Water Quality Research and Monitoring Program

Fiscal Year 2008
Annual Report

City of Santa Barbara
Creeks Division
October 16, 2008

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The Creeks Division wishes to thank the volunteers, interns, Creeks Advisory Committee, and staff who assisted with sampling design, storm monitoring, creek walks, laboratory work, and data analysis. Cover invertebrate photo from California Department of Fish and Game (http://www.dfg.ca.gov/cabw/cabwhome.html).

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I. INTRODUCTION

The Creeks Division has begun reporting water quality monitoring results on an annual schedule with quarterly updates. This is the Fiscal Year 2008 Annual Report, which includes new data and analysis from the fourth quarter as well as the results from the previous three FY08 quarterly reports. See table below for the dates of each quarter.

The primary purpose of this report is to serve as a record of Creeks Division research and monitoring efforts to answer pertinent questions. The secondary purpose is to communicate with members of the public who have an interest in the research questions, sampling activities, and findings of the Creeks Division Research and Monitoring Program.

Quarterly Calendar FY08	
FY08 Quarter 1 (Summer)	Jul. 1 – Sept. 30, 2007
FY08 Quarter 2 (Fall)	Oct. 1 – Dec. 31, 2007
FY08 Quarter 3 (Winter)	Jan. 1 – Mar. 31, 2008
FY08 Quarter 4 (Spring)	Apr. 1 – Jun. 30, 2008

Following a brief introduction to the program goals and research questions, the report organization is based on the outline of the Fiscal Year 2008 Research Plan, a summary of which is presented at the end of this report. Status of research efforts, sampling results, and data analysis are presented below. Recommendations to changes in the sampling program are interspersed in the report where appropriate. Recommendations will be implemented in the Fiscal Year 2009 Research and Monitoring Plan. For additional background on program goals, sampling methods, regulatory context, and a glossary of terms, see the 2001-2006 Water Quality Monitoring Report.

PROGRAM GOALS AND MOTIVATION

The primary goals of the monitoring program are to:

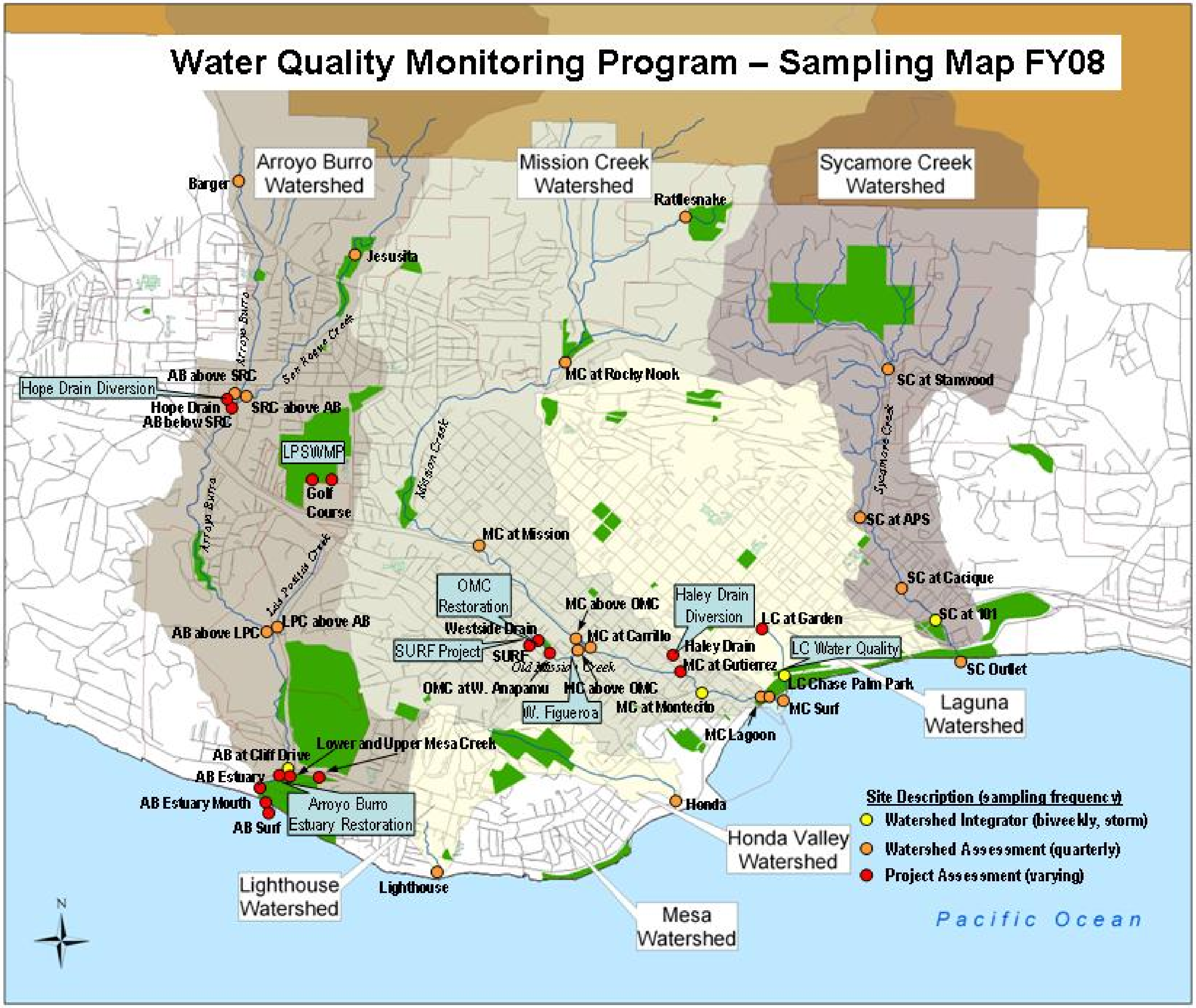
- Quantify the levels (concentration and flux, or load) of microbial contamination and chemical pollution in watersheds throughout the city.
- Evaluate the effectiveness of the City's restoration and water quality treatment projects in reducing contaminant and pollutant levels.

The secondary goals of the program are to:

- Determine the water quality for aquatic organisms, including fish, invertebrates, amphibians, and plants, in watersheds throughout the city.
- Evaluate the effectiveness of the City's restoration and water quality treatment projects in improving water quality for aquatic organisms.

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

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



Water Quality Monitoring Program – Sampling Map FY08
Arroyo Burro Watershed
Mission Creek Watershed
Sycamore Creek Watershed
Barger
Rattlesnake
Jesusita
Arroyo Burro
San Roque Creek
AB above SRC
Hope Drain Diversion
Hope Drain
AB below SRC
SRC above AB
MC at Rocky Nook
SC at Stanwood
LPSWMP
Golf Course
Mission Creek
Sycamore Creek
SC at APS
MC at Mission
Arroyo Burro
Las Positas Creek
SC at Cacique
OMC Restoration
Haley Drain Diversion
MC above OMC
LC at Garden
SC at 101
AB above LPC
LPC above AB
Westside Drain
MC at Carrillo
Haley Drain
LC Water Quality
SURF Project
SURF
MC at Gutierrez
SC Outlet
Old Mission Creek
LC Chase Palm Park
OMC at W. Anapamu
MC above OMC
MC at Montecito
W. Figueroa
MC Surf
Laguna Watershed
MC Lagoon
Lower and Upper Mesa Creek
AB at Cliff Drive
AB Estuary
AB Estuary Mouth
Arroyo Burro Estuary Restoration
AB Surf
Honda
Site Description (sampling frequency)
Watershed Integrator (biweekly, storm)
Watershed Assessment (quarterly)
Project Assessment (varying)
Honda Valley Watershed
Lighthouse Watershed
Lighthouse
Mesa Watershed
N
Pacific Ocean

I

PROGRAM ELEMENTS AND QUESTIONS

Routine Watershed Assessment

Routine watershed assessment focuses on microbial pollution (as defined by indicator bacteria) and water quality for aquatic organisms (physicochemical properties such as pH, temperature, dissolved oxygen, turbidity, conductivity). During Fiscal Year 2008, Routine Watershed Assessment also focused on quantifying loads of pollutants in creeks during dry weather.

Research questions:

- Is overall water quality, in terms of indicator bacteria and physicochemical properties, getting better over time?
- Are new hot spots emerging?
- Which subwatersheds contribute the greatest loads of pollutants to creeks in Santa Barbara?
- Do creeks in Santa Barbara have problems with toxicity, particularly in relation to dissolved copper, in dry weather?
- How contaminated and/or toxic is sediment at creek outfall sites?
- How does creek water quality relate to beach warnings at Santa Barbara beaches?

Storm Monitoring

Trace metals, pesticides/herbicides, and additional organic pollutants can have deleterious effects on aquatic organisms and human health. The purpose of storm monitoring is to identify chemical constituents of concern and to identify pollution hot spots. The monitoring program over the past two years has strived to sample for the "worst-case scenario" in order to identify pollutants of concern.

Research Questions:

- What are the highest concentrations of pollutants of concern during storm events, particularly seasonal first flush storms?
- What are the loads of pollutants discharged from Santa Barbara creeks during storms?
- How do concentrations and loads vary during storms?
- What are the sources and routes of pollutants during storms?
- Do creeks in Santa Barbara have problems with toxicity, particularly in relation to dissolved copper, during storm events?
- How do restoration/treatment projects impact water quality during storm events?

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.

Research Questions:

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

Creeks Walks

Creek walks from the ocean to upper watersheds are used to identify problem areas and track changes due to natural processes and human activity. Problem areas may include sources of polluted input to the creeks, sites of habitat degradation, or failing bank structures. Problem areas that are typically not seen from roads can be identified, cleaned up, and monitored.

Research Questions:

- How have the number and location of water pollution sources changed over time?
- Are there new problems in creeks that need to be addressed?
- Were decreases in trash observed between 1999 and 2005 due to creek flow histories or the impact of City programs?
- Will the installation of catch basin screens lead to decreased trash observed in creeks?

Microbial Source Tracking

Microbial source tracking is used to develop better tools for tracking fecal pollution in creeks and to identify sources of indicator bacteria. The Creeks Division has gathered extensive data on the presence of indicator bacteria throughout its watersheds, the specific sources of pollution and the degree to which the recreational waters are harmful to human health are not known.

Research Questions

- Which locations in creeks and drains have consistent presence of human waste?
- Where does such waste enter drainage sytems?
- What happens to the signals of human waste and indicator bacteria levels as water moves downstream away from the source?
- How does presence of human waste relate to beach warnings?

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:

- What is the baseline of biological integrity for benthic macroinvertebrates in creeks?
- Are there differences between upper watershed and lower watershed sites?
- Are there differences among watersheds?
- How does the biological integrity in our creeks change over time?
- How does the biological integrity respond to habitat restoration projects?

II. ROUTINE WATERSHED ASSESSMENT

BIWEEKLY SAMPLING AT INTEGRATOR SITES

The Creeks Division seeks to track long term changes in water quality and relate creek water quality to beach warnings by conducting biweekly sampling for fecal indicator bacteria and field parameters at integrator sites for each watershed. Integrator sites are the lowest points in the watershed that are above tidal influence. The four integrator sites are Arroyo Burro at Cliff Drive (AB Cliff), Mission Creek at Montecito Street (MC Montecito), Laguna Channel at Chase Palm Park (LC at CPP), and Sycamore Creek at the railroad bridge (SC Railroad). The Sycamore Creek site is often dry during the summer and fall).

At each site, a multi-parameter meter was used to test for temperature, dissolved oxygen (mg/l and % saturation), conductivity, total dissolved solids (TDS), salinity, and pH. In addition, samples collected at each site were tested at El Estero for three types of indicator bacteria: Total Coliform, *E. coli*, and Enterococcus. The samples were also tested for turbidity using a meter in the El Estero lab. Visual observations, such as algae coverage, trash, and fecal material, were also recorded at each site.

General Observations

Quarter 1 (Summer): This year was a drought year, as the previous winter's rainfall totals were some of the lowest on record. Not surprisingly, flow was lower than usual in the creeks; Sycamore was completely dry by early July. As is typical in the warmer months, high algal growth in the early part of summer gradually gave way to high plant growth; by the end of summer, sites like Arroyo Burro were nearly choked.

Trash was observed at all sites; however Mission Creek continues to have the most severe problem of all the integrator sites. In addition, a higher-than-normal amount of fecal material was observed this summer at the Mission Creek site, under the Montecito Street bridge. No fecal material was observed at the Laguna or Arroyo Burro sites.

Quarter 2 (Fall): Creek flows remained low throughout much of the quarter, with virtually no rainfall until mid-December when a series of small storms helped to replenish creek flows.

Trash and fecal material were less prominent at integrator sites this quarter. Hypodermic needles were found at the Mission Creek site in October. As temperatures cooled and rain fell, plant growth slowed and was mostly cleared by late December.

Quarter 3 (Winter): Winter rains restored higher (sometimes heavy) flows to all four integrator sites this quarter. Two large storms brought heavy rain in January, and a series of small storms brought light- to medium- rainfall in February.

In general, trash was lighter this quarter than past quarters, as higher winter flows flush debris downstream and discourage transient activities. Human feces were observed at Sycamore Creek on one occasion.

Quarter 4 (Spring): This spring quarter was very dry, with only one very light rain in early April. As a result, flows gradually decreased at all four integrator sites. As is typical of this time of year, algal growth was strong- particularly at Arroyo Burro, Mission, and Sycamore.

Trash was observed at all sites but was not excessive. However, the Sycamore Creek site had a large increase in human feces, which were found on four occasions. In addition, two hypodermic needles were found at the site in April.

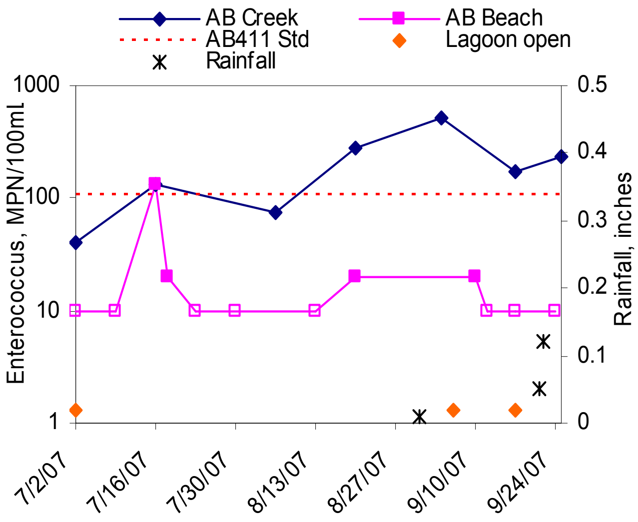
Indicator Bacteria

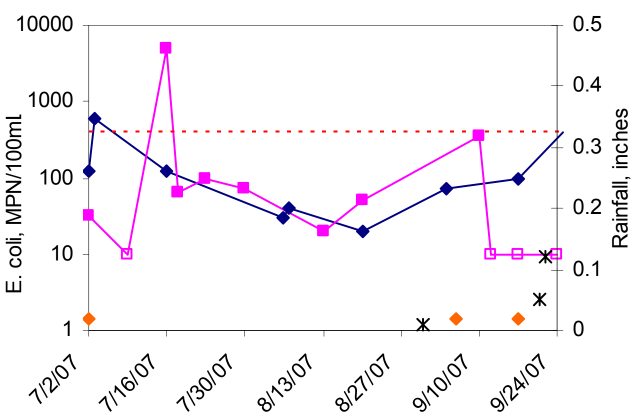
Quarter 1 (Summer)
Median results for each indicator bacteria group were in the typical range observed in the past several years for each integrator station (see table below).

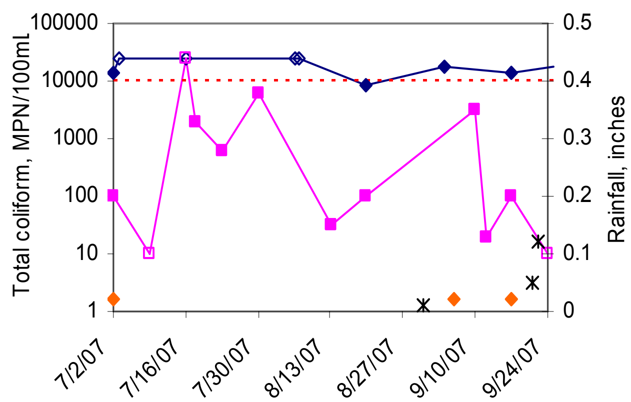
Q1 Indicator bacteria: median results at integrator sites			
Integrator Site	Total Coliform	*E. coli*	Enterococcus
Arroyo Burro at Cliff Drive	17,329	96	171
Laguna Channel at Chase Palm Park	>24,192	733	351
Mission Creek at Montecito St.	19,863	2489	132

Indicator bacteria levels in ocean samples (collected and analyzed by the County) are much more variable than those found in creek samples, likely due to turbulent mixing of source and receiving waters. For Arroyo Burro Beach and East Beach at Mission Creek, the plots below show the relationships among creek indicator bacteria levels, beach data, rainfall, and whether the lagoons were open or closed. For Enterococcus at both beaches, *E. coli* at Arroyo Burro Beach, and Total Coliform at Arroyo Burro Beach, there was no clear relationship among variables and beach data (visual observation only, no statistical analysis conducted). Total Coliform and *E. coli* at East Beach did appear to relate to the lagoon status (during dry weather) and rainfall amounts (even though the lagoon was not open). Note that the Creeks Division tests for *E. coli*, the largest subset of fecal coliforms, and the County tests for all fecal coliforms. The categories are used interchangeably here. In addition, load results are not shown due to the small variation in flow during this quarter.

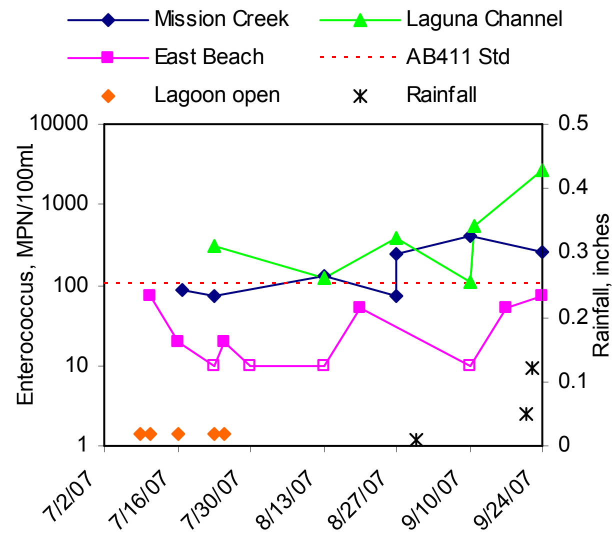
Arroyo Burro Creek and Beach

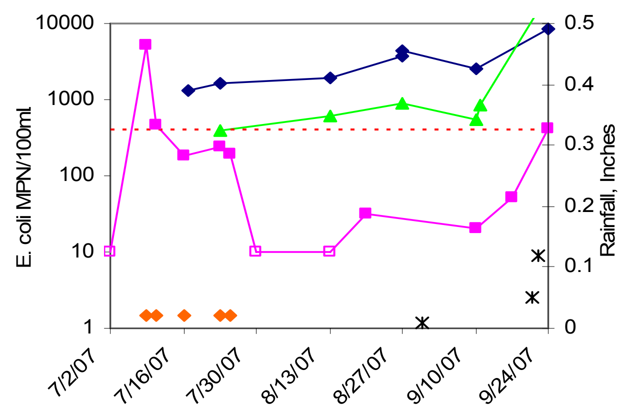


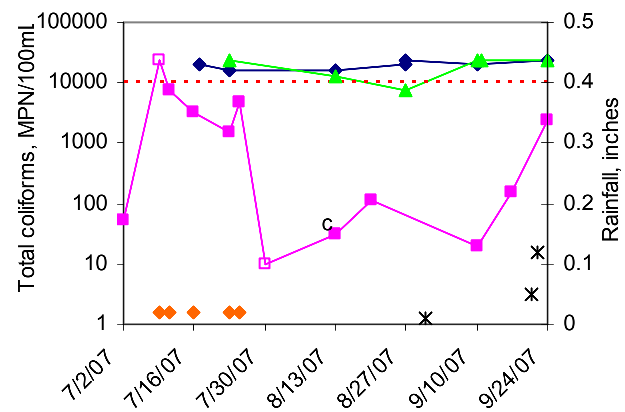




Mission Creek, Laguna Channel, and East Beach at Mission Creek mouth







* Open symbols represent values above or below thresholds, e.g. >24,192 or <10.

Quarter 2 (Fall)

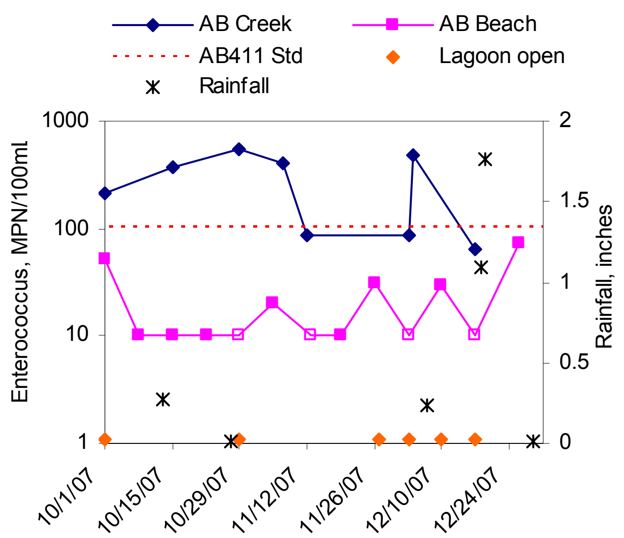
Median results for each indicator bacteria group were in the typical range observed in the past. In the case of Total Coliform, median results decreased significantly from the previous quarter at all sites (with the exception of Sycamore which was not tested last quarter). Other results were more varied: *E. coli* and Enterococcus both increased at Arroyo Burro, both decreased at Laguna Channel, and at Mission *E. coli* decreased significantly while Enterococcus doubled. Sycamore results appear very high but it is important to note that the dataset was very limited as sampling occurred only in December after several rain events.

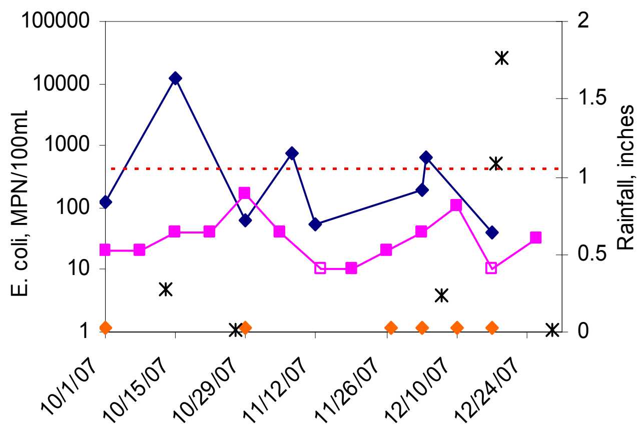
Q2 Indicator bacteria: median results at integrator sites			
Integrator Site	Total Coliform	*E. coli*	Enterococcus
Arroyo Burro at Cliff Drive	6,292.5	161.5	290
Laguna Channel at Chase Palm Park	19,863	195	171
Mission Creek at Montecito St.	10,462	857	288
Sycamore Creek at Railroad Bridge *(*limited dataset for December only)*	>24,192*	676*	1,137*

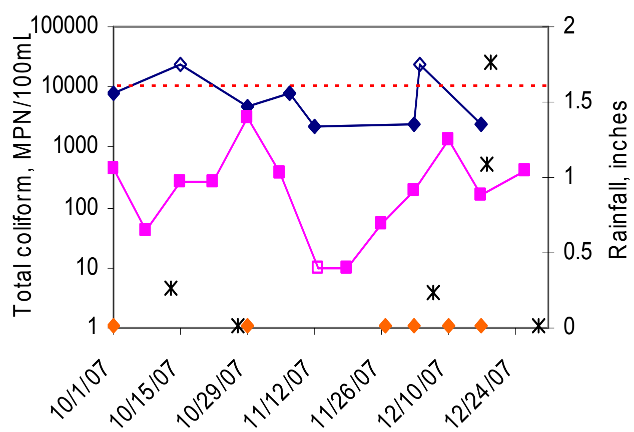
For Arroyo Burro Beach, East Beach at Mission Creek, and East Beach at Sycamore Creek, the plots below show the relationships among creek indicator bacteria levels, beach data, rainfall, and whether the lagoons were open or closed. For all three types of indicator bacteria, there was no clear and consistent relationship among variables and beach data at Arroyo Burro or at East Beach at Sycamore (visual observation only, no statistical analysis conducted). It is important to note, however, that creek sampling was very limited on Sycamore, and the lagoon mouth was not open at East Beach at Sycamore for any dates. For Enterococcus and Total Coliform at East Beach at Mission, there does appear to be a correlation with rainfall and lagoon status (although the lagoon was only open on one sampling date). *E. coli* at East Beach at Mission did appear to relate to lagoon status (again, lagoon was only open on one sampling date) but the relationship to rainfall is not as clear.

Quarter 2 (Fall), continued

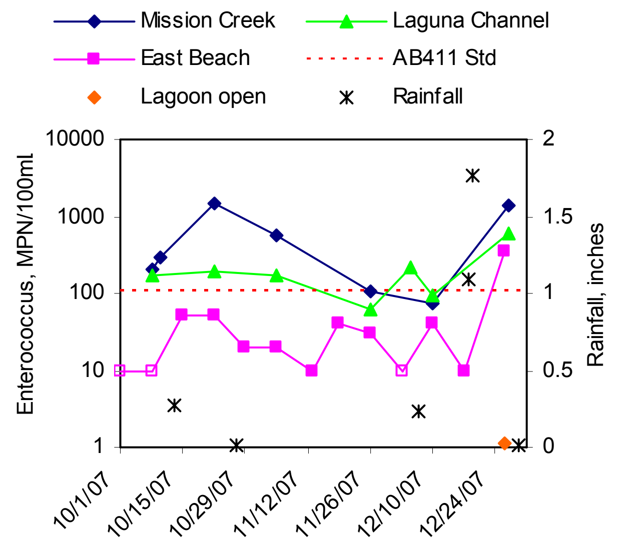
Arroyo Burro Creek and Beach

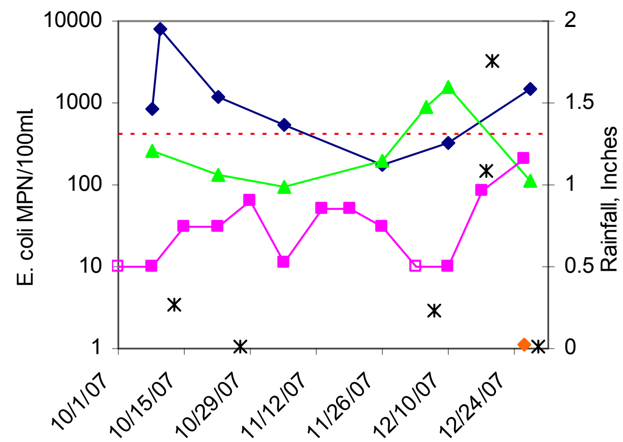


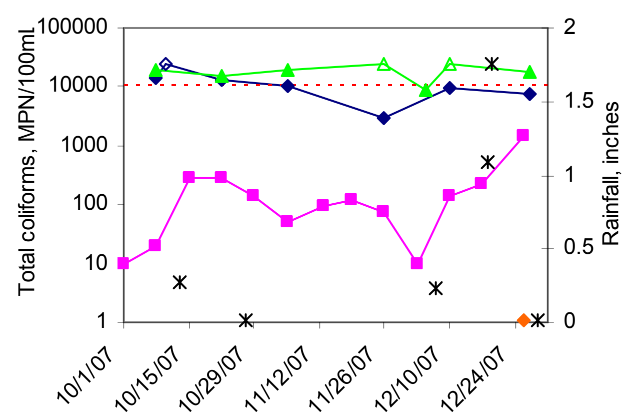




Mission Creek, Laguna Channel, and East Beach at Mission Creek mouth







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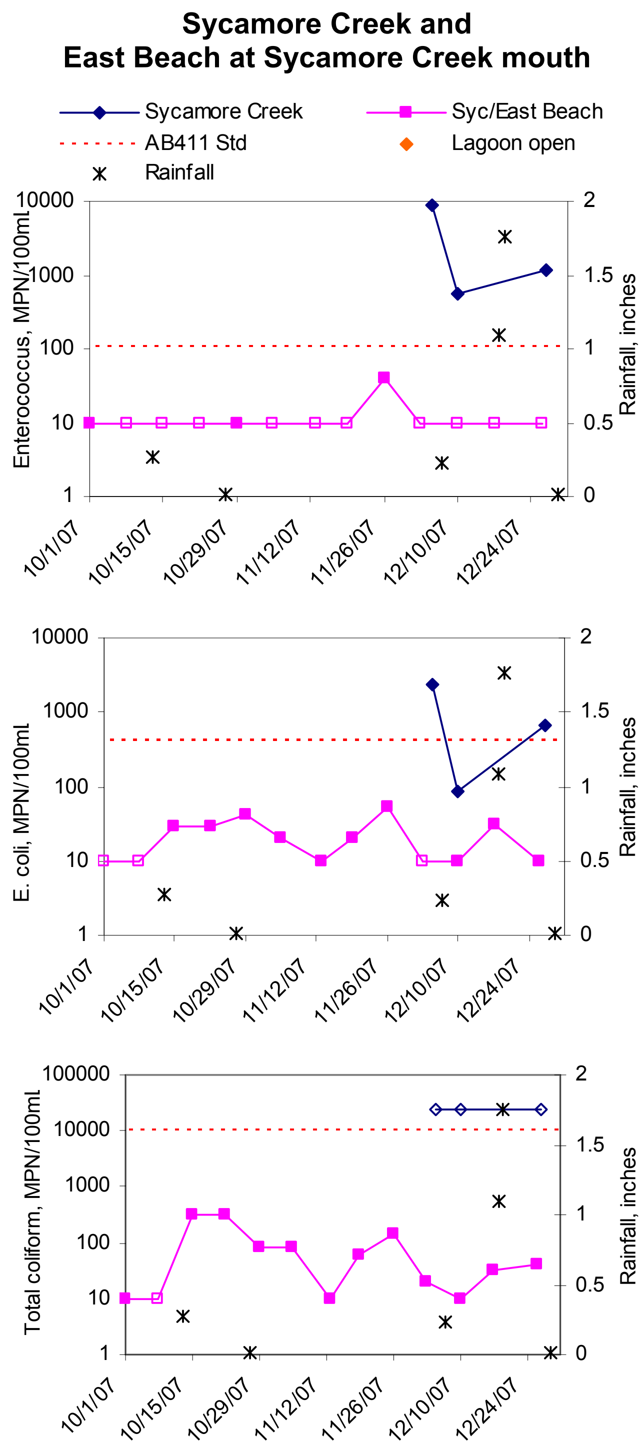
Quarter 2 (Fall), continued



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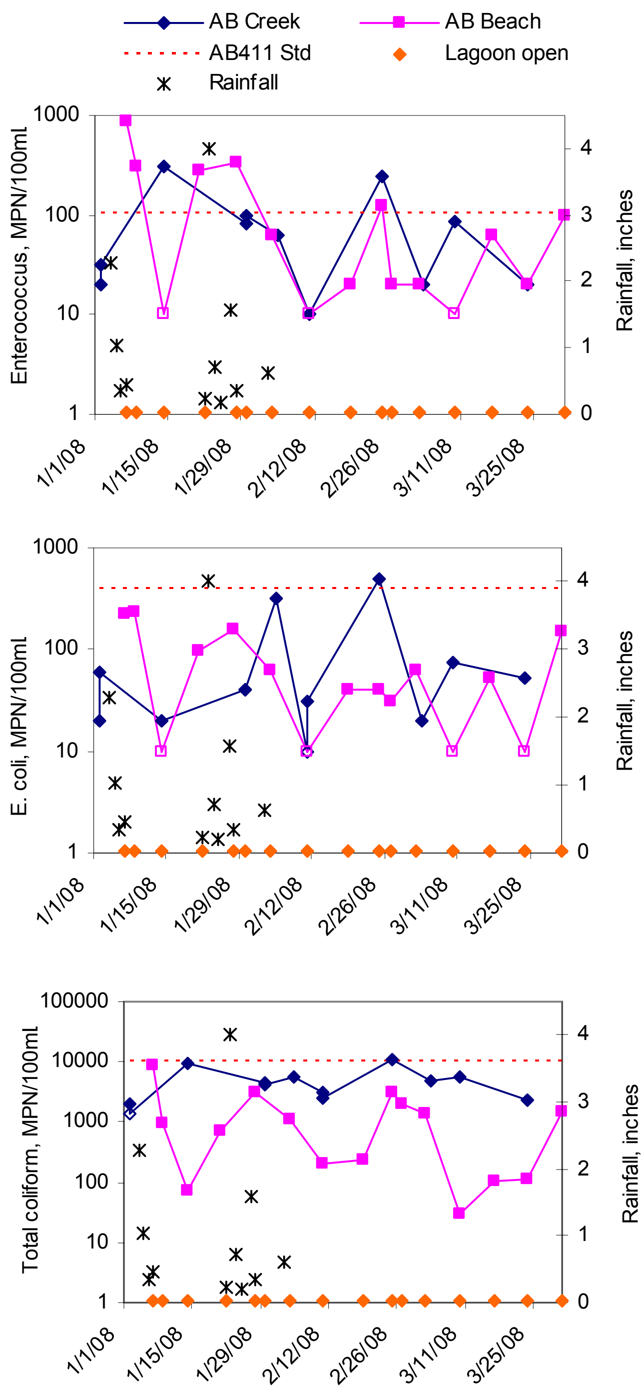
Quarter 3 (Winter)
This quarter there was an overall decrease in indicator bacteria. Median results for all indicator bacteria groups decreased at all sites, with only one exception: Total Coliform at Mission Creek increased slightly. A possible explanation for the overall decrease might be flushing and diluting of bacteria by winter rainfall.

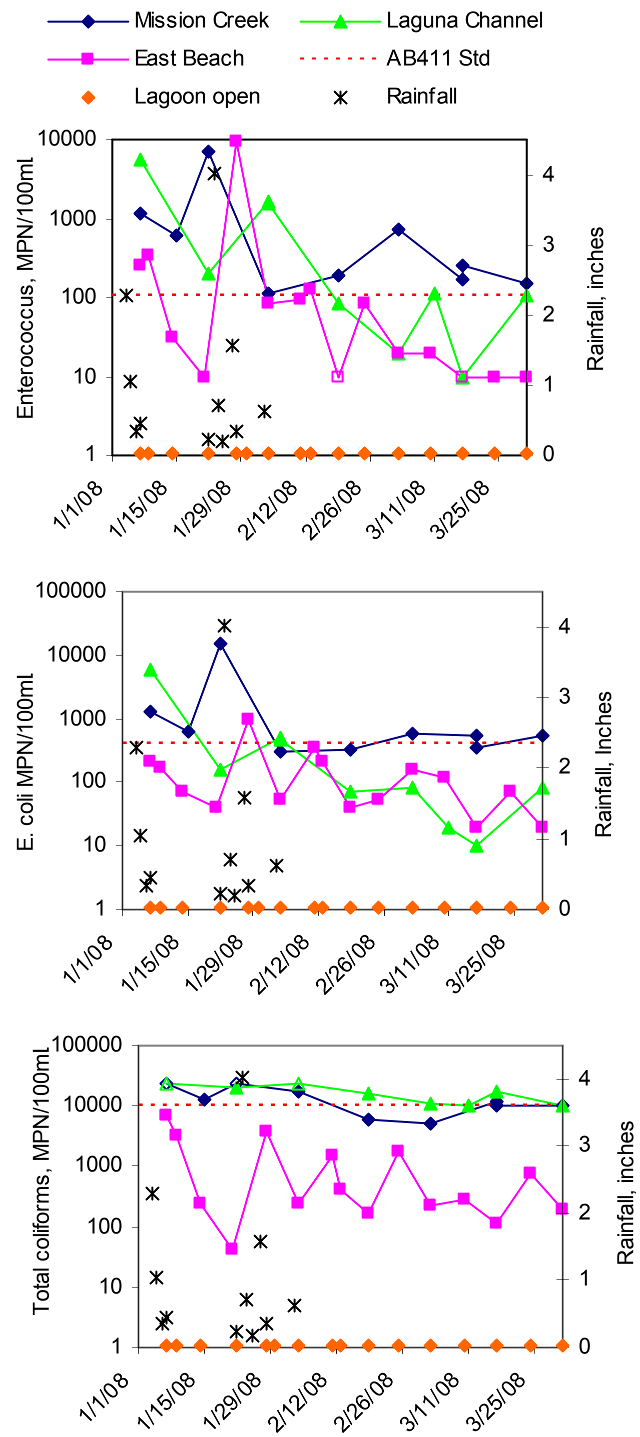
Q3 Indicator bacteria: median results at integrator sites			
Integrator Site	Total Coliform	*E. coli*	Enterococcus
Arroyo Burro at Cliff Drive	4,229	41	47
Laguna Channel at Chase Palm Park	17,329	85	110
Mission Creek at Montecito St.	12,033	554	247
Sycamore Creek at Railroad Bridge	17,695.5	245.5	283.5

For Arroyo Burro Beach, East Beach at Mission Creek, and East Beach at Sycamore Creek, the plots below show the relationships among creek indicator bacteria levels, beach data, rainfall, and whether the lagoons were open or closed. There does not appear to be any clear correlation between beach bacteria levels, creek data, and lagoon status (all lagoons were open for most of the quarter) in any of the graphs. However, in the early part of the quarter when rainfall was heavy, there does appear to be some correlation between rainfall and beach bacteria levels. Bacteria levels began high at all beaches early in the quarter with the first batch of storms in early January, then dropped during the lull in rainfall in mid- to late- January, then rose again with the second batch of storms in late-January to early-February, then fell again as the last rains tapered off. This pattern can be seen to some degree on every graph.

Arroyo Burro Creek and Beach



Mission Creek, Laguna Channel, and East Beach at Mission Creek mouth



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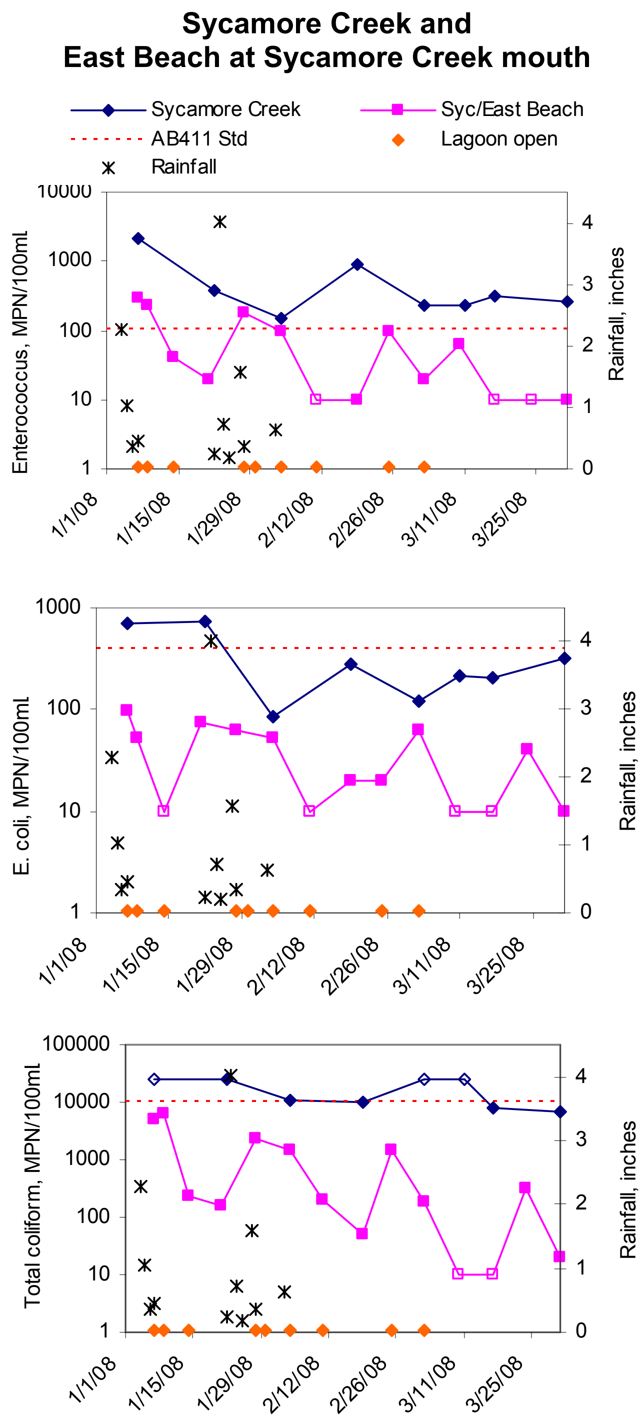
Quarter 3 (Winter) continued



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Quarter 4 (Spring)

With the onset of the dry season, indicator bacteria results were mixed for this quarter- there is no clear pattern for any site or indicator bacteria group when compared to last quarter's results. The one exception is Laguna Channel, where all three types of indicator bacteria increased, and Enterococcus reached its highest level of the year.

