
Clean Creeks
HEALTHY BEACHES
CITY OF SANTA BARBARA

# Water Quality Monitoring Program Report 2001-2006

SEAL OF THE CITY OF SANTA BARBARA
CALIFORNIA

City of Santa Barbara
Creeks Restoration and Water Quality Improvement Division
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*Terms marked with an asterisk are defined in a glossary at the end of this report.

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# I. INTRODUCTION

Water quality monitoring allows the City of Santa Barbara (City) Creeks Division to identify problems, track changes over time, assess the performance of restoration and treatment projects, and build a baseline of data for future projects. The City uses many tools for monitoring, including tests for indicator bacteria and chemical pollutants, field tests of water quality parameters relevant to aquatic organisms, DNA-based methods, creek walks, and biological assessments. The program goals and specific research questions, balanced against cost constraints, drive the choice of methods and sampling strategies for each component of the monitoring program.

## PROGRAM GOALS AND MOTIVATION

**The primary goals of the monitoring program are to:**

- Quantify the levels 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.

## PROGRAM ELEMENTS

The monitoring program consists of seven key elements:

1. **Routine watershed assessment** focuses on microbial contamination*, as measured by indicator bacteria*, and water quality parameters (physicochemical* properties including pH, temperature, dissolved oxygen, turbidity, conductivity). These data are to establish baseline information, track long-term changes, and identify emerging hot spots.

2. **Storm monitoring** is used to identify chemical constituents of concern and to identify pollution* hot spots. Sampling is also used to ask questions about how pollutants reach the creeks, e.g. do some pollutants arrive during first flush storms while others arrive during large, sustained events? Data are also used to establish baselines and evaluate the performance of storm water management projects.

3. **Restoration and water quality treatment assessment** is used to determine the success or projects in lowering microbial and chemical pollution levels and improving water quality for aquatic organisms.

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4. **Biological assessment** uses benthic* macroinvertebrate* surveys and an index of biological integrity* to assess and track the health of creeks for aquatic organisms.

5. **Creek walks** from the ocean to upper watersheds are a used to identify problem areas within creeks and track changes due to natural processes and development. Problem areas may include sources of polluted input to the creek or sites of habitat degradation.

6. **Microbial source tracking***is used to develop better tools for tracking fecal pollution in creeks and to identify sources of indicator bacteria.

7. **Special studies** are undertaken to address various questions and issues that arise.

## BACKGROUND

The Creeks Division Monitoring Program began in May 2001 and since then has collected extensive data on indicator bacteria and water quality parameters. Early efforts focused largely on quantifying the degree of microbial pollution in creek water and identifying hot spots in order to prioritize treatment projects, as described in the City's Bacterial Reduction Study (2002). Additional goals were to establish baselines for indicator bacteria and water quality parameters in order to track improvements over time, and to understand the connections between creek and lagoon water quality to beach warnings*. Results from 2001-2003 were presented in the City's 2003 Water Quality Monitoring Program Report (many of the documents referenced in this report are available on the Creeks Division web page at www.sbcreeks.com).

In 2004, the monitoring program was expanded and modified, particularly by expanding the storm-monitoring and the restoration/water quality treatment assessment elements to include regular testing for chemical pollutants. Prior to 2004, samples were tested for a limited number of chemical pollutants in some storm water samples. In addition, the Creeks Division sponsored a UCSB Bren School graduate project that focused on evaluating the relationship between the types of land use and pollution in storm water ("Bren land use report"; Aguinaga et al. 2005).

In 2005 the Creeks Division continued to implement the monitoring program and made a few minor modifications to improve storm monitoring and incorporate recommendations from the Bren land use report. As an example, the Bren land use report recommended classifying sampling sites based on their role as integrator* or indicator* sites. Integrator sites, typically located at the downstream end of a watershed or subwatershed, are used to assess the total pollution impact on the watershed and how watershed-wide projects can improve water quality. Indicator sites are located at the outflow of smaller drainage areas that can be categorized by land use(s).

## REPORT OVERVIEW

The purpose of the five-year water quality report (Water Quality Monitoring Program Report 2001-2006; see attached Executive Summary) is to record the efforts of the Monitoring Program in a way that is meaningful to the public while also being worthwhile technically. A second purpose is to compile and synthesize the data in ways that can be used to inform decisions. Last, the report provides an opportunity to revisit research questions based on the results obtained.

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After a brief introduction to the monitoring program, the report provides information on how water quality is defined, what constitutes a pollutant of concern, and the sources, criteria, and impacts of different pollutants and parameters. After describing the methods of analysis, research questions, sampling strategies, results, and discussion are presented for reach program element. Selected results are presented for routine watershed assessment, including long term data on indicator bacteria, and storm monitoring, including data on chemical pollutants. The report also contains baseline data for project assessment and creek walk data from 2005. Results from special studies include precision of indicator measurements, a study on foam at Arroyo Burro Beach in January 2006, and an analysis of beach warnings at County-monitored beaches within the City. The report summarizes recent results from bioassessment and microbial source tracking, both of which are conducted by outside contractors. The report concludes with key findings and general recommendations for future monitoring. The appendices include a glossary to define technical terms, each of which is denoted in the text by an asterisk, climate data, and additional methods and results.

## II. DEFINING WATER QUALITY

Water quality refers to the physical, chemical, and biological properties of water (drinking water, creek water, ocean water, etc.), in relation to use of the water (drinking, recreation, aquatic habitat, etc.). "Good" water quality implies that the physical, chemical, and biological properties of the water support a particular use. "Good" water quality for one use is not necessarily good water quality for all uses, e.g., some creek water may be cold, clear, and oxygenated enough to support steelhead fish, but still contain levels of indicator bacteria that are not safe for recreational contact. "Bad" water quality, on the other hand, implies that properties(s) of the water do not support an intended use, e.g. creek water may be too warm, silty, or low in oxygen, for steelhead to flourish or even survive.

### IDENTIFYING POLLUTANTS OF CONCERN

One of the main goals of the monitoring program is to identify pollutants or classes of pollutants that are problematic in Santa Barbara watersheds. In order to define constituents of concern*, it is necessary to know the designated (or beneficial*) creek uses to be protected, the values measured in the environment, the detection limits* of the analytical techniques (or practical quantification levels*; PQL), and the criteria* for defining harmful impacts.

In order to relate physical, chemical, and biological properties of water to the beneficial use of interest, measured values from monitoring efforts are compared against criteria (also called standards or thresholds) that are known to be related to the use. Every creek in Santa Barbara has been classified according to beneficial uses it supports (Table 1), and several different sources provide relevant criteria for each beneficial use. Using the steelhead example, the beneficial use is termed Cold Habitat, and the threshold for dissolved oxygen is 7.0 mg/L for Cold Habitat. That is, it is known that steelhead function better when the dissolved oxygen is greater than 7.0 mg/L. Therefore, when trying to interpret dissolved oxygen values in providing adequate habitat for steelhead, they must be above the standard to be considered adequate.

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**Table 1. Beneficial uses of Santa Barbara creeks as designated by the RWQCB.**

| | Arroyo Burro Estuary | Arroyo Burro Creek | Mission Creek | Rattlesnake Canyon | Laguna Channel | Sycamore Creek |
|---|---|---|---|---|---|---|
| **Municipal and Domestic Supply (MUN)** | | X | X | X | | X |
| **Agricultural Supply (AGR)** | | | | | | X |
| **Groundwater Recharge (GWR)** | | X | X | X | X | X |
| **Water Contact Recreation (REC-1)** | X | X | X | X | X | X |
| **Non-Contact Water Recreation (REC-2)** | X | X | X | X | X | X |
| **Wildlife Habitat (WILD)** | X | X | X | X | X | X |
| **Cold Fresh Water Habitat(COLD)** | | | X | X | | X |
| **Warm Freshwater Habitat (WARM)** | X | X | X | X | X | X |
| **Migration of Aquatic Organisms (MIGR)** | | | X | X | | X |
| **Spawning, Reproduction, and/or Early Development (SPWN)** | X | X | X | X | X | X |
| **Preservation of Habitats of Special Biological Significance (BIOL)** | | X | | | | |
| **Rare, Threatened or Endangered Species (RARE)** | | X | X | | | X |
| **Estuarine Habitat (EST)** | X | | X | | | X |
| **Freshwater Replenishment (FRESH)** | | X | X | | | X |
| **Commercial and Sport Fishing (COMM)** | X | X | X | X | X | X |

[a] Called "Waste Slough" in State Water Board Documents. See Appendix A for definitions of beneficial uses.

The technical terms used by the State to define a water quality standard* are the pollutant of concern*, the beneficial use* to be protected (the US EPA uses "designated use"), and the water quality objectives* (the USEPA uses "criteria").

There are several sources of criteria and/or guidance that may pertain to different pollutants and different beneficial uses, including the RWQCB's Basin Plan* (CA EPA 1994), the California Toxics Rule* (CTR; US EPA 2000), the US EPA's Current National Recommended Water Quality Criteria (US EPA 2006), and the Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California, known as the State Implementation Plan, or SIP (CA EPA, 2005). Generally, these documents guide the permit process for industrial dischargers on the state and federal level. Permitees are prohibited from releasing effluent that would cause the receiving waters* to exceed criteria that are based on protecting aquatic life and human health. The City of Santa Barbara is currently not regulated to conduct sampling in creeks or to meet any water quality objectives.

For most priority pollutants, criteria can be found in the CTR, the Basin Plan, and/or the US EPA's National Water Quality Criteria. Criteria may differ based on the water hardness, the form of the pollutant (dissolved or total), the designated beneficial use, and the frequency of exposure (continuous or maximum concentration criteria, relating to chronic and acute toxicity, respectively). The Creeks Division uses the appropriate criteria to evaluate the status of creek and lagoon water in order to meet program goals and objectives. According to the SIP,

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however, municipal storm water is not subject to the same standards as those required for industrial permits. The SIP also states that if a Basin Plan water quality objective and a CTR criterion are in effect for the same priority pollutant, the more stringent of the two applies. The Model Monitoring Program for Southern California, a document prepared as a response to state legislation (SB 72) that requires standardization of storm water monitoring, notes that appropriate criteria should be selected based on the regulatory context and the research questions (Model Monitoring Technical Committee, 2004).

In the results discussed in this report, the most stringent criteria were chosen to compare with results. For many constituents, regulatory criteria are promulgated for acute and continuous exposure by aquatic organisms. Although storm water may appear sufficiently sporadic to quality as acute exposure, the definition of acute is that the concentration is reached only once in three years. The criteria for continuous exposure, which relate to chronic toxicity, are more stringent and appropriate for storm water. For criteria that are designated "hard" or "soft", water was assumed to be hard (> 100 mg $CaCO_3$).

## INDICATOR BACTERIA

### Definitions

The most commonly used indicators of fecal contamination are groups of indicator bacteria* that are cultured from environmental samples. Total coliforms, fecal coliforms (a subset of total coliforms), *Escherichia coli* (a subset of fecal coliforms), and enterococci (a subset of fecal streptococci) are the most widely used indicator bacteria. The City collects data on total coliform, *E. coli*, and enterococcus. *E. coli* values can be converted to approximate fecal coliform values when necessary.

Indicator bacteria are always found in high concentrations in human waste and sewage. Indicator bacteria are used to predict the likelihood that human waste/sewage is present in environmental samples. The bacteria are normal – and beneficial – inhabitants of human intestines. However, human waste can also contain pathogenic (disease-causing) microorganisms (viruses, bacteria, and protozoa). *The vast majority of indicator bacteria are not pathogens, and the vast majority of pathogens are not indicator bacteria.* Measuring pathogens directly is too costly, time-consuming, and inefficient to be used at this time.

Unfortunately, indicator bacteria do not always indicate the presence of human waste/sewage, and that is the main weakness in using indicator bacteria to assess the risk to human health from swimming. First, indicator bacteria are found in the intestines and waste of other mammals (dogs, cats, raccoons, etc.) and birds. Waste from other animals is far less likely to contain microorganisms that are harmful to humans. Second, indicator bacteria can survive and even multiply in the environment, including in storm drains. At the present time, indicator bacteria are the cheapest and fastest ways to assess contamination.

The problems with indicator bacteria are acknowledged at state and federal regulatory levels, but no alternative tools are yet available for routine analysis. Throughout the world a major research effort is underway to find better methods for assessing health risk and for tracking sources of pollution. The City is contributing to the goal of obtaining more specific indicators for human and animal waste with the microbial source tracking* project described below.

### Sources

Sources of total coliforms include plants, soils, human waste, and animal waste, including dogs, cats, birds, horses, and raccoons). Fecal coliforms, including *E. coli*, and enterococci are more

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specific to the intestinal tracks and waste of mammals and birds. Most indicator bacteria can survive, if not grow, in the environment naturally. Indicator bacteria can be found in high levels in nonurbanized areas. Recently it was shown that *E. coli* and Enterococcus can survive and multiply in biofilms (slime layers made of bacteria) in storm drains.

Human waste – and associated indicator bacteria – may reach urban creeks from leaking septic tanks, leaking sewer lines, illicit connections to storm drains, storm water runoff over contaminated ground (e.g., near hiking trails or encampments), or by using the creeks themselves as latrines or receptacles for waste.

Dry weather sources of indicator bacteria may very well be different than storm-generated indicator bacteria.

**Harmful effects**

Swimming in water contaminated with pathogenic (illness-causing) microorganisms, including bacteria, protozoa, and viruses can cause illness in a small percentage of people. Many studies have been done throughout the world examining the ability of indicator bacteria to predict illness. Overall, the most consistent statistical relationship is between enterococcus concentrations and gastrointestinal (GI) illness (vomiting, diarrhea, and fever). In most cases, enteric viruses likely cause swimming-related GI illnesses.

More serious diseases and outbreaks of illness are tracked in order to understand the causes and links among patients. The Center for Disease Control has a surveillance program to track outbreaks of swimming-related illnesses. Since the program began in 1978, no outbreaks have been reported from swimming at ocean beaches. Within Santa Barbara County, medical providers and labs are required to report outbreaks and cases of serious illness (e.g. Hepatitus A) to the Environmental Health Services Department. No reports of outbreaks or serious illness in the County have been attributed to swimming in creeks or oceans.

**Criteria**

In order to understand the extent of microbial pollution in creeks, lagoons, and the beach, it is necessary to compare the observed indicator bacteria levels to criteria* that are set to protect human health. The criteria are formulated to predict illness from pathogenic microbes based on exposure to indicator bacteria at certain concentrations. Numerous epidemiological studies* have been used to calculate criteria for indicator bacteria. In general, criteria are calculated with the underlying basis that recreational contact with the designated water body should lead to less than eight illnesses per 1,000 swimmers in freshwater and less than 19 illnesses per 1,000 swimmers at marine beaches (US EPA 1986).

Regulatory jurisdiction for setting standards and the numerical criteria* for recreational contact standards* for indicator bacteria have been the subject of much attention over the past five years. Criteria vary based on fresh vs. marine water, the group of indicator bacteria used, the statistical procedure used (geometric mean*, or geomean*, vs. single sample maximum*), the type and degree of recreational contact, and the selected epidemiological studies that are used to calculate risk, as shown in Table 2 and Table 3.

At the present time, the guidance for indicator bacteria criteria in marine waters in California is clear and consistent among agencies. In February 2006 the United States Environmental Protection Agency (US EPA) approved the State Water Resources Control Board's* (SWRCB) California Ocean Plan* (California Environmental Protection Agency 2005), which sets recreational contact criteria for total coliform*, fecal coliform*, and enterococcus* in coastal

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waters and enclosed bays and estuaries* for the entire state (Table 3). The County of Santa Barbara uses these criteria for reporting indicator bacteria results and posting beach warnings* when necessary (County of Santa Barbara 2003). The City also uses these standards when assessing samples collected in the ocean and lagoons.

The state mandate for using indicator bacteria criteria does not currently apply to freshwater areas such as creeks, streams and/or freshwater lakes and guidance for determining freshwater criteria is less clear. The guidance for freshwater recreation includes the US EPA's Water Quality Standards for Coastal and Great Lakes Recreation Waters, Final Rule (2004), the Regional Water Quality Control Board's* (RWQCB) Basin Plan*, promulgated by the California Environmental Protection Agency (CA EPA 1994), and a Draft Amendment to the Basin Plan (CA EPA, pending). The US EPA recommends freshwater criteria for *E. coli* and enterococcus that vary based on the frequency of full contact recreation (Table 2). The Basin Plan contains a single set of criteria for all waters with recreation as a beneficial use* (REC-1*) that is valid only for fecal coliform, and does not discriminate between inland surface waters, which are freshwater, and enclosed bays and estuaries*, which are brackish or marine. The Draft Amendment to the Basin Plan, which is pending approval, provides alternative criteria for fecal coliform and *E. coli* in inland surface waters but does not provide criteria for total coliform or enterococcus.

Exceedances of the California Ocean Plan standards (formerly known as AB 411 standards) require posting of warning signs at the beach area where recreational water contact may occur. This state mandate does not currently apply to freshwater areas such as creeks, streams and/or freshwater lakes. The California Ocean Plan requires weekly testing at qualified beaches to evaluate human health risk. The Creeks Division does not sample frequently enough to use the geometric mean* as an evaluative tool.

This report uses the criteria for fecal coliform from the Draft Amendment's single sample maximum for REC-1 inland surface waters and for enterococcus uses the US EPA's single sample maximum for infrequent recreational contact (Table 2). For *E. coli*, this report uses both the EPA's and the Draft Amendment's single sample maximums. The difference between the *E. coli* criteria is due to the classifications of recreational contact. The US EPA includes criteria for areas with infrequently used full-body contact, which is appropriate for creeks in Santa Barbara. The RWQCB provides a single set of criteria for water bodies with contact recreation (REC-1), including wading and swimming, and does not discriminate based on the amount of usage.

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**Table 2. Summary of criteria for indicator bacteria in freshwater.**

| Regulation or Guidance Document | Criteria for Freshwater: Total Coliform | Fecal Coliform | *E. coli* | Entero-cocci |
|---|---|---|---|---|
| U.S. EPA (2004) for beaches with infrequent use | | | | |
| *Geomean** | | | 126 | 33 |
| *Single sample maximum** | | | 576 | 151 |
| RWQCB Basin Plan (1994) for inland surface waters and enclosed bays and estuaries designated REC-1* | | | | |
| *Geomean* | | 200 | | |
| *Single sample maximum* | | 400 | | |
| RWQCB Basin Plan Draft Amendment (pending approval) for inland surface waters designated REC-1* | | | | |
| *Geomean* | | 200 | 126 | |
| *Single sample maximum* | | 400 | 235 | |

**Table 3. Summary of criteria for indicator bacteria in marine water.**

| Regulation or Guidance Document | Criteria for Marine Water: Total Coliform (TC) | Fecal Coliform (FC) | *E. coli* (EC) | Entero-cocci (ENT) |
|---|---|---|---|---|
| California Ocean Plan (2005) | | | | |
| *Geomean** | 1,000 | 200 | | 35 |
| *Single sample maximum** | 10,000 | 400 | | 104 |
| RWQCB Basin Plan (1994) Enclosed bays and estuaries* designated REC-1* | | | | |
| *Geomean* | | 200 | | |
| *Single sample maximum* | | 400 | | |
| RWQCB Basin Plan Draft Amendment (2004) Enclosed bays and estuaries designated REC-1* | | | | |
| *Geomean* | 1,000 | 200 | | 35 |
| *Single Sample Maximum* | 10,000 | 400 | | 104 |

## PHYSICOCHEMICAL PROPERTIES

Physicochemical properties of water include conductivity, dissolved oxygen (DO), pH, temperature, and turbidity. These are also called “conventional water quality parameters,” or “field parameters.” The sources, effects, and criteria of the field parameters are discussed below. Additional information can be found in Santa Barbara Channel Keeper’s Stream Team reports.

### Sources, Effects and Criteria

*Conductivity* is roughly synonymous with salinity, or saltiness of water. It is also a proxy for Total Dissolved Solids (TDS). Dissolved solids, or salts, arise naturally from dissolution of natural minerals in groundwater and surface water. Anthropogenic inputs include nutrients and pollutants. There is no ecological criterion for conductivity (Table 4). Conductivity is used to assess the extent of tidal influence in creeks, the arrival of storm water in creeks and drains (low conductivity due to rain), and to identify transient pollution problems (unusually high conductivity).

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*Dissolved oxygen* is an important parameter for assessing creek water quality for aquatic habitat. Low dissolved oxygen can be deleterious for fish and invertebrate species. Dissolved oxygen enters creek water by equilibrating with the air and entraining bubbles in riffles and drops. Dissolved oxygen is also produced by aquatic plants, including algae. Oxygen is depleted by aquatic organisms, primarily, when bacteria break down organic material. Harmful effects of hypoxia (low oxygen) are stress and death to aquatic organisms. The cutoff for harmful effects is around 5-7 mg/L (Table 4).

The parameter *pH* is a measure of the hydrogen ion concentration, and indicates the acidity of water. Low pH refers to acidic water; high pH to water that is basic. Low pH can harm certain organisms and cause certain toxic compounds to go into solution. Changes in pH can be brought about by temperature and dissolved oxygen changes. Criteria for pH include upper and lower bounds for aquatic habitat and recreational contact.

*Turbidity* refers to the "cloudiness" of water. High turbidity can harm aquatic organisms by destroying habitat (in the case of invertebrates) and impacting behavior, e.g. foraging, in fish. Sources of turbidity include suspended sediment and blooms (rapid growth) of algae and bacteria.

**Table 4. Summary of criteria for physicochemical properties**

| Parameter | RWQCB Basin Plan Objectives (Beneficial Uses) | Additional Objectives |
|---|---|---|
| Conductivity, uS | No criterion | |
| Dissolved Oxygen (DO), mg/L | >7.0 (COLD, SPAWN)<br>>5.0 (WARM, SPAWN) | |
| pH | 7-8.5 (COLD, WARM)<br>6.5-8.3 (MUN, AGR, REC-1, REC-2)<br>Changes in normal ambient pH levels shall not exceed 0.5 in fresh waters (COLD, WARM) | |
| Temperature, °C | At no time or place shall the temperature be increased by more than 5°F above natural receiving water temperature (WARM, COLD) | > 24 deg C [a] (Channelkeeper, US EPA)<br>> 20 mean, >25 short term (SYSTRT, 2000) |
| Turbidity, NTU | 1. Where natural turbidity is between 0 and 50 Jackson Turbidity Units (JTU), increases shall not exceed 20 percent.[b]<br>2. Where natural turbidity is between 50 and 100 JTU, increases shall not exceed 10 JTU.<br>3. Where natural turbidity is greater than 100 JTU, increases shall not exceed 10 percent. (RWQCB BP) | 1. Summer Season (June 1-Oct. 1) – algal bloom indicator = 2.34 NTU (EPA)<br>2. Effects on steelhead noticeable at ~ 25 NTU. |

[b]NTU are approximately equivalent to JTU.

## METALS

The Creeks Division has collected data on both dissolved and total trace metals, including arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver and zinc.

### Sources/mechanisms

Sources of metals may come from erosion of natural deposits, pesticides, industrial waste discharges, agricultural waste, automobile parts such as break pads, or corroding metal pipes and storage tanks.

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**Harmful effects**
Trace metals can have direct toxic effects on aquatic plants and animals. They can also bioaccumulate* in aquatic species, such as mussels, and then have dangerous impacts all the way through the food chain. Metals can also accumulate in the sediments of streams, lakes, and estuaries, potentially being resuspended during storm events.

**Criteria**
Metals in storm water can be measured in two forms, dissolved and total recoverable. In general, metals are more bioavailable and more toxic in the dissolved form. The EPA and State criteria to protect aquatic and human life have been updated to reflect dissolved metal toxicity. However, when mass emissions or loads are the focus of interest, total metals may be the appropriate target (Model Monitoring Technical Committee, 2004). Relevant criteria are included where results are presented.

## HERBICIDES/PESTICIDES

The Creeks Division tests for the herbicide glyphosate (a component of Rodeo and Roundup) and a suite of organophosphorus (OP) pesticides including malathion, parathion, and 24 others.

**Sources/mechanisms**
Sources of herbicides and pesticides include residential and commercial landscaping. Runoff over landscaping treated with the chemicals provides a route of entry to the creeks.

**Harmful effects**
Glyphosate is one of the most toxic herbicides to plants but is not generally toxic to animals or humans in low doses. Glyphosate is strongly adsorbed to soil, with little potential for leaching to ground water. Microbes in the soil readily and completely degrade it even under low temperature conditions. It tends to adhere to sediments when released to water and does not tend to accumulate in aquatic life.

The California Department of Fish and Game permits the use of certain herbicides containing glyphosate (e.g. Rodeo) in aquatic environments; therefore, it is assumed that glyphosate does not harm aquatic life when applied according to the product label. However, many herbicides containing glyphosate (including Roundup) are not approved for use in aquatic environments because they contain additional toxic compounds such as polyoxyethyleneamines. Roundup is commonly used in residential and commercial landscaping and is therefore a concern to creek water quality.

In terms of human health, glyphosate is classified as a Tier 2 (less toxic) pesticide according to the City's IPM program. The USEPA does not consider Glyphosate a cancer risk to humans. Additional information can be found in documentation for the City's integrated pest management (IPM) program.

Aquatic invertebrates and freshwater fish, particularly salmonids and centrarchids, are sensitive to OP pesticides, including malathion and parathion. The OP pesticides cause reproductive impairment and deformities of fishes.

**Criteria**
For many of the herbicides and pesticides that are tested, relevant criteria do not exist or are below the levels of detection currently available. Therefore, it can be considered problematic if

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herbicides and pesticides are frequently detected in creeks, regardless of their levels. Relevant criteria are shown where results are presented.

**ADDITIONAL ORGANIC POLLUTANTS**

Additional pollutants analyzed include anionic surfactants (methylene blue active substances; MBAS), oil and grease, and total recoverable hydrocarbons (TRPH).

Anionic surfactants (MBAS) are found in household cleaning products (soaps, detergents), car cleaning products, driveway sealers, some pesticides/fungicides. The surfactants can be toxic at high concentrations. When surfactants interact with environmental matrices, they can create properties such as foaming, emulsification, and particle suspension. The primary reason MBAS is sampled is as a tracer of wastewater or washing processes reaching storm water.

Oil and grease affects the feeding and reproduction of aquatic organisms. Marine larvae are most susceptible to oil and grease pollution. Sources include cars leaking oil or fuel, spillage at fueling stations, and discarding of oil or fuel into storm drains. The current criterion for the Basin Plan is narrative rather than numeric.

## III. METHODS

**SAMPLING LOCATIONS**

The Creeks Division has collected samples at many sites in the Santa Barbara watersheds over the past five years (). Sites are comprised of creek, drain, lagoon and beach locations. Following the lead of the Bren report, sites are now put in the context of integrator and indicator when possible. The Creeks Division also samples at project assessment sites for restoration and water quality treatment projects. Table 5 lists the sites and classifications where data for this report was collected. Maps of the locations are shown in Figure 1, Figure 2, Figure 11, , and Figure 13.

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**Table 5. Sampling locations for the Monitoring Program results presented in this report.**

| Site name (Abbreviation) | General Location | Site Classification |
|---|---|---|
| *Arroyo Burro (AB) Watershed* | | |
| AB Surf | Surf zone 50 ft west of estuary mouth | Assessment |
| AB Estuary (Mouth, Mid, and Upper) | Arroyo Burro Estuary | Assessment |
| Mesa Creek | Mesa Creek above Arroyo Burro Estuary | Assessment |
| AB at Cliff | Arroyo Burro at Cliff Drive | Downstream Integrator*, Assessment |
| Portesuello | Discharge of spring water to Arroyo Burro near Portesuello Ave. | |
| AB Below LPC | Arroyo Burro below confluence with Las Positas Creek | |
| LPC Above LPC | Las Positas Creek above confluence with Arroyo Burro | |
| LPC Head | Las Positas Creek at Modoc Rd. | Assessment |
| AB Above LPC | Arroyo Burro above confluence with Las Positas | |
| AB Valle Verde | AB Creek at Torino Rd. | Midstream Integrator |
| AB Below SRCe | AB Creek below Hope Ave. | Assessment |
| Hope Drain | Drain below Hope Ave. | Commercial Indicator, Assessment |
| SRC Above AB | San Roque Creek above confluence with Arroyo Burro | |
| AB Above SRC | Arroyo Burro above confluence with San Roque Creek | |
| Jesusita | Jesusita Creek at Jesusita Trail | Upper Watershed Indicator |
| AB Barger | Arroyo Burro at Barger Canyon | Upper Watershed Indicator |
| *Lighthouse Watershed* | | |
| Lighthouse Creek | La Mesa Park | Downstream Integrator |
| *Honda Watershed* | | |
| Honda Creek | Honda Creek at SBCC | Downstream Integrator |
| *Mission Creek (MC) Watershed* | | |
| MC Lagoon | Mouth of Lagoon at E. Beach | Integrator Mission and Laguna watersheds combined |
| MC at Montecito | Mission at Montecito Street | Downstream Integrator |
| MC @ Guttierez | Mission Creek at Guttierez St. | Assessment |
| HLDa | Haley Drain above Filter | Commercial Indicator, Assessment |
| HLDb | Haley Drain below Filter | Commercial Indicator, Assessment |
| Carrillo Drain | Mission Creek at Carrillo Street | Commercial Indicator, Assessment |
| OMC at W. Anapamu | Old Mission Creek (OMC) at West Anapamu Street | Residential Indicator, Assessment |
| Westside Drain | Drain to OMC at West Victoria | Residential Indicator, Assessment |
| San Pasqual Drain | Drain to OMC above bioswale | Residential Indicator, Assessment |
| Mission Canyon | Mission Canyon Rd. | Upper Watershed Integrator |
| Rattlesnake | Rattlesnake Creeks at Las Canoas Rd. | Upper Watershed Indicator |
| *Laguna Watershed* | | |
| LC at Chase Palm | Laguna Channel at Chase Palm Park | Downstream Integrator, completely developed |
| *Milpