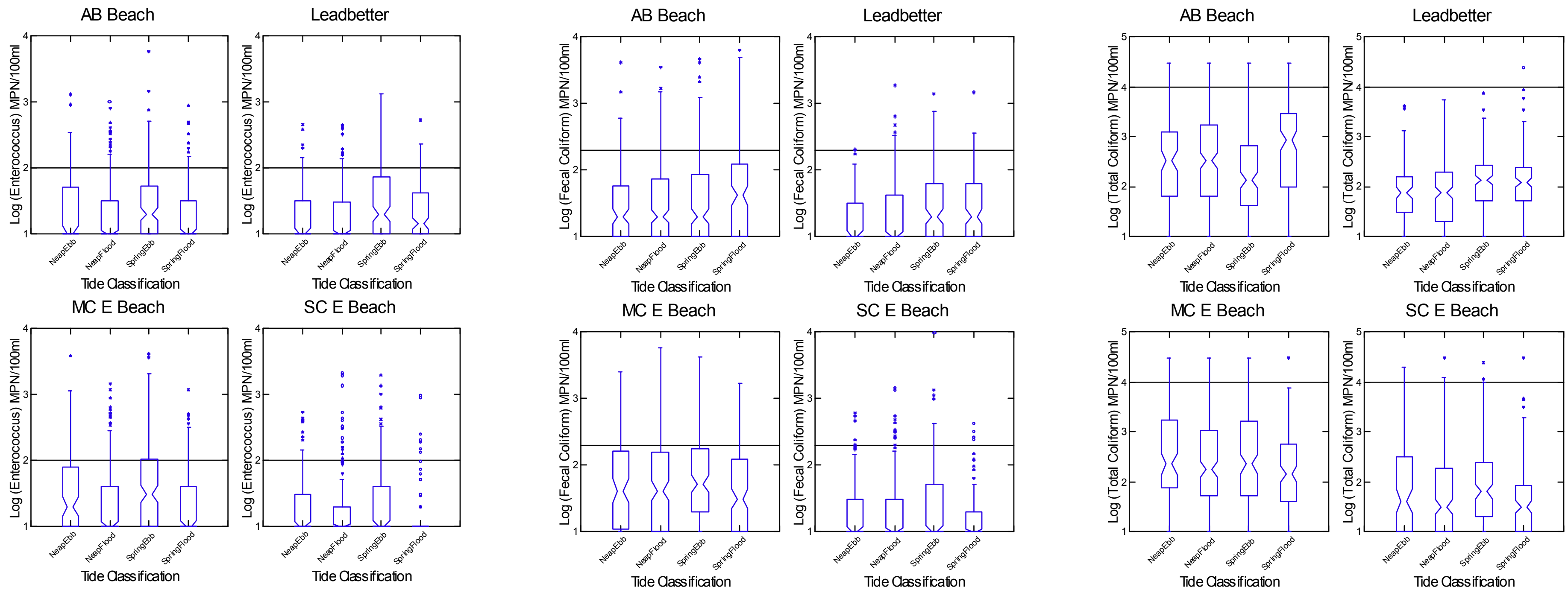


Figure 5:



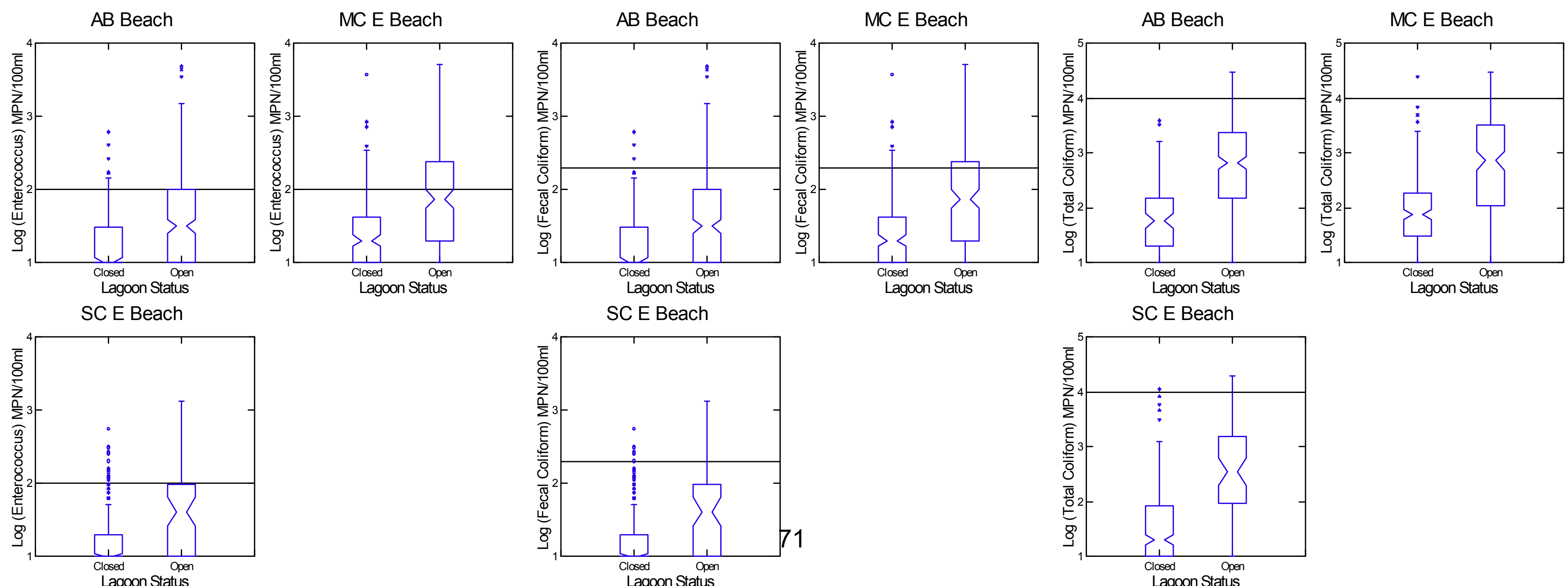
Enterococcus: Spring/Neap and Flood/Ebb (Dry Days) Fecal Coliform: Spring/Neap and Flood/Ebb (Dry Days)Total Coliform: Spring/Neap and Flood/Ebb (Dry Days)