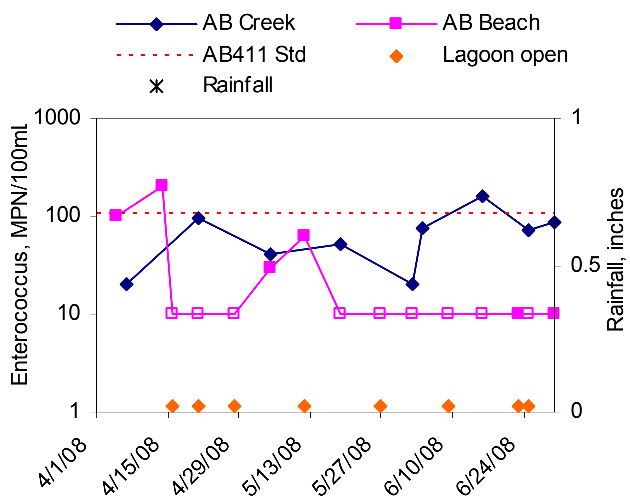
While no major patterns emerged between quarters 3 and 4, it is interesting to look at the pattern for the whole year. With the exception of the high Enterococcus levels at Laguna this quarter (mentioned above), it is clear that overall, bacteria reached their highest levels during quarters 1 and 2 (July through December). This is generally the driest part of the year, as the bulk of the winter rains typically arrive in Quarter 3 (Winter).

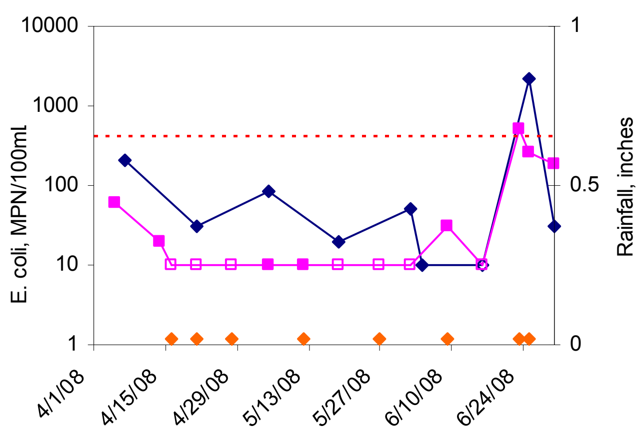
Q4 Indicator bacteria: median results at integrator sites			
Integrator Site	Total Coliform	*E. coli*	Enterococcus
Arroyo Burro at Cliff Drive	14,136	41	73
Laguna Channel at Chase Palm Park	19,863	299	857
Mission Creek at Montecito St.	12,033	882	199
Sycamore Creek at Railroad Bridge	14,013.5	252.5	279.5

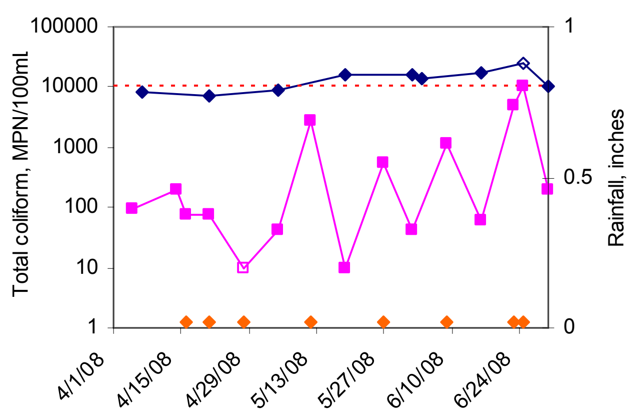
For Arroyo Burro Beach, East Beach at Mission Creek, and East Beach at Sycamore Creek, the plots below show the relationships among creek indicator bacteria levels, beach data, rainfall, and whether the lagoons were open or closed (note that there was no rainfall this quarter). For Arroyo Burro and Mission, no clear patterns emerge between these four parameters, with one exception: Total Coliform levels at Arroyo Burro appear to be closely linked to lagoon status during the second half of the quarter. The most interesting observations come from the Sycamore graphs; with no rainfall and a closed lagoon mouth, the beach bacteria levels remained at steady, near-zero levels throughout the entire quarter.

Quarter 4 (Spring) continued

Arroyo Burro Creek and Beach







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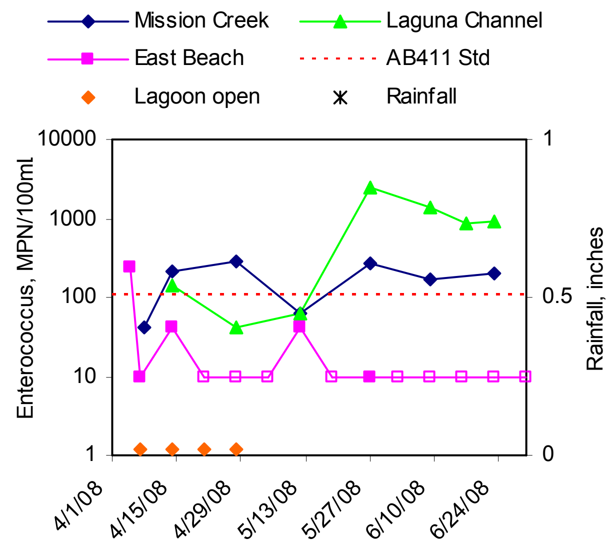

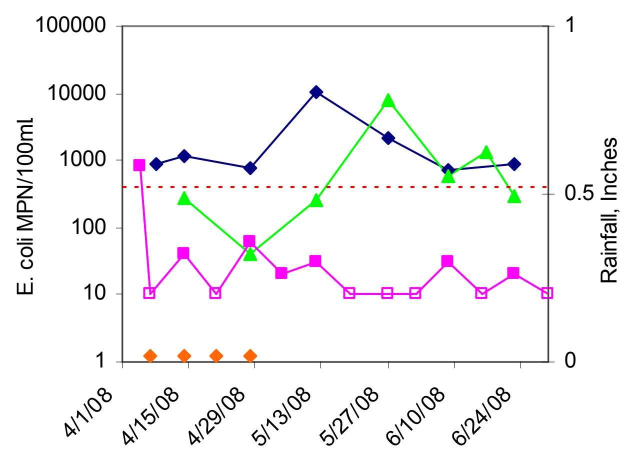

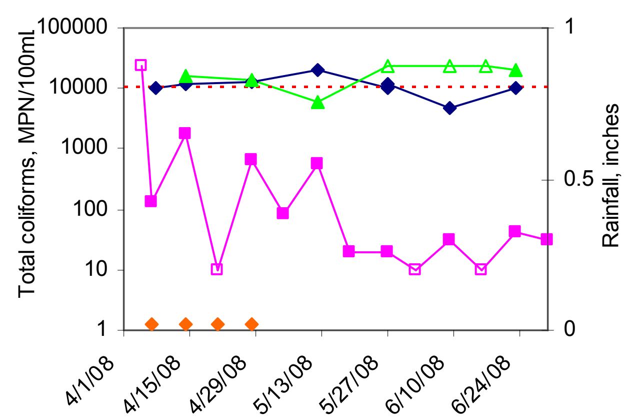

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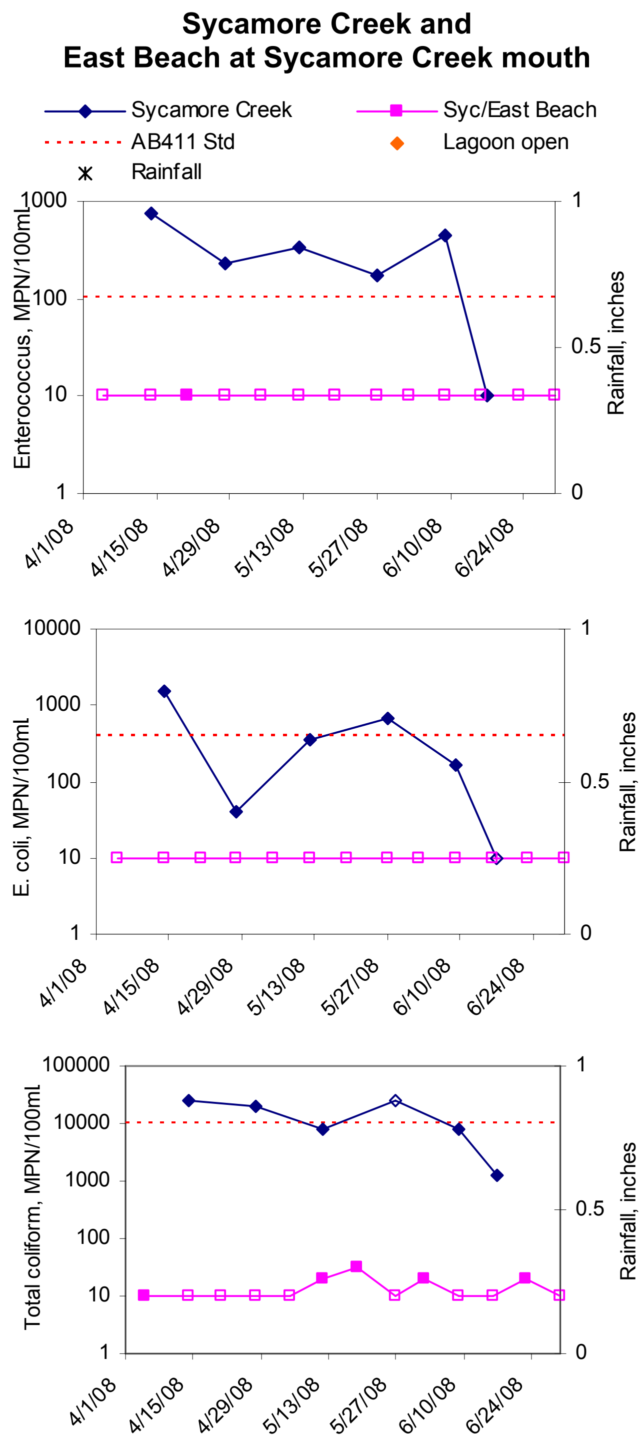
Quarter 4 (Spring) continued



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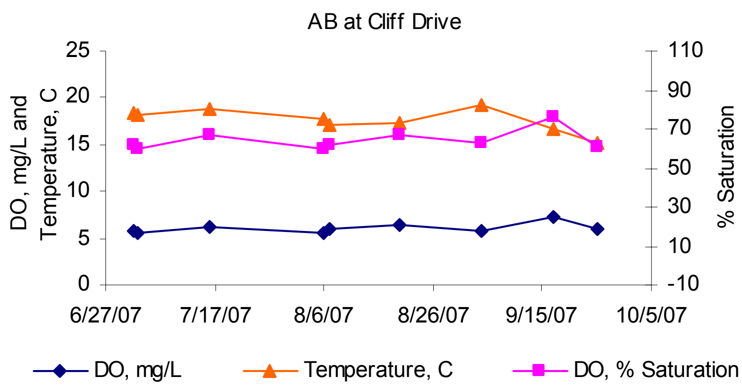
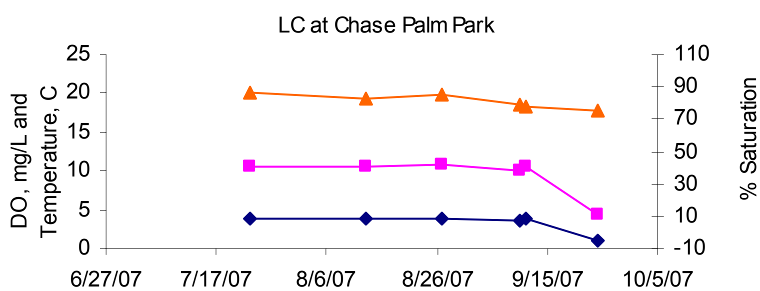
Field Data

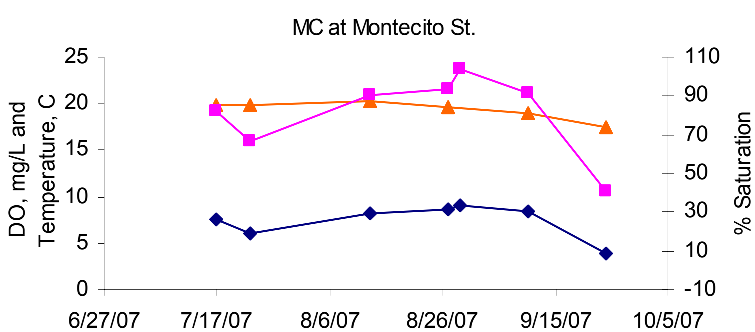
Quarter 1 (Summer)
Most field parameters were well within accepted levels for aquatic organisms, with the exception of dissolved oxygen at Laguna Channel and Mission Creek at Montecito St. As shown in the graphs below, dissolved oxygen (mg/L and % saturation) was at levels deemed safe for steelhead on all sample dates at Arroyo Burro at Cliff and all samples dates except one at Mission Creek at Montecito St. Dissolved oxygen was consistently below the threshold at Laguna Channel at Chase Palm Park. Dissolved oxygen concentrations do not appear related to temperature over this quarterly sampling period.

Average values for field parameters at integrator sites: Quarter 1 (Summer)

Integrator Site	**N**	**Conductivity µS**	**DO mg/L**	**DO %Sat**	**pH**	**Salinity ppt**	**TDS mg/L**	**Temp, ºC**	**Turbidity NTU**
Arroyo Burro at Cliff Drive	9	1923	6.1	64	7.5	1.1	1407	17.6	2
Laguna Channel at Chase Palm Park	6	1157	3.3	36	7.4	0.7	849	19.0	4
Mission Creek at Montecito Street	7	1096	7.4	81	7.2	0.6	797	19.3	0.9







Quarter 2 (Fall)

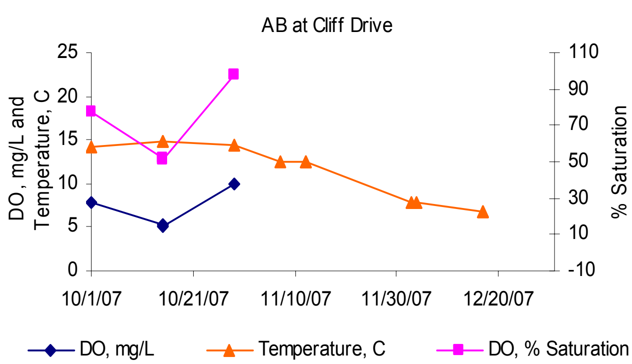
This quarter, most parameters were well within accepted levels, with the exception of dissolved oxygen at Laguna Channel. This site regularly exhibits unusually low dissolved oxygen levels. It is important to note that the dissolved oxygen meter was not functioning properly throughout much of the quarter, therefore the dataset for dissolved oxygen at all sites is very limited. It is also important to remember that Sycamore Creek was dry for much of the quarter, so the dataset for this creek is limited to only a few sampling dates in December.

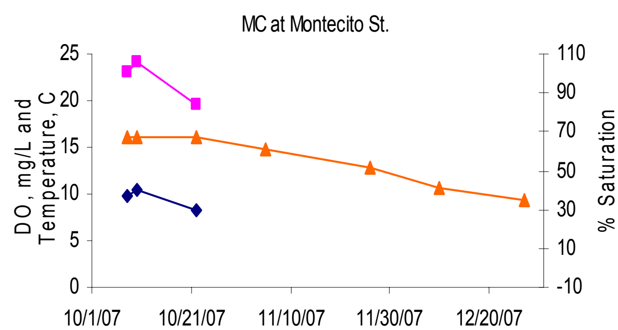
Average values for field parameters at integrator sites: Quarter 2 (Fall)

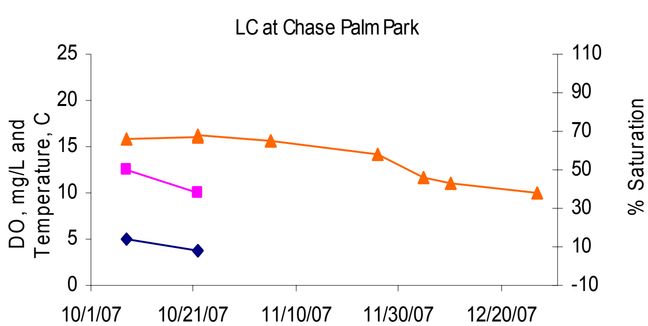
Integrator Site	N	Conductivity uS	DO mg/L	DO %Sat	pH	Salinity ppt	TDS mg/L	Temperature ºC	Turbidity NTU
Arroyo Burro at Cliff Drive	11/4*	1422	7.04	69	7.0	0.9	1204	11.4	3.3
Laguna Channel at Chase Palm Park	9/3*	862	4.16	42	7.0	0.5	674	14.0	2.8
Mission Creek at Montecito Street	7/3*	844	9.51	97	6.8	0.5	662	13.7	1.0
Sycamore Creek at Railroad bridge**	3/0*	5466	-	-	6.7	3.4	3684	10.0	1.0

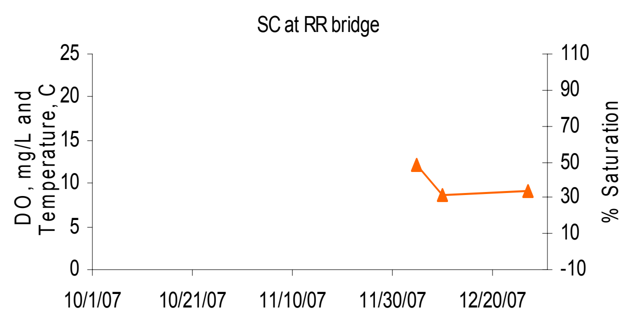
* The first number shown represents the number of readings for all parameters except DO (mg/L and %Sat), the second number shown represents the number of dissolved oxygen readings. The dissolved oxygen probe was not functioning correctly for much of the quarter.

** Sycamore Creek was dry for much of the quarter; therefore the dataset is very limited.









Quarter 3 (Winter)

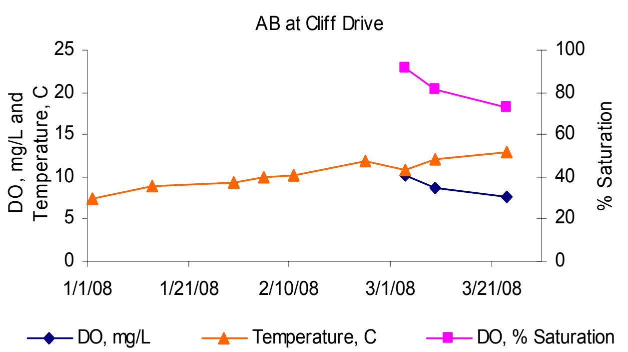
This quarter, field parameters were within acceptable levels, with the usual exception of low dissolved oxygen at Laguna Channel. The field data shows typical trends associated with winter conditions: lower temperatures, higher dissolved oxygen levels, and higher turbidity levels (caused by storm runoff). Conductivity, pH, TDS and salinity are also generally lower than the previous quarter due to the addition of fresh water from storms; however Laguna Channel actually showed a slight increase in conductivity this quarter. As with last quarter, the dataset for dissolved oxygen is very limited due to difficulties with the meter in the early part of the quarter.

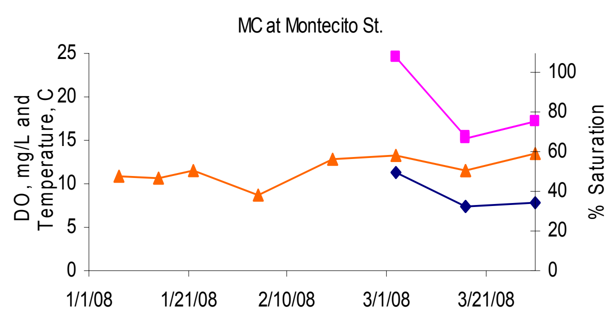
Average values for field parameters at integrator sites (Quarter 3 (Winter)**)**

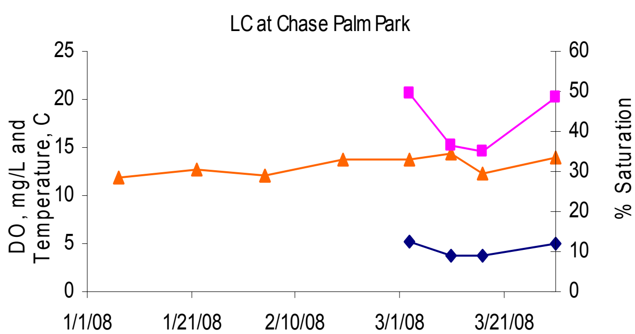
Integrator Site	N*	Conductivity uS	DO** mg/L	DO** %Sat	pH	Salinity ppt	TDS mg/L	Temperature ºC	Turbidity NTU
Arroyo Burro at Cliff Drive	12/3	1240	8.89	82	7.1	0.8	1015	10.0	5.8
Laguna Channel at Chase Palm Park	9/4	912	4.43	42	6.8	0.6	754	13.0	5.4
Mission Creek at Montecito Street	9/4	573	8.48	80	6.6	0.4	487	11.6	4.7
Sycamore Creek at Railroad bridge	8/4	988	11.41	107	7.1	0.6	798	11.5	2.4

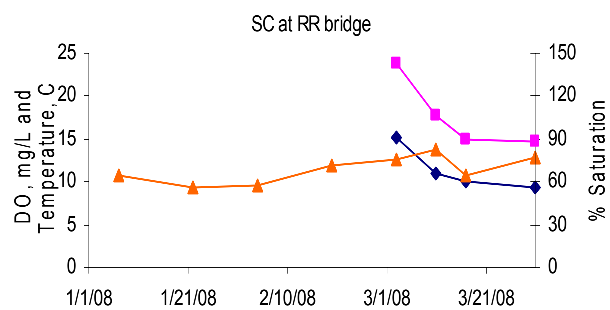
* The first number shown in the "N" column represents the number of readings for all parameters except DO (mg/L and %Sat), the second number shown represents the number of dissolved oxygen readings. The dissolved oxygen probe was not functioning correctly during the early part of the quarter; a new meter was purchased at the end of February.

** DO readings are from March only.







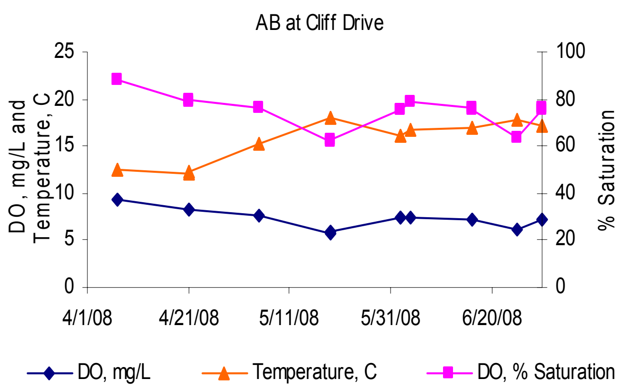


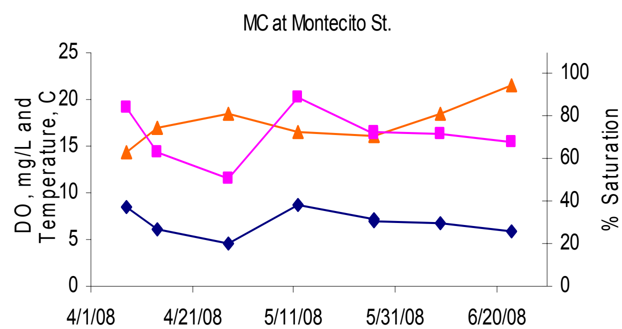
Quarter 4 (Spring)

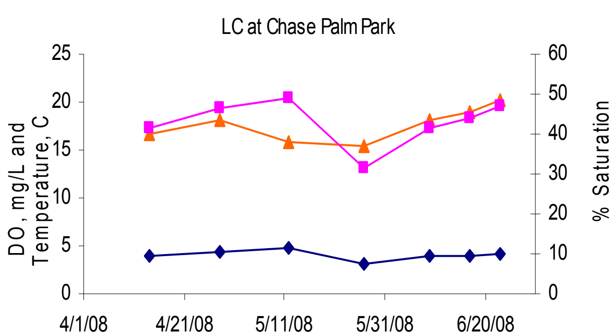
As with the previous three quarters, most parameters are within acceptable levels with the exception of low dissolved oxygen at Laguna Channel. This quarter's field data reflects the typical patterns associated with warmer springtime conditions. With warmer weather and virtually no rainfall, temperature, pH and conductivity increased while turbidity and dissolved oxygen decreased. In the temperature vs. DO graphs below, a typical inverse relationship is seen at Arroyo Burro and Mission. However the pattern is not as clear for the other two integrator sites- in fact, there appears to be more of a direct relationship between DO and temperature which may indicate a problem with overgrowth of algae.

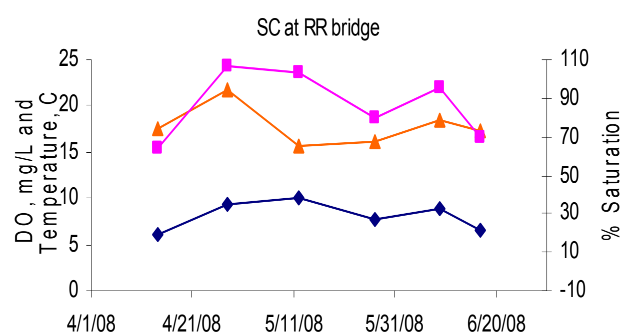
Average values for field parameters at integrator sites: Quarter 4 (Spring)

Integrator Site	N	Conductivity uS	DO mg/L	DO %Sat	pH	Salinity ppt	TDS mg/L	Temperature ºC	Turbidity NTU
Arroyo Burro at Cliff Drive	15	1852	7.45	75	7.7	1.2	1460	15.7	2.0
Laguna Channel at Chase Palm Park	7	1680	4.06	43	7.3	1.0	1269	17.6	3.5
Mission Creek at Montecito Street	9	1046	6.84	71	7.0	0.6	794	17.3	1.0
Sycamore Creek at Railroad bridge	6	1830	8.14	86	7.6	1.1	1379	17.8	1.3









QUARTERLY SNAPSHOT SAMPLING FOR EACH WATERSHED

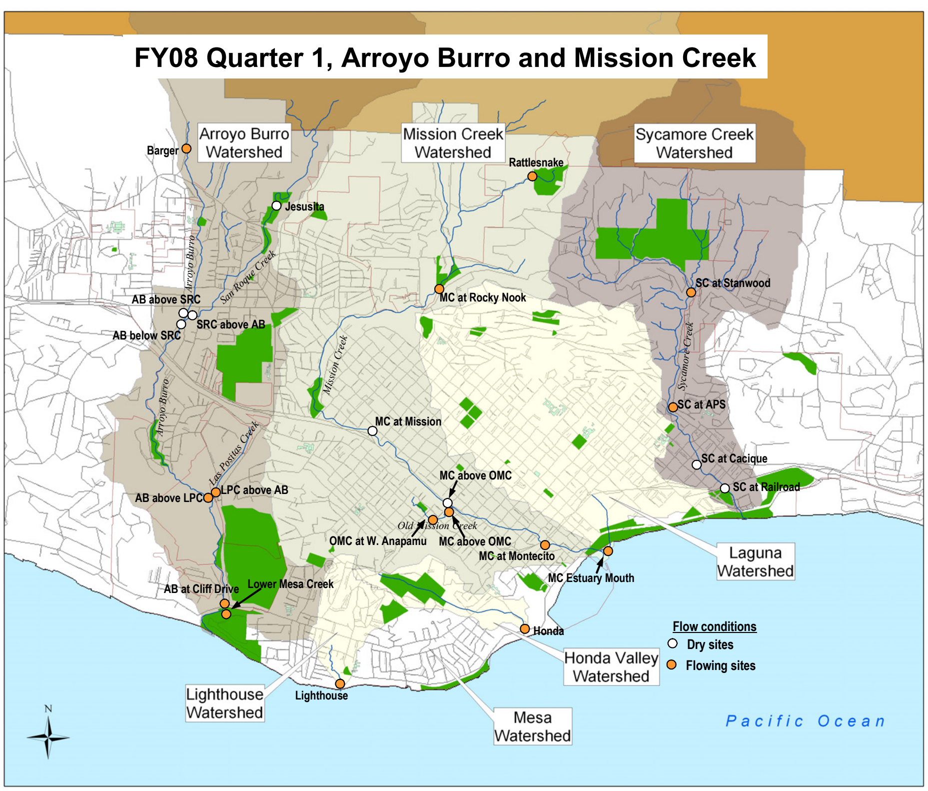
Quarterly snapshot sampling is conducted in order to track long term changes and to identify pollutant routes to creeks. The Creeks Division modified quarterly sampling efforts considerably in the FY08 Research Plan. Quarterly sampling was used to estimate the load of bacterial and chemical pollutants entering the creeks in separate drainage areas (see map below). Flow was measured at each sampling location (see section on load tracking tools below). Fecal indicator bacteria, dissolved copper, total metals, and suspended solids concentrations were also measured. The load, or the flux, is obtained by multiplying flow rate by the concentration of a constituent, resulting in the amount of material moving through the creek per unit of time. This is the first time that the Creeks Division has acquired load estimates throughout a watershed. By calculating the difference between loads in two creek locations, the amount of material that enters the creek in a particular stream reach can be estimated.

Quarter 1 (Summer)

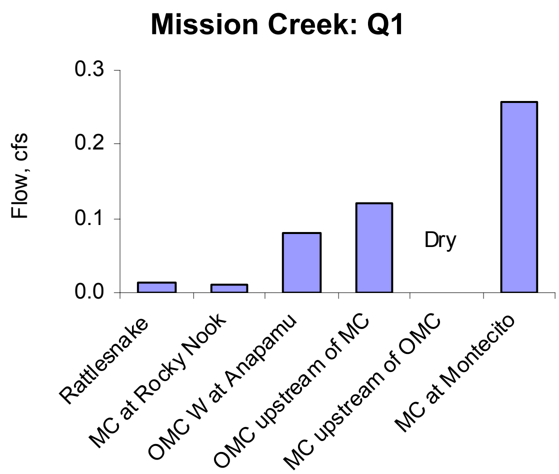
Quarterly results and analysis are presented for Arroyo Burro (August 7) and Mission Creek (July 17). There were no replicates collected in this sampling effort because replication will be conducted on a seasonal time scale. The variation in concentrations and loads over time will dwarf the variation from collecting replicate samples on a single day. Results from Sycamore Creek are presented below. Limited sampling due the dry integrator site prevented a watershed scale analysis. See map below for locations.

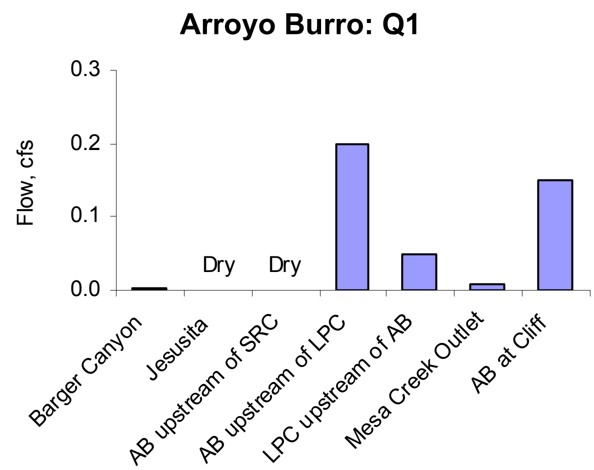
Sediment sampling was not conducted due to delays in identifying a protocol for sampling and analysis. Sediment will be collected in the following quarter.

In the results presented below, bar charts show the absolute levels of concentration and load for each constituent, at each sampling point. Pie charts illustrate the percent of material entering the creeks in particular reaches



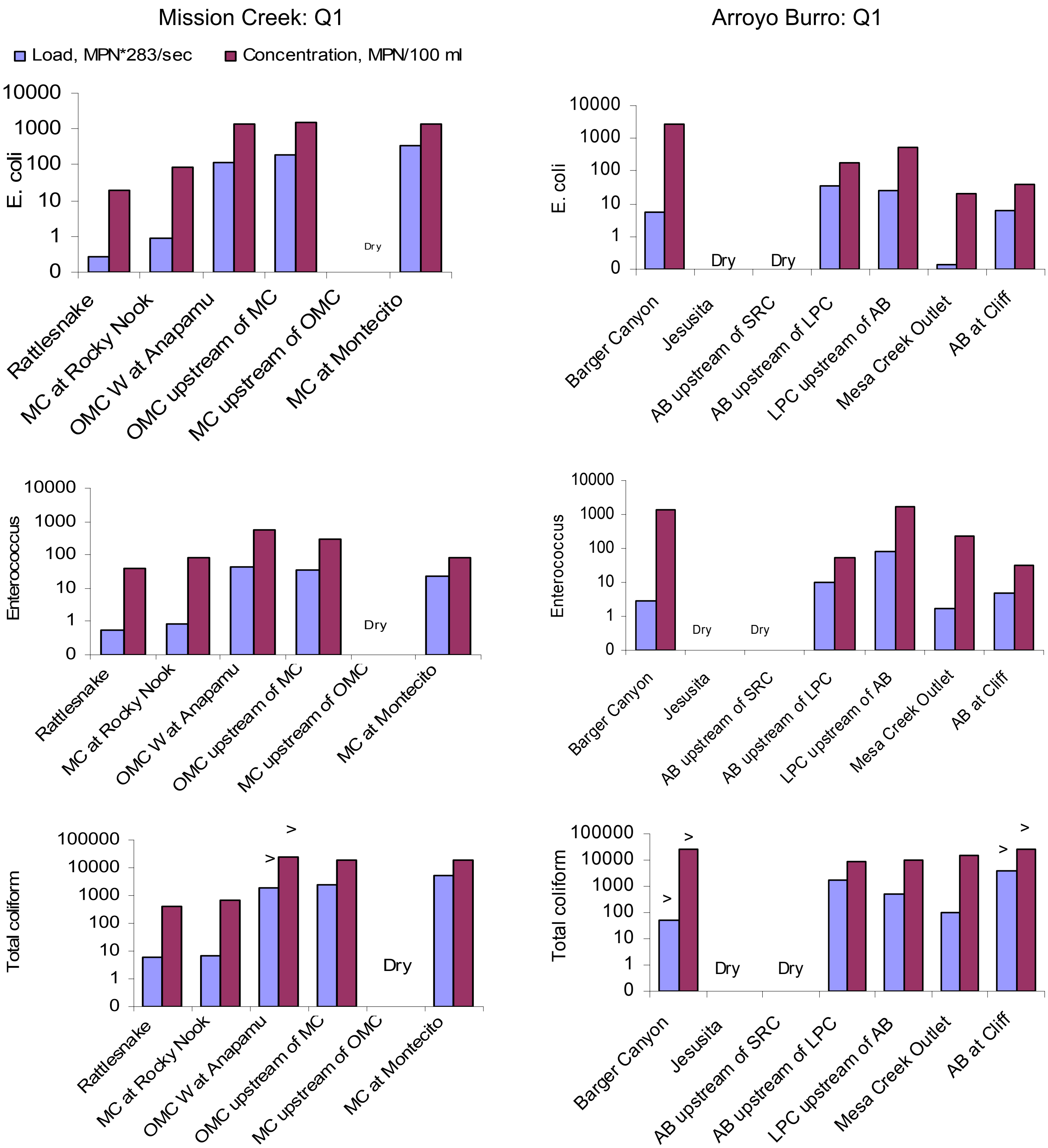
Flow: In both Arroyo Burro and Mission Creek, the upper sites had very low flow (<0.015 cfs). Both creeks were completely dry in the mid-watershed locations (confluence of Arroyo Burro and San Roque Creek, and Mission Creek at Old Mission Creek, respectively; see map). In Arroyo Burro, the flow increased substantially at the confluence of Las Positas Creek, and then decreased at Cliff Drive. Minor input was received from Mesa Creek. In Mission Creek, an equal amount of flow was received from Old Mission Creek and in the reach between Old Mission Creek and Montecito Street. Pie charts are located below, in the indicator bacteria section, to aid comparisons.





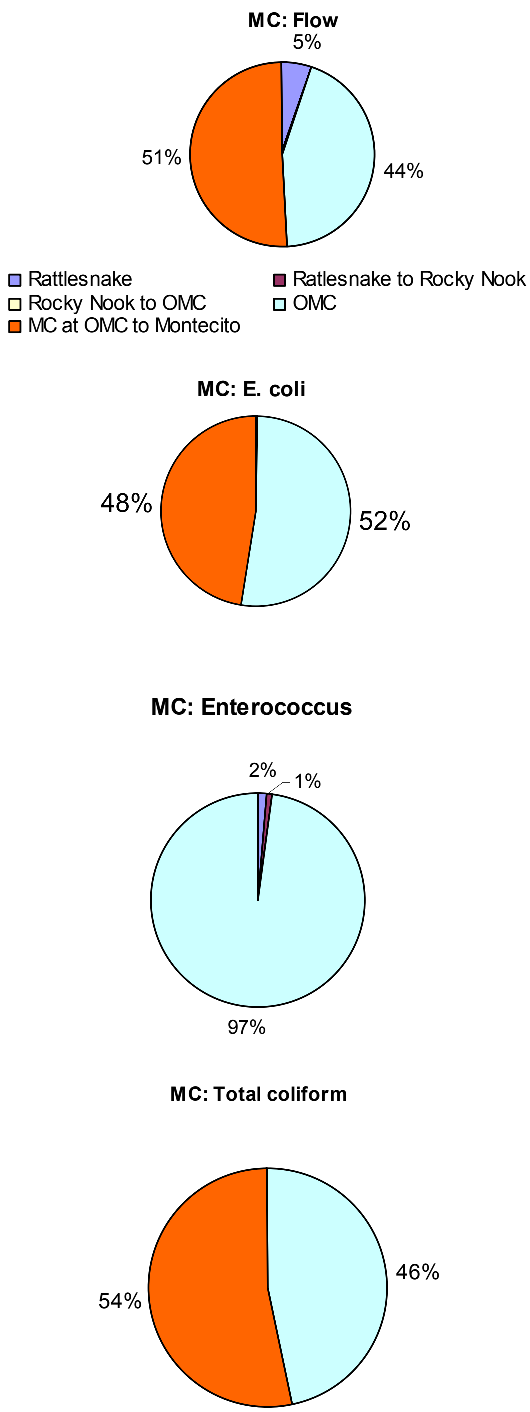
Indicator Bacteria: In Mission Creek, indicator bacteria concentrations increased by one to two orders of magnitude from upstream to downstream. The loads increased in a similar pattern. The loads in the upper watershed were much lower than the loads below the dry reaches.

In Arroyo Burro, hot spots in concentrations were observed at Barger Canyon and Las Positas Creek upstream of the confluence with Arroyo Burro. Despite the lower flow rates at these sites, the loads of *E. coli* and Enterococcus were of the same order of magnitude as they were at the lower watershed sites.

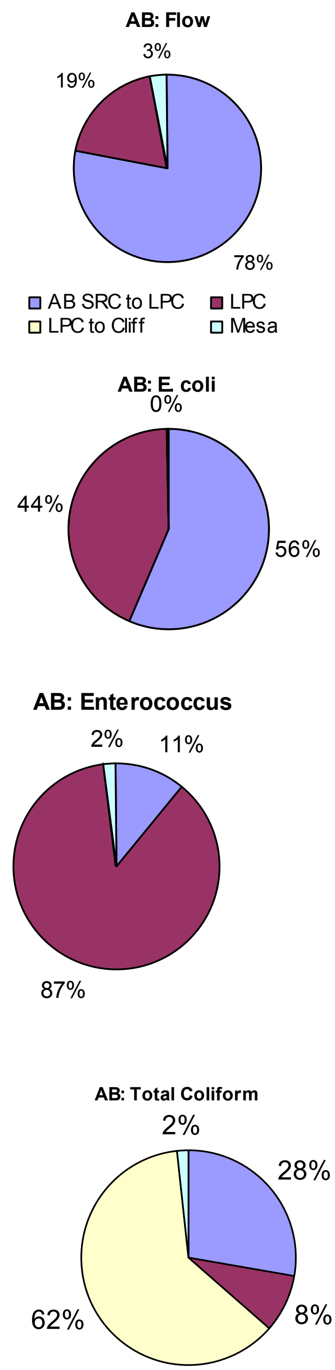

Mission Creek: Q1
Arroyo Burro: Q1
Load, MPN*283/sec
Concentration, MPN/100 ml
E. coli
Enterococcus
Total coliform
10000
1000
100
10
1
0
100000
Dry
>
Rattlesnake
MC at Rocky Nook
OMC W at Anapamu
OMC upstream of MC
MC upstream of OMC
MC at Montecito
Barger Canyon
Jesusita
AB upstream of SRC
AB upstream of LPC
LPC upstream of AB
Mesa Creek Outlet
AB at Cliff

The pie charts show that for Mission Creek, approximately the same load of *E. coli* and Total Coliform were received from Old Mission Creek and the reach from Old Mission Creek to Montecito Street, following flow patterns. Nearly all of the Enterococcus was received from Old Mission Creek. In Arroyo Burro, patterns were more variable. Approximately half of the *E. coli* arose from the reach between San Roque Creek and Las Positas Creek confluences. The other half came from Las Positas Creek. For Enterococcus, most of the bacteria entered from Las Positas Creek, and for total coliform, most of the bacteria entered in the stretch from Las Positas Creek to Cliff Drive. Note that zero and negative (decrease in load) values are not shown on these pie charts.

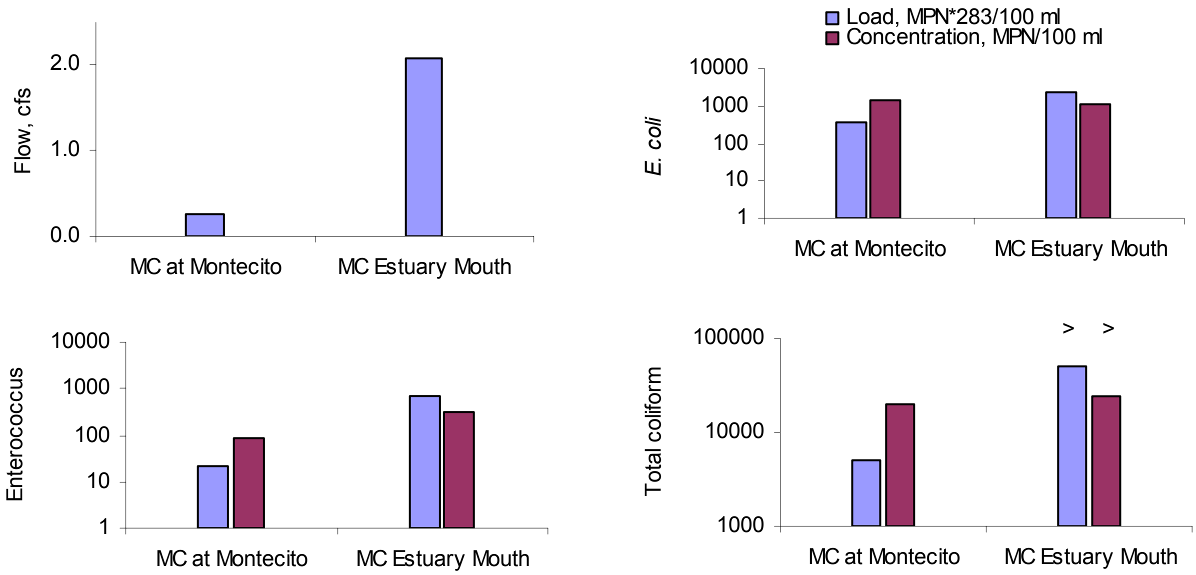
Mission Creek: Q1



Arroyo Burro: Q1

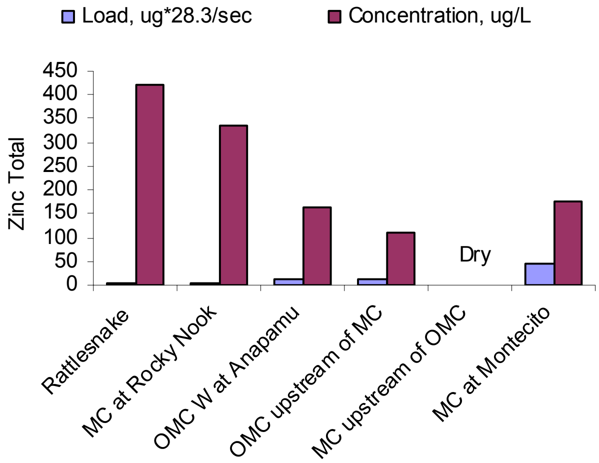


Discharge from Mission Lagoon – During quarterly sampling at Mission Creek, the lagoon (estuary) was draining out. The load of indicator bacteria leaving the lagoon was approximately ten times that measured at Montecito St. Additional analysis would be required to determine the reason for the increase, but it is likely a combination of filling of the estuary with creek water and stirring up of sediments during tidal changes. A retrospective check of tidal charts shows that the tide was rising during this time, which is not what was observed at the lagoon mouth.

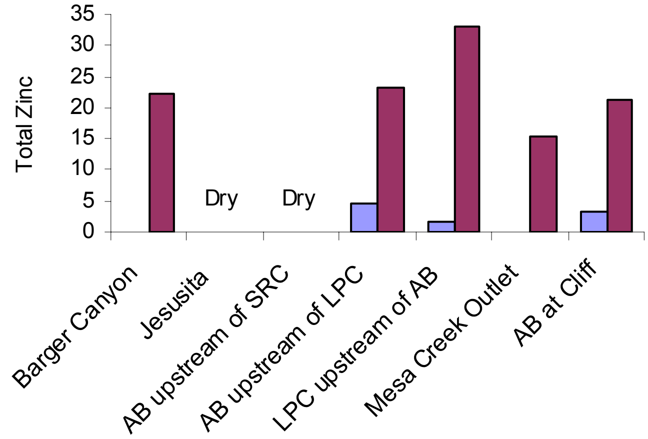


Metals – Dissolved copper and total zinc were the only metal pollutants that were detected consistently enough to examine watershed patterns. Total zinc concentrations were much higher in Mission Creek, including Rattlesnake, than in Arroyo Burro. Almost all of the values in Mission Creek were higher than the outdated criteria for total zinc (only dissolved criteria are now established). See Storm Monitoring and Copper Toxicity below for criteria. Dissolved copper was highest at Barger Canyon (35 ug/L) and was 1-3 ug/L for the remainder of the sites in both watersheds. With the exception of the copper result for Barger Canyon, none of these levels are harmful to aquatic organisms. For both watersheds, loads of total zinc and dissolved copper tracked flow rates, due to relatively small variations in concentrations.

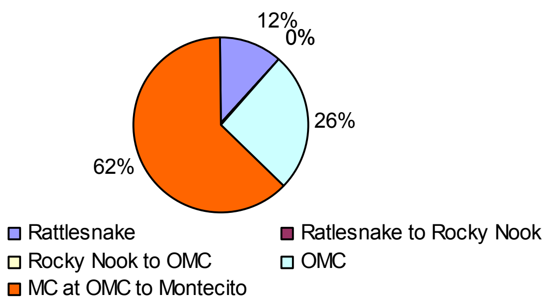
Mission Creek: Q1



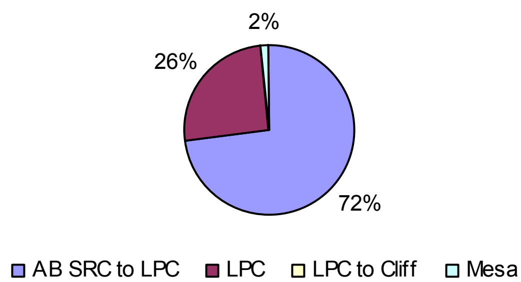
Arroyo Burro: Q1

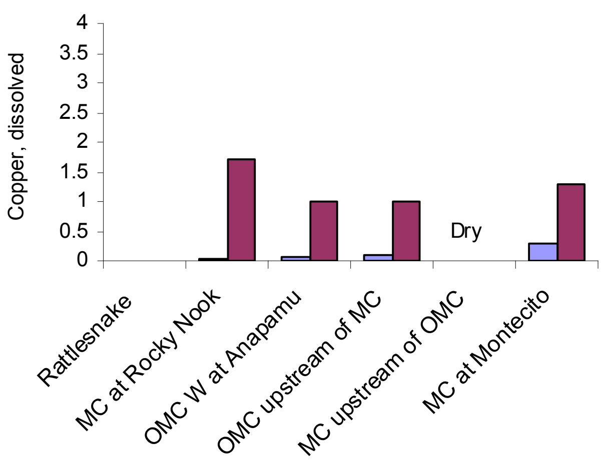


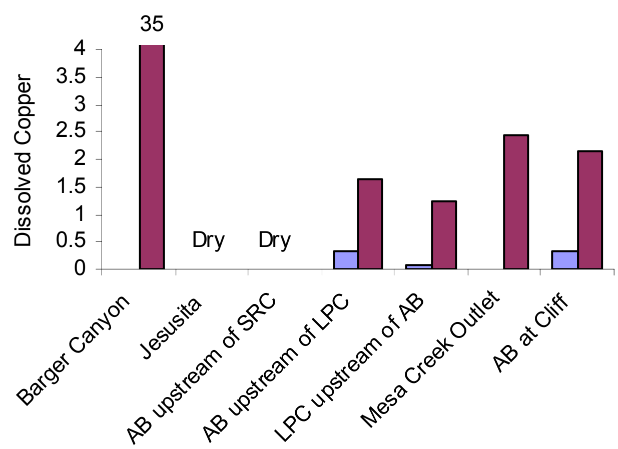
MC: Total Zinc



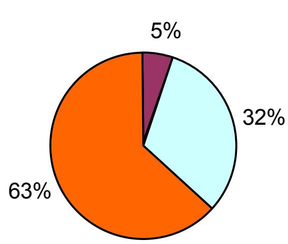
AB: Total Zinc



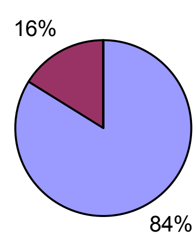




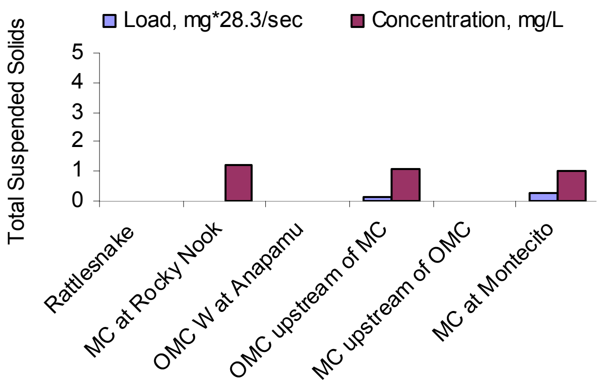
MC: Dissolved Copper

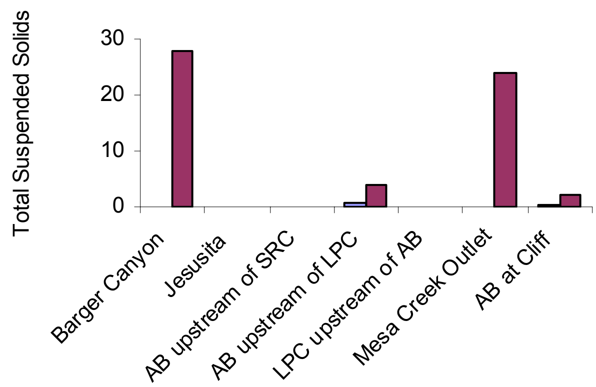


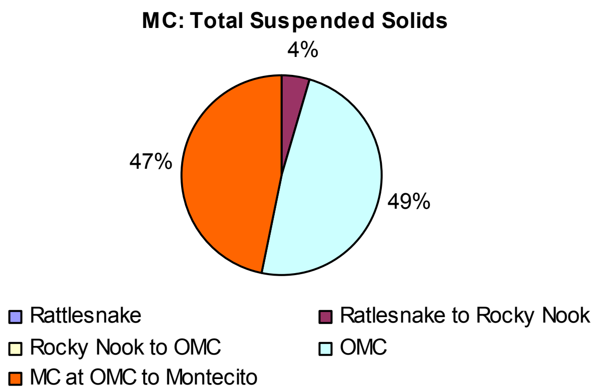
AB: Dissolved Copper

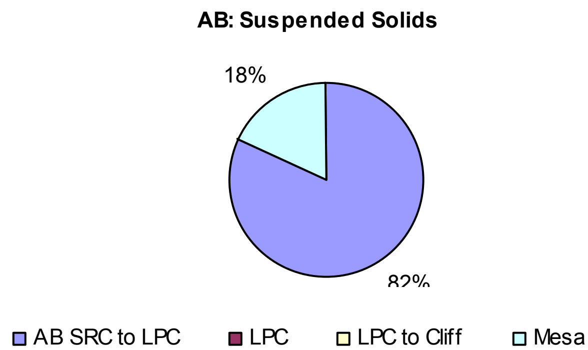


Total suspended solids – Total suspended solids were higher in Mission Creek than Arroyo Burro, and came primarily from Old Mission Creek and the lower reach of Mission Creek.





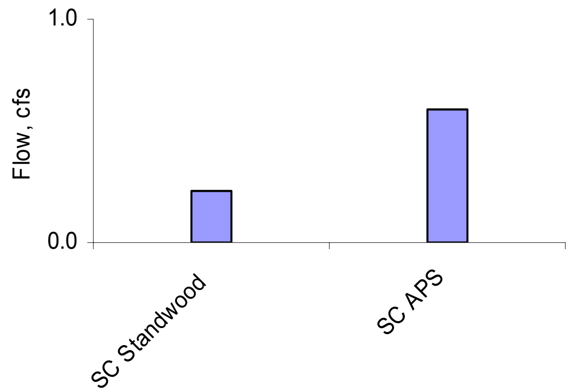


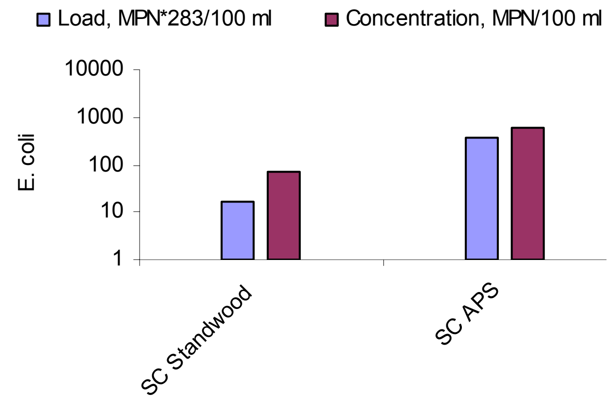


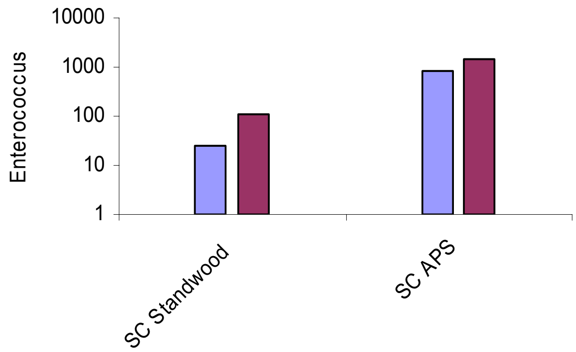
Toxicity – Toxicity was tested at the integrator sites for Arroyo Burro and Mission Creek. Because Sycamore Creek was dry at the railroad bridge, the toxicity sample was collected from Sycamore Creek at APS. Results showed 100% survival in 100% sample and TU(a) = 0 for Arroyo Burro at Cliff and Sycamore Creek at APS. For Mission Creek at Montecito, results were 90% survival in 100% sample, with a TU(a)=0.59, which exceeds the Ocean Plan criteria (see Storm Monitoring below).

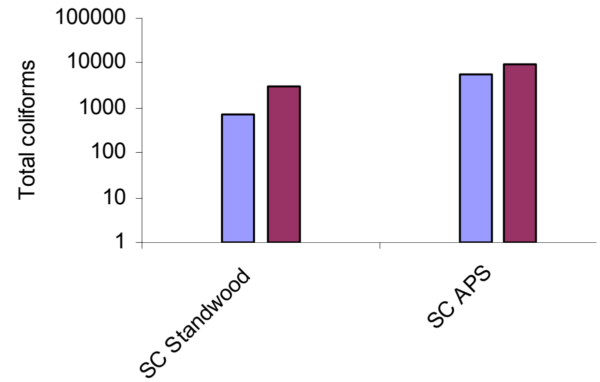
Sycamore creek- Flow, indicator bacteria, and total zinc results in Sycamore Creek were comparable in the mid watersheds to the other creeks. Dissolved copper was not detected at either sampling location.

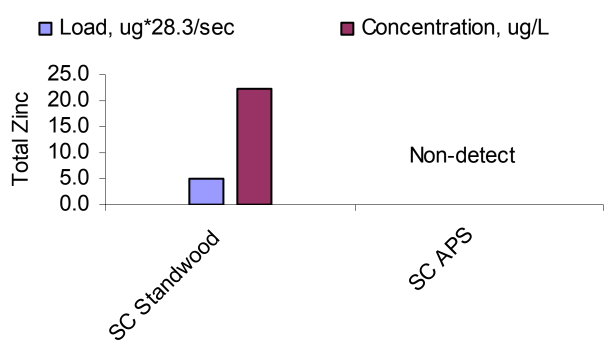
Sycamore Creek: Q1

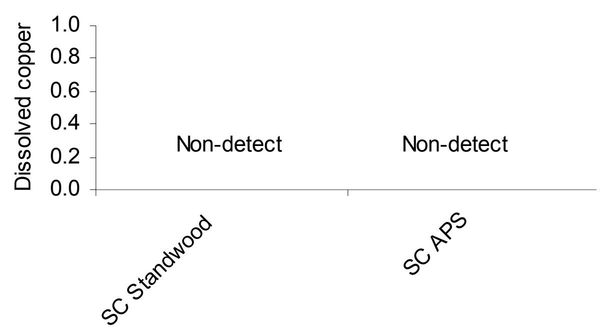


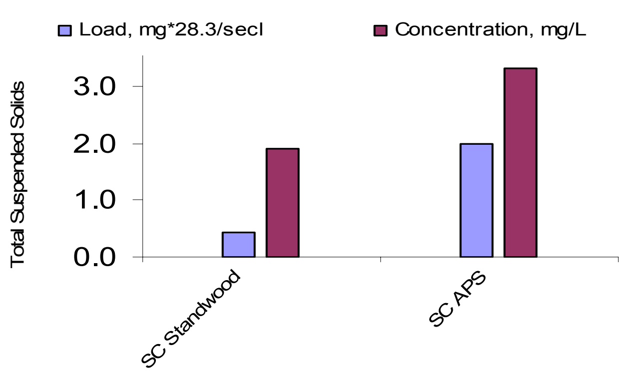










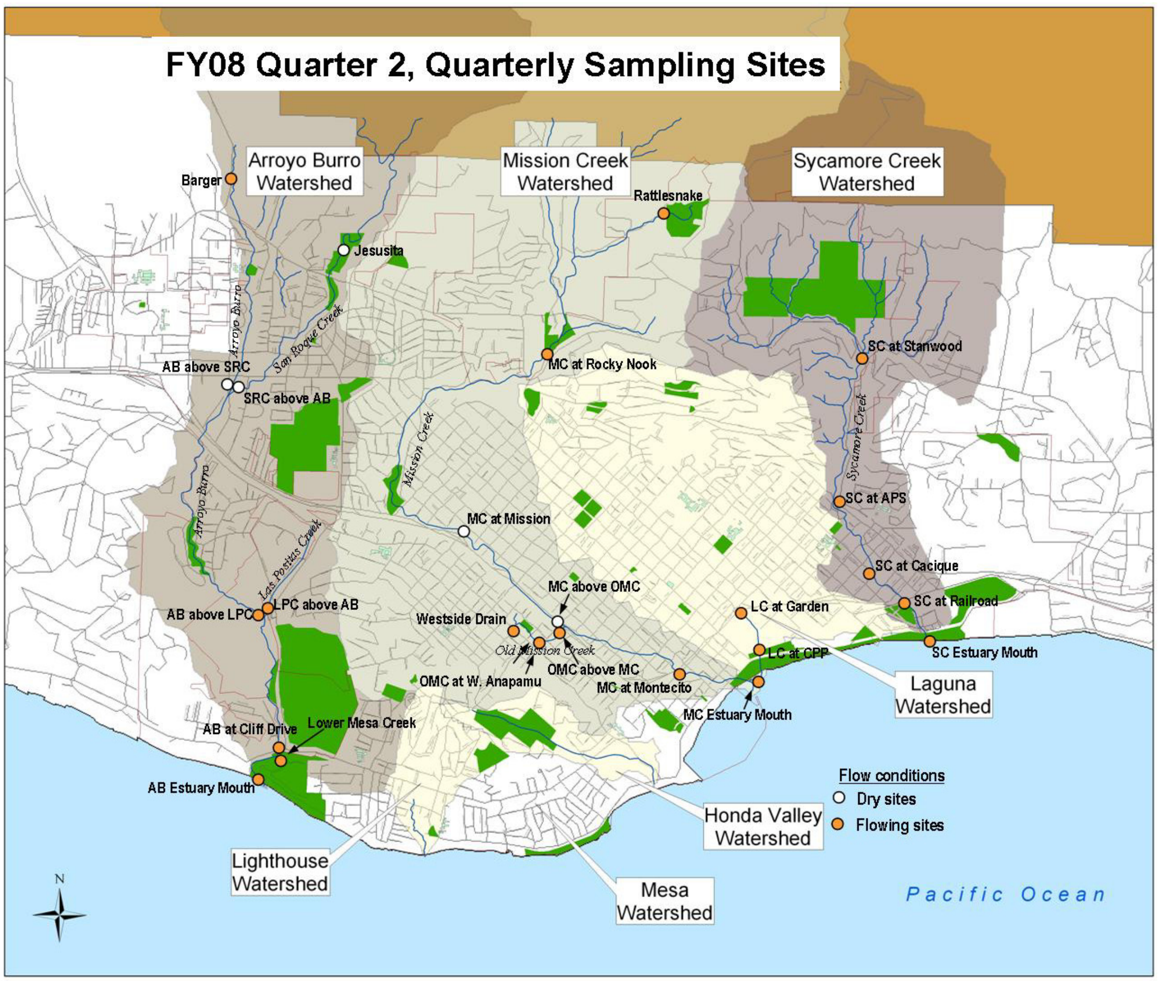


Quarter 2 (Fall)

Quarterly results and analysis are presented for Arroyo Burro (November 7), Mission Creek (October 10), and Sycamore Creek (December 5). There were no replicates collected in this sampling effort because replication will be conducted on a seasonal time scale. The variation in concentrations and loads over time will dwarf the variation from collecting replicate samples on a single day. Several sites could not be sampled due to dry or extremely low-flow conditions. See map below for locations.

Sediment sampling was also conducted this quarter and is discussed later in this report.

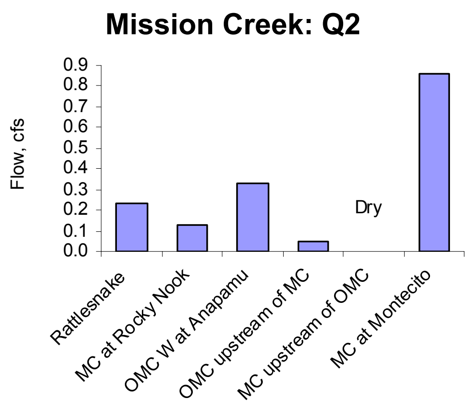
In the results presented below, bar charts show the absolute levels of concentration and load for each constituent, at each sampling point. Pie charts illustrate the percent of material entering the creeks in particular reaches.

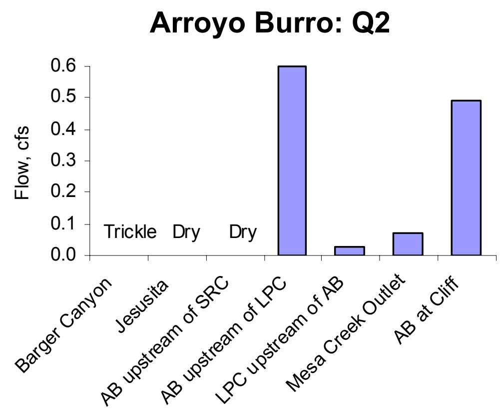


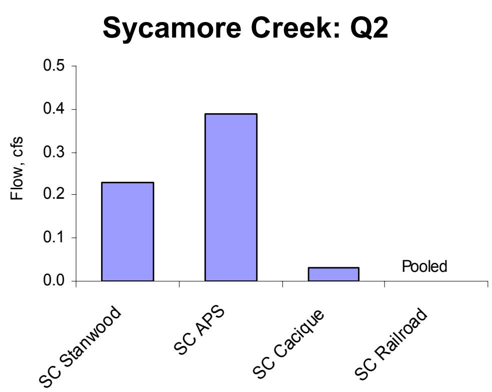
Flow: The bar graphs below show flow at three watersheds on quarterly sampling days. Flow patterns this quarter were very similar to the previous quarter at both Arroyo Burro and Mission; upper sites had very low flow, middle sites were dry, and flow increased substantially in the lower watersheds. Lower watershed flows in these creeks were substantially higher than the previous quarter, however; flow at integrator sites (MC at Montecito and AB at Cliff) were 2-3x higher than the first quarter. It is important to note that the freeway drain above MC at

Montecito was flowing heavily on the day of sampling, contributing to unusually high flows at this site.

At Sycamore Creek, flow conditions were unusual due to several factors. First, a reservoir in the upper watershed was flushed prior to sampling, causing two sites (SC at Cacique and SC at railroad bridge) to flow suddenly when they had been dry previously (since early summer). Second, an unusually high swell and high tide caused the lagoon to back up past the railroad bridge, causing pooled, brackish conditions at the integrator site (SC at railroad bridge) on the day of sampling.





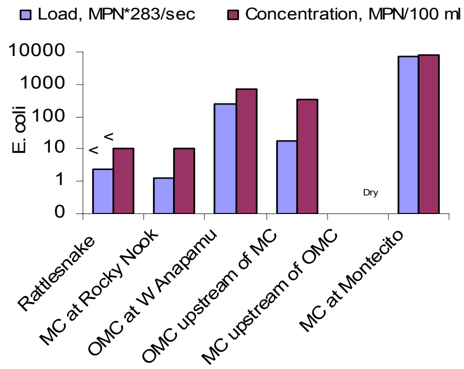


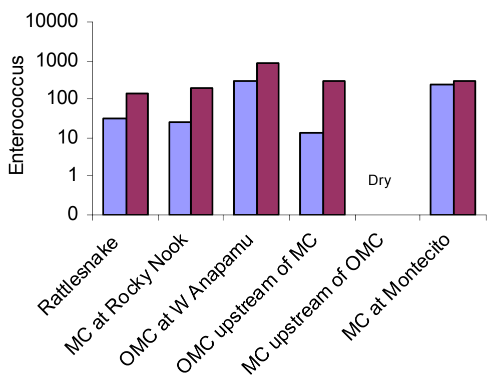
Indicator Bacteria: In Mission Creek, bacteria was highest (in terms of both concentration and load) at MC at Montecito and at OMC at W. Anapamu. It is interesting to note that both concentration and load decreased for all three types of indicator bacteria over the relatively small creek segment between OMC at W. Anapamu and OMC upstream of MC.

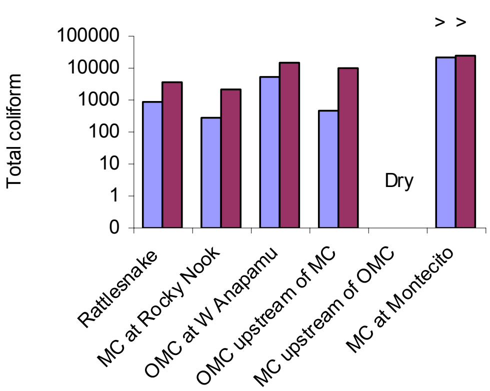
In Arroyo Burro, Barger Canyon was once again a major hot spot for concentration, however very low flows at this site compared to higher flows in the lower watershed made the loads at Barger less significant than in Quarter 1 (Summer). Unlike in Quarter 1 (Summer), Las Positas Creek did not stand out as a bacteria hot spot this quarter; concentrations and loads were consistently higher at the downstream site (AB at Cliff Dr.). Concentration and load at Mesa Creek were higher relative to the rest of the watershed than they were in the previous quarter.

In Sycamore Creek, concentrations generally increased steadily from upstream to downstream. While concentrations were slightly lower at the lowest site (SC at Railroad), it is important to note that the site was pooled due to a very high tide and therefore the creek water was heavily diluted by ocean water. Due to limited flow measurements, loads are difficult to analyze on a watershed-wide basis.

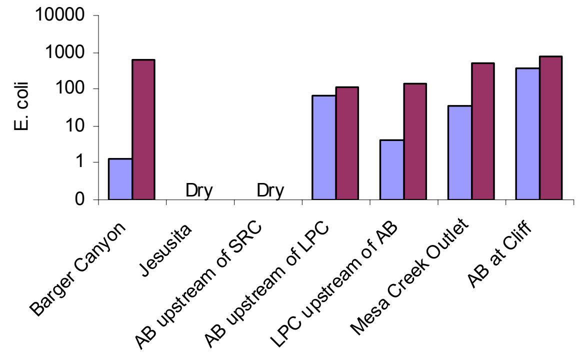
Mission Creek: Q2

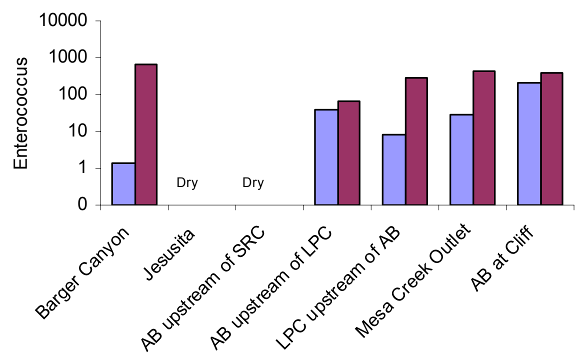


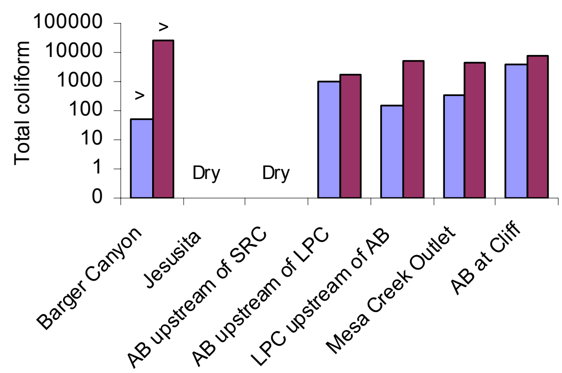


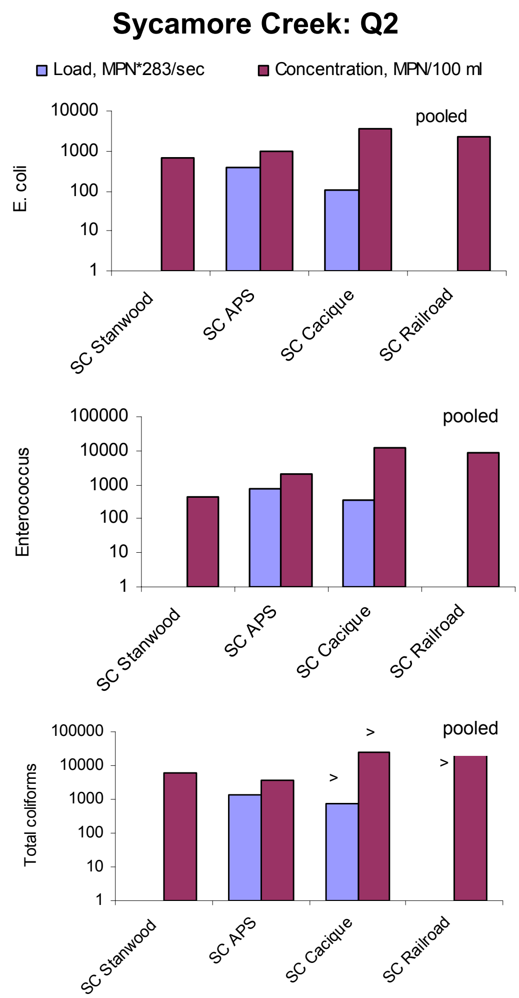


Arroyo Burro: Q2









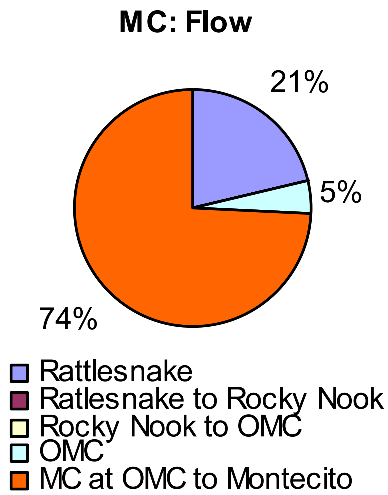
The pie charts for Quarter 2 (Fall) show that for Mission Creek, a very large majority of the flow and bacteria loads came from the reach between MC at OMC and Montecito Street. Interestingly, Rattlesnake Creek contributed the second highest flow and bacteria loads in the watershed. OMC played a much less significant role in flow and bacteria loads than it did during the first quarter.

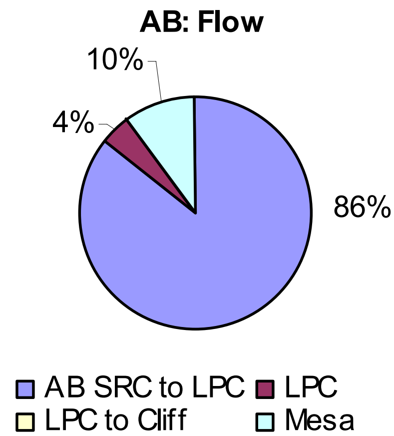
In Arroyo Burro, the majority of flow was received between the San Roque Creek and Las Positas Creek confluences. The reach between LPC to Cliff does not appear on the flow pie chart because flow decreased slightly over this reach. However, this reach contributed the majority of bacteria loads for all three types of indicator bacteria.

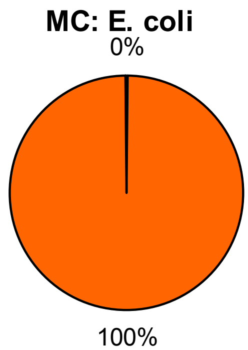
Pie graphs are not shown for Sycamore Creek because of unusual flow conditions; this type of analysis produced inaccurate results.

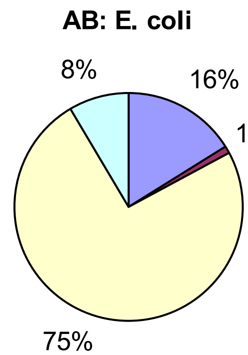
Mission Creek: Q2

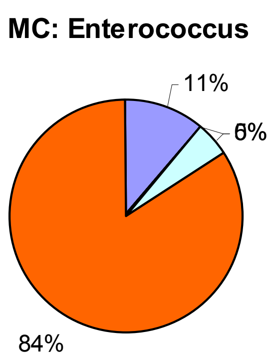
Arroyo Burro: Q2

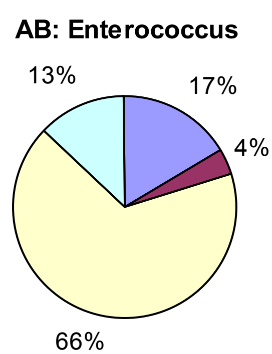


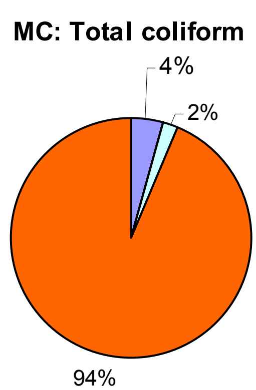


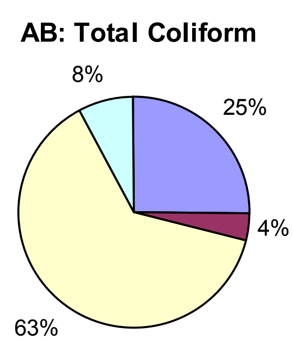












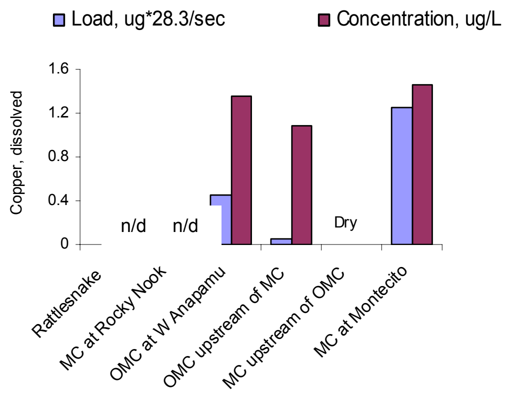
Metals- Dissolved copper was the only metal found consistently in all three watersheds and is shown in the bar and pie graphs below. For both Mission and Arroyo Burro, nearly all of the dissolved copper entered the creeks in the lower reaches of the watersheds (MC at OMC to Montecito St. and LPC to Cliff Dr.). In Sycamore the results are not as clear due to unusual flow conditions and limited flow measurements; the pie graph results may be misleading.

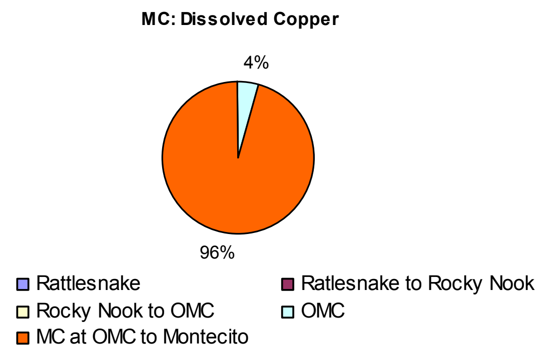
Zinc is shown only for Mission Creek as it was not detected consistently in the other watersheds. Similar to other pollutants, the majority of zinc entered the watershed between MC at OMC and Montecito St. It is interesting to note on the bar graph that zinc was not detected at OMC at W. Anapamu, but was detected in fairly high concentrations a short distance downstream at OMC above MC.

Graph key:

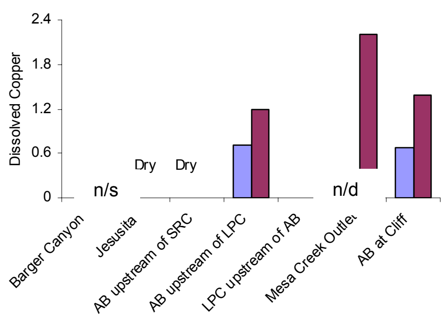
- dry: Site was dry and was not sampled
- n/d: the constituent was not detected at the site
- n/s: the constituent was not sampled due to extremely low flow

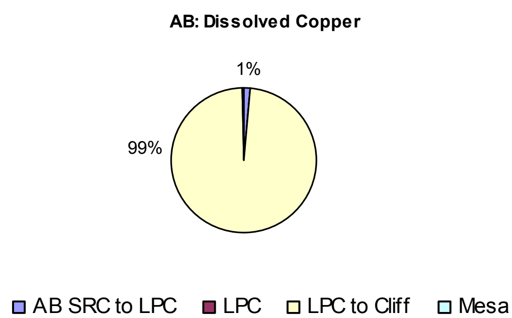
Mission Creek: Q2



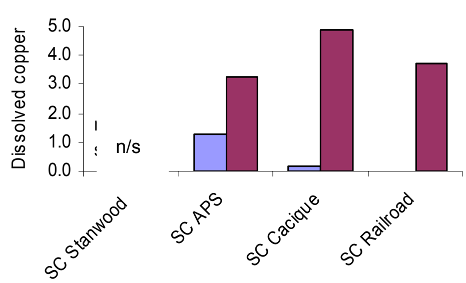


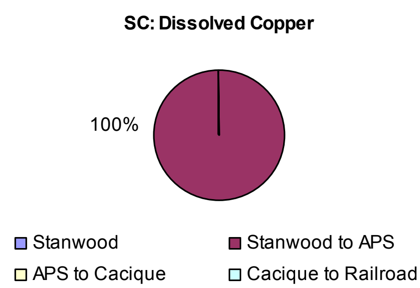
Arroyo Burro: Q2



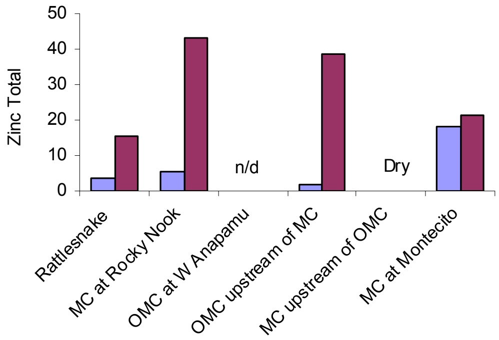


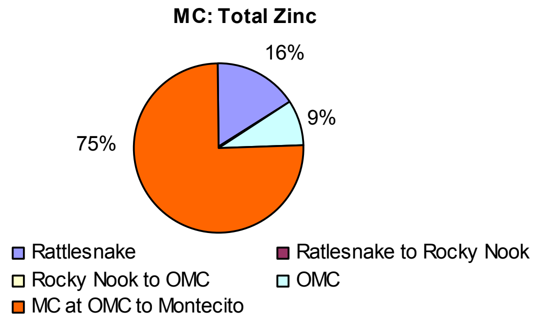
Sycamore Creek: Q2





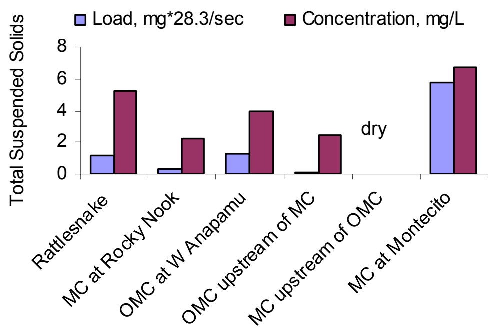
Mission Creek: Q2

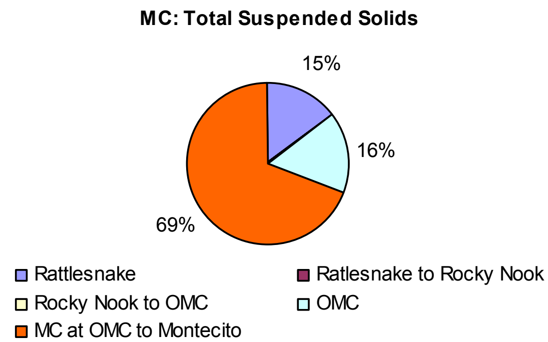




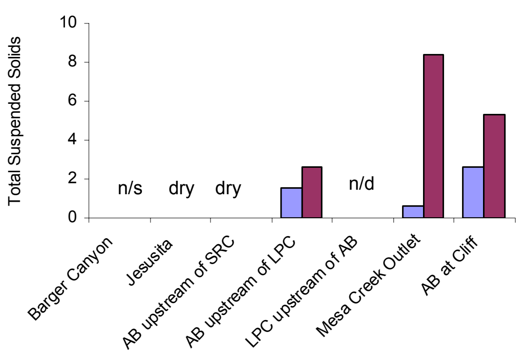
Total Suspended Solids- In Mission Creek, the greatest load of total suspended solids entered in the lowest reach (MC at OMC to Montecito St.). In Arroyo Burro, the greatest load entered between San Roque Creek and Las Positas Creek. Mesa Creek had the highest TSS concentrations of any site. Concentrations at Sycamore were highest at APS; again the pie chart may be misleading due to unusual flow conditions and limited flow measurements.

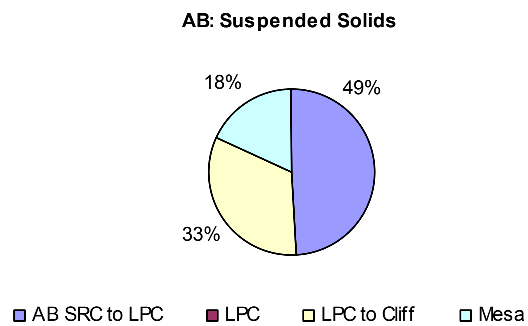
Mission Creek: Q2



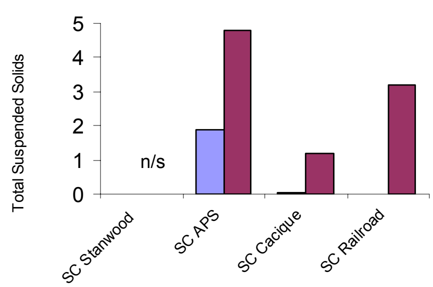


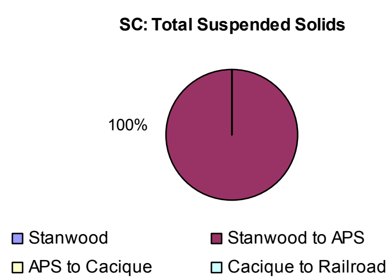
Arroyo Burro: Q2





Sycamore Creek: Q2

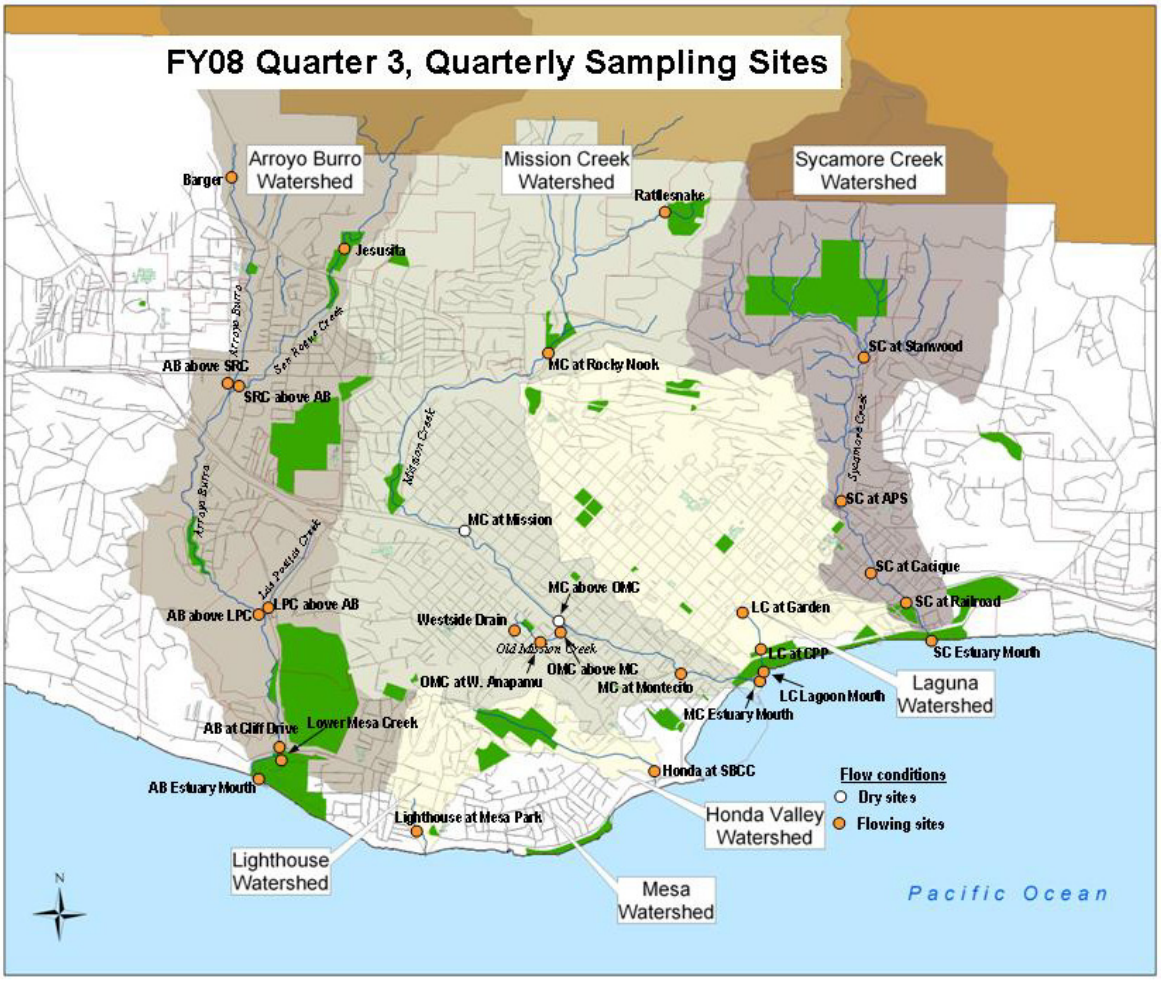




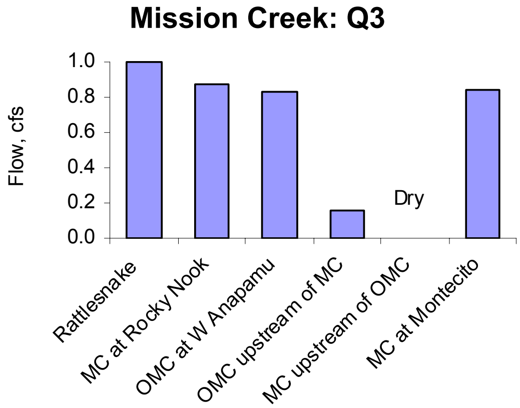
Toxicity- During Quarter 2 (Fall), toxicity was tested at all four integrator sites. Results were 100% survival for Laguna Channel and Sycamore Creek, and 95% for both Mission Creek and Arroyo Burro. This score translates to a toxicity score of .41 TU(a), which exceeds the California Ocean Plan criteria of .3 TU(a).

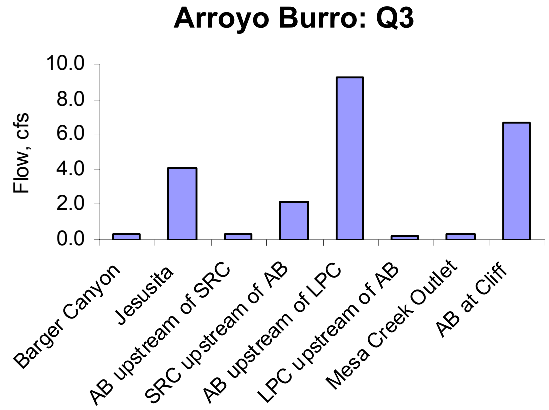
Quarter 3 (Winter)
Quarterly results and analysis are presented for Mission Creek (January 15), Arroyo Burro (February 5), and Sycamore Creek (March 11). Due to more consistent wet-season flow conditions, more sites were sampled this quarter than in Q2.

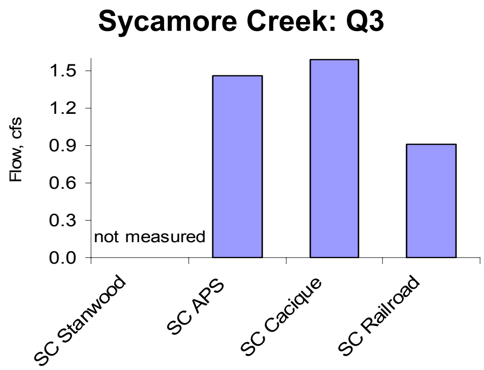
In the results presented below, bar charts show the absolute levels of concentration and load for each constituent, at each sampling point. Pie charts illustrate the percent of material entering the creeks in particular reaches.



Flow: The bar graphs below show flow at three watersheds on quarterly sampling days. Because this quarter was during the wet season, flow conditions were generally very different from the previous quarter with fewer dry sites and more normal flow patterns throughout the watersheds. Specifically, it is worth noting that Arroyo Burro's quarterly sampling was conducted approximately 3 days after a large rain event, and Mission Creek's quarterly sampling was conducted approximately one week after a large rain event.





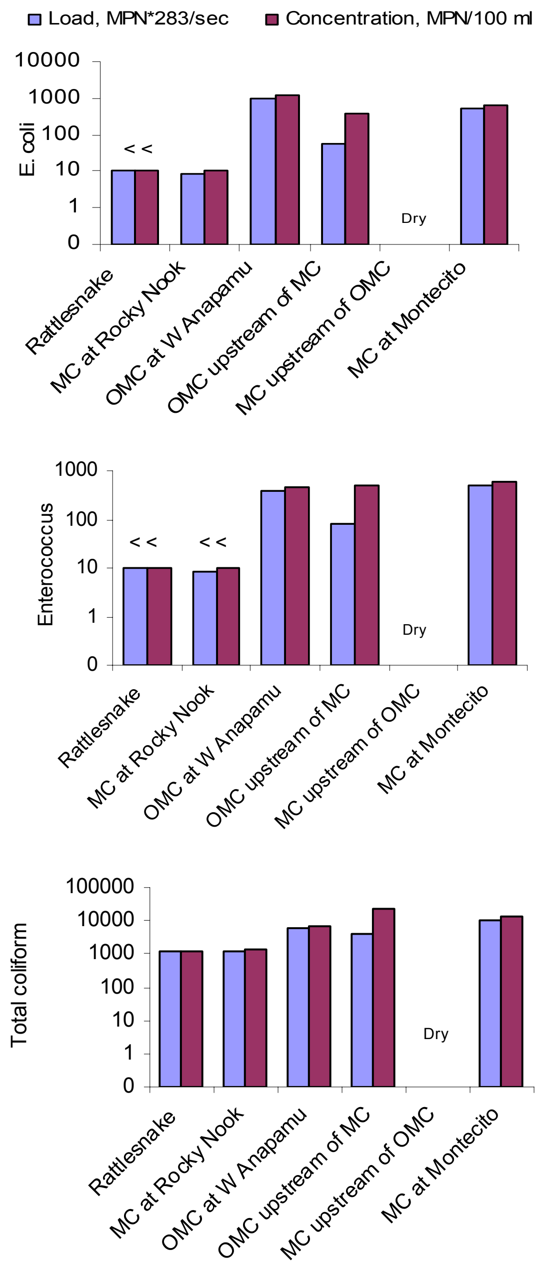


Indicator bacteria: In Mission Creek, results were similar to the previous quarter. Bacteria was highest (in terms of both concentration and load) at Montecito Street and at Old Mission Creek (both sites), and lowest in the upper reaches of the watershed.

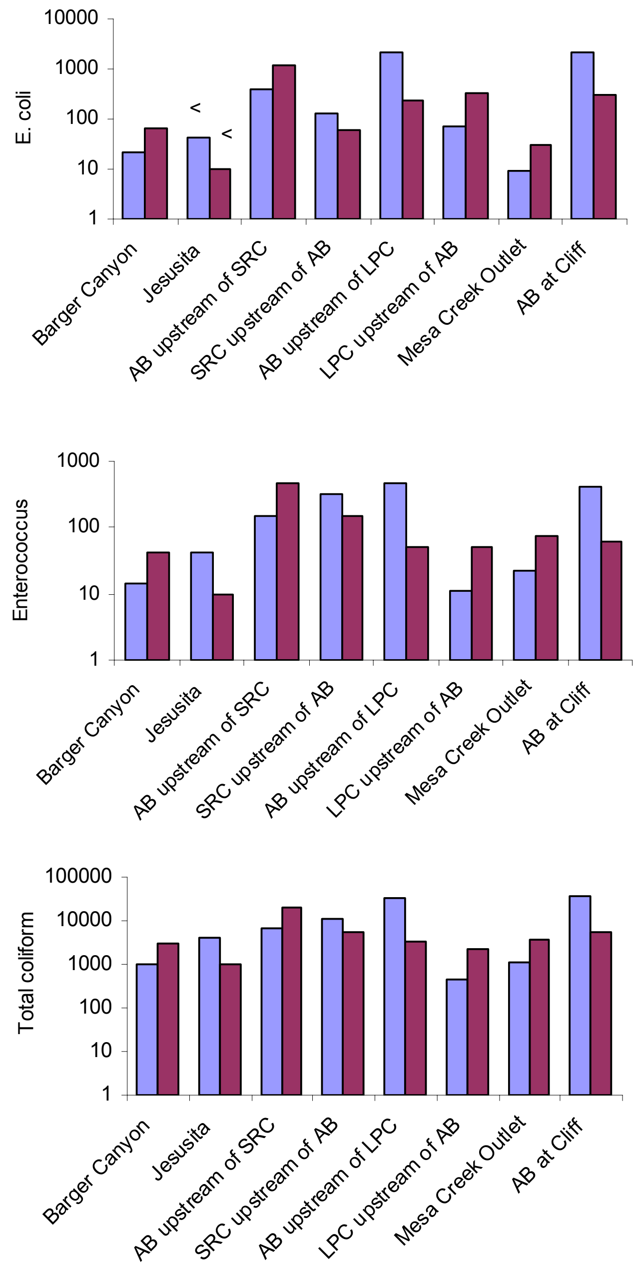
In Arroyo Burro, results varied more from Q2, mainly due to rainy-season flow conditions (allowing many more sites to be sampled and analyzed). However, the highest loads were again found at the same two sites: AB upstream of LPC and AB at Cliff. Concentrations at Barger, relative to the other sites, were much lower this quarter than in previous quarters.

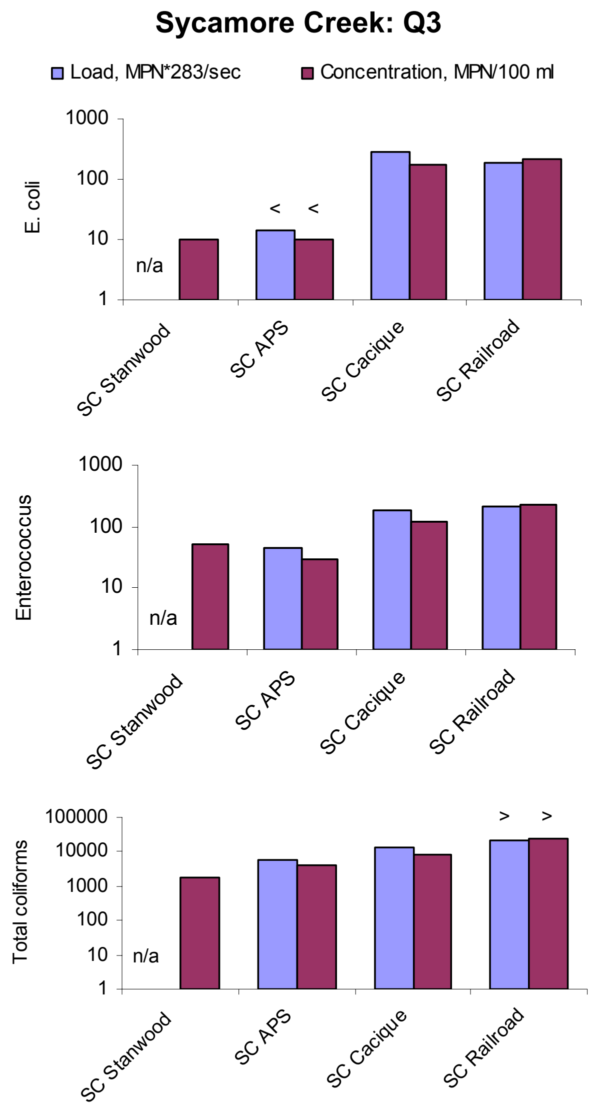
In Sycamore, while concentration patterns were similar to the previous quarter, load patterns were quite different. Rather than decreasing from upstream to downstream as they did in Q2, loads increased steadily from APS traveling downstream to Cacique and the railroad bridge.

Mission Creek: Q3



Arroyo Burro: Q3





The pie charts for Mission Creek show that while the majority of flow was received from the highest reach of the watershed (Rattlesnake), the highest bacteria loads came consistently from the lowest reach between OMC and Montecito St. The second highest contributor of bacteria loads was Old Mission Creek.

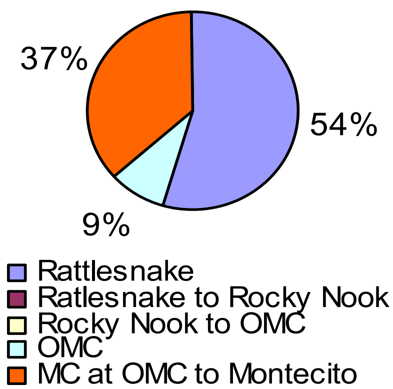
For Arroyo Burro, the largest contributor of flow and bacteria loads was between SRC and LPC, with the major exception of Enterococcus where the largest portion entered on San Roque Creek between Jesusita and the confluence with AB. Another reach that contributed a substantial portion of all three types of bacteria was AB between Barger and the confluence with SRC.

In Sycamore Creek, the majority of flow was received from the upper reaches above APS (because flow could not be measured at Stanwood, it is unknown what proportion of flow was received between APS and Stanwood, and above Stanwood). However, the large majority of bacteria loading occurred below APS, in the middle reach between APS and Cacique.

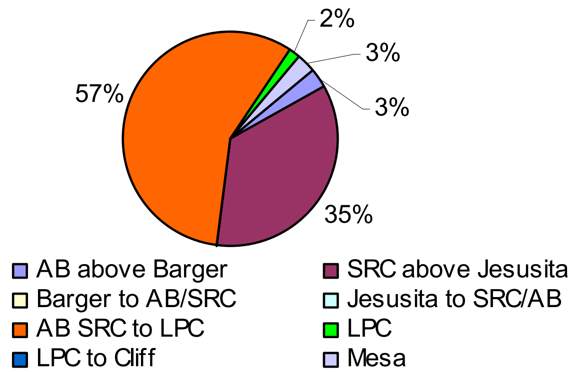
Mission Creek: Q3

Arroyo Burro: Q3

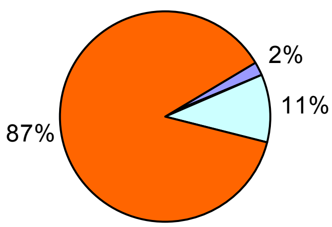
MC: Flow



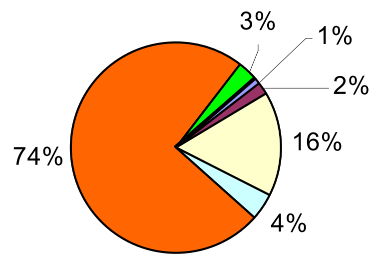
AB: Flow



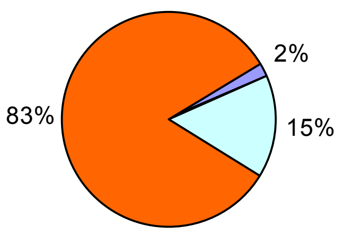
MC: E. coli



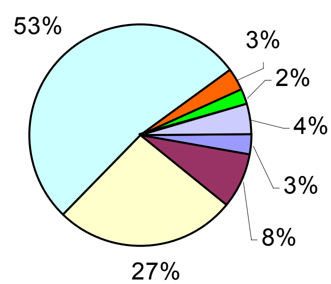
AB: E. coli



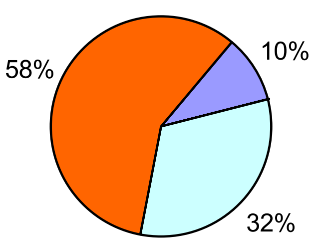
MC: Enterococcus



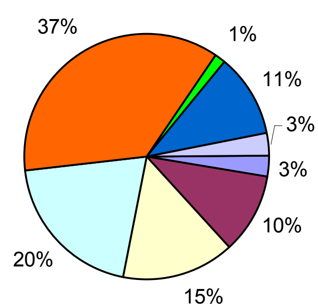
AB: Enterococcus



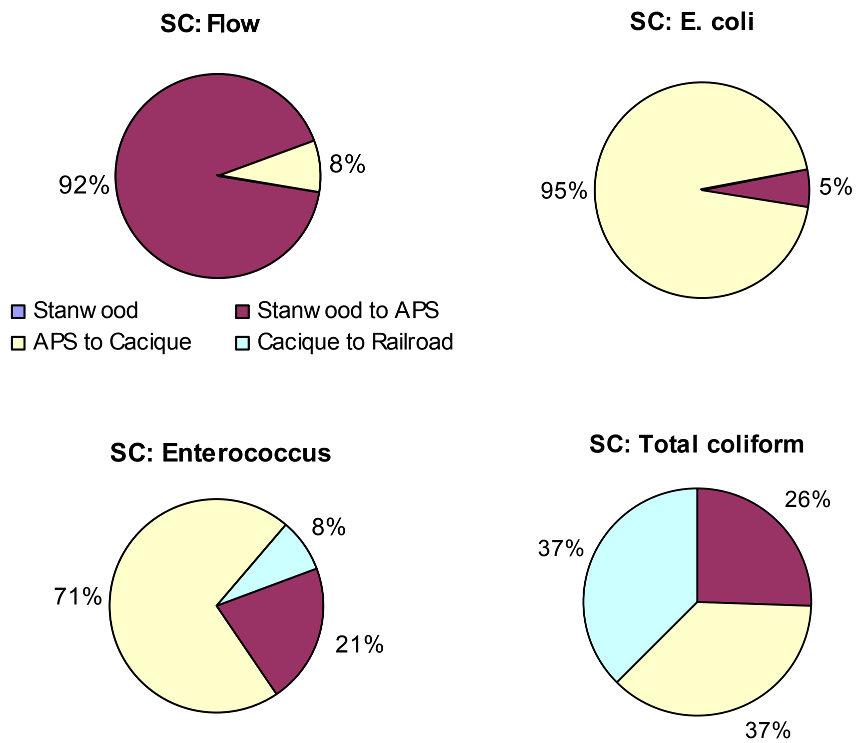
MC: Total coliform



AB: Total Coliform



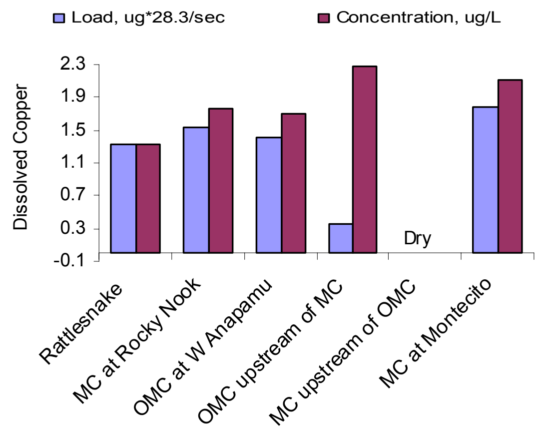
Sycamore Creek: Q3

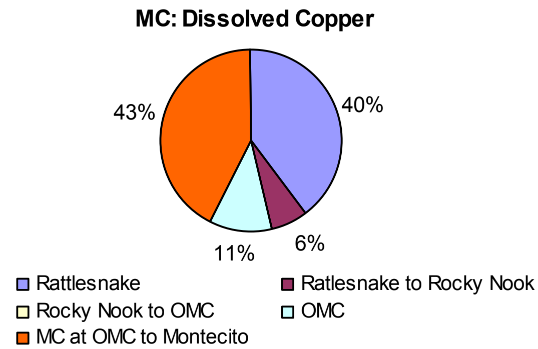


Metals- Dissolved copper was the only metal of interest found consistently throughout all three watersheds. For Mission Creek, the largest load of copper (43%) entered in the lowest reach (OMC to Montecito), however the total percentage was much less than in Q2 (96%). Interestingly, the upper reach Rattlesnake was a close second this quarter (40%), compared to 0% (non-detect) in Q2. For Arroyo Burro, the middle reach (SRC to LPC) was the largest contributor with 54%. This result is very different from Q2, however this is likely due to drastically different flow conditions between the two quarters (many sites could not be analyzed in Q2 because they were dry or too low to sample). For Sycamore, loading increased between APS and Cacique this quarter, compared to Q2 when 100% was attributed to the section above APS. It is important to remember that no sample was collected at Stanwood therefore it is not known how much loading occurred between those two sites or above Stanwood and the pie graph may be inaccurate.

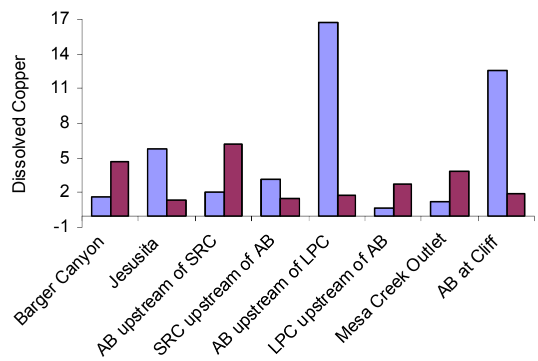
Total zinc and total iron were found consistently only in Arroyo Burro and are shown in the graphs below. For zinc, the largest load entered between LPC and Cliff Drive. For iron, the largest load entered between SRC and LPC.

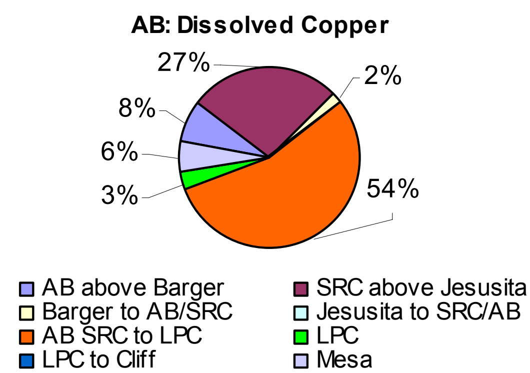
Mission Creek: Q3



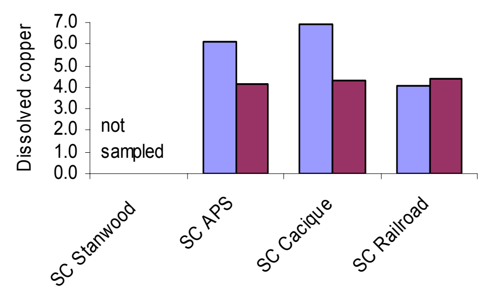


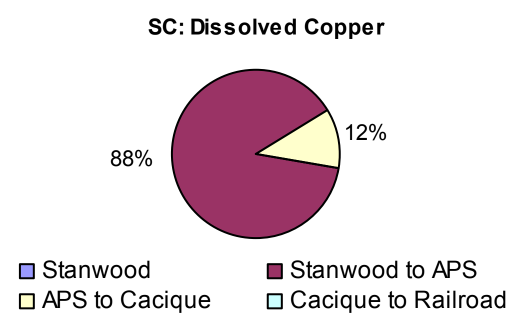
Arroyo Burro: Q3



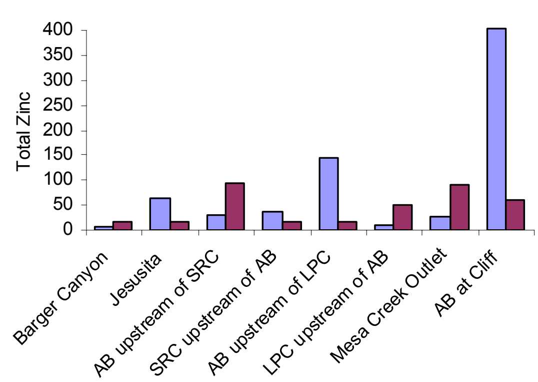


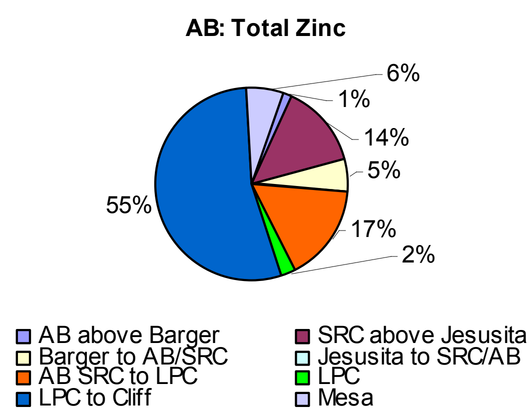
Sycamore Creek: Q3



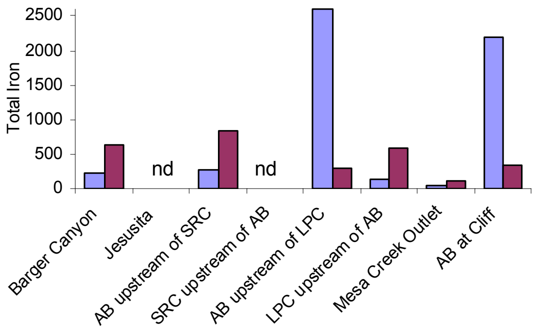


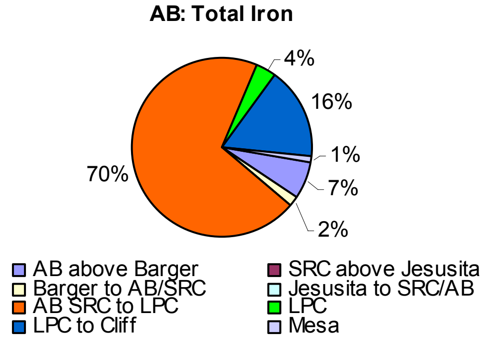
Arroyo Burro: Q3





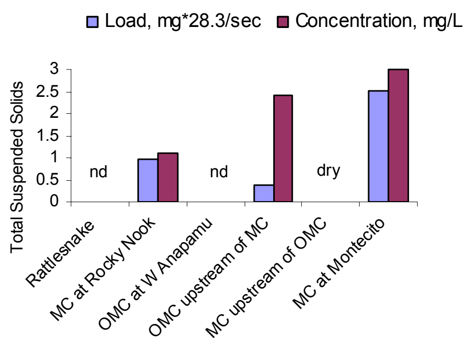
Arroyo Burro: Q3

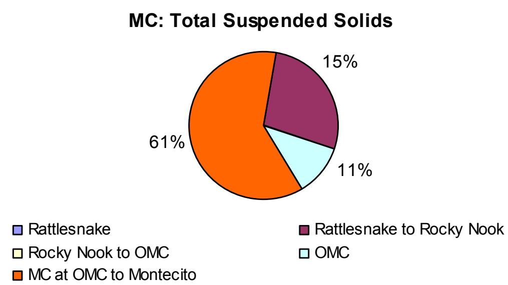




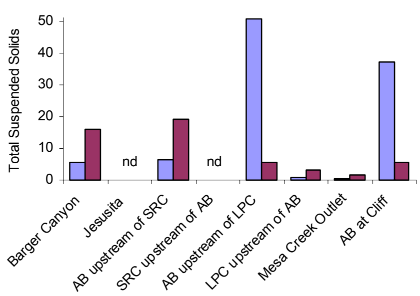
Total Suspended Solids- In general, results were similar to Q2 in terms of the reaches with the largest load contributions of total suspended solids: Mission Creek between OMC and Montecito St., Arroyo Burro between SRC and LPC, and Sycamore between Stanwood and APS. However some other results were very different: Rattlesnake went from 15% last quarter to zero (non-detect) this quarter, and total loads increased dramatically at several sites on Arroyo Burro (although this was likely due to sampling within days of a large storm). With Sycamore, while the pie graph shows 100% contribution above APS, it is important to remember that no sample was collected upstream at Stanwood therefore it is not known how much loading occurred between those two sites or above Stanwood and the pie graph may be inaccurate.

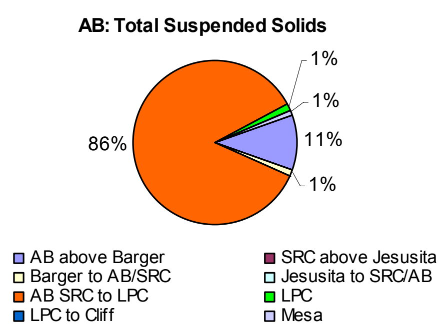
Mission Creek: Q3



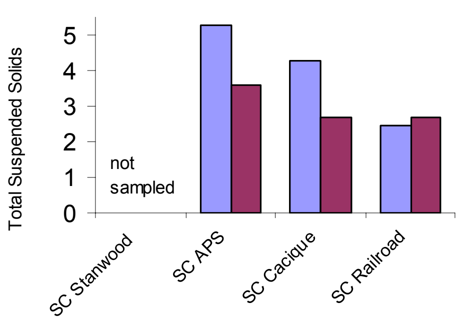


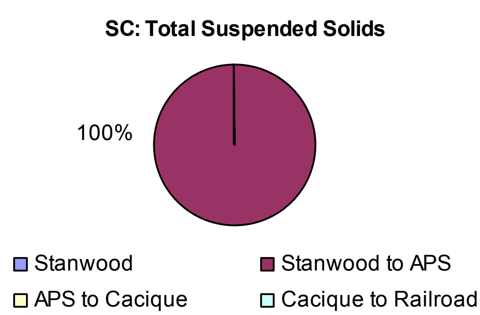
Arroyo Burro: Q3





Sycamore Creek: Q3



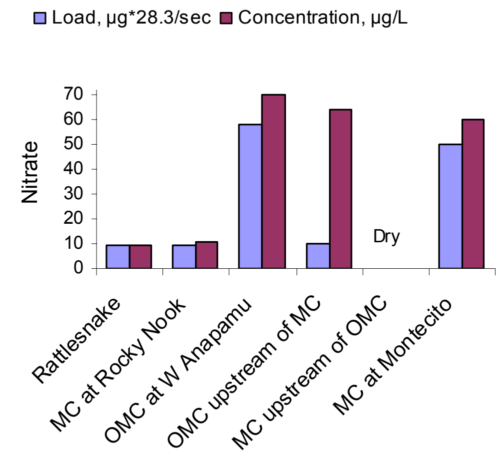


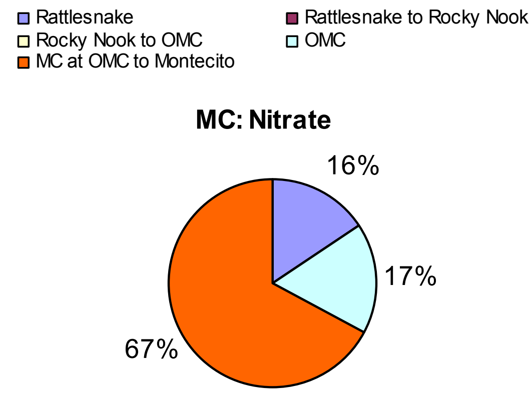
Nutrients: In Mission Creek watershed, Old Mission Creek had the highest loads and concentrations of all three nutrients (especially the upper site- OMC at W. Anapamu). However, because nutrient levels generally decreased before the confluence with Mission Creek, OMC was not always the highest contributor of nutrients to Mission Creek itself (as seen on the pie graphs).

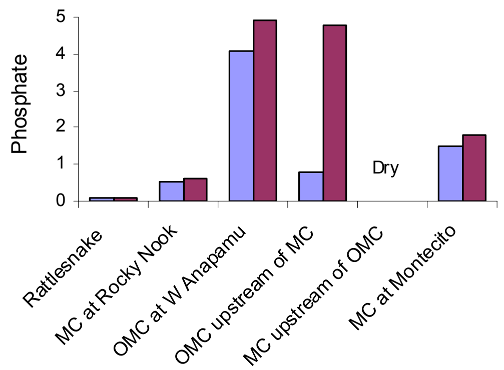
In Arroyo Burro, the highest loads of all three nutrients were found at AB upstream of LPC and AB at Cliff Drive. According to the pie charts, the large majority of nitrate and phosphate entered the creek between the confluence of AB and SRC (at Hope Ave.) and AB above LPC. However, it is important to note that no nutrient sample was collected at SRC upstream of AB; therefore a level of zero was used for the purpose of calculations. This means that the percentage shown in the pie graphs for AB SRC to LPC is likely an over-estimate. In reality it is likely that nutrients at SRC upstream of AB were not zero, and that some portion of the nutrient loading attributed to AB SRC to LPC actually entered SRC somewhere between Jesusita and the confluence with AB. In contrast with nitrate and phosphate, the large majority of ammonium entered the creek in the lowest section, between LPC and Cliff Dr.

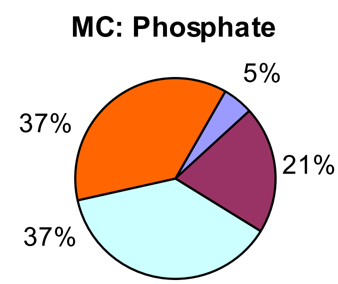
In Sycamore Creek, the highest loads and concentrations of all three nutrients were found at APS, and decreased steadily through the lower sections of the watershed. However, it is important to remember that no nutrient sample was collected upstream at Stanwood, therefore it is not known how much nutrient loading occurred between those two sites or above Stanwood and the pie graph may be inaccurate.

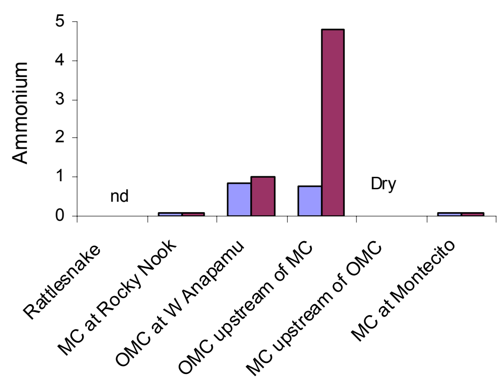
Mission Creek Nutrients: Q3

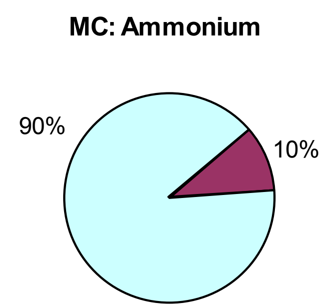




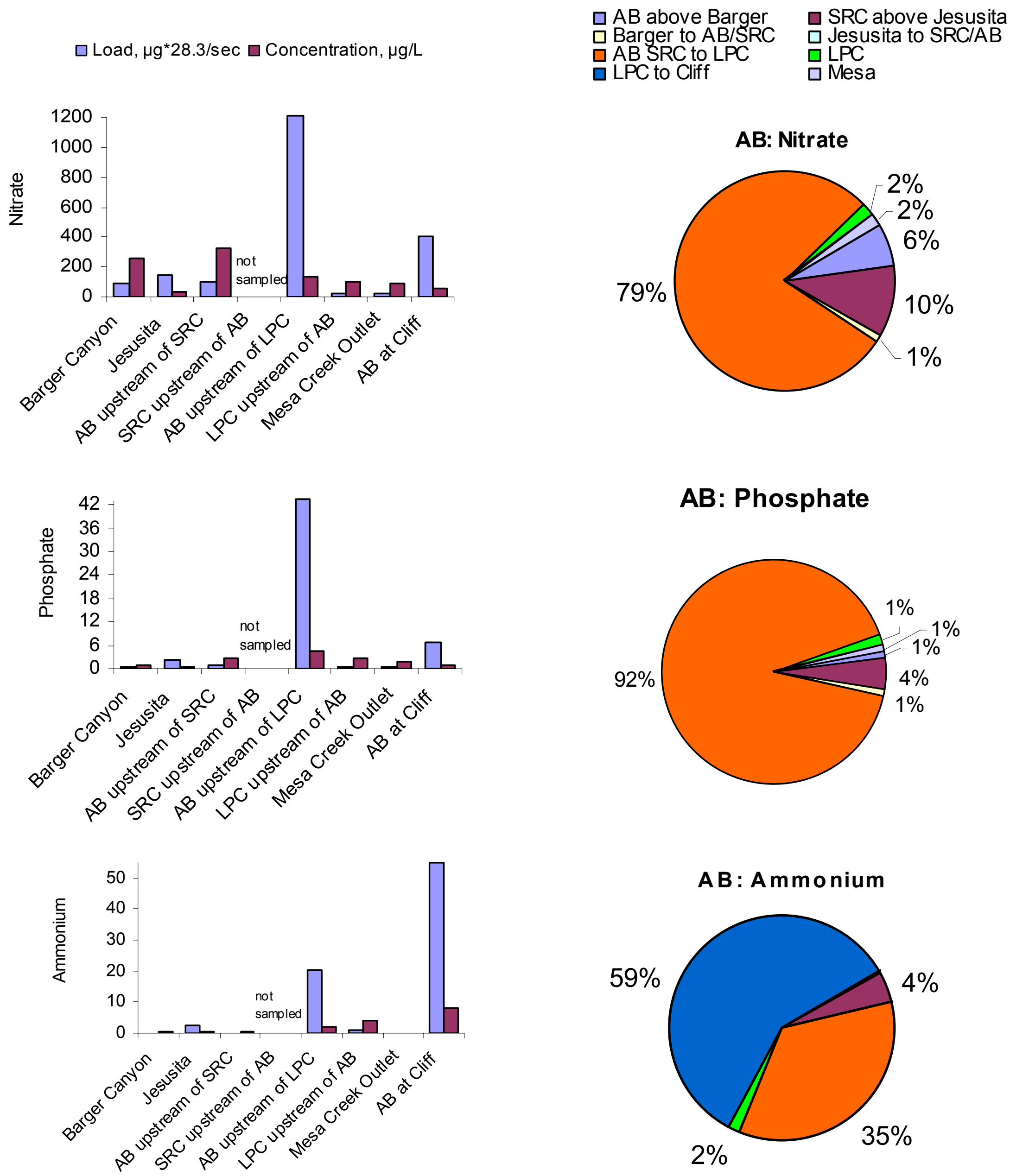


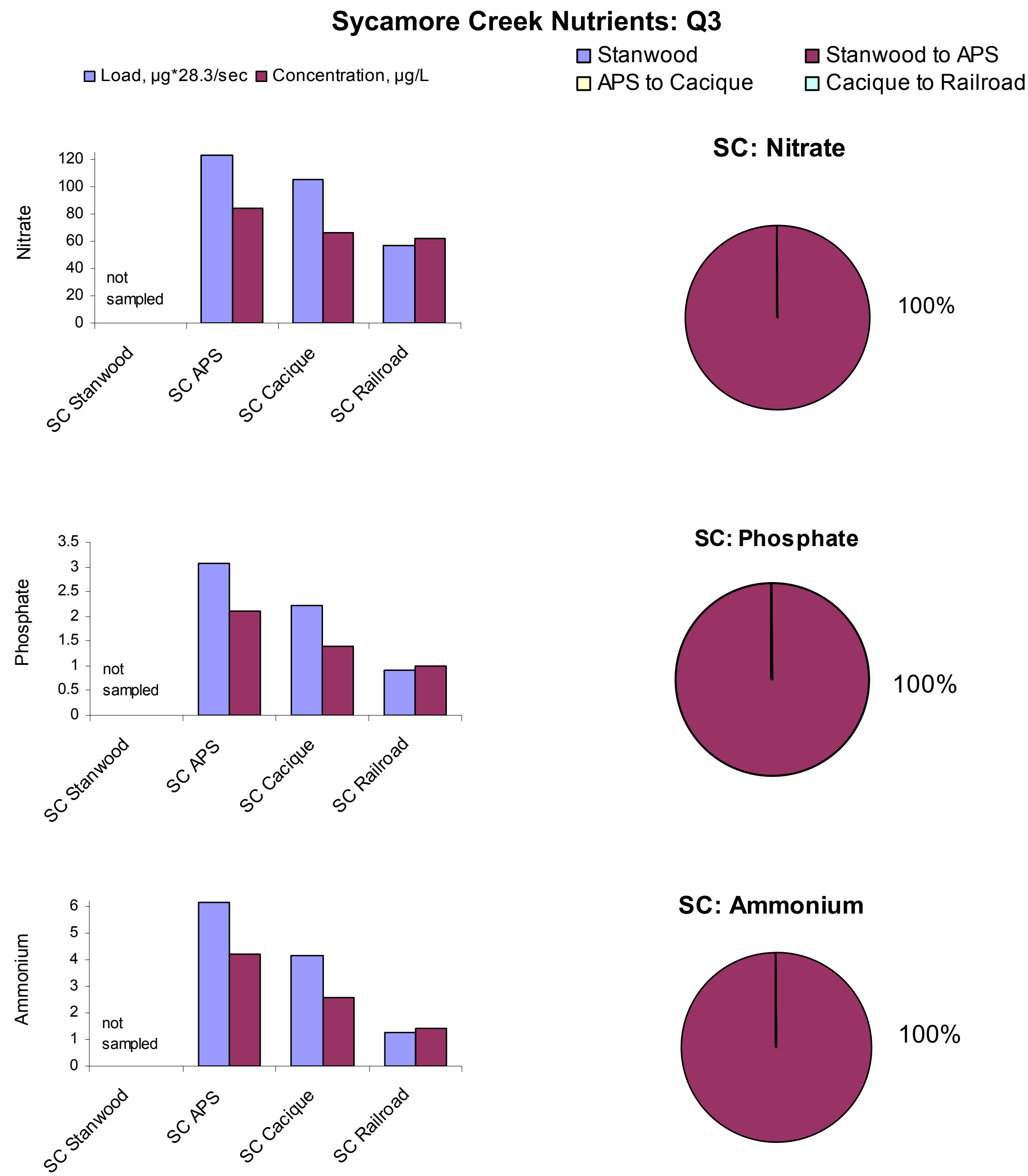






Arroyo Burro Nutrients: Q3

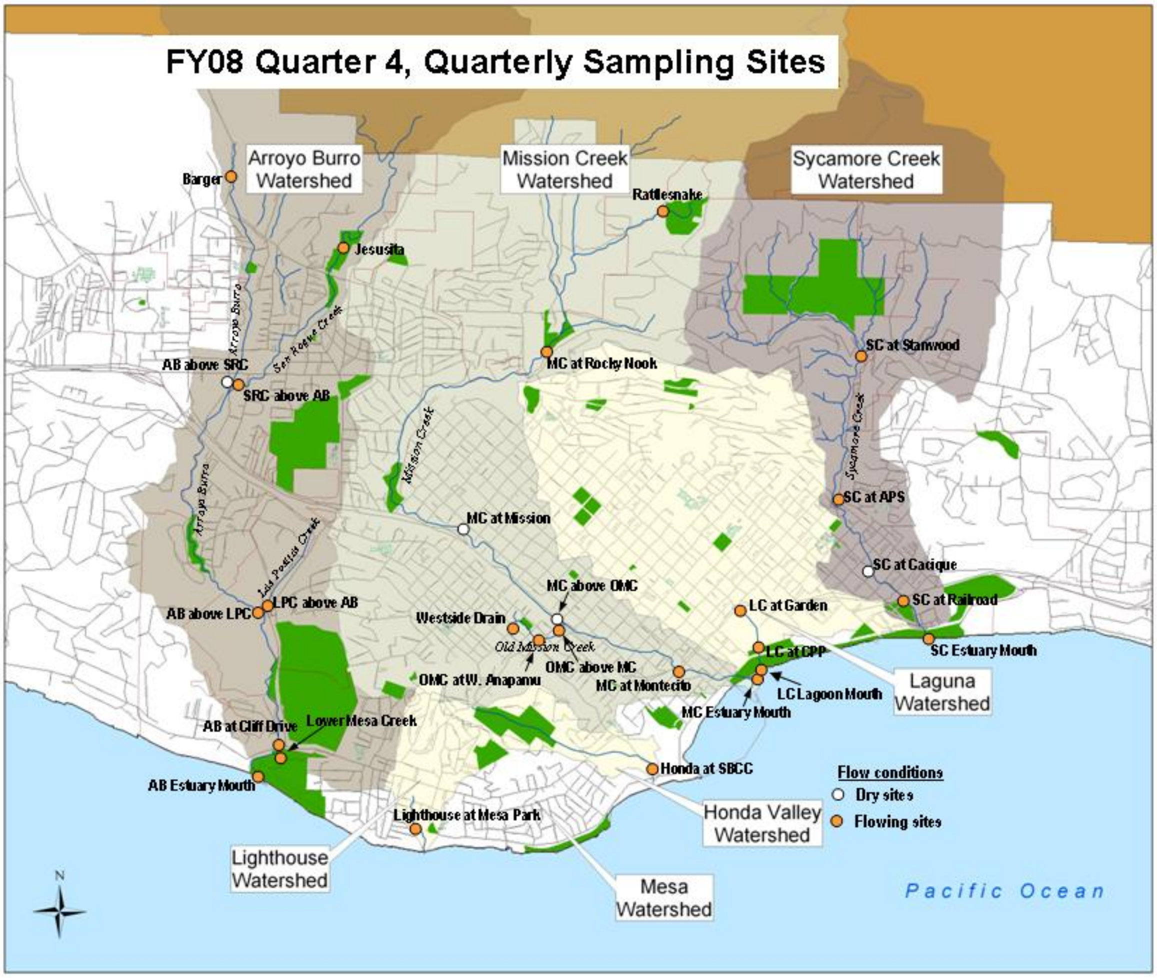




Toxicity- During Quarter 3 (Winter), toxicity was tested at all four integrator sites. Results were 100% survival for Arroyo Burro, Laguna, and Sycamore, and 95% survival for Mission. This score translates into a toxicity score of .41 TU(a), which exceeds the California Ocean Plan criteria of .3 TU(a). Mission Creek has exceeded this level every quarter so far this year.

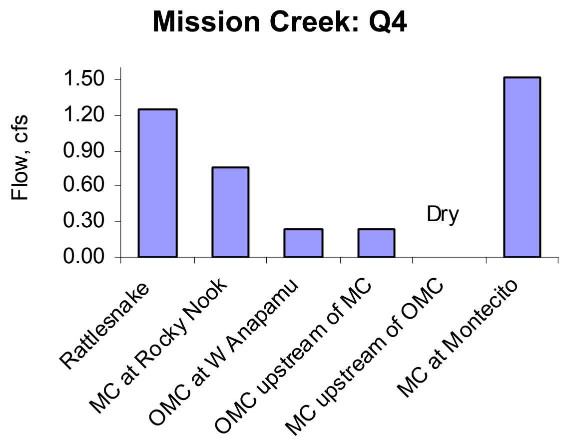
Quarter 4 (Spring)
Quarterly results and analysis are presented for Mission Creek (April 8), Arroyo Burro (June 4), and Sycamore Creek (June 17).

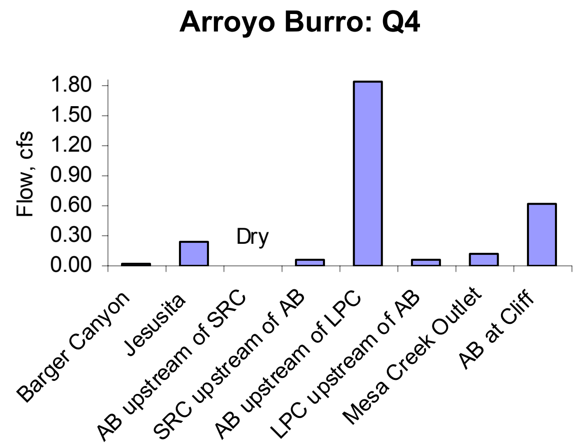
In the results presented below, bar charts show the absolute levels of concentration and load for each constituent, at each sampling point. Pie charts illustrate the percent of material entering the creeks in particular reaches.

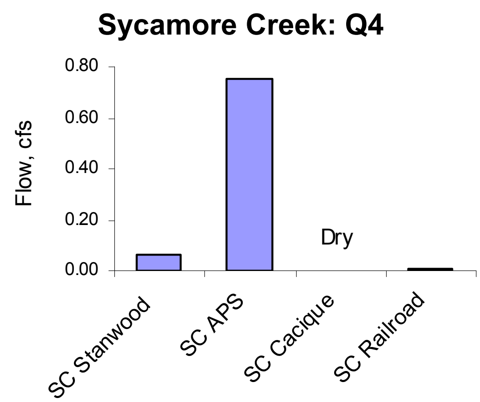


Flow: The bar graphs below show flow at three watersheds on quarterly sampling days. Flow conditions were fairly different from Q3 due to seasonal variation, especially at Arroyo Burro and Sycamore.

Because a flow measurement was not taken at OMC at W. Anapamu (Mission Creek watershed), the flow shown in the graph (and used for analysis throughout this section) was actually the measurement from the Westside Drain, just upstream. Because there are no considerable inputs between these two sites, this should be a reasonable substitution and should provide a fairly accurate analysis. The low flow measured at OMC upstream of MC may have been due to fluctuations in flow due to the Westside SURF project.





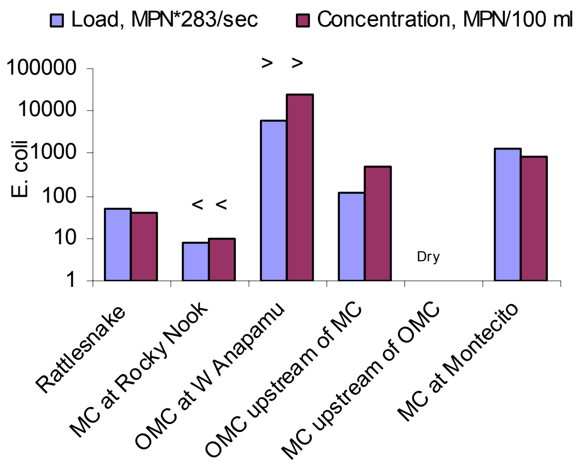


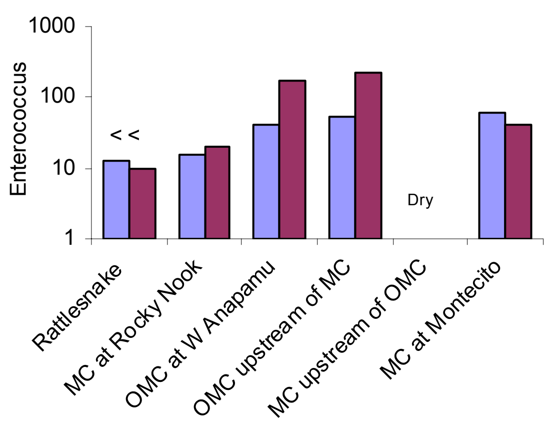
Indicator bacteria – In Mission Creek, results were similar to previous quarters: bacteria was highest (in terms of both concentration and load) at Montecito St. and Old Mission Creek (both sites), and lowest in the upper reaches of the watershed.

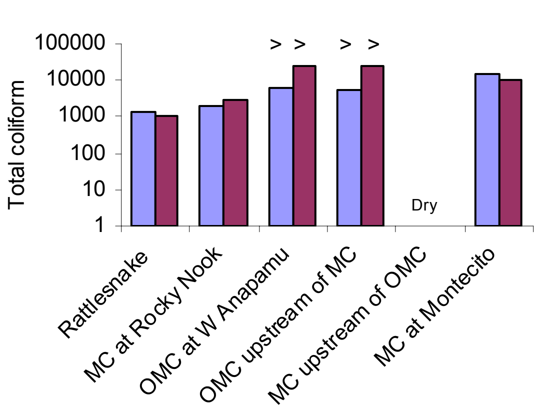
In Arroyo Burro, results were similar to last quarter, with the highest loads and concentrations found at AB upstream of LPC and AB at Cliff. However, this quarter Mesa Creek also stood out as a major contributor of bacteria, particularly with *E. coli*. In addition, Barger Canyon had very high enterococcus concentrations that contributed substantial loading despite its very low flow.

In Sycamore, results varied greatly from Q3, mainly due to very different flow conditions in the lower watershed. The two upper sites (Stanwood and APS) had the highest loads and concentrations of all three bacteria types.

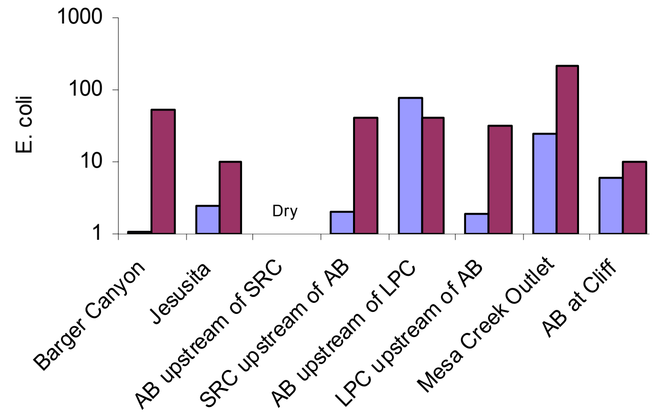
Mission Creek: Q4

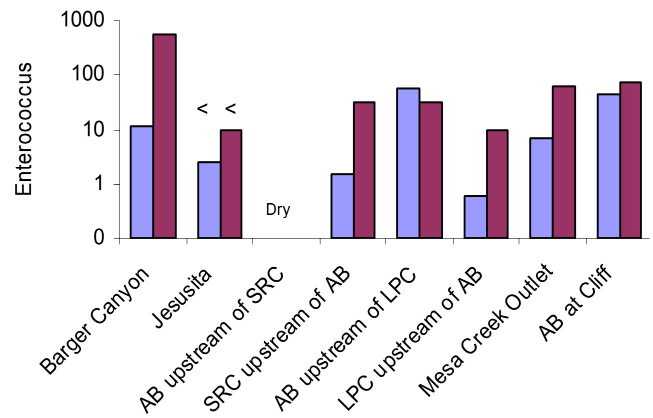


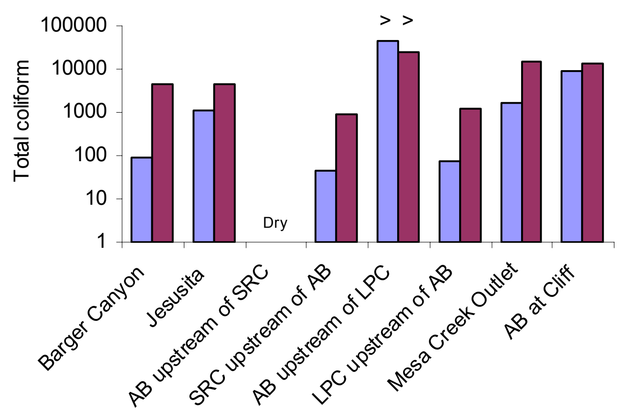


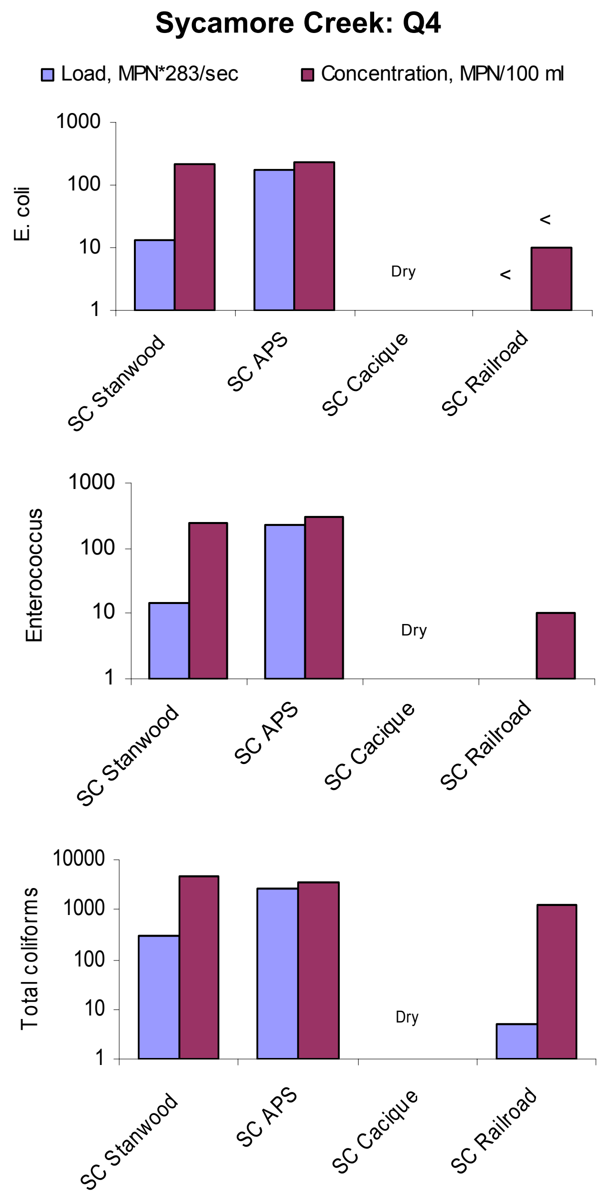


Arroyo Burro: Q4







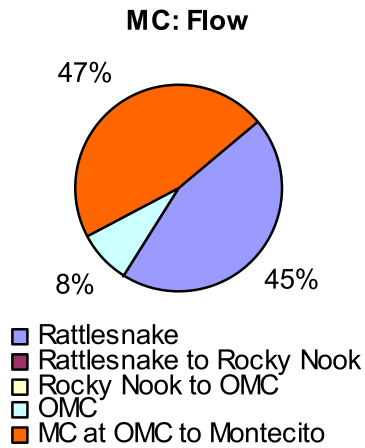


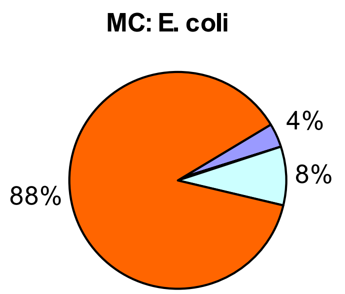
The pie charts for Mission Creek show that the majority of flow was received from the lowest reach (OMC to Montecito) and the highest reach (Rattlesnake). For bacteria, results are somewhat mixed. While the lowest reach contributed the highest loads of *E. coli* and Total Coliform, Old Mission Creek contributed the large majority of Enterococcus this quarter.

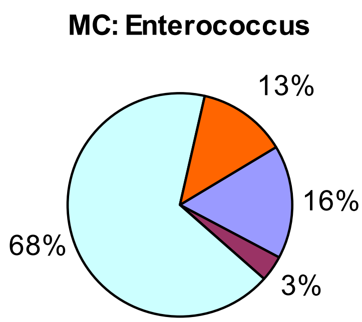
For Arroyo Burro, the middle reach from SRC to LPC was by far the largest contributor of flow, as well as all three bacteria types.

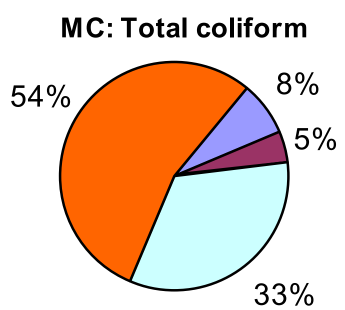
For Sycamore, the reach between Stanwood and APS was by far the largest contributor of flow, as well as all three bacteria types. However, it is important to keep in mind that Cacique was dry and could not be sampled, therefore analysis from the lower watershed may be inaccurate.

Mission Creek: Q4

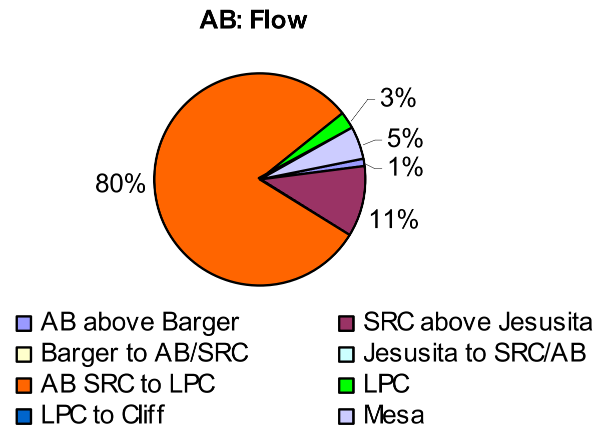


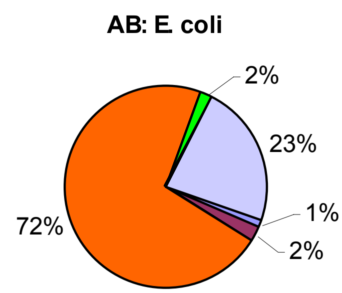


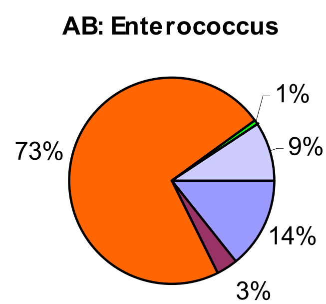


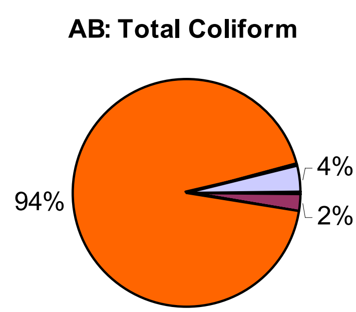


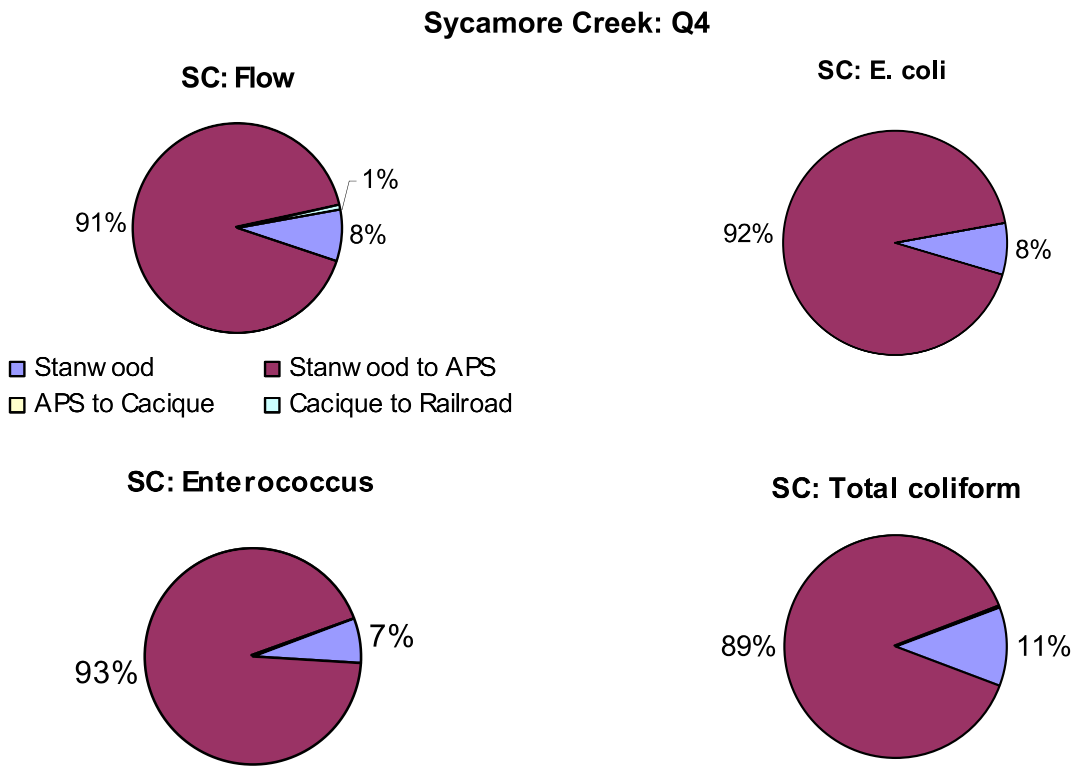
Arroyo Burro: Q4











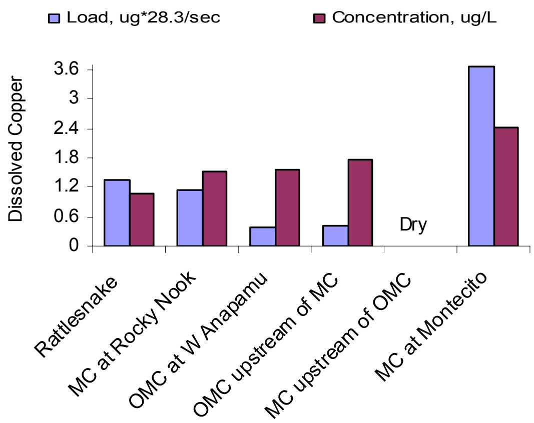
Metals- Dissolved copper and total zinc were the only two metals found consistently through all three watersheds, and are analyzed in the graphs below. In addition, total iron is shown for Arroyo Burro (the only watershed where it was detected somewhat consistently).

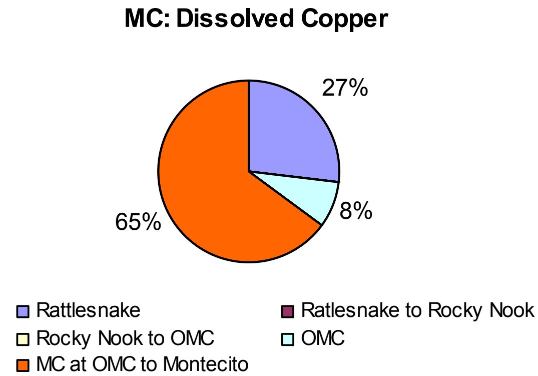
For dissolved copper in Mission Creek, the largest load (65%) entered in the lowest reach OMC to Montecito; this has been the case during every quarter this year. Once again, Rattlesnake was the second highest contributor (27%). In Arroyo Burro, the largest load (84%) entered in the lower-middle reach between SRC and LPC. Barger Canyon, while contributing very little in terms of load, was a major hotspot as far as concentration. In Sycamore, nearly the entire dissolved copper load entered in the reach between Stanwood and APS.

For total zinc in Mission Creek, the highest loads were found above Rattlesnake and in the Old Mission Creek tributary while only a small portion of loading occurred in the lower reach. Zinc in Arroyo Burro shows very interesting results: the highest loading occurred in the lowermost (LPC to Cliff, 61%) and uppermost (above Jesusita, 34%) reaches. In Sycamore, the large majority of zinc loading occurred between Stanwood and APS. It is important to keep in mind, however, that no sample was obtained at Cacique therefore analysis from the lower watershed may be inaccurate.

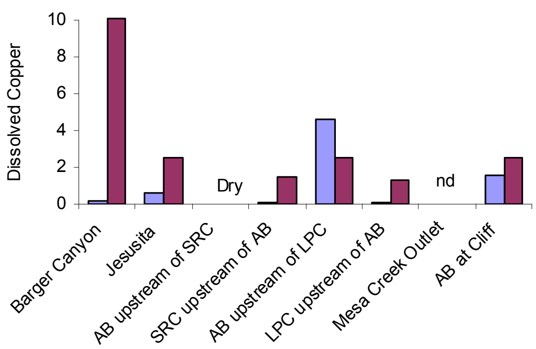
In Arroyo Burro, nearly all loading of total iron occurred in the lowest portions of the watershed: on the main stem of Arroyo Burro below the confluence with LPC, the LPC tributary itself, and the Mesa Creek tributary.

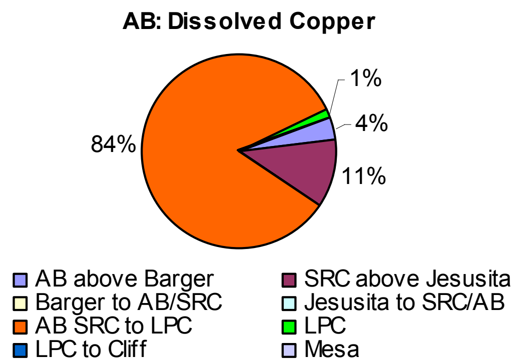
Mission Creek: Q4



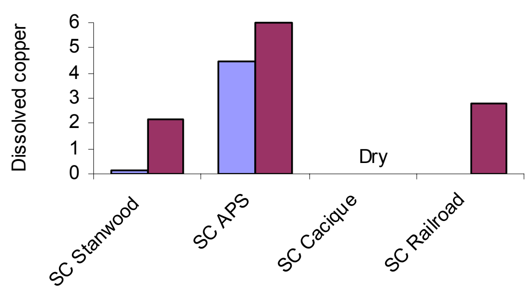


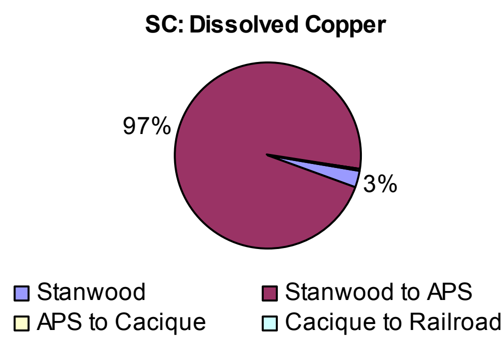
Arroyo Burro: Q4



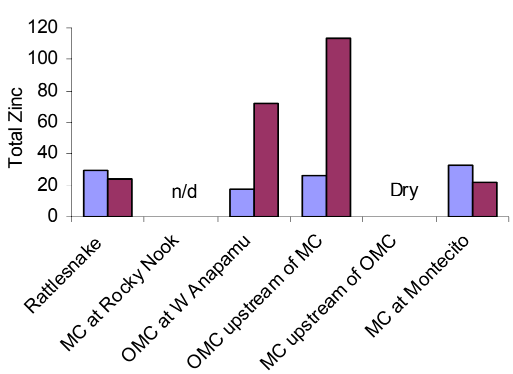


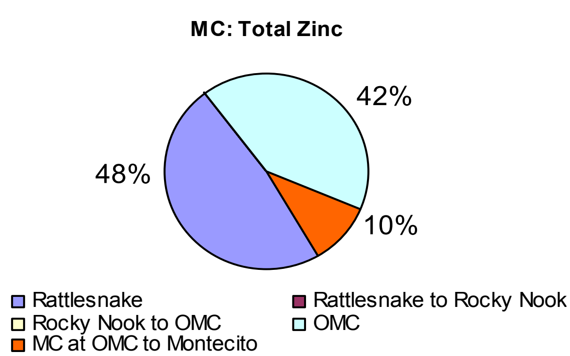
Sycamore Creek: Q4



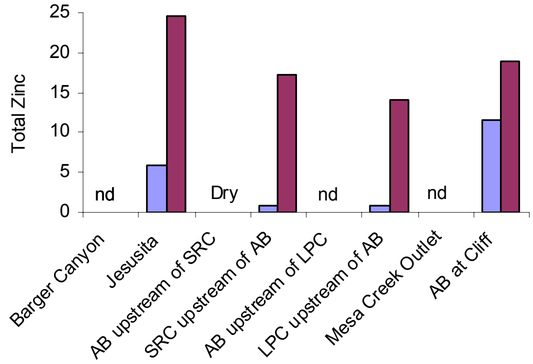


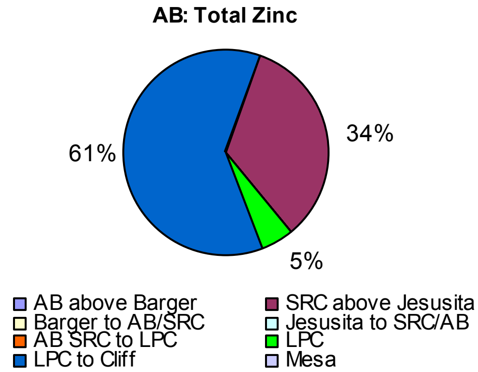
Mission Creek: Q4



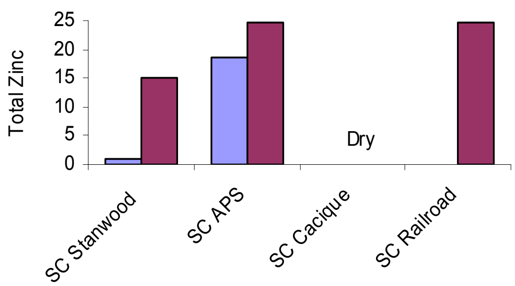


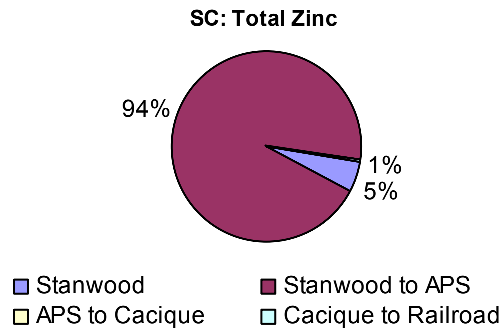
Arroyo Burro: Q4



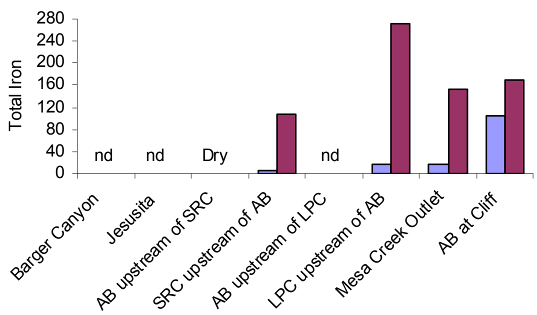


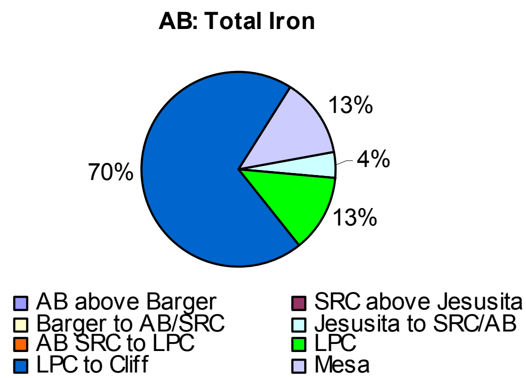
Sycamore Creek: Q4





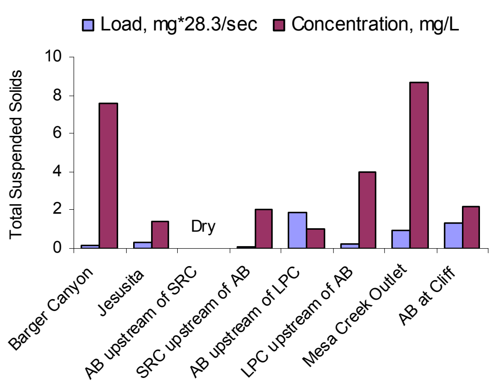
Arroyo Burro: Q4

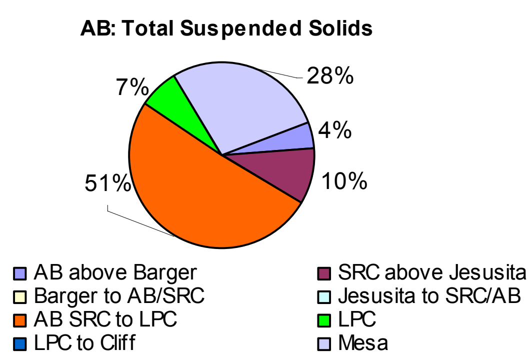




Total Suspended Solids- This quarter, total suspended solids were detected only in Arroyo Burro. Approximately half of the loading occurred in the middle reach from SRC to LPC. Mesa Creek was also a substantial contributor in terms of both load and concentration.

Arroyo Burro: Q4



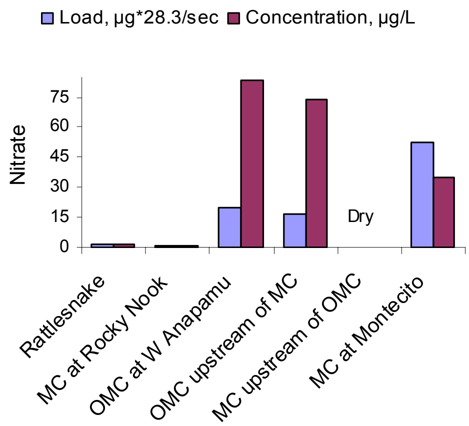


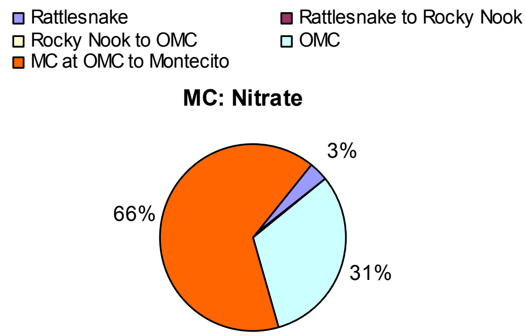
Nutrients- In Mission Creek, the highest loads of all three nutrients were found in the lowest reach of the watershed. Concentrations of nitrate and phosphate, however, were highest in the Old Mission Creek tributary.

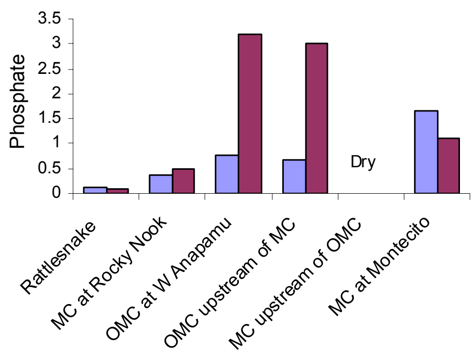
In Arroyo Burro, results were very mixed. Barger Canyon, despite having very low flow, was a major hotspot for nitrate with extremely high concentrations and the highest loading in the watershed. The second highest nitrate loading was found in the lower reach between LPC and Cliff Dr. For phosphate, the highest contributors in terms of both concentration and load were the two main tributaries: San Roque Creek and Las Positas Creek. For ammonium, the lower reach between LPC and Cliff contributed the large majority of the load. It is important to note that no nutrient sample was taken at AB upstream of LPC, therefore the loads represented in the pie graphs may be inaccurate in the lower reaches (AB SRC to LPC and LPC to Cliff). Values for AB upstream of LPC were treated as zero, therefore all nutrient loading between AB SRC and Cliff were attributed to the lowest reach (LPC to Cliff). In reality, it is likely that some of the nutrient loading attributed to the lowest reach (LPC to Cliff) actually entered the creek between SRC and LPC and should be represented by an orange-colored slice on the pie charts.

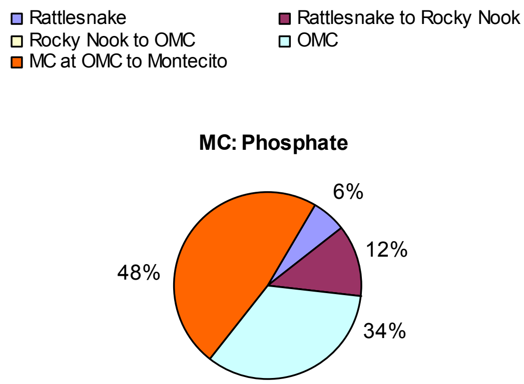
In Sycamore Creek, almost all of the nutrient loading occurred in the two upper portions of the watershed. For nitrate, nearly all loading occurred in the uppermost reach (above Stanwood), while for phosphate and ammonium, most of the loading occurred between Stanwood and APS. It is important to keep in mind, however, that no sample was obtained at Cacique therefore analysis from the lower watershed may be inaccurate.

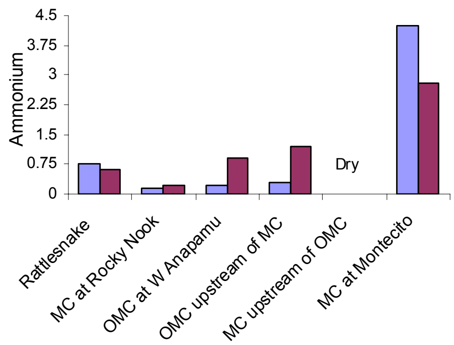
Mission Creek Nutrients: Q4

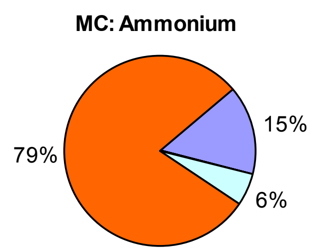




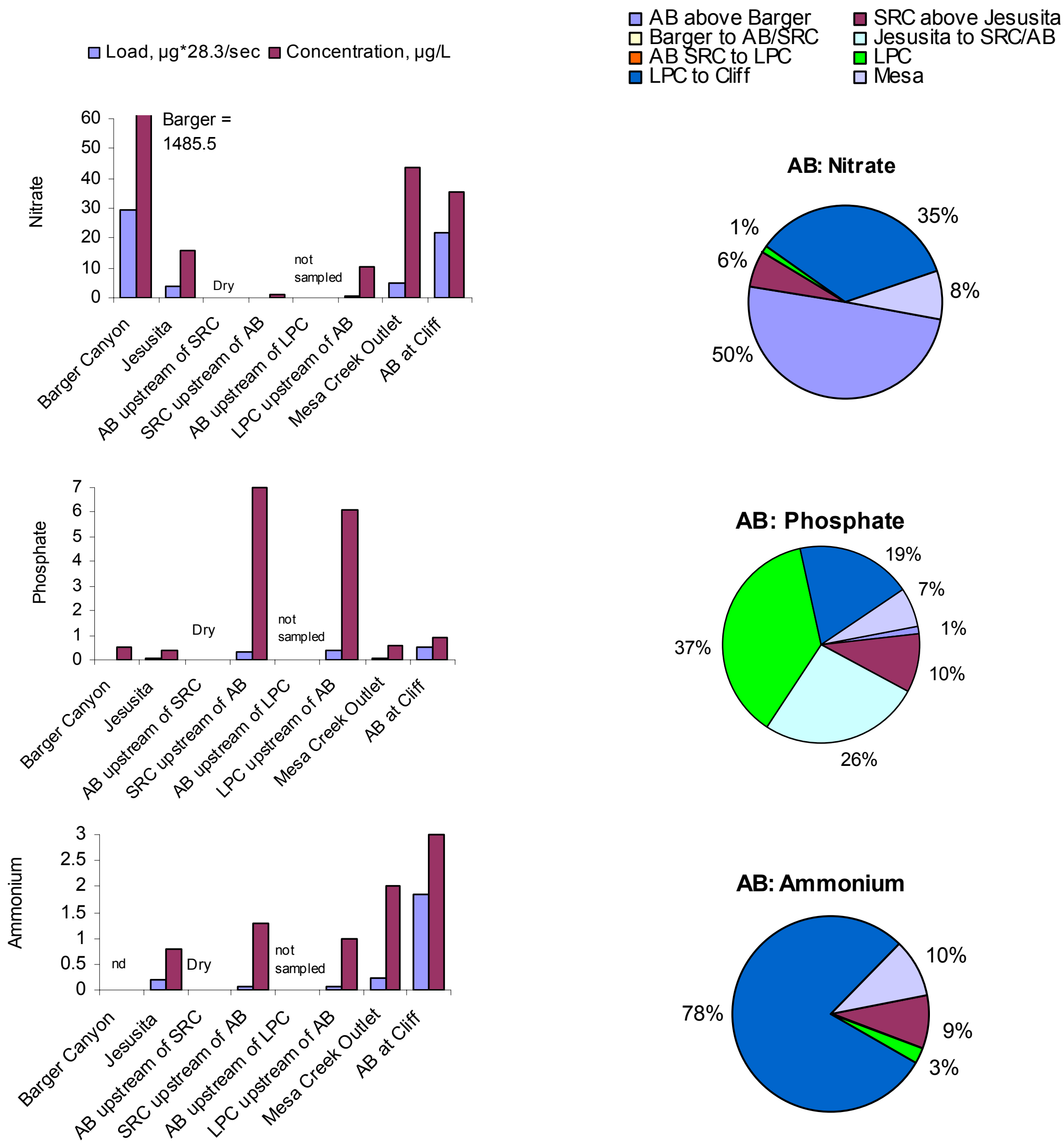




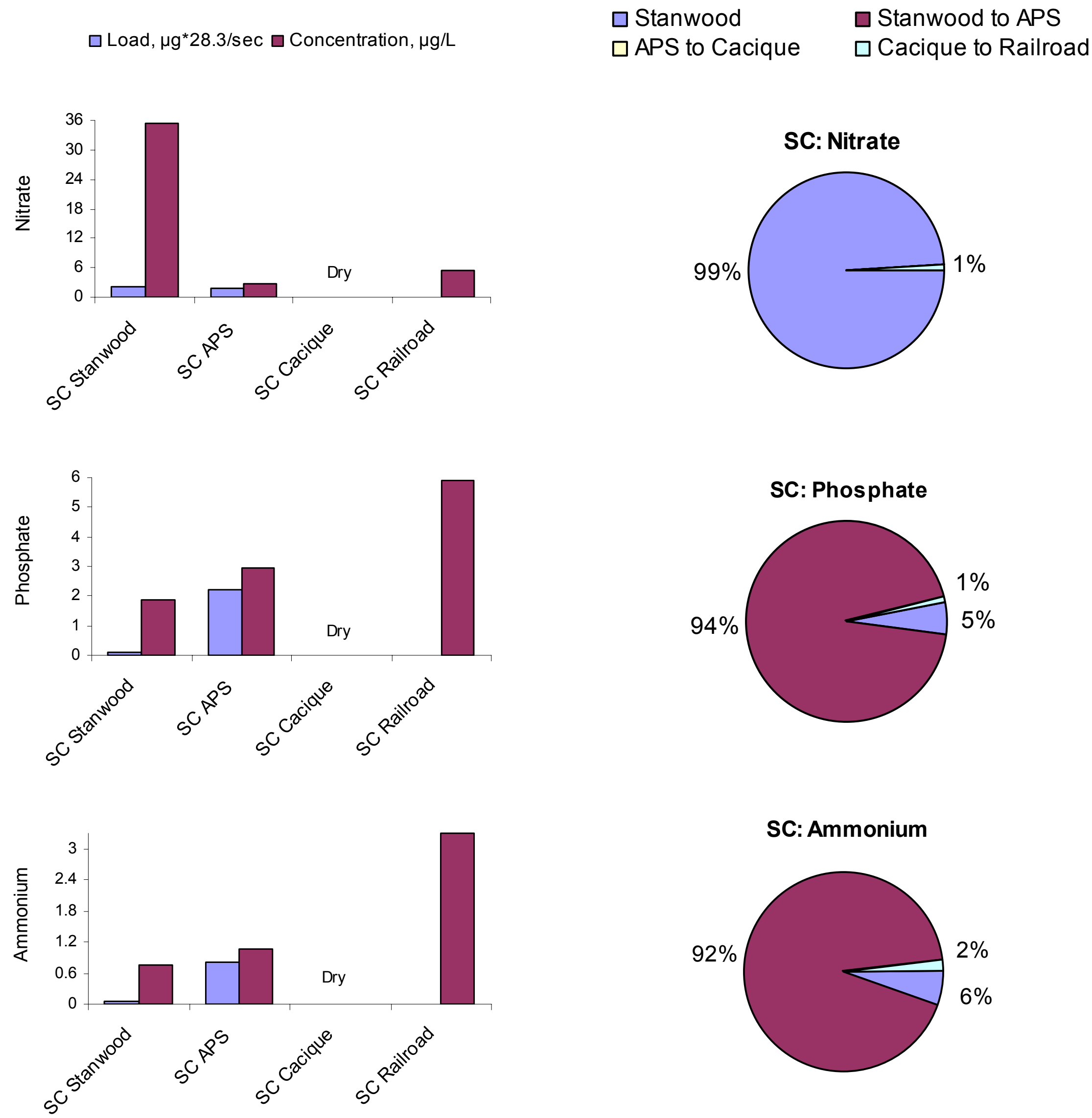




Arroyo Burro Nutrients: Q4



Sycamore Creek Nutrients: Q4



Toxicity- During Quarter 4 (Spring), toxicity was tested at all four integrator sites. Results were identical to those from Q3: 100% survival for Arroyo Burro, Laguna, and Sycamore, and 95% survival for Mission. This score translates into a toxicity score of .41 TU(a), which exceeds the California Ocean Plan criteria of .3 TU(a). Mission Creek exceeded this level every quarter this year.

TOXICITY TESTING

During FY08, toxicity was tested at the four integrator sites during quarterly sampling, first flush sampling, and annual sediment sampling. The table below summarizes all of the results, shown as both percent survival (%) and toxicity score (TU(a)) for water samples. Sediment sample results are shown only as percent survival (%), as no criteria currently exist for toxicity in sediment. Water sample results that exceeded the California Ocean Plan criteria of .3 TU(a) (corresponding to 98% survival) are highlighted in yellow. It is important to note that the standard is very stringent, in that it is higher than the requirement for survival in the control samples of state-certified laboratories (90% survival).

Sampling event	Mission Creek	Arroyo Burro	Laguna Channel	Sycamore Creek
First Flush Fall 07	100%, 0 TU(a)	95%, .41 TU(a)	100%, 0 TU(a)	not sampled- dry
Sediment Fall 07	97%	98%	100%	98%
Quarter 1 (Summer)	90%, .59 TU(a)	100%, 0 TU(a)	not sampled	100%, 0 TU(a)*
Quarter 2 (Fall)	95%, .41 TU(a)	95%, 0.41 TU(a)	100%, 0 TU(a)	100%, 0 TU(a)
Quarter 3 (Winter)	95%, .41 TU(a)	100%, 0 TU(a)	100%, 0 TU(a)	100%, 0 TU(a)
Quarter 4 (Spring)	95%, .41 TU(a)	100%, 0 TU(a)	100%, 0 TU(a)	100%, 0 TU(a)

* Sycamore's integrator site (railroad bridge) was dry, therefore toxicity sample was taken at first available flowing site (APS).

The results for the past year indicate that while no results are particularly high (the lowest survival rate was 90%), Mission Creek seems to have the poorest water quality in terms of toxicity. Mission exceeded the California Ocean Plan criteria during every quarterly sampling event. Arroyo Burro also exceeded the criteria, but only twice (during first flush and Quarter 2. Results at Laguna and Sycamore were near-perfect. The Creeks Division may consider comparing our results with those collected by CCAMP, and consider additional organisms for testing.

Dissolved Copper Toxicity

As noted in the 2001-2006 Water Quality Monitoring Report, dissolved copper has exceeded water criteria more than any other constituent. This is a common problem in many municipalities. However, high dissolved copper levels do not always correspond with high levels of toxicity, and therefore the US EPA has recently revised the criteria for dissolved copper (http://www.epa.gov/waterscience/criteria/copper/2007/index.htm). Copper toxicity occurs by blocking the sodium uptake binding sites on fish gill surfaces. Several constituents in creek water, along with temperature and pH, can increase or decrease the availability of dissolved copper to result in toxicity. Hard water, as found in Santa Barbara creeks, contains ions that compete with copper and reduce its toxicity. The new criteria put forth by the US EPA require the use of the Biotic Ligand Model to create site- specific acute and chronic dissolved copper criteria. The model requires the collection of additional data (calcium, magnesium, sodium, potassium, sulfate, chloride, alkalinity, and dissolved organic carbon,), along with temperature and pH. The following table shows the 27 data points that have been collected during quarterly sampling efforts, ranked in decreasing copper toxicity. The ranking is done by Acute Toxicity Units, which relate the measured copper concentration to the calculated acute criteria (CMC). On one date at Rattlesnake, the measured concentration was greater than the CMC, mostly due to a low pH level in the creek. For dry-weather sampling, it is more logical to look at the chronic criteria for continuous exposure (CCC). On April 8, 2008, both Rattlesnake and MC at Rocky Nook had measured concentrations that exceeded the chronic criteria, again due to low pH. We do not know what caused such low pH levels at these two sites. Overall, it does not appear that Santa Barbara creeks have a chronic copper toxicity problem in dry weather, at least in terms of standard toxicity tests. Additional samples and model runs need to be collected before a conclusion can be drawn about storm water runoff.

Site	Date	Measured Cu, ug/L	Final Acute Value (FAV), ug/L	CMC (CMC=FAV/ 2), ug/L	CCC (CCC=FAV/ ACR), ug/L	Acute Toxic Units (Cu/CMC)
MC Rocky Nook	8-Apr-08	1.51	2.83	1.42	0.88	1.07
Rattlesnake	8-Apr-08	1.08	2.81	1.40	0.87	0.77
MC Montecito	8-Apr-08	2.42	20.48	10.24	6.36	0.24
SRC Jesusita	4-Jun-08	2.56	22.86	11.43	7.10	0.22
AB us LPC	7-Nov-07	1.20	13.66	6.83	4.24	0.18
SC APS	5-Dec-07	3.24	45.41	22.71	14.10	0.14
AB Barger	4-Jun-08	10.10	213.32	106.66	66.25	0.09
AB us LPC	4-Jun-08	2.51	64.94	32.47	20.17	0.08
OMC us MC	8-Apr-08	1.76	47.13	23.57	14.64	0.07
LC CPP	5-Dec-07	1.68	46.52	23.26	14.45	0.07
LC Garden	17-Jun-08	2.36	67.68	33.84	21.02	0.07
Mesa lower	7-Nov-07	2.21	75.56	37.78	23.46	0.06
LC CPP	17-Jun-08	4.41	152.89	76.45	47.48	0.06
SC Railroad	5-Dec-07	3.73	133.45	66.72	41.44	0.06
SC Cacique	5-Dec-07	4.86	178.18	89.09	55.34	0.05
WSD	8-Apr-08	1.30	49.38	24.69	15.33	0.05
SC Stanwood	17-Jun-08	2.16	82.86	41.43	25.73	0.05
LPC us AB	4-Jun-08	1.28	60.96	30.48	18.93	0.04
AB Cliff	7-Nov-07	1.39	71.68	35.84	22.26	0.04
SC APS	17-Jun-08	5.97	325.29	162.65	101.02	0.04
OMC W Anapamu	8-Apr-08	1.55	89.41	44.70	27.77	0.03
AB Est Mouth	4-Jun-08	3.78	240.39	120.20	74.66	0.03
SC Railroad	17-Jun-08	2.80	183.46	91.73	56.97	0.03
AB Cliff	4-Jun-08	2.53	260.92	130.46	81.03	0.02
SRC us AB	4-Jun-08	1.48	170.05	85.02	52.81	0.02
LPC us AB	7-Nov-07	-	7.82	3.91	2.43	-
Mesa lower	4-Jun-08	-	181.04	90.52	56.22	-

Dissolved copper is also known to cause chemosensory deprivation in juvenile fish. In this case, water hardness does not necessarily decrease the neurotoxicity. A recent paper (McIntyre et al., 2008) suggests that in hard water the effect is seen at greater than 20 ug/L dissolved copper, which has not been found in dry weather. Looking back at previous storm water results, five of 99 samples had levels greater than 20 ug/L.

It is recommended that dry weather testing for dissolved copper and associated parameters not be continued. Wet weather testing should be continued until approximately twenty data points have been obtained.

SEDIMENT SAMPLING AT LAGOON SITES

Some pollutants are known to adhere to sediments and persist for a much longer time than they do in the water column. In response to informal recommendations from the Creeks Advisory Committee, the FY08 Research Plan called for quarterly sediment sampling, however due to the unexpected high cost of processing these samples the decision was made to sample sediment annually. In November 2007, Creeks staff conducted its first lagoon sediment sampling event.

Methodology- Based on methods used by the Southern California Coastal Water Research Program, staff used a short section of wide PVC pipe (4 inch diameter), along with a flat shovel, for collecting lagoon sediment samples. The PVC pipe was pushed down into the sediment, approximately three inches deep. The flat shovel was then slid underneath the pipe to hold the sediment inside the pipe as it is 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.

Results

The following table summarizes the results of the sediment sampling. It is important to note that criteria for sediment are very limited therefore the ability to evaluate the results is also limited. Based on the available criteria, the only constituents found in above-normal levels were in the Chlorinated Pesticides family, both found in Laguna Channel. DDE was found in the "low disturbance" category, and Chlordane was found in the "moderate disturbance" category. Interestingly, despite these results, Laguna Channel had the best results (100% survival) for toxicity.

Constituent	Units	Arroyo Burro	Mission	Laguna	Sycamore	Disturbance Category*
Metals						
Arsenic	mg/kg	3.45	2.59	3.9	4.44	n/a
Cadmium	mg/kg	0.405	0.173	0.629	0.708	n/a
Chromium	mg/kg	20.2	11.8	11.5	29.2	n/a
Copper	mg/kg	8.58	8	21	15.6	reference
Lead	mg/kg	7.15	13.9	26.4	6.84	reference
Nickel	mg/kg	21.4	11.4	10.8	32.5	n/a
Selenium	mg/kg	1.9	1.58	2.85	3.95	n/a
Silver	mg/kg	ND	ND	0.33	ND	n/a
Zinc	mg/kg	35.1	31.4	81.3	57	reference
Mercury	mg/kg	ND	0.0317	0.0329	0.0215	reference
PAHs						
Naphthalene	ug/kg	130	80	160	96	unknown
Acenaphthylene	ug/kg	ND	ND	ND	ND	unknown
Acenaphthene	ug/kg	ND	ND	ND	ND	unknown
Fluorine	ug/kg	ND	ND	ND	11	unknown
Phenanthrene	ug/kg	ND	23	32	ND	unknown
Anthracene	ug/kg	ND	ND	ND	ND	unknown
Fluoranthene	ug/kg	ND	67	72	ND	unknown
Pyrene	ug/kg	41	53	120	22	unknown
Benzo (a) Anthracene	ug/kg	18	29	40	ND	unknown
Chrysene	ug/kg	27	49	78	14	unknown

PAHs *continued*	**Units**	**Arroyo Burro**	**Mission**	**Laguna**	**Sycamore**	**Disturbance Category***
Benzo (b) Fluoranthene	ug/kg	ND	ND	ND	ND	unknown
Benzo (k) Fluoranthene	ug/kg	60	16	1000	390	unknown
Benzo (a) Pyrene	ug/kg	ND	27	ND	ND	unknown
Dibenz (a,h) Anthracene	ug/kg	ND	ND	ND	ND	unknown
Benzo (g,h,i) Perylene	ug/kg	11	17	ND	ND	unknown
Indeno (1,2,3-c,d) Pyrene	ug/kg	ND	31	47	ND	unknown
Pesticides and Herbicides						
EPA 8081A (Chlorinated Pesticides)	ug/kg	ND	ND	Chlordane: 22 4,4'-DDE: 1.2	ND	Laguna: low (DDE), Moderate (Chlordane); other creeks: reference/non-detect
EPA 8141A (Organophosphorus Pesticides)	mg/kg	ND	ND	ND	ND	n/a
EPA 8151A (Chlorinated Herbicides)	ug/kg	ND	ND	ND	ND	n/a
Pyrethroids	ng/dry g	ND	ND	ND	ND	n/a
PCBs	ug/kg	ND	ND	ND	ND	reference/non-detect
Toxicity (% survival)	% survival	98	97	100	98	n/a

Table Information:
Disturbance Category scores are as follows:
1) Reference (best)
2) Low disturbance
3) Moderate disturbance
4) High disturbance (worst)

* Disturbance Category scores taken from SWRCB Draft Sediment Quality Plan updated 1/31/08.
“n/a” means no criteria are currently available
“unknown” means that criteria is available but not enough information is known to determine score

NUTRIENTS AND EUTROPHICATION

Nutrients are an important component of water quality in creeks, lagoons, and the coastal ocean. While aquatic plants need nutrients to grow, high concentrations can cause excess algal blooms and a subsequent depletion of oxygen. Low oxygen concentrations can stress and even kill aquatic invertebrates and fish. Possible sources of nutrient pollution in developed areas include fertilizers used in agriculture and landscaping, animal waste, and leaking septic tanks or sewage lines.

The Creeks Division has conducted monitoring and outreach related to nutrient pollution since 2001. Early efforts involved sampling during storm events, with samples processed by outside laboratories. In 2004, the Creeks Division's Monitoring Program expanded and began conducting monthly sampling of nutrients at restoration sites. In Fall 2004, the Creeks Division developed a relationship with UCSB's Santa Barbara Channel Long Term Ecological Research project, which has since analyzed City nutrient samples without charge. As described in the Creeks Division's 2007-2008 Research Plan, the Creeks Division now tests restoration sites and additional creek sites on a quarterly basis. Flow rates are also measured so that loads of nutrients entering creeks reaches can be estimated. In addition, the SBC LTER has provided the City with access to several years of nutrient data, providing a thorough description of nutrient concentrations and fluxes in Arroyo Burro and Mission Creek from 2001-2006.

Nutrient Criteria

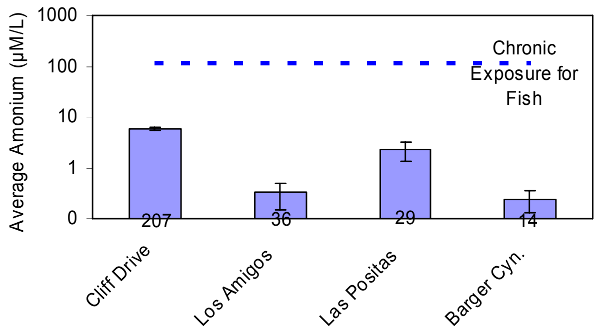
When analyzing water quality data, it is imperative to have criteria, or thresholds, for interpreting concentrations. The existing criteria for nutrients in surface waters are lacking and will be addressed in the coming years on a state and national level. The State's Central Coast Basin Plan guideline for nutrients, which the Plan calls "biostimulatory substances," is that they "should not be present at concentrations that promote aquatic growths to the extent that such growths cause nuisance or adversely affect beneficial uses." In a 2006 report, the State used numerical criteria for classifying nitrogen and phosphorus concentrations as indicating low, moderate, and high environmental quality. The City has used these criteria to interpret nutrient data from Arroyo Burro and Mission Creek in dry periods, during which algal blooms would likely occur.

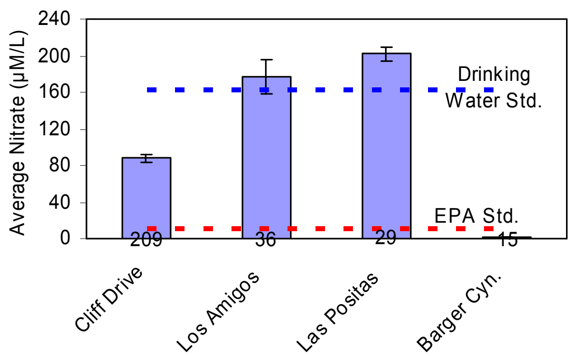
Nutrients Concentrations in Arroyo Burro and Mission Creek

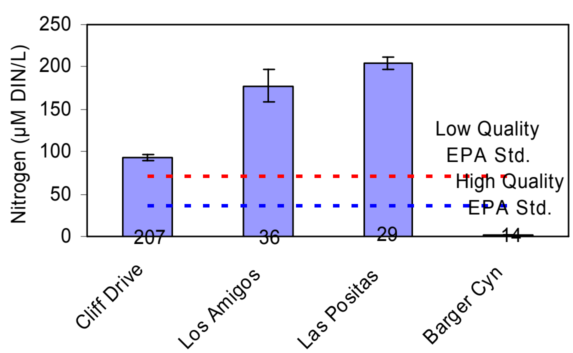
As shown in the figures below, Arroyo Burro and Mission Creek are impacted by nutrients in the urban areas. In the upper watersheds, nitrogen and phosphorus concentrations are usually indicative of moderate and high quality conditions. In the central urban areas, nutrient concentrations increase and are more often indicative of low quality habitat, where eutrophication is likely to be a problem. At the lowest creeks sites, i.e., the integrator sites on Arroyo Burro (Cliff Drive) and Mission Creek (Montecito Street), some nutrient concentrations decrease slightly, likely due to nutrient uptake and/or dilution with clean groundwater.

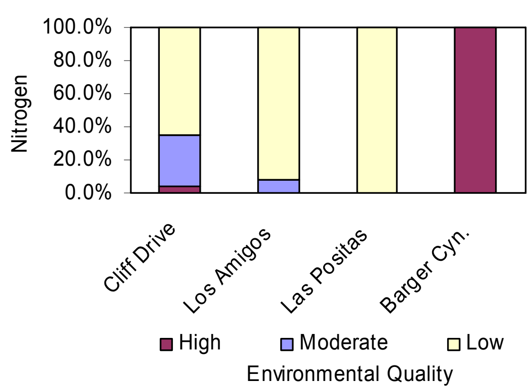
NUTRIENTS: NITROGEN

ARROYO BURRO

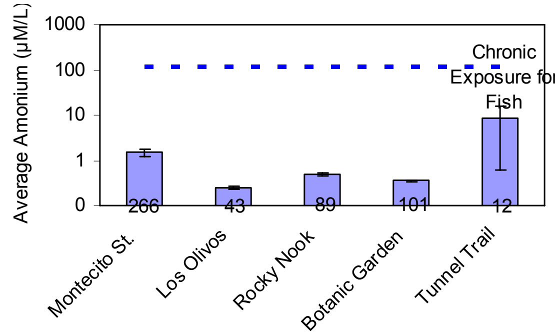


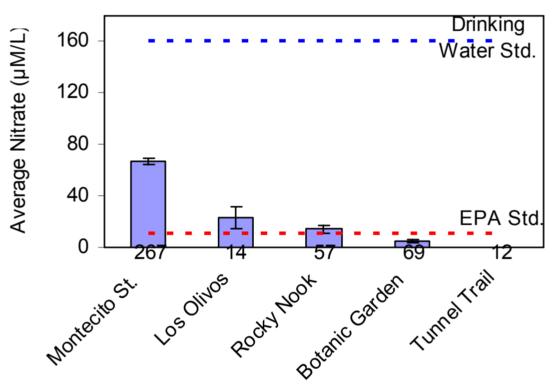


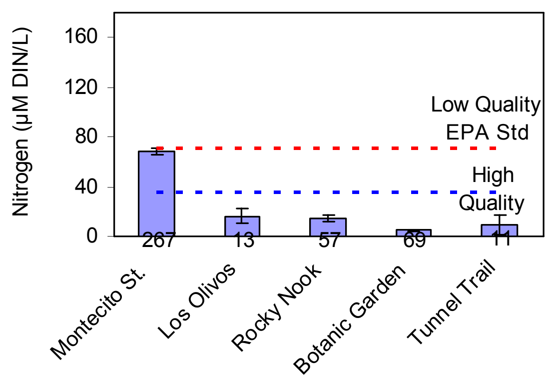


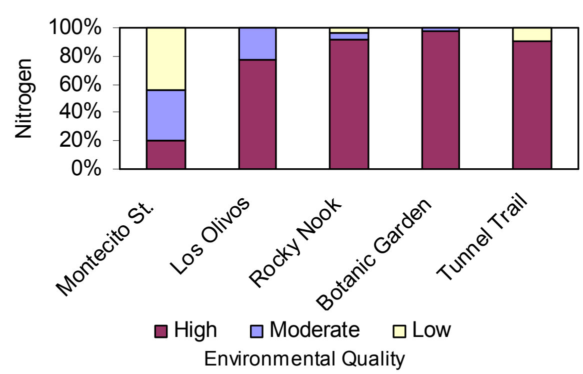


MISSION CREEK



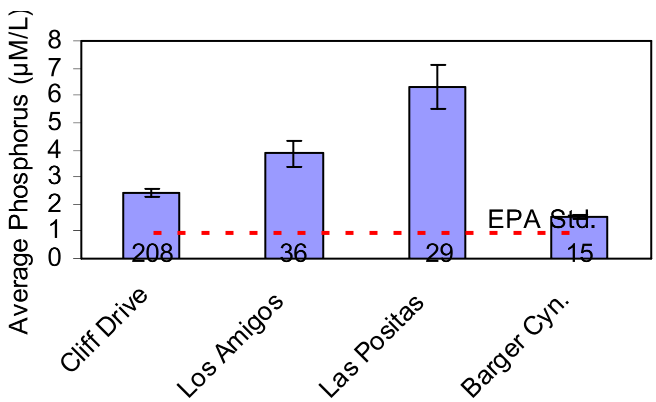




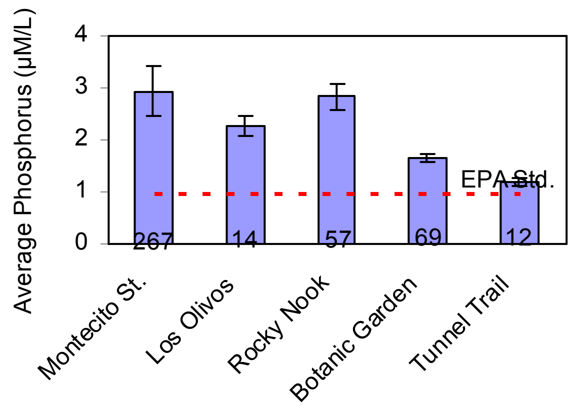


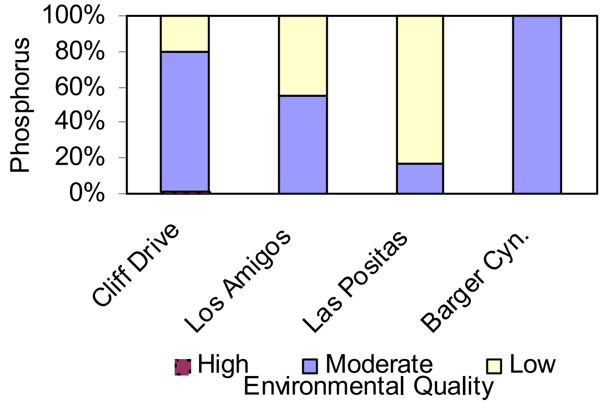
NUTRIENTS: PHOSPHATE

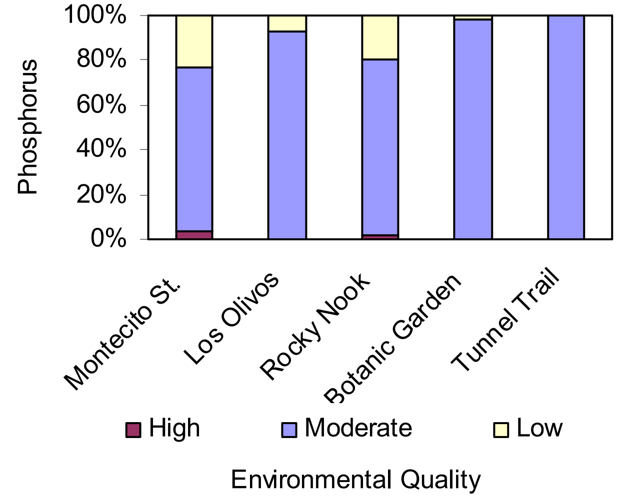
ARROYO BURRO



MISSION CREEK







Nutrient Loads

As shown in the quarterly analysis above (Quarters 3 and 4), nutrient loads become high in the urban corridors of the watersheds and stabilize at the integrator sites. It is important to note that this summary is based on only two sample dates. In general, the loads among creek are similar during base flow. For Mission Creek, the inputs of nutrients are generally split between Old Mission Creek and the Mission Creek between Old Mission Creek and Montecito Street. Areas above Rocky Nook also contribute a 3-30% of the nutrient load to Mission Creek. For Arroyo Burro, the results differed considerably between Quarter 3 and Quarter 4, likely due to the higher flows measured for Quarter 3. During Quarter 3, the highest nutrient input occurred between San Roque Creek and Las Positas Creek. Quarter 4 results are difficult to interpret due to lack of sampling at the confluence of Las Positas Creek and Arroyo Burro. Sycamore Creek shows declining nutrient loads from APS down to the railroad bridge.

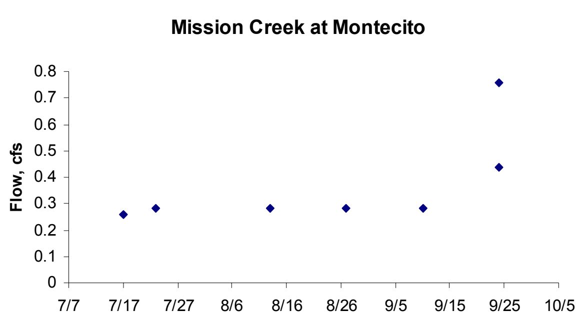
Dissolved Oxygen Levels

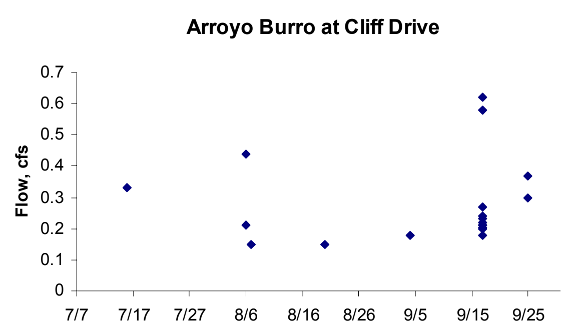
The most harmful impact of eutrophication for aquatic animals is low levels of dissolved oxygen. The table below shows dissolved oxygen levels (concentration and percent saturation) for the sites sampled more than four times over the year. Yellow shading marks the sites with low oxygen in greater than ten percent of the samples. The Andre Clark Bird Refuge has the lowest readings of the sites, due to intense eutrophication and stratification. Laguna Channel at Chase Palm Park likely has low oxygen levels due to ground water supply with low dissolved oxygen. Mission Creek at Gutierrez is a real concern because this is a stretch of creek that steelhead migrate through.

StationID	n	Median, mg/L	Median, % Sat	n<3 mg/L	n 3-5 mg/L	>105 % Sat.
AB Cliff	34	7.0	77	0	0	0
AB downstream SRC	9	11.5	111	0	0	6
AB Estuary Mouth	20	8.3	98	2	0	8
ACBR inflow	4	5.1	49	1	1	0
ACBR landing	9	0.6	71*	5	0	2
ACBR outlet	19	0.2	2	13	0	0
LC Chase Palm Park	20	3.9	42	1	15	0
MC at Gutierrez	19	7.8	77	0	7	4
MC at Montecito	25	7.9	82	0	2	3
Mesa lower	25	9.7	103	0	0	10
Mesa upper	19	9.4	91	0	0	6
OMC W Anapamu	24	7.7	82	0	0	0
SC Railroad	10	9.4	93	0	0	4
Westside Drain	23	8.5	92	0	0	0

DEVELOPMENT OF TOOLS TO TRACK FLUXES AND LOADS.

Creeks Division staff obtained training in measuring flow rates using manual methods, all of which depend on measuring the flow velocity and obtaining the stream cross sectional area. Velocity has been measured with a velocity meter (impeller) and timing a floating object. The time to fill a known volume (bucket and timer) method has also been employed. Staff now measure flow rates routinely at all biweekly integrator sites (except Laguna Channel) and quarterly sampling sites. Below are flow results for the lower watershed integrator sites from Quarter 1 (Summer) (Sycamore Creek was dry).





Measuring flow rates during low-flow conditions is notoriously challenging and imprecise. Creeks Division staff conducted a test and found that variability is much greater between locations of flow measurement than it is among operators (staff) or methods of velocity measurement. The test was conducted at Arroyo Burro at Cliff Drive on September 17, 2007.

In general, if all the measurements from one person at one site are averaged, the results were very close the corresponding measurements by the other person (e.g. .22 and .21 cfs). Using the velocity meter and the floating method in the fastest section produces consistent results; 3 out of 4 measurement (by the same persons) produced identical flows between the meter and float method. So it seems that the methods and people measuring produce consistent results.

However, it appears that the location of the measurement can greatly influence the consistency of the results. We sampled in two very close locations; at the concrete weir and in the natural channel just above it. The two average flows at the weir were .21 and .22 cfs, while the two average flow measurements in the channel were .58 and .64 cfs. This also means that most of the variability that we see in measurements (including previous estimates in the flow log book) could be from measuring the flow in different locations. For increased consistency it will be important to identify permanent cross sections to estimate the flow every time.

	Flow, cfs (Operator: LAG)	**Flow, cfs (Operator: TM)**
Location: Weir X-Section		
Meter Fastest section Multiple w/ reset Multiple w/o reset	 0.21 0.21 0.26	 0.23 0.18 0.19
Float Fastest	 0.21.	 0.27
Weir Average	0.22	0.21
Location: Natural Channel X-Section		
Meter Fastest section Multiple w/ reset Multiple w/o reset	 0.71 0.51 0.4	 0.63 0.69 0.64
Float Fastest	 0.71	 0.63
Weir Average	0.58	0.64

In addition to manual measurements, the Creeks Division purchased and installed a permanent flow meter at Arroyo Burro at Cliff Drive. The division also purchased an auto sampler that can be controlled by the flow gauge. The equipment will be used during the storm monitoring of Fiscal Year 2009.

RAPID RESPONSE TO PERSISTENT BEACH WARNINGS

The Creeks Division closely monitors the results of the County's beach water quality testing each week. When warnings are found at beaches within the City, the results are compared to nearby creek results for that same day or week to look for a possible correlation. If three out of four tests reveal warnings at a beach within the City, and those warnings appear to correlate with high bacteria levels in a nearby creek, Creeks Division staff is prepared to conduct a rapid response investigation into possible contamination sources in the creek. Below is a table of warnings found during each quarter.

Quarter 1 (Summer)
In July, three out of four tests on Mission Creek did reveal warnings; unfortunately, due to staff error, a rapid response investigation was not conducted.

Quarter 2 (Fall)
Only three warnings occurred this quarter; two at Leadbetter and one at Mission.

Quarter 3 (Winter)
This quarter, due to heavy rains, warnings were posted frequently at beaches within the City. On several occasions, three out of four tests triggered warnings at these beaches: Arroyo Burro (once) and East Beach at Mission Creek (twice). While observing three out of four warnings would normally trigger a sanitary survey by the Creeks Division, after careful consideration staff decided that the sanitary survey was not needed in any of these instances. The purpose of the sanitary survey is to investigate possible contamination sources, but in the case of heavy rains, it is well known that these high bacteria levels were caused by general urban stormwater runoff. Therefore the decision was made to not perform sanitary surveys if the warnings followed heavy rains events.

Quarter 4 (Spring)
Five warnings occurred this quarter: three at Arroyo Burro, one at East Beach at Mission, and one at Leadbetter. No sanitary survey was triggered.

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

County Beach Sampling Results

Highlighted rows indicate that rainfall occurred within the week preceding sampling.

Quarter 1 (Summer)

Date	Arroyo Burro Beach	East Beach-Mission Creek	East Beach-Sycamore Creek	Leadbetter Beach
07/02/07				
07/09/07		Warning (all indicators)		
07/11/07		Warning (FC=455)		
07/16/07	Warning (all indicators)			Warning (ENT=231)
07/23/07		Warning (FC:TC)		
07/25/07				
07/30/07				Warning (ENT=134)
08/01/07				Warning (ENT=2035)
08/13/07				
08/20/07				
09/10/07	Warning (FC:TC)			
09/12/07				

09/17/07				
09/24/07		Warning (FC=416)		

Quarter 2 (Fall)

10/01/07				Warning (ENT=121)
10/03/07				
10/08/07				
10/15/07				
10/22/07				
10/29/07				
11/05/07				
11/13/07				Warning (ENT=355)
11/15/07				
11/19/07				
11/26/07				
12/03/07				
12/10/07				
12/17/07				
12/26/07		Warning (ENT=354, FC:TC)		

Quarter 3 (Winter)

01/07/08	Warning (ENT=162)	Warning (ENT=249)	Warning (ENT=294)	
01/09/08	Warning (ENT=305)	Warning (ENT=345)	Warning (ENT=233)	
01/14/08				
01/21/08	Warning (ENT=278)		*Closed* (sewage spill)	
01/28/08	Warning (ENT=332)	Warning (FC=990, ENT=9208, FC:TC)	Warning (ENT=181)	
02/04/08				
02/11/08		Warning (FC:TC)		
02/13/08		Warning (EC=126)		
02/19/08				
02/25/08	Warning (ENT=122)			Warning (ENT=121)
02/27/08				
03/03/08				
03/10/08				
03/17/08				
03/24/08				
03/31/08				

Quarter 4 (Spring)

04/05/08		Warning (TC>24192, FC=836, Ent=240)		
04/07/08				
04/14/08	Warning (Ent=203)			
04/16/08				
04/21/08				
04/28/08				
05/05/08				
05/12/08				
05/19/08				
05/27/08				
06/02/08				
06/09/08				
06/16/08				
06/23/08	Warning (FC=496)			Warning (FC=1860, FC:TC)
06/25/08	Warning (TC=10462)			
06/30/08				

FIB/FIELD SAMPLING AT DRAIN OUTLETS AND UP DRAINAGE NETWORKS

While systematic sampling of drains did not take place, Laguna Channel source tracking and the input to Bohnett Park from Old Mission Creek was investigated.

The Laguna Watershed Study began during Fiscal Year 2008. The Creeks Division collected the following data to assist in choosing sample locations.

Saite	Date	E Coli, MPN/100 ml	Enterococcus, MPN/100 ml	Total MPN/100 ml
LC 702Lag	4/16/2008	354	669	19863
LC fwyon	4/16/2008	161	98	17329
LC fwyon	4/16/2008	169	97	12033
LC fwyonC	4/16/2008	145	121	17329
LC LagDLG	4/16/2008	<10	<10	<10
LC LagGut	4/16/2008	122	41	9804
LC LagHal	4/16/2008	10	30	6867
LC Lagoff	4/16/2008	158	20	9804
LC OliMon	4/16/2008	<10	121	10462
LC QuarGut	4/16/2008	41	74	10462
LC SalGut	4/16/2008	<100	156	68670
LC 702Lag	4/22/2008	<10	<10	650
LC fwyon	4/22/2008	121	74	6488
LC fwyonC	4/22/2008	86	20	5794
LC LagDLG	4/22/2008	<10	<10	<10
LC LagGut	4/22/2008	74	20	2282
LC LagHal	4/22/2008	<10	31	1860
LC Lagoff	4/22/2008	41	20	3654
LC OliMon	4/22/2008	10	131	24192
LC QuarGut	4/22/2008	197	<10	>24192
LC SalGut	4/22/2008	<10	20	64880
LC CPP	4/28/2008	41	41	14136
LC 702Lag	4/30/2008	52	52	11199
LC fwyon	4/30/2008	601	201	>24192
LC fwyonC	4/30/2008	106	171	17329
LC LagDLG	4/30/2008	<10	<10	20
LC LagGut	4/30/2008	228	122	>24192
LC LagHal	4/30/2008	109	10	12997
LC Lagoff	4/30/2008	156	134	19863
LC OliMon	4/30/2008	272	145	10462
LC QuarGut	4/30/2008	545	166	>24192
LC SalGut	4/30/2008	73	63	>24192
AnxMH LC	6/10/2008	>241920	15000	>241920
AnxMH LC	6/10/2008	>241920	9590	>241920
Anxpipe LC	6/10/2008	24890	970	>241920

Consistently high levels of indicator bacteria and sewage-like odors suggest that the San Pascual Drain should be tested in the future for human waste.

Site	Date	E Coli, MPN/100 ml	Enterococcus, MPN/100 ml
OMC upstream of Westside Dr.	17/Jul/2007	3654	3076
OMC upstream of Westside Dr.	24/Jul/2007	6867	12033
OMC upstream of Westside Dr.	28/Aug/2007	12033	4611
OMC upstream of Westside Dr.	23/Apr/2008	74	63
San Pascual Manhole 1	09/Jul/2007	>24192	17329
San Pascual Manhole 1	24/Jul/2007	733	4106
San Pascual Manhole 1	28/Aug/2007	>24192	>24192
San Pascual Manhole 1	24/Oct/2007	>24192	>24192
San Pascual Manhole 1	24/Oct/2007	46110	24810
San Pascual Manhole 1	23/Apr/2008	4106	5172

Watershed models to improve interpretation of monitoring data.

Status: The Creeks Division remains interested in watershed modeling but will not actively pursue the purchase and implementation of a model at this time due to time requirements for other tasks. Staff are seeking examples of how municipalities or agencies have utilized watershed models to guide policy and prioritization, prior to investing the funds and staff resources to conduct modeling. Staff has recently obtained literature that may illustrate the benefits of watershed modeling. In addition, the TMDL for Santa Barbara Beaches is now in development by the Central Coast RWQCB and the process will begin with watershed modeling of indicator bacteria. Creeks Division Staff will use this opportunity to learn about the utility of their modeling approach.

Using GIS to organize, present, and analyze water quality data.

Status: Creeks Division staff have made the substantial effort to implement an Access database to house sampling data and have migrated existing data to the new database. This effort has improved the ability of Staff to gather and compare data from different constituents, locations, and dates in a much more efficient and quality-controlled manner. Now that the City has upgraded the GIS programs, renewed effort will be made to map water quality data.

III. RESTORATION AND WATER QUALITY PROJECT ASSESSMENT

LAS POSITAS STORMWATER MANAGEMENT PROJECT

The Las Positas Stormwater Management Project, scheduled to begin in the fall of 2008, aims to treat stormwater runoff before it enters Las Positas Creek. The focal point of the project is the Santa Barbara Golf Club, which receives runoff from surrounding areas and discharges into the creek. In order to evaluate the effectiveness of the project, Creeks Division staff conducted storm sampling at key inflow and runoff sites surrounding the golf course during two storms this winter.

Storm sampling sites:

1) San Jose neighborhood drain: This site contains runoff from a residential neighborhood, which flows onto the golf course.
2) SW corner drainage: This site contains runoff from the Stevens Road residential area, as well as from the golf course.
3) SW Earl Warren drainage: This site contains runoff from the golf course and from the Earl Warren Showgrounds.
4) Golf course Western drainage: This site is one of the main drainage points for the golf course, also called “Basin 4.”
5) Golf course Eastern drainage: This site is another main drainage point for the golf course, also called “East Basin.”
6) Adams School composite: This is a composite of several drains that discharge behind the school.
7) Las Positas Drain: This drain contains runoff from Las Positas Road and neighborhoods to the east.

Results

All samples were tested for indicator bacteria, nutrients, total suspended solids, and total metals. In addition, inflow sites (sites 1, 6, and 7) were tested for MBAS (surfactants) and oil and grease. Results are summarized below.

Indicator Bacteria: Results for indicator bacteria were extremely high for most tests performed. All samples for both storms far exceeded criteria for Enterococcus (151 MPN/100ml) and Total Coliform (10,000 MPN/100ml). About half of the samples exceeded the *E. coli* standard of 235 MPN/100ml, except for sites 3 and 4 which did not exceed this standard during either storm.

<u>*Nutrients:*</u> Nitrate, phosphate, and ammonium were tested at all sites. Site 2 had the highest nutrient results by far during both storms. All sites greatly exceeded various EPA and State

criteria for nitrate and phosphate (levels ranged from 2- to 140-times the EPA's recommended regional criteria). Ammonium levels did not exceed criteria at any site.

Total suspended solids: Total suspended solids were tested at all sites. Results ranged from 24 mg/l at site 4 to 324 mg/l at site 5. The median result for TSS was 99.5. No criteria exist for total suspended solids.

Total metals: Total metals were tested at all sites. There are no current criteria for total metals, however outdated EPA criteria are used for reference purposes.

- Copper was detected at all sites during both storms. Sites 1, 2, 5, and 7 exceeded the outdated EPA standard of .0094 mg/l.
- Chromium was detected at two sites (5 and 7) during both storms but did not exceed the outdated EPA standard of .086 mg/l.
- Iron was detected at all sites during both storms, however no criteria are available for reference purposes. The highest levels were found at sites 1, 3, 5, and 7.
- Lead was detected only once, at site 5. The result was .0175 mg/l, which did exceed the outdated EPA standard of .0053 mg/l.
- Manganese was detected at all sites during both storms, however no criteria are available for reference purposes. The highest levels were found at sites 2, 5, and 7.
- Mercury was detected once at site 1 and once at site 7; neither result exceeded the outdated EPA standard of .00091 mg/l.
- Nickel was detected at all sites except site 4, however no results exceeded the outdated EPA standard of .052 mg/l.
- Potassium was detected at all sites during both storms, however no criteria are available for reference purposes. The highest levels were found at sites 2 and 4.
- Zinc was detected at all sites during both storms. The outdated EPA criterion of .12 mg/l was exceeded at site 7 during both storms, and at site 5 during one storm.
- Arsenic and cadmium were not detected in any samples.

MBAS: Methylene Blue Active Substances (MBAS) were only tested at the three inflow sites (1, 6, and 7). MBAS were detected at all three sites. The current criteria for MBAS, found in the Regional Water Quality Control Board's Basin Plan, is .2 mg/l. Site 7 exceeded this standard during both storms; site 6 exceeded during one storm, and site 1 did not exceed the standard.

Oil and grease: Oil and grease was tested only at the three inflow sites (1, 6, and 7), but was only detected at site 7. There is no numerical standard for oil and grease; levels are considered unacceptable only if sheen is visible on the surface. No sheen was observed at any of the sites.

Next Steps

Creeks staff had planned to sample one additional storm in the fourth quarter; however rainfall was inadequate for sampling runoff. After the project is completed, staff will perform post-project sampling that can be compared with pre-project sampling results to evaluate the overall effectiveness of the project in terms of water quality impacts.

ANDRE CLARK BIRD REFUGE TESTING

For several days in the summer of 2007, the Andre Clark Bird Refuge was emitting very strong, foul odors that were noticed by Parks staff as well as the general public (Creeks Division received several calls inquiring about the odors). Creeks staff conducted some basic testing and confirmed that the odors were caused by a "turnover" event, where low-dissolved oxygen waters and anaerobic sediments from the bottom of the lagoon were brought to the surface. Since that time, Creeks and Parks staff has sought to gain a better understanding of what causes these turnover events. Occasional and irregular testing was conducted in the fall and winter upon request from Parks staff.

During Quarter 3 (Winter), Creeks staff met to discuss a more permanent sampling plan for the bird refuge. The goal of the sampling is to gain better background information about the lagoon's water quality and to learn what triggers the turnover events. Following is a brief description of the sampling plan that was chosen:

Frequency: Options were discussed ranging from daily to weekly to monthly testing; ultimately the decision was made to test once per month in order to conserve limited staff time.

Sites: Three sites were chosen for sampling: the creek/inflow site on the NW side of the lagoon, the landing/dock area just west of the parking lot, and the outlet at Cabrillo Blvd.

Constituents: Staff will use standard water quality meters to test in the field for dissolved oxygen, temperature, conductivity, TDS, pH, and salinity. Samples will be taken and tested for the following constituents at various laboratories:

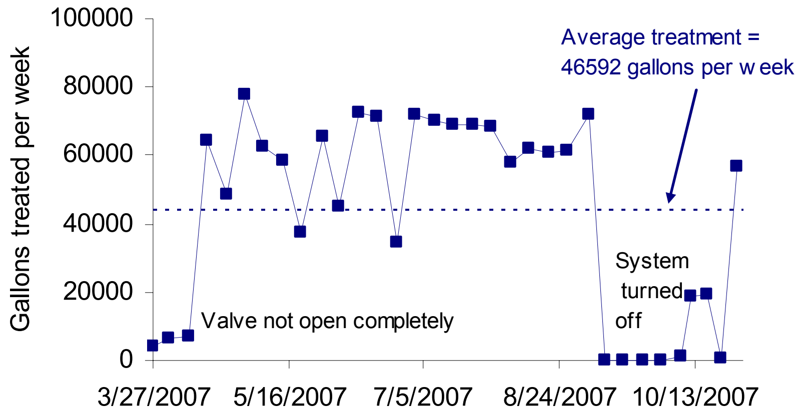
- Bacteria, BOD, and color (El Estero)
- Nutrients (UCSB)
- Chlorophyll A (Sierra Environmental Monitoring in Reno)

In addition, field observations such as color, odor, and water depth will be recorded at each site.

Staff began implementing the new sampling plan at the end of this quarter- the first sampling event was conducted on March 26. Monthly sampling will continue at least through the end of summer.

SURF WATER QUALITY IMPROVEMENT PROJECT

The Westside SURF Project began treating water from the Westside storm drain on March 27, 2007. The figure below shows the operation of the SURF facility during its first season of operation. The second season of data will be presented in the FY09 report. The following data are contained in the Final Report to the State. The monitoring was required by the grant that funded the project, as described in the Monitoring Plan.



Gallons treated per week at the Westside SURF Project.

Water Quality Monitoring

. The goals of the monitoring plan for the SURF Project were to:

- Quantify the loads of indicator bacteria that are prevented from entering Old Mission Creek, Mission Creek, and East Beach at Mission Creek as a result of installing the Project.
- Quantify the effect of the Project in reducing loads of indicator bacteria entering Old Mission Creek, i.e. quantify the fraction of dry-season runoff in the Westside Storm Drain that is diverted for treatment.
- Test the effectiveness of Project components, i.e. the effect of the media filters and the UV equipment on lowering indicator bacteria levels.
- Test for the effect of the Project reducing concentrations of indicator bacteria in downstream creek reaches.
- Test for the effect of the Project on reducing beach postings. Data on beach postings will be obtained from the Santa Barbara County.
- Conduct one detailed study of the distribution of indicator bacteria immediately downstream of the treatment facility, i.e., test whether and where bacterial regrowth or additional input occurs.

Summary of Monitoring Design (April 1- October 31)

Monitoring Goal (see above)	Indicator Bacteria Concentration	Flow
1) Load Treated	Weekly (Monday), Laboratory	Weekly flow volume, Instrument
2) Percent of Load Treated	Upon observation of untreated flow, Laboratory	Upon observation of untreated flow, Field
3) Effect of Project components	Monthly, Laboratory	-
4) Downstream Concentration – Creek Sites	Bi-Weekly (Monday), Laboratory	-
5) Downstream Concentration - Beach	Weekly (Monday), Laboratory (County)	-
6) Potential Regrowth/Input Downstream	Once per AB411 season, Laboratory	Once per AB411 season, Instrument and Field

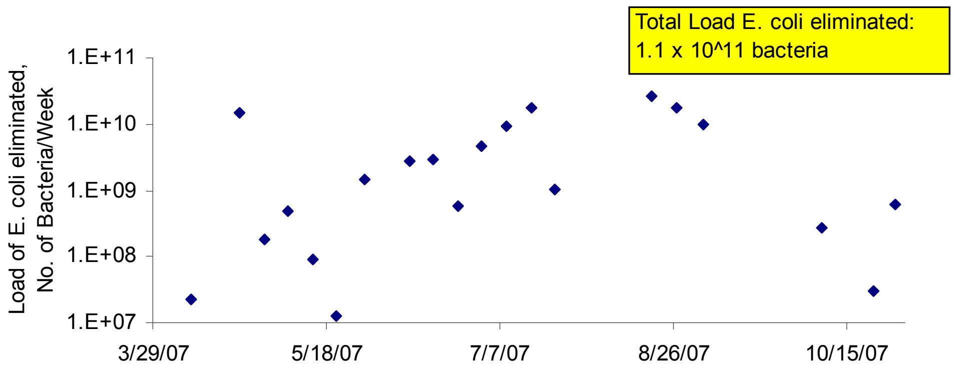
Sampling was carried out according to the approved QAPP and Monitoring Plan.

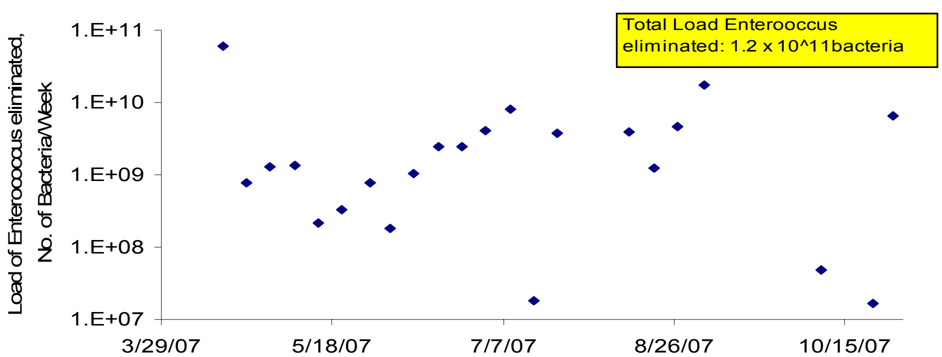
Map of sampling locations for Monitoring Plan. Yellow represents biweekly samples and green represents weekly samples.

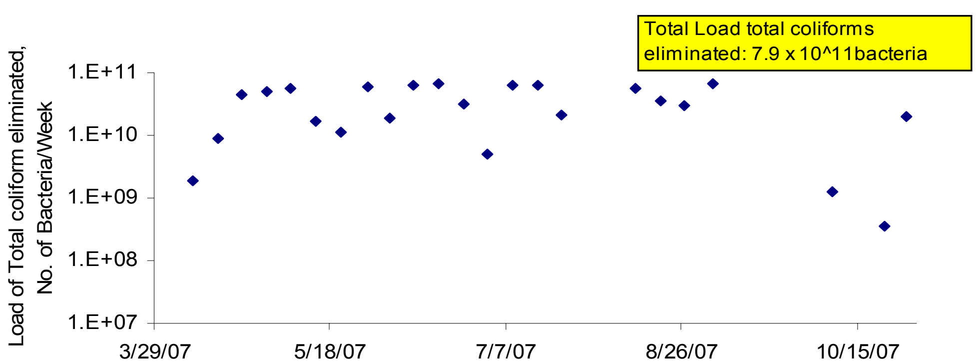
Load Reduction Results

The load of indicator bacteria prevented from entering Old Mission Creek during the 2007 AB411 season was approximately 1.1 x 10^{11} *E. coli* bacteria, 1.2 x 10^{11} Enterococcus bacteria, and 7.9 x 10^{11} total coliform bacteria (see figure below). The loads were calculated based on the weekly flow volumes multiplied by the indicator bacteria values from the inlet port each week, and a conversion factor:

Load (No. of bacteria/time) = Concentration (MPN/100 ml) x Flow rate (gallons/week) x 37.9



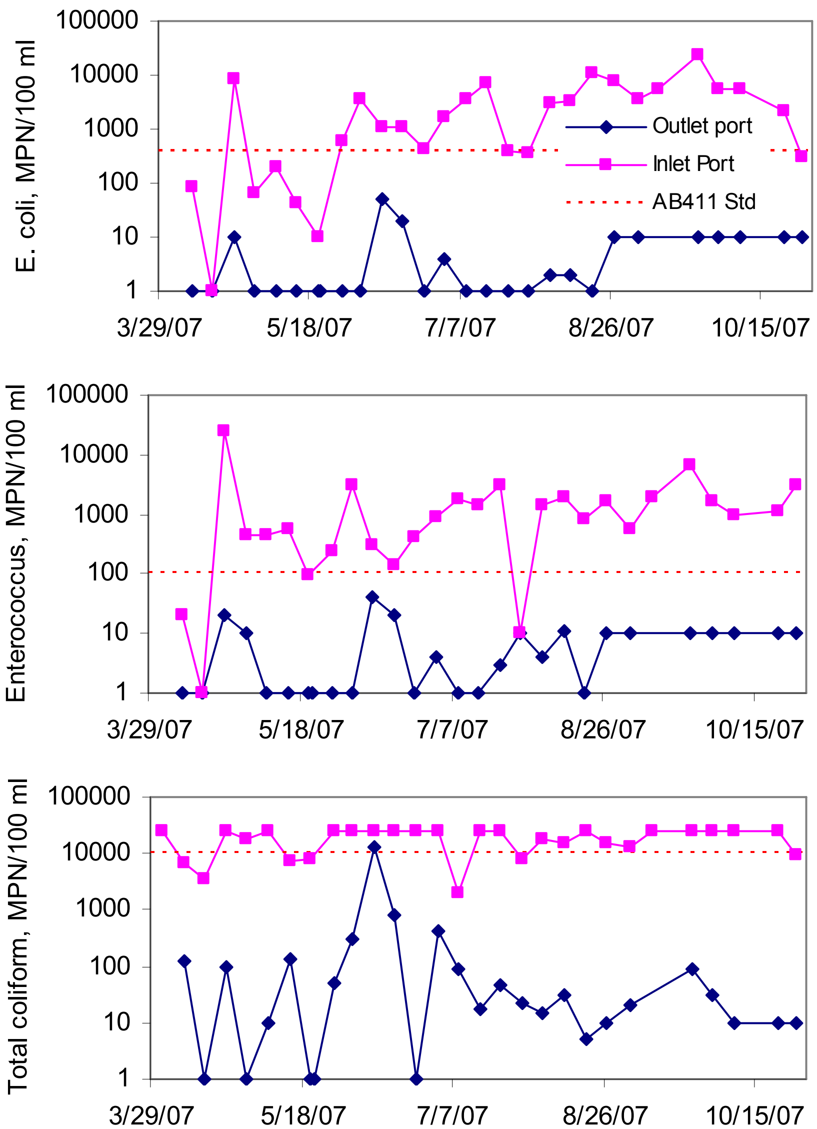




Load reduction of indicator bacteria obtained by installation of the Westside SURF Project.

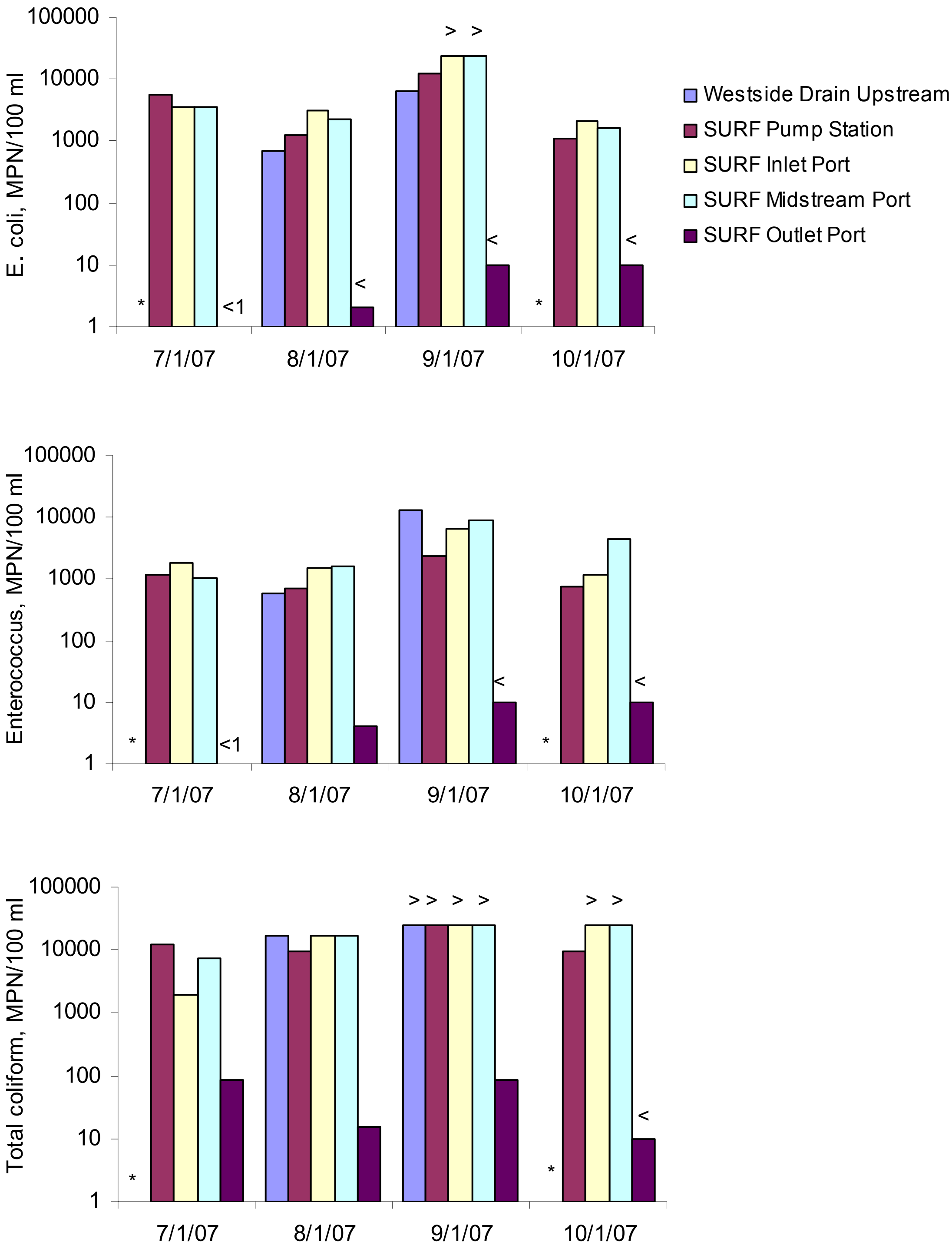
Effectiveness of Project components

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 ~1000 MPN/100, to < 10 MPN/100 ml (see figure below). Total coliform was generally reduced to 1-100 MPN/100 ml.



Weekly data demonstrating effectiveness of Westside SURF Project in reducing indicator bacteria concentrations.

Monthly sampling was conducted to test indicator bacteria values at locations within the SURF Project (see figure below). Results showed no consistent patterns among sample locations. There was a suggestive pattern of higher indicator bacteria concentrations in the pump station, inlet port, and midstream port (downstream of media filters). One hypothesis is that surface biofilms may form and slough bacteria. The media filters did not appear to remove bacteria.



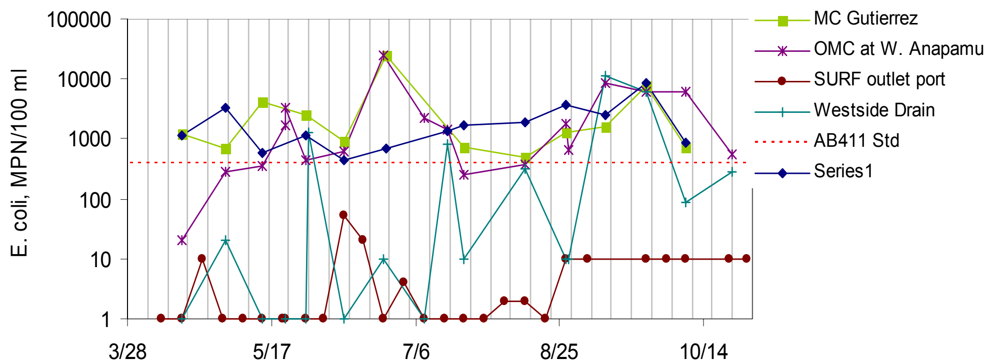
Monthly sampling data showing impact of Project components. Asterisk represents missing data, and >,< symbols represent values greater or less than thresholds.

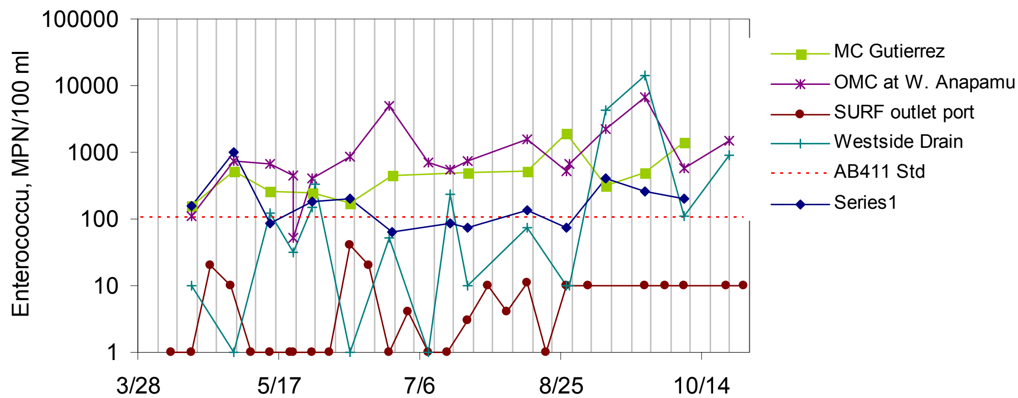
Downstream Impacts

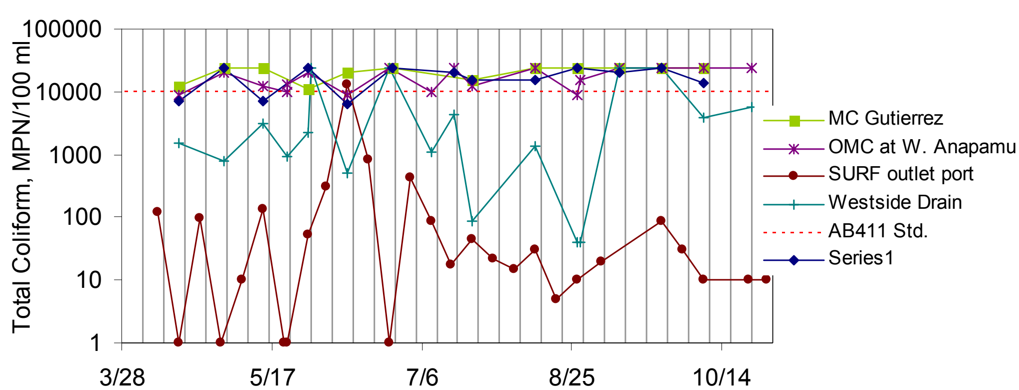
The downstream impact of the diversion Projects is of chief interest to the Creeks Division and the local community. Samples collected at the Westside Drain outlet, immediately downstream of the Project, were variable and often close to background levels, despite the low concentration of indicator bacteria in the facility's outlet port (see figure below). At the next downstream site, Old Mission Creek at W. Anapamu St., indicator bacteria levels were consistently at background levels 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.

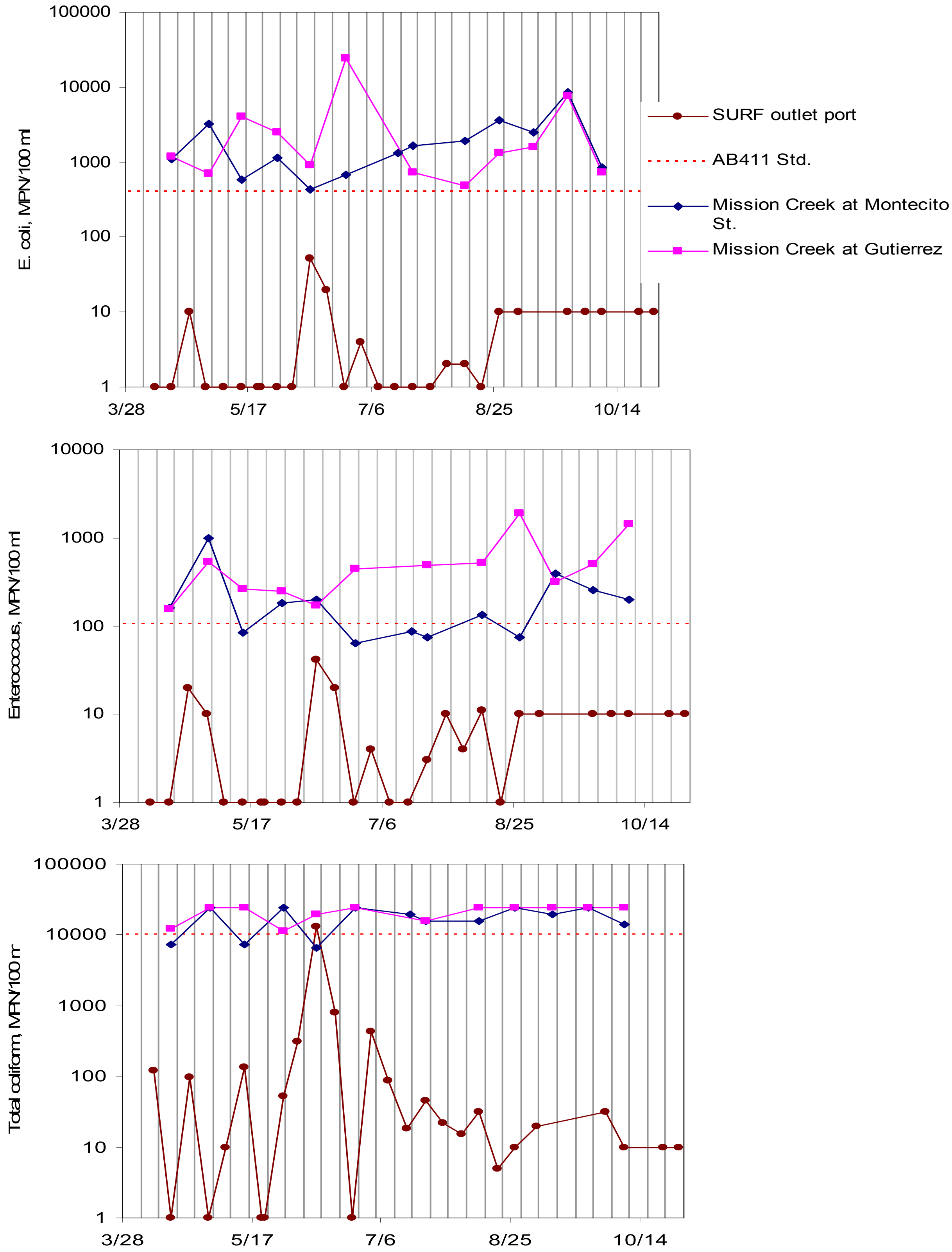
This result also points to the importance of expanding the focus of the State's efforts to research and development of additional assessment and source tracking tools, as described in the Proposition 50 Clean Beaches Initiative grant guidelines







Downstream impacts of Westside SURF Project in Old Mission Creek.



Downstream impacts of the Westside SURF Project in Mission Creek.

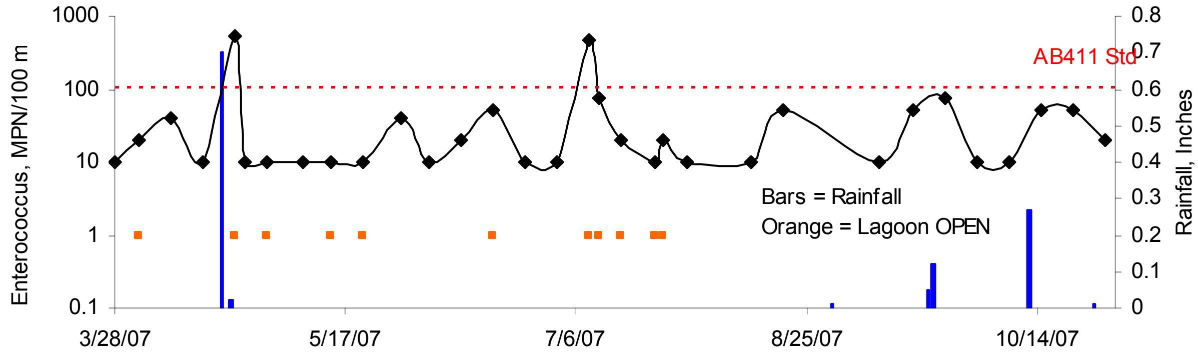
AB411 Beach Data

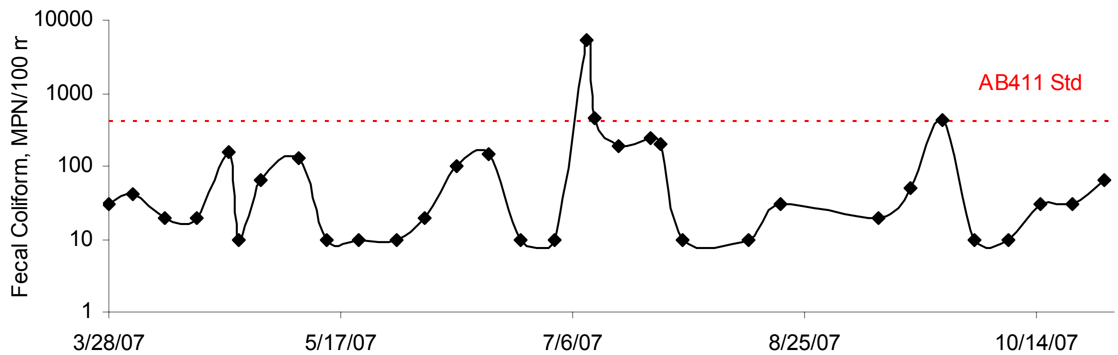
Overall, beach water quality in California was better in 2007 than in 2006 due to a relatively mild winter. East Beach at Mission Creek had beach warnings for each indicator (see figure below). The AB411 indicator bacteria data collected by the County in the surf zone did not reflect the installation of the Westside SURF Project, which began operation on March 26, 2007. As stated above, it is very important to note that these results do not mean that the ocean is not safer for swimming and recreation due to the installation of the Project.

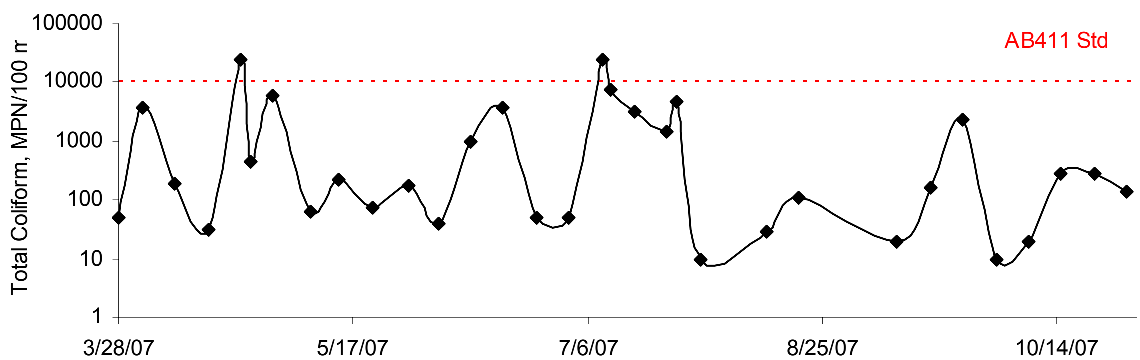
As mentioned in the Introduction, Mission Creek is not suitable for end-of-pipe treatment near the beach. Because of this limitation, the City has long known that decreasing the number of beach warnings will require a long-term capital strategy that may include installation of diversion and treatment Projects at multiple drain outlets, augmented by source reduction achieved by education, outreach, and enforcement activities. Despite the lack of results in indicator bacteria levels and beach warnings, the City and residents are encouraged that the number of pathogens in the creeks, and ultimately the oceans, has been decreased by the installation and operation of the UV facility

Additional Inputs

One study was conducted to identify additional inputs of human waste and/or indicator bacteria to Old Mission Creek near the SURF facility. Using flow measurements and indicator bacteria concentrations, it was found that the water coming from the San Pascal Drain and through the Bohnett Park Oxbow, while only a trickle, harbors very high levels of indicator bacteria (data not shown). In the oxbow area, City staff often observe human waste, often in the wetted area near the channel flow, despite the presence of permanent restrooms in Bohnett Park. The City's Creeks Division pays a private contractor to remove human waste from this area on a weekly basis. In addition, the Creeks Division has reestablished a porta-potty in the pocket-park area to discourage contamination of the channel. In casual conversations with local park users, many people are afraid to use the porta-potty and restroom for fear of getting sick. The City will conduct additional research to investigate outreach options, potential BMPs, and source-tracking to examine the impact of human waste.







2007 AB411 beach data for East Beach at Mission Creek.

ARROYO BURRO ESTUARY RESTORATION PROJECT

Mesa Creek Daylighting

As part of the Arroyo Burro Estuary Restoration Project completed by the City of Santa Barbara, a 300-foot section of Mesa Creek was restored from a buried culvert to an open creek.

Indicator bacteria - Fecal indicator bacteria (FIB) data collected before and after construction of the project demonstrated an improvement in water quality at the discharge of Mesa Creek into Arroyo Burro Estuary. Samples were collected biweekly (N=60 pre-construction and N=59 post-construction) from the upper- and lower-most points in the channel. The median concentration of FIB at the lower site decreased from 201 to 74 MPN/100 ml for *E. coli*, 258 to 197 MPN/100 ml for enterococcus, and 9208 to 7701 for total coliform. Prior to construction, the proportion of sample dates that showed reduced indicator bacteria concentrations at the lower site was 50% for *E. coli* , 48% for enterococcus and 52% for total coliform, suggesting a random relationship between the two sample sites. Post-construction, most sample days showed lower FIB concentrations in the downstream sample, with proportions significantly different than 50% (paired sign test): 90% of days for *E. coli* ($p \leq 0.001$), 82% for enterococcus ($p \leq 0.001$), and 62% for total coliform ($p \leq 0.1$). In most cases the reduction did not bring the FIB levels within recreational standards. Mechanisms for the reduction may include UV degradation, sedimentation of particle-attached bacteria, competition and/or predation from microorganisms, and dilution with clean ground water.

Temperature - Prior to construction, temperature did not change much from upstream to downstream. As would be expected, temperature increased moving downstream once the culvert was removed and the riparian zone was opened to sunlight. As the riparian zone fills in, and different seasons are tested, this relationship may change.

pH - On average, pH increased from upstream to downstream prior to construction, and decreased slightly from upstream to downstream post construction. Both relationships were significant under the paired sign test ($\alpha =< 0.01$). It is not yet understood what caused the change.

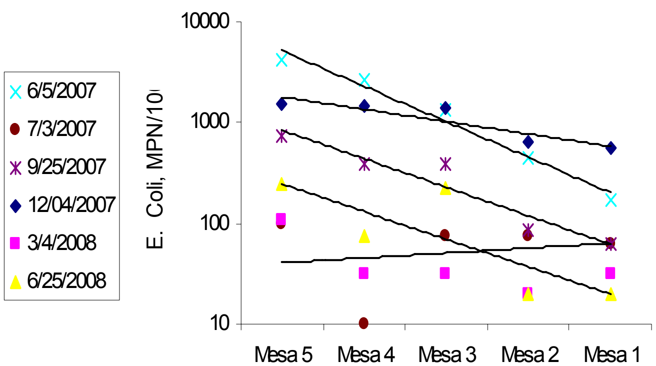
Dissolved Oxygen – Both measured of dissolved oxygen, concentration and saturation, were tested. Both parameters increased as water flowed through the culvert (prior to construction), contrary to expectations. After the culvert was daylighted, both parameters decreased moving downstream. All relationships were significant under the paired sign test ($\alpha =< 0.01$). One explanation may be that groundwater entering the creek channel is low in oxygen. Another may be that roughness in the corrugated culvert may have aerated the water.

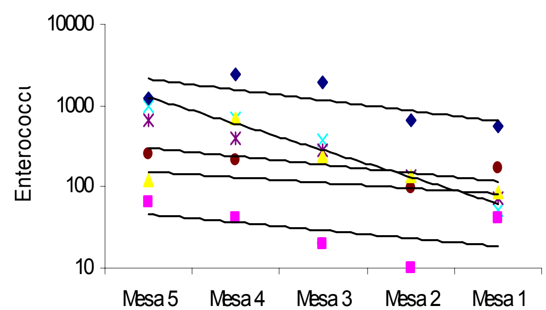
TDS and Turbidity – Neither parameter showed meaningful differences from upstream to downstream.

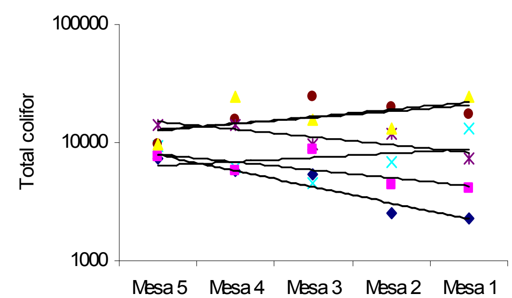
Additional sampling: it is recommended that biweekly sampling continue until September 30. 2008. At that time, the same number of pre- and post-construction samples will have been collected. The analysis conducted here should be updated, and sampling goals should be reassessed at that point.

Change in bacteria and field parameters from upstream to downstream, before and after the Mesa Culvert was removed.

	E. coli	Ent	Total Col	Temp	pH	DO Conc.	Do Sat.	TDS	Turbidity
	MPN/100 ml	MPN/100 ml	MPN/100 ml	C		mg/L	%	mg/L	NTUs
Pre-construction				**58**	**57**	**61**	**52**	60	60
Number of pairs (ties eliminated)	67	67	60						
Upper Mesa (above culvert), median	183	225	8164	13.27	8.07	9.0	88	2711	0.71
Lower Mesa (below culvert), median	201	258	9208	13.30	8.13	10.3	101	2727	0.62
Change from up- to downstream	increase	increase	increase	slight increase	increase	increase	increase	slight increase	slight decrease
Paired Sign Test (n=)	not sig	not sig	not sig	sig (<0.01)	sig(<0.01)	sig (<0.01)	sig(<0.01)	sig(<0.01)	not sig
Post-construction	40	40	38	37	37	37	37	37	39
Upper Mesa Creek, median (n)	210	329	7486	12.83	7.71	10.7	100	2544	0.93
Lower Mesa Creek, median (n)	80	207	6867	15.42	7.47	9.0	82	2548	1.73
Change from up- to downstream	decrease	decrease	decrease	increase	decrease	decrease	decrease	slight increase	slight increase
Paired Sign Test (n=)	sig (<0.01)	sig (<0.01)	not sig	sig(<0.01)	sig(<0.01)	sig (<0.01)	sig (<0.01)	not sig	not sig







IV. STORM MONITORING

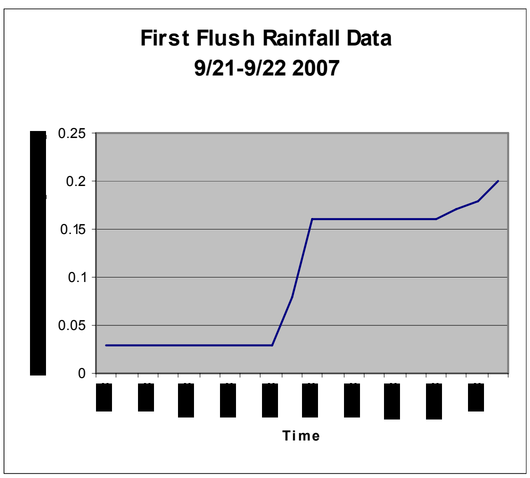
FIRST-FLUSH SAMPLING AT INTEGRATOR SITES (SEPTEMBER 21, 2007)

Introduction

The goal of this sampling event was to catch the “first flush” storm of the 2007-08 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 on Thursday, September 20th and was expected to last through Saturday the 22nd. Rainfall was expected to reach .5 to 1 inch in most coastal areas, with as much as 2 to 3 inches in the coastal mountains. As the storm approached, however, it stalled over the ocean and weakened somewhat before finally reaching the Santa Barbara area on Friday morning.

Light rain fell on Friday morning, the 21st, but then skies became clear again for the rest of the morning. Clouds returned in the early afternoon, and rain began to fall again around 3pm. Rain was steady, and eventually became very heavy at times. At approximately 3:45, when adequate runoff was observed on the streets, the decision was made by Leigh Ann and Jill M. to meet at the office and begin sampling.



This graph shows cumulative rainfall through the duration of the storm, using rainfall amounts recorded at the Santa Barbara Airport. The pink shaded portion indicates the period during which sampling was conducted.

The original plan was to use two teams of two staff members each for sampling, but most staff members were unavailable at this time therefore only one team (Leigh Ann and Jill M.) went out. The four Integrator Sites were to be sampled:

Sycamore Creek at the railroad bridge (near the Zoo)
Laguna Channel at Chase Palm Park
Mission Creek at Montecito Street
Arroyo Burro at Cliff Drive

At sites Laguna, Mission, and Arroyo Burro, staff confirmed that the creeks were definitely receiving runoff; flow was visibly higher than normal and other visible signs of runoff (foam, brown coloration, and oily sheen) were observed as well. The exception was Sycamore Creek, which was not flowing at all, and was therefore not sampled.

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-meter, and flow measurements were taken at site 4 (Arroyo Burro) but not at the other sites.

After sampling was completed, coolers were packed with ice and brought back to the office for pickup by the Calscience courier on Saturday morning.

Lastly, samples were filtered for nutrient analysis by the UCSB LTER laboratory. These samples were stored on ice and delivered to UCSB the following week.

The next week, rainfall totals for the storm showed that a total of 0.20 inches had fallen over the course of the storm at the Santa Barbara Airport. Rainfall totals were checked on the National Weather Service website: http://www.wrh.noaa.gov/

Results from this storm study are summarized in a table on the following page. Nutrient results are not included as they are not yet available from UCSB.

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.

Constituent	Laguna Channel at Chase Palm Park	Mission Creek at Montecito St.	Arroyo Burro Creek at Cliff Dr.	Criteria in mg/L unless otherwise noted (source)
Metals (mg/L)				
Arsenic, total	ND	ND	ND	.15 (EPA CCC, old)
Cadmium, total	ND	ND	ND	.00027 (EPA CCC, old)
Calcium, total	112	137	191	no criteria
Chromium, total	ND	ND	ND	.086 (EPA CCC, old)
Copper, total	ND	.0165	ND	.0094 (EPA CCC, old)
Copper, dissolved	.00214	.0143	.00268	0.044, 0.091, 0.031 for these sites (EPA CCC, based on BLM)
Lead, total	ND	ND	ND	.0053 (EPA CCC, old)
Mercury, total	ND	ND	ND	.00091 (EPA CCC, old)
Nickel, total	ND	ND	ND	.052 (EPA CCC, old)
Iron, total	.437	.399	.280	no criteria
Magnesium, total	44.7	49.0	83.2	no criteria
Manganese, total	.118	.210	.195	no criteria
Potassium, total	7.11	4.07	4.61	no criteria
Sodium, total	130	135	187	no criteria
Zinc, total	.0103	.0567	ND	.12 (EPA CCC, old)
Pesticides and Herbicides				
EPA 8151A[1] (ug/L)	ND	ND	ND	no criteria
EPA 8081A[2] (ug/L)	ND	ND	ND	no criteria
EPA 8141A[3] (mg/L)	ND	ND	ND	limited criteria[4]
Glyphosate (ug/L)	ND	ND	ND	.7
Other				
Total suspended solids (mg/L)	12	16	9.6	no criteria
Oil and grease (mg/L)	1.9 (and visible sheen)	2.4 (and visible sheen)	1.4	Visible sheen (BP)
MBAS (mg/L)	ND	.22	ND	.2 (BP)
Toxicity (TUa)	0.00	0.00	0.41	.3 (OP)
Dissolved Organic Carbon (mg/L)	6.4	20	8.6	no criteria
Chloride (mg/L)	150	100	280	230 (EPA CCC, old)
Sulfate (mg/L)	210	320	460	no criteria
Alkalinity (mg/L)	290	350	760	>20 (EPA CCC, old)
Hardness (mg/L)	470	550	790	no criteria

[1] Chlorinated herbicides: Dalapon; Dicamba; MCPP; MCPA; Dichlorprop; 2,4-D; 2,4,5-TP; 2,4,5-T; 2,4-DB; Dinoseb

[2] 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

[3] 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

[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.

Acronyms used:
EPA- USEPA's Current National Recommended Water Quality Criteria (US EPA, 2005)
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

The results of this first flush sampling had both similarities and differences when compared with previous storms. With metals, only total and dissolved copper exceeded criteria this time; in the past there have typically been many more than this (lead, nickel, zinc, cadmium, and chromium). With the exception of zinc, none of these metals were detected at all during this storm.

Previous results from Creeks Division sampling showed high levels of dissolved copper, at levels that were considered to be harmful to aquatic life. However, the toxicity of different forms of copper was not understood, and new criteria were in development by the USEPA. The new criteria for copper is based on the Biological Ligand Model (BLM) and requires the input of ten parameters, including temperature, pH, calcium, magnesium, sodium, chloride, sulfate, alkalinity, and dissolved organic carbon. In sites analyzed thus far, pH variations have the most impact on calculate criteria.

Pesticides and herbicides were not detected in any samples during this storm, and have rarely been detected in past storms. It is important to note that the aquatic life criteria for some organophosphorus pesticides (EPA 8141A) are lower than the minimum detection limit of our laboratory, therefore it is unknown whether those particular criteria were exceeded.

Other pollutants were detected in higher levels during this storm than in the past, and several exceeded criteria. Oil and grease was detected in all samples, and exceeded criteria at two sites. In the past, oil and grease has only been detected in approximately half of the samples (using the same detection limit). MBAS was only detected in one sample this year, compared to all samples last year (also using the same detection limit). Before last year, however, MBAS was rarely detected.

This was the second time the City has tested for toxicity during a storm; however different sites were tested both years (with the exception of Laguna Channel which has shown no toxicity in both tests). Like last year, only one site exceeded criteria. This year the exceedance was found at Arroyo Burro, which was not tested for toxicity last year. Last year's exceedance was found at Haley Drain, which was not tested this year. The toxicity units of 0.41 TUa at Arroyo Burro correspond with 95% survival of fathead minnows over 96 hours in 100% sample.

Several new constituents were added this year for use in calculating criteria for dissolved copper (calcium, magnesium, sodium, chloride, sulfate, alkalinity, and dissolved organic carbon). All of these were detected, but only chloride exceeded standards. High levels of chloride (as well as sulfate, magnesium, and calcium) are normal for this region due to easily-eroded marine sediments in the local geology.

V. SOURCE TRACKING

Fiscal Year 2008 was used to apply for grant funds, finalize grant agreements, and award contracts for two source tracking grants. The sampling for the Laguna Watershed Study began in Fiscal Year 2008.

VI. CREEK WALKS

In July, August, and September 2007, Creeks Division staff conducted creek walks on Sycamore, Mission, and Arroyo Burro watersheds. The purpose of the creek walks was to perform routine annual monitoring of creek conditions, and to note any abnormal impairments not noted in previous years.

Creek walk methodology was simplified this year. In previous years, a GPS unit was used to map all impairments, including stream bank modifications, erosion problems, in-stream pollution, and side drains. With the exception of in-stream pollution (generally consisting of small trash), these impairments generally did not change from year to year, and therefore repeating this time-consuming process every year seemed to be an inefficient use of staff time. Therefore, the decision was made to forego the process of mapping all of the impairments. Instead, staff walked the creeks with the following specific goals in mind:

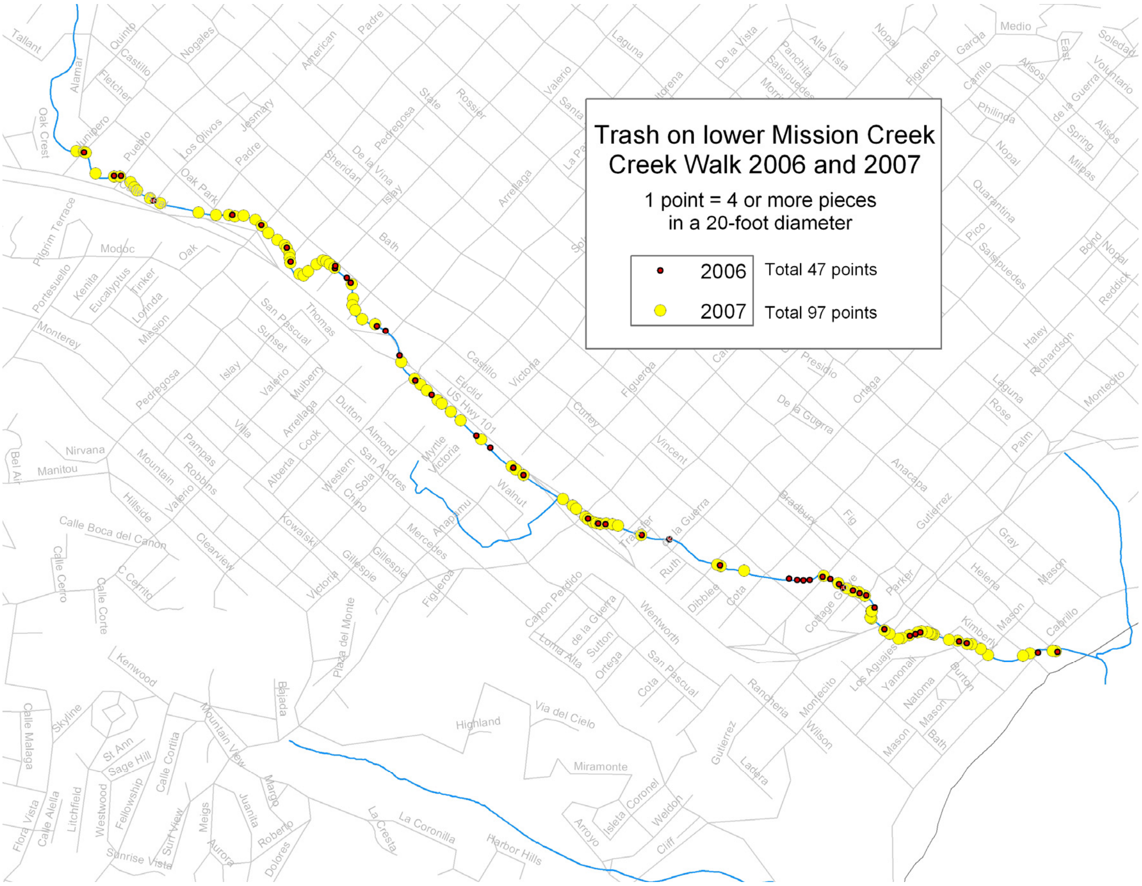
- Document new impairments not found in previous years
- Document immediate enforcement issues (dump sites, water pumps, etc.)
- Use the GPS to map trash on lower Mission Creek only (lagoon to Oak Park), for comparison with previous years
- Quantify and categorize trash on Old Mission Creek, for use in evaluating the effectiveness of the upcoming catch basin screen installation project

This modified approach to Creek Walks did end up saving substantial staff time; it was estimated that most walks were completed in half the normal time. In total, the walks took 7 days, compared to 11 last year. The Creek Walks were completed in the following segments:

- Sycamore Creek (all)
- Mission Creek: Cabrillo Blvd. to Oak Park
- Mission Creek: Oak Park to Foothill Rd.
- Arroyo Burro: Cliff Dr. to Veronica Springs
- Arroyo Burro: Veronica Springs to Hope Ave.
- Arroyo Burro: Hope Ave. to Foothill Rd.
- San Roque Creek: Hope Ave. to Foothill Rd.

Because the goals were modified this year, the methodology was very simplified (with the exception of lower Mission Creek and Old Mission Creek). Two staff members simply walked the creeks, looking for new impairments not found in previous years, and noting immediate enforcement issues. In these cases, the location was noted and photos were taken where appropriate. Enforcement issues were reported to enforcement staff (Tim and Autumn) for follow-up.

In the case of lower Mission Creek, the GPS was used to map trash for comparison with past years. For this section, staff used the same criteria used last year: one point was logged for areas with 4 or more pieces of trash within a 20-foot diameter. In areas with continuous trash, one point was logged approximately every 20 feet. For future years, it is important to use these same criteria so that comparisons can be made. A map comparing the 2006 and 2007 results is below, and shows that substantially more trash was found in 2007 (97 points) than in 2006 (47 points).



In the case of Old Mission Creek, the goal was to quantify and categorize trash to help evaluate the upcoming catch basin screen installation project. Staff walked the creek and counted and categorized every piece of trash, tallied by hand in a notebook. A complete discussion of the methodology can be found in a document called “OMC walk summary” (H:\users\Creeks\Water Quality Monitoring\WQ Analyst\Creek Walk\2007). A spreadsheet containing the trash data, named “OMC trash summary 9.5.07”, can be found in the same folder.

In conclusion, this year’s Creek Walks were effective in evaluating the general condition of the creeks, identifying immediate enforcement issues, and collecting targeted data for specific projects. By simplifying the methodology and narrowing the goals, the time spent by staff on the project was greatly reduced as well.

VII. BIOASSESSMENT

Bioassessment is conducted by Ecology Consulting every spring. The following summary and results are taken from the ____, based on sampling conducted in April and May 2007. Results from spring 2008 sampling are being analyzed by the consultant.

Summary of Results and Discussion

Index of Biological Integrity (IBI) scores at most of the study reaches were lower in 2007 compared to the previous two years, mostly due to dramatic increases in the percentage of non-insects and Dipterans, and a corresponding decrease in the percentage of Ephemeroptera, Plecoptera, and Tricoptera taxa. The lack of rainfall and scouring discharges during the previous winter, one of the driest on record, are thought to be the cause of this widespread trend (see table below). In most cases, IBI scores for individual study reaches were still within the ranges established in previous years of study. The notable exception to this was AB3 (San Roque Creek near Foothill), which had IBI scores of between 36 and 44 (Fair) in six previous years, but this year had an IBI score of 20 (Very Poor). If a downward trend in IBI score continues at this site, upstream sources of pollution from surface water runoff and groundwater inputs should be investigated.

The 2008 sampling year will mark the ninth consecutive year of bioassessment studies in local creeks. Considerably more data representing a wider range of conditions and study reaches is now available compared to when the IBI was initially developed in 2003. Next year or the following year, the IBI scoring system will be revisited and refined in light of the additional years of data that have been collected.

IBI Scores and Classifications from 2000 to 2007

Study Reach	IBI Score									Classification Range
	2000	2001	2002	2003	2004[1]	2005	2006	2007	Range	
SY1-SC Mason	-	-	18	32	24	36	38	22	18-38	Very Poor to Fair
SY3 – SC near Stanwood	-	-	-	32[2]	26[2]	34[2]	38	22	22-38	Very Poor to Fair
M1-MC de la Guerra	14	-	14	14	16	22	16	16	14-22	Very Poor
M2 – OMC Bohnett	-	-	14	14	16	30	26	18	14-30	Very Poor to Poor
M3 – MC Rocky Nook	50	-	48	42	46	40	50	38	38-50	Fair to Good
M4 – Rattlesnake	52	-	-	-	-	-	-	56	52-56	Good to Excellent
M7 – OMC W. Anapamu	-	-	-	-	-	-	24	18	18-24	Very Poor to Poor
AB1- AB near Veronica Meadows	-	-	22	26	28	32	34	28	22-34	Very Poor to Poor
AB3 – SRC near Foothill	44	44	44	36	-	38	44	20	20-44	Very Poor to Fair
AB4 – SRC us AB	-	-	-	-	-	-	28	14	14-28	Very Poor to Poor
AB5 – Mesa Creek Lower	-	-	-	-	-	-	-	22	22	Poor
GAV1 – Gaviota Creek	-	-	42	38	-	32	-	38	32-42	Poor to Fair

* Table from Ecology Consultants

VIII. SAMPLING SCHEDULE

Summary of Sites and Sampling Frequency

	ROUTINE WATERSHED			PROJECT ASSESSMENT			STORM		
SITE	FIB/field	Constit.	Nuts.	FIB/field	Constit.	Nuts.	FIB/field	Constit.	Nuts.
Arroyo Burro Watershed									
ABSurf				biweekly					
AB Lagoon Mouth				biweekly	quarterly	quarterly			
AB Lagoon, Lower		quar-sed							
AB1850	Biweekly -F	quarterly + toxicity			quarterly	quarterly		First Flush+2	First Flush+2
Mesa below				Biweekly -F	quarterly	quarterly			
Mesa above				Biweekly					
AB above LPC	quarterly	Quarterly							
LPC above AB	quarterly	Quarterly							
AB below SRC				Biweekly *					
AB above SRC	quarterly	Quarterly							
SRC above AB	quarterly	Quarterly							
Barger	quarterly	Quarterly							
Jesusita	quarterly	Quarterly							
Golf Course				Storm	storm	storm			
Hope Drain-Load				Monthly					
Spatial Intensive at AB				quarterly					
Mission Creek Watershed									
Surf Zone	quarterly								
MC Lagoon Mouth	quarterly								
MC Lagoon Upper		quar-sed							
MC at Montecito	Biweekly -*F	quarterly +toxicity	quarterly					First Flush+2	First Flush+2
MC Guiterrez				Biweekly					
MC above confluence	Quarterly								
MC at Mission	Quarterly	quarterly	quarterly						
MC at Rocky Nook	Quarterly	quarterly	quarterly						
Rattlesnake	Quarterly	quarterly	quarterly						
OMC above confluence	Quarterly	quarterly	quarterly						
OMC at W. Anapamu				Biweekly	quarterly	quarterly			

Westside Drain				Biweekly	quarterly	quarterly			
SURF-load				weekly during dry					
SURF-month				monthly during dry					
Haley Drain-load				Monthly					
W. Fig-site(s)				storm	storm				
LC (if joined)	Quarterly								
Spatial Intensive at Bohnett				quarterly					
Laguna Watershed									
LC @ CPP	Biweekly	quarterly +sed+tox	quarterly					First Flush+2	First Flush+2
LC at Garden				quarterly	quarterly				
Manhole 1 (TBD)				quarterly	quarterly				
Manhole 2 (TBD)				quarterly	quarterly				
Manhole 3 (TBD)				quarterly	quarterly				
Sycamore Watershed									
SC Surf	Quarterly								
SC Outlet (if running)	Quarterly								
SC at 101	Biweekly -*F	quarterly +sed+tox	quarterly					First Flush+2	First Flush +2
SC at Cacique	Quarterly	quarterly	quarterly						
SC at APS	Quarterly	quarterly	quarterly						
SC at Stanwood	Quarterly	quarterly	quarterly						
Additional									
Lighthouse	Quarterly								
Honda	Quarterly								
Additional Drains (TBD)	125	20							
Additional Storm (TBD)							100	20	10

Sampling Plan for Quarterly Snapshots

Arroyo Burro

Site	Flow	FIB/Field	Constituents	Nutrients
Jesusita	estimate area/velocity	water	water	water
Barger	estimate area/velocity	water	water	water
SRC above AB	estimate area/velocity	water	water	
AB above SRC	estimate area/velocity	water	water	water
AB above LPC	estimate area/velocity	water	water	
LPC above AB	estimate area/velocity	water	water	water
Mesa low	TBD	water	water	water
AB at Cliff	TBD (LTER)	water	water+tox	water
Lagoon, lower			sediment	
Lagoon Mouth	estimate area/velocity	water	water	
Surf	n/a	water		

Mission Creek

MC at Rattlesnake	estimate area/velocity	water	water	water
MC at Rocky Nook	USGS gauge	water	water	water
MC at Mission	USGS gauge	water	water	water
MC above confluence	TBD	water		
OMC above confluence	bucket/timer	water	water	water
OMC WSD	flow gauge/bucket timer	water	water	water
OMC Bohnett Park	n/a	water	water	water
Montecito	estimate/LTER gauge	water	water+toxicity	water
Laguna Channel (if lagoons joined)	estimate area/velocity	water		
Upper Lagoon	n/a		sediment	
Lagoon Mouth	estimate area/velocity	water		
Surf	n/a	water		

Sycamore Creek

Surf	n/a	water		
Outlet-if running	estimate area/velocity	water		
SC at 101	estimate area/velocity	water	water+sed+tox	water
SC at Cacique	estimate area/velocity	water	water	water
SC at APS	estimate area/velocity	water	water	water
SC at Stanwood	estimate area/velocity	water		water

Laguna Channel

LC at Chase Palm Park	n/a	water		
LC at Garden Onramp	estimate area/velocity	water		
Manhole 1 (TBD)	virtual bucket	water	water+sed	water
Manhole 2 (TBD)	virtual bucket	water	water	water
Manhole 3 (TBD)	virtual bucket	water	water	water

Additional creeks

Site	Flow	FIB/Field	Constituents	Nutrients
Lighthouse	estimate area/velocity	water		
Honda	estimate area/velocity	water		

Sediment does not have to be on same day.

Constituent Lists

	First Flush	Basic Storm	Quarterly	Quarterly with Toxicity
Hardness	X	X	X	X
TSS	X	X	X	X
Oil and Grease	X	X		
MBAS	X	X		
Dissolved copper	X	X	X	X
MBAS	X	X		
EPA 8081A (chlorinated pesticides)	X			
EPA 8141A (organo-phosphorus pesticides)	X			
EPA 8151A (chlorinated herbicides)	X			
Glyphosate	X			
Total Digestion (metals)	X	X	X	X
Total Metals (group)	X	X	X	X
Toxicity (% survival)	X			X