Figure 6:



Enterococcus: Lagoon Opening (Dry Days) Fecal Coliform: Lagoon Opening (Dry Days) Total Coliform: Lagoon Opening (Dry Days)

Figure 7



Appendix B: Exceedance Tables

Wet and Dry Statistics 1996-2009

		All Beaches	AB	Leadbetter	MC E Beach	SC E Beach
Enterococcus	**Dry**	Median: ≤10, n=2267 % exc. 12.24	Median: ≤10, n=570 % exc. 11.50	Median: ≤10, n=576 % exc. 10.76	Median: ≤10, n=570 % exc. 17.37	Median: ≤10, n=551 % exc. 9.26
		***	***	***	***	***
	Wet	Median: 96, n=401 % exc. 48.13	Median: 133, n=102 % exc. 57.84	Median: 52, n=101 % exc. 37.62	Median: 312.5, n=100 % exc. 62.00	Median: 52, n=98 % exc. 34.69
Fecal Coliform	**Dry**	Median: 20, n=2229 % exc. 5.61	Median: 20, n=574 % exc. 7.49	Median: ≤10, n=562 % exc. 1.60	Median: 41, n=556 % exc. 10.61	Median: ≤10, n=537 % exc. 2.61
		***	***	***	***	***
	Wet	Median: 85.5, n=392 % exc. 20.92	Median: 134.5, n=102 % exc. 22.55	Median: 41, n=98 % exc. 11.22	Median: 209, n=97 % exc. 37.11	Median: 41, n=95 % exc. 12.63
Total Coliform	**Dry**	Median: 119, n=2229 % exc. 4.31	Median: 279.5, n=574 % exc. 8.54	Median: 98, n=562 % exc. 0.18	Median: 189, n=556 % exc. 7.19	Median: 41, n=537 % exc. 1.12
		***	***	***	***	***
	Wet	Median: 1602, n=392 % exc. 25.00	Median: 3165.5, n=102 % exc. 33.33	Median: 612.5, n=98 % exc. 7.14	Median: 4884, n=97 % exc. 41.24	Median: 959, n=95 % exc. 17.89

Note: Medians are in MPN/100ml

Wet refers to days in which it rained more than either 0.05" in the prior 24 hours or 0.1" in the prior 48 or 72 hours

* <0.05 **<0.01 ***<0.001 from the Kruskall-Wallis Test

Spring and Neap Tides (Dry Days) 1996-2009

		All Beaches	AB	Leadbetter	MC E Beach	SC E Beach
Enterococcus	Spring	Median: ≤10, n=1137 % exc. 13.25	Median: ≤10, n=285 % exc. 12.50	Median: 20, n=290 % exc. 13.10	Median: 20, n=287 % exc. 18.47	Median: ≤10, n=275 % exc. 8.73
		***		***		
	Neap	Median: ≤10, n=1130 % exc. 11.23	Median: ≤10, n=285 % exc. 10.49	Median: ≤10, n=286 % exc. 8.39	Median: ≤10, n=283 % exc. 16.25	Median: ≤10, n=276 % exc. 9.78
Fecal Coliform	Spring	Median: 20, n=1116 % exc. 5.65	Median: 31, n=288 % exc. 8.33	Median: 20, n=282 % exc. 2.13	Median: 41, n=279 % exc. 9.68	Median: ≤10, n=267 % exc. 2.25
		***	*	***		
	Neap	Median: ≤10, n=1113 % exc. 5.57	Median: 20, n=286 % exc. 6.64	Median: ≤10, n=280 % exc. 1.07	Median: 41, n=277 % exc. 11.55	Median: ≤10, n=270 % exc. 2.96
Total Coliform	Spring	Median: 120, n=1116 % exc. 3.85	Median: 228, n=288 % exc. 8.33	Median: 122, n=282 % exc. 0.35	Median: 183, n=279 % exc. 5.38	Median: 41, n=267 % exc. 1.12
				***		
	Neap	Median: 119, n=1113 % exc. 4.76	Median: 325, n=286 % exc. 8.74	Median: 74, n=280 % exc. 0.00	Median: 200, n=277 % exc. 9.03	Median: 31, n=270 % exc. 1.11

Note: Medians are in MPN/100ml

* <0.05 **<0.01 ***<0.001 from the Kruskall-Wallis Test

Spring and Neap Tides (Dry Days and Lagoon Closed) 1996-2009

		All Beaches	AB	MC E Beach	SC E Beach
Enterococcus	**Spring**	Median: ≤10, n=332 % exc. 5.42	Median: ≤10, n=60 % exc. 8.33	Median: ≤10, n=107 % exc. 8.41	Median: ≤10, n=165 % exc. 2.42
		*		*	
	Neap	Median: ≤10, n=295 % exc. 3.73	Median: ≤10, n=42 % exc. 2.38	Median: ≤10, n=100 % exc. 2.00	Median: ≤10, n=153 % exc. 5.23
Fecal Coliform	**Spring**	Median: ≤10, n=318 % exc. 1.26	Median: 20, n=60 % exc. 1.67	Median: 20, n=101 % exc. 2.97	Median: ≤10, n=157 % exc. 0.00
			**		
	Neap	Median: ≤10, n=285 % exc. 0.70	Median: ≤10, n=42 % exc. 2.38	Median: 20, n=95 % exc. 0.00	Median: ≤10, n=148 % exc. 0.68
Total Coliform	**Spring**	Median: 52, n=318 % exc. 0.63	Median: 79, n=60 % exc. 0.00	Median: 63, n=101 % exc. 0.99	Median: 20, n=157 % exc. 0.64
			**		
	Neap	Median: 41, n=285 % exc. 0.00	Median: 20, n=42 % exc. 0.00	Median: 84, n=95 % exc. 0.00	Median: 20, n=148 % exc. 0.00

Note: Medians are in MPN/100ml

* <0.05 **<0.01 ***<0.001 from the Kruskall-Wallis Test

High and Low Tide (Dry Days) 1996-2009

		All Beaches	AB	Leadbetter	MC E Beach	SC E Beach
Enterococcus	Very High	Median: ≤10, n=580 % exc. 12.54	Median: ≤10, n=146 % exc. 12.16	Median: ≤10, n=147 % exc. 14.29	Median: 20, n=146 % exc. 16.44	Median: ≤10, n=141 % exc. 7.09
	High	Median: ≤10, n=647 % exc. 9.12	Median: ≤10, n=164 % exc. 10.98	Median: ≤10, n=164 % exc. 6.71	Median: ≤10, n=161 % exc. 10.56	Median: ≤10, n=158 % exc. 8.23
		***	*		***	
	Low	Median: ≤10, n=534 % exc. 11.57	Median: ≤10, n=132 % exc. 6.72	Median: ≤10, n=137 % exc. 14.60	Median: ≤10, n=135 % exc. 15.56	Median: ≤10, n=130 % exc. 9.23
	Very Low	Median: ≤10, n=506 % exc. 16.60	Median: 20, n=128 % exc. 16.41	Median: ≤10, n=128 % exc. 7.81	Median: 20, n=128 % exc. 28.91	Median: ≤10, n=122 % exc. 13.11
Fecal Coliform	Very High	Median: 20, n=564 % exc. 6.91	Median: 31, n=148 % exc. 10.14	Median: 20, n=141 % exc. 2.84	Median: 46.5, n=140 % exc. 12.86	Median: ≤10, n=135 % exc. 1.48
	High	Median: ≤10, n=635 % exc. 3.78	Median: 20, n=164 % exc. 7.93	Median: ≤10, n=160 % exc. 0.63	Median: 31, n=157 % exc. 4.46	Median: ≤10, n=154 % exc. 1.95
		**		*	***	
	Low	Median: 20, n=527 % exc. 4.55	Median: 20, n=134 % exc. 5.97	Median: 20, n=134 % exc. 1.49	Median: 31, n=132 % exc. 8.33	Median: ≤10, n=127 % exc. 2.36
	Very Low	Median: 20, n=503 % exc. 7.55	Median: 20, n=128 % exc. 5.47	Median: ≤10, n=127 % exc. 1.57	Median: 86, n=127 % exc. 18.11	Median: ≤10, n=121 % exc. 4.96
Total Coliform	Very High	Median: 119, n=564 % exc. 3.90	Median: 257.5, n=148 % exc. 8.78	Median: 98, n=141 % exc. 0.71	Median: 166.5, n=140 % exc. 4.29	Median: 41, n=135 % exc. 1.48
	High	Median: 100, n=635 % exc. 2.83	Median: 303.5, n=164 % exc. 8.54	Median: 100, n=160 % exc. 0.00	Median: 121, n=157 % exc. 1.91	Median: 31, n=154 % exc. 0.65
		***			***	
	Low	Median: 100, n=527 % exc. 4.74	Median: 223, n=134 % exc. 9.70	Median: 109, n=134 % exc. 0.00	Median: 181, n=132 % exc. 7.58	Median: 31, n=127 % exc. 1.57
	Very Low	Median: 160, n=503 % exc. 6.16	Median: 352.5, n=128 % exc. 7.03	Median: 86, n=127 % exc. 0.00	Median: 359, n=127 % exc. 16.54	Median: 52, n=121 % exc. 0.83

Note: Medians are in MPN/100ml

* <0.05 **<0.01 ***<0.001 from the Kruskall-Wallis Test

Flooding and Ebbing Tide (Dry Days) 1996-2009

		All Beaches	AB	Leadbetter	MC E Beach	SC E Beach
Enterococcus	Slack-High	Median: ≤10, n=891 % exc. 9.19	Median: ≤10, n=223 % exc. 9.82	Median: ≤10, n=226 % exc. 6.64	Median: ≤10, n=223 % exc. 11.21	Median: ≤10, n=219 % exc. 9.13
	Flood	Median: ≤10, n=381 % exc. 9.42	Median: ≤10, n=97 % exc. 11.22	Median: ≤10, n=96 % exc. 8.33	Median: ≤10, n=95 % exc. 14.74	Median: ≤10, n=93 % exc. 3.23
		***	*	**	**	***
	Ebb	Median: 20, n=741 % exc. 17.23	Median: 20, n=186 % exc. 14.89	Median: 20, n=189 % exc. 18.52	Median: 20, n=188 % exc. 23.94	Median: ≤10, n=178 % exc. 11.24
	Slack-Low	Median: ≤10, n=254 % exc. 12.60	Median: ≤10, n=64 % exc. 7.81	Median: ≤10, n=65 % exc. 6.15	Median: 20, n=64 % exc. 23.44	Median: ≤10, n=61 % exc. 13.11
Fecal Coliform	Slack-High	Median: 20, n=868 % exc. 4.72	Median: 20, n=224 % exc. 8.93	Median: 20, n=218 % exc. 1.38	Median: 31, n=215 % exc. 6.51	Median: ≤10, n=211 % exc. 1.90
	Flood	Median: ≤10, n=382 % exc. 6.81	Median: 25, n=98 % exc. 10.20	Median: ≤10, n=96 % exc. 2.08	Median: 52, n=95 % exc. 12.63	Median: ≤10, n=93 % exc. 2.15
		*		*	*	**
	Ebb	Median: 20, n=725 % exc. 5.79	Median: 20, n=188 % exc. 5.32	Median: 20, n=183 % exc. 2.19	Median: 41, n=182 % exc. 12.09	Median: ≤10, n=172 % exc. 3.49
	Slack-Low	Median: 20, n=254 % exc. 6.30	Median: 20, n=64 % exc. 4.69	Median: ≤10, n=65 % exc. 0.00	Median: 52, n=64 % exc. 17.19	Median: ≤10, n=61 % exc. 3.28
Total Coliform	Slack-High	Median: 109, n=868 % exc. 4.26	Median: 330, n=224 % exc. 10.71	Median: 99, n=218 % exc. 0.00	Median: 132, n=215 % exc. 4.65	Median: 31, n=211 % exc. 1.42
	Flood	Median: 124, n=382 % exc. 4.45	Median: 654.5, n=98 % exc. 10.20	Median: 85.5, n=96 % exc. 1.04	Median: 295, n=95 % exc. 6.32	Median: 20, n=93 % exc. 0.00
			*	*	**	*
	Ebb	Median: 122, n=725 % exc. 3.59	Median: 156, n=188 % exc. 4.79	Median: 121, n=183 % exc. 0.00	Median: 227, n=182 % exc. 8.24	Median: 57.5, n=172 % exc. 1.16
	Slack-Low	Median: 120.5, n=254 % exc. 6.30	Median: 254, n=64 % exc. 9.38	Median: 63, n=65 % exc. 0.00	Median: 229.5, n=64 % exc. 14.06	Median: 31, n=61 % exc. 1.64

Note: Medians are in MPN/100ml

* <0.05 **<0.01 ***<0.001 from the Kruskall-Wallis Test

VI. SOURCE TRACKING AND ILLICIT DISCHARGE DETECTION

Extensive field work was conducted in support of the State-funded Source Tracking Protocol Development Project, including dye testing, smoke testing, automatic storm drain sampling. Results will be presented in future reports. In addition, a Water Environment Research Foundation-funded project was conducted to test the use of canine scent tracking (sewage sniffing dogs). The Abstract, Benefits, and Executive Summary from the Draft Final Report are presented here:

Title:
CANINE SCENT AND MICROBIAL SOURCE TRACKING IN SANTA BARBARA, CA

Authors:
Jill Murray, Ph.D., Scott Reynolds, Patricia Holden, Ph.D., Laurie Van De Werfhorst

Abstract:
Advances in microbial source tracking have enabled communities to gain more information about the specific hosts that may be responsible for elevated indicator bacteria levels in recreational waters. However, even when human-specific contamination can be traced to general areas, finding exact origins remains challenging due to sample costs and processing times. This study sought to test the use of a new qualitative tool for source tracking, canine scent tracking (sewage-sniffing dogs), to provide real-time results and low sample cost for illicit discharge detection.

Canine responses were compared against traditional wastewater indicators, illicit discharge detection tracers, and emerging human-specific waste markers in storm drain locations in Santa Barbara, CA. Canine scent tracking was also tested for effectiveness in locating contaminated inputs to storm drains, addressing a specific hypothesis of contamination arising from illicit dumping from recreational vehicles, and conducting systematic outfall and storm drain reconnaissance. Based on the statistical and qualitative results presented in this pilot-scale study, canine scent tracking is a tool that should be expanded for use by researchers and stormwater managers.

Benefits:

- Demonstrates that canine scent tracking is an efficient and effective method that can be added to the toolbox of water quality researchers and stormwater managers.
- Demonstrates that canine responses can be used effectively with traditional and newer, DNA-based methods for assessing contamination with human waste.
- Demonstrates that the major advantages of canine scent tracking are the real time results, high number of sites that can be tested per day, and low cost per sample.
- Demonstrates that canine scent tracking can be used to locate sources of contamination to storm drains, as well as bracket areas for further study.
- Demonstrates that canine scent tracking can be used to test specific hypotheses, e.g. that illicit RV dumping may contaminate storm drains, as well as be used for systematic storm drain and outfall reconnaissance.

Executive Summary:
The City of Santa Barbara, located in coastal Southern California, has implemented concerted efforts to locate and reduce the contamination of recreational waters by fecal indicator bacteria

(FIB). While multiple FIB sources including wild and domesticated animals likely exist, in past work with the University of California, Santa Barbara (UCSB), microbial source tracking has shown that human-specific waste markers are present in some storm drains (municipal separate storm sewers, or MS4s) that discharge to creeks and coastal areas. The DNA-based methods used to discover sewage contamination in storm drains are time consuming and expensive, making such approaches impractical for surveying large areas of the City infrastructure. Also, efforts to locate specific inputs to storm drains have been hindered by the lack of a relatively inexpensive, real-time method to assess contamination at large numbers of sites. Canine scent tracking for use in illicit discharge, detection, and elimination (IDDE) work was developed recently, beginning in 2006. One canine, Sable, was trained by Mr. Scott Reynolds, at the time with Tetra Tech and now with Environmental Canine Services, LLC (ECS), to alert to raw sewage and detergents. The dog's sensitivity, based on fecal indicator bacteria measurements, was demonstrated previously in field trials.

The City of Santa Barbara, UCSB, and ECS, teamed up to further investigate the use of sewage sniffing dogs to aid in source tracking work with financial support from the Water Environment Research Federation (WERF). The objectives of the project were to: 1) compare canine responses to chemical and microbial source tracking indicators; 2) use canine scent tracking for working upstream of known problem areas to locate or bracket inputs; 3) investigate canine scent tracking for use in testing a hypothesis about recreational vehicle dumping to storm drains; 4) determine the feasibility of canine scent tracking for use in systematic outfall and storm drain reconnaissance; and 5) conduct training to introduce the approach to stormwater professionals.

ECS provided two trained dogs, Sable and Logan, and two highly experienced human handlers for the field work. Sable is a rescued German Shepherd mix who has been trained to alert "Yes" to the scent of contamination by barking (Figure ES-1); Logan is rescued collie mix to has been trained to alert "Yes" by sitting (Figure ES-2).

Sable alerts to the scent of contamination by barking.

Logan alerts by sitting.

Over 130 sites were visited, with 26 water samples collected. Methods for water testing included field parameters (temperature, conductivity, and dissolved oxygen), traditional waste water indicators (FIB), IDDE tracers chemicals (potassium, fluoride, ammonia, and surfactants), contemporary human-specific waste markers (human-specific Bacteroidales, Methanobrevibacter smithii nifH gene) and chemical markers for sewage (caffeine and cotinine). Fecal indicator bacteria (total coliform, E. coli and enterococci) were quantified using IDEXX defined substrate methods. Enterococci were also enumerated using quantitative polymercase chain reaction (qPCR), as was human-specific Bacteroidales (HBM-qPCR). The Methanobrevibacter smithii nifH gene was assessed for presence or absence using PCR (Mnif-PCR). Caffeine and cotinine were quantified using commercial ELISA test kits. Statistical analyses included nonparametric tests (Mann-Whitney and Chi-square) to determine if the samples with negative and positive canine responses came from different populations, based on chemical and microbial indicators. Statistical tests of canine responses were conducted separately for each dog.

Results from comparing canine and wastewater indicators showed that the dogs' responses were more often positive for samples with higher levels of most microbial and human-specific waste markers. Statistically significant results ($p<0.05$) were obtained for the comparison of both dogs to HBM-qPCR and total coliform and for one of the dogs to E. coli, enterococci (by cultivation and qPCR methods), Mnif-PCR, and caffeine. For samples with detectable levels of any of the four human-specific waste markers (11 samples), the two dogs alerted positively 70% and 100% of the time, with associated Chi-square probabilities of 0.13 and 0.0035, respectively. For samples in which both dogs responded negatively (7 samples), no human-waste specific markers were detected.

Efforts to use canine scent tracking to work upstream from known sites of storm drain contamination were successful. In several locations, canine responses led to the bracketing of smaller areas for future work with camera, smoke, and/or dye testing. At one storm drain site known to harbor human waste contamination, on-the-ground field work with the dogs allowed the research team to trace the input to an exact location where leaking sanitary sewer and storm drain pipes were causing untreated sewage to enter the storm drain. The real time results and high number of sites tested per hour by the canines provided a substantive advantage in this type of investigation.

An investigation of hypothesized illicit recreational vehicle dumping of black water tanks to catch basins and drop inlets to storm drains was aided greatly by the inclusion of canine scent tracking. The research team covered over ten city blocks and two parking lots frequented by long-term recreational vehicle dwellers for overnight parking. By investigating every catch basin, drop inlet, and wet spots in the gutter and parking lane, two RVs with leaking black water tanks were identified. No signs of deliberate dumping were observed. Previous efforts by the City to address this hypothesis were stymied by the lack of ability to discriminate between catch basins or gutters that were wet from dumping versus irrigation runoff.

Previous efforts have employed canine scent tracking for illicit discharge detection in rural areas. Here we show that the approach also works in urban settings, where manholes were opened systematically to investigate large areas of Mission Creek watershed. Work in overgrown creek channels was less successful due to the difficulty of observing flowing outfalls.

The primary recommendation from this project is that canine scent tracking can be used effectively in urban source tracking work, primarily to qualitatively survey large areas as a first tier of investigation that could precede and prioritize quantitative assessment using microbial and chemical human-specific waste markers. As the pool of available canines and handlers expands, attention should be paid to training some dogs to alert to broad suites of markers, while others should be limited to a narrow indicator, in an effort to discriminate among wash water, sewage, and grease trap overflows. Last, an unexpected benefit of canine scent tracking during this project was the increased interest and cooperation from residents, recreational vehicle dwellers, and business owners in illicit discharge detection and stormwater pollution when the dogs were present.

APPENDIX A. FY10 RESEARCH AND MONITORING PLAN

City of Santa Barbara Creeks Division
Water Quality Monitoring Program

FY10 RESEARCH PLAN

The goals of the monitoring program are to:

1. Quantify the levels (concentration and flux, or load) of microbial contamination and chemical pollution in watersheds throughout the city.
2. Evaluate impacts of pollution on beneficial uses of creeks and beaches, including recreation and habitat for aquatic organisms.
3. Evaluate the effectiveness of the City's restoration and water quality treatment projects, which includes collecting baseline data for future projects.
4. Identify sources of contaminants and pollution in creeks and storm drains.
5. Evaluate long-term trends in water quality.

The underlying motivation behind the monitoring program is to obtain information that the City can use to:

1. Develop strategies for water quality improvement, including prioritization of capital projects and outreach/education programs.
2. Communicate effectively with the public about water quality.

PROGRAM ELEMENTS AND QUESTIONS

A. Watershed Assessment

Research questions:

1. Is overall water quality, in terms of indicator bacteria and field properties, getting better over time?
2. How contaminated and/or toxic is sediment at creek outfall sites?
3. What is the impact of eutrophication on Santa Barbara creeks?

B. Storm Monitoring

Research Questions:

1. What are the highest concentrations of pollutants of concern during storm events, particularly seasonal first flush storms? Do creeks and/or storm drains in Santa Barbara have problems with toxicity during storm events?
2. What are the impacts of the Jesusita Fire on water quality?
3. What are the loads of pollutants discharged from Santa Barbara creeks during storms?
4. What are the sources and routes of pollutants during storms?
    a. How do concentrations and loads vary during storms and from site to site?
        - Fecal indicator bacteria
        - Slurry seal/PAHs/Foam
        - Metals
        - Nutrients
5. How do restoration/treatment projects impact water quality during storm events?

C. Restoration and Water Quality Project Assessment

The Creeks Division has completed several restoration and water quality improvement capital projects over the past several years. Project assessment is used to determine the success of projects in lowering microbial and chemical pollution levels and improving water quality for aquatic organisms. In some cases project monitoring is grant-required, and the remaining is for internal review of project success. Additional monitoring is conducted to ensure that the facility is performing as intended.

Research Questions:

1. Do Creeks Division projects result in improved water quality, as reflected in pre- and post-project, and/or, upstream to downstream, conditions?
2. What is the baseline water quality at future restoration/treatment sites?
3. What are the mechanisms of project success?

4. Are installed projects functioning correctly?

List of Projects

1. Westside SURF and Old Mission Creek Restoration
2. Arroyo Burro Restoration, including Mesa Creek daylighting
3. Hope and Haley Diversions
4. Laguna Channel Disinfection (Source Tracking)
5. Golf Course Project (Storm)
6. San Pascual Drain (Source Tracking)
7. Parking Lot LID (Storm)
8. Debris Screens (Creek Walks)
9. Mission Creek Fish Passage (Eutrophication/Dissolved Oxygen)
10. Bird Refuge

D. Beach water quality

Research questions:

1. How to creeks and storm drains relate to beach water quality and warnings?
2. How do other factors (kelp, tides, temperature, and beach use) relate to beach warnings?
3. What are the causes of persistent beach warnings that occur?
4. What is the risk to human health from recreation in creeks and beaches in Santa Barbara?

E. Source Tracking/Illicit Discharge Detection

Research questions:

1. Which subdrainages and/or contribute the greatest loads of pollutants to creeks in Santa Barbara? (CBI)
2. Where, when and how is human waste and/or sewage entering storm drains and creeks?
   a. What happens to the signals of human waste and indicator bacteria levels as water moves downstream away from the source?
   b. How does presence of human waste relate to beach warnings?
3. Do rotting plant material and sediment contribute to high FIB levels in storm drains?
4. What are the impacts of reservoir flushing on metals?
5. Are new hot spots emerging?
6. Specific areas of concern: Barger Canyon, Las Positas Creek, Haley Drain

F. Creeks Walks/Clean ups

Research Questions:

1. Are there new problems in creeks that need to be addressed?
2. Is the amount of trash in creeks decreasing over time?
3. Were decreases in trash observed between 1999 and 2005 due to creek flow histories or the impact of City programs?
4. Will the installation of catch basin screens lead to decreased trash observed in creeks?

G. Bioassessment

The biological assessment element is used to assess and monitor the biological integrity of local creeks as they respond through time to natural and human influences.

Research Questions:

1. What is the baseline of biological integrity for benthic macroinvertebrates in creeks?
2. Are there differences between upper watershed and lower watershed sites?
3. Are there differences among watersheds?
4. How does the biological integrity in our creeks change over time?
5. How does the biological integrity respond to water quality and restoration projects?

H. Methods Development

1. Can we use the following potential new tools?
   a. Can a chemical fingerprint be used to identify types of sources?
   b. Can the Microtox assay be used?
   c. Can screening kits be used?

d. K-9 forensics?

PROGRAM ELEMENT and QUESTIONS	CONSTITUENTS/METHODS	SITES	FREQUENCY	PROJECTED COST
A. Watershed Assessment				
1. Is overall water quality, in terms of indicator bacteria and field properties, getting better over time?	Indicator bacteria, field parameters, flow	Integrator Sites Honda and Lighthouse	Biweekly Quarterly	$3,024
2. How contaminated and/or toxic is sediment at creek outfall sites?	Metals, PAHs, Toxicity, Herbicides, Pesticides, including Pyrethroids. Add transnonachlor and sublethal toxicity.	Estuarine or lower creek sites	Yearly, in late summer	$8,760
B. Storm Monitoring				
1. What are the highest concentrations of pollutants of concern during storm events, particularly seasonal first flush storms? Do creeks and/or storm drains in Santa Barbara have problems with toxicity during storm events?	Metals, Herbicides, Pesticides, Nutrients, Oil and Grease, Toxicity	Integrator Sites and four storm drains	Yearly, first flush. Collect creek samples early during runoff event. Collect drain samples second.	$9,256
2. What are the impacts of the Jesusita Fire on water quality.?	Metals, PAHs, Sediment, Nutrients, field parameters, toxicity	Mission Canyon at Mission. Mission at Montecito later in storm.	Yearly, first flush.	$1,500
3. What are the loads of pollutants discharged from Santa Barbara creeks during storms?	Metals	Arroyo Burro at Cliff (location of flow gauge and autosampler)	Conduct composite sampling according to Caltrans (2008) during a 1" forecasted storm.	$850
4. What are the sources and routes of pollutants during storms?	Fecal indicator bacteria, Sediment, MBAS (or cationic surfactants), PAHs. Visual observation for foam during storm event.	Arroyo Burro at Cliff Simulated rain and runoff from recently sealed parking lots and/or streets.	Conduct composite sampling according to Caltrans (2008) during a 1" forecasted storm.	$3,745
5. How do restoration/treatment projects impact water quality during storm events?	Bacteria, nutrients, metals, sediment Bacteria, nutrients, metals, sediment, oil and grease, MBAS and toxicity	Seven sites at Golf Course Parking Lot Four	Three storms post project for Golf Course. First flush for Parking Lot 4.	$4,737

PROGRAM ELEMENT and QUESTIONS	CONSTITUENTS/METHODS	SITES	FREQUENCY	PROJECTED COST
C. Restoration and Water Quality Project Assessment				
1. Westside SURF and Old Mission Creek Restoration (see annual report for details)	Indicator bacteria and field parameters	SURF up, SURF down, Westside Drain, OMC at W. Anapamu, 10 sites between Westside Drain and W. Anapamu	Weekly for SURF operation, biweekly for downstream impacts, and quarterly for regrowth study	$4,509
2. Arroyo Burro Restoration, including Mesa Creek daylighting (Suspension of quarterly testing until results from biweekly testing warrant a change).	Indicator bacteria and field parameters	AB at Cliff, Mesa upper, Mesa lower, AB Estuary upper, AB Estuary Mouth, AB Surf	Biweekly	$4212
3. Hope and Haley Diversions	Indicator bacteria and field parameters	Hope Diversions, Haley Pump	Biannual	$108
4. Laguna Channel Disinfection (Source Tracking)	Indicator bacteria and field parameters	Laguna at Chase Palm (already covered by routine)	Biweekly	Included above.
5. Golf Course Project (Storm)	See storm monitoring			Included above.
6. Parking Lot LID (Storm)	See storm monitoring			Included above.
7. Debris Screens (Creek Walks)	See creek walks			No lab cost.
8. Mission Creek Fish Passage (Eutrophication/Dissolved Oxygen)	Dissolved Oxygen, pH, temperature, conductivity	MC Lagoon, MC upper reaches	Install probes for summer months, collect data continuously	No lab cost.
9. Bird Refuge	Indicator bacteria, chlorophyll a, nutrients, and field parameters	Bird Refuge Inflow, Landing and Outlet	Monthly	$1,884
D. Beach water quality				
1. How to creeks and storm drains relate to beach water quality and warnings, along with other factors such as kelp, tides, temperature (air,	Multivariate statistical model on retrospective data. Also see source tracking.			No lab cost.

PROGRAM ELEMENT and QUESTIONS	CONSTITUENTS/METHODS	SITES	FREQUENCY	PROJECTED COST
creek, ocean), beach use?				
2. Is growth on sediment and/or kelp responsible for beach warnings?	Sample plan to be determined.			$2,700
3. What are the causes of persistent beach warnings that occur?	Conduct additional surveillance and sampling (indicator bacteria and/or DNA techniques) up creek and within estuaries when persistent warnings occur			$1,350
4. What is the risk to human health from recreation in creeks and beaches in Santa Barbara?	Use forthcoming epidemiology studies in Southern California to conduct simple model of illness rates at Santa Barbara beaches.			No lab cost.
E. Source Tracking/Illicit Discharge Detection				
1. Which subdrainages and/or contribute the greatest loads of pollutants to creeks in Santa Barbara? (CBI)	Source Tracking Grant			Grant funded..
2. Where, when and how is human waste and/or sewage entering storm drains and creeks?	Source Tracking Grant			Grant funded.
3. What happens to the signals of human waste and indicator bacteria levels as water moves downstream away from the source?	Source Tracking Grant			Grant funded.
4. How does presence of human waste relate to beach warnings?	Source Tracking Grant			Grant funded.
5. Do rotting plant material and sediment contribute to high FIB levels in storm drains?	Work with Streets Division to conduct pilot study on catch basin and storm drain cleaning on indicator bacteria levels.	Possible site: Montecito St. in Laguna Channel Watershed. Ideal sites are located at terminal upstream end of storm drain, with easy access for cleaning and sampling.	Monthly.	$2,700
6. What are the impacts of reservoir flushing on metals?	Metals, sediment.	Rattlesnake Creek and Reservoir outlet.	Single event.	$575

PROGRAM ELEMENT and QUESTIONS	CONSTITUENTS/METHODS	SITES	FREQUENCY	PROJECTED COST
7. Are new hot spots emerging?	Observation, enforcement.	Serena Drain and others		
8. Specific areas of concern: Barger Canyon Las Positas Creek Lower Mission Mid Arroyo Burro	Chemical fingerprint (Fluoride, potassium, ammonium, boron, MBAS) , indicator bacteria	Barger Canyon (5 sites upstream) Las Positas Creek (Modoc to Arroyo Burro, 5 sites) Lower Mission (5 sites between OMC and Montecito Street) Mid Arroyo Burro (5 sites SRC and LPC)	Quarterly	$12,000
F. Creeks Walks/Clean ups				
1. Are there new problems in creeks that need to be addressed?	Creek clean ups			No lab cost.
2. Is the amount of trash in creeks decreasing over time?	Weight of trash removed each year.			No lab cost.
3. Were decreases in trash observed between 1999 and 2005 due to creek flow histories or the impact of City programs?	Continue measuring and marking GPS coordinates of trash in Old Mission Creek and Lower Mission Creek (Oak Park to beach).			No lab cost.
4. Will the installation of catch basin screens lead to decreased trash observed in creeks?	See 3.			No lab cost.
G. Bioassessment	See Bioassessment Proposal and Reports.			No lab cost.
H. Methods Development				
1. Can a chemical fingerprint be used to identify types of sources?	Chemical fingerprint (Fluoride, potassium, ammonium, boron, MBAS)	Fingerprint sources: groundwater, city water, reclaimed water, irrigation runoff, wastewater influent.		$3,000
2. Can the Microtox assay be used?	Investigate costs and options.			No lab cost.
3. Investigate field screening kits.	Investigate costs and options.			
4. K-9 forensics?	Investigate costs and options.			No lab cost.

PROGRAM ELEMENT and QUESTIONS	**CONSTITUENTS/METHODS**	**SITES**	**FREQUENCY**	**PROJECTED COST**
TOTAL LAB COST				$64,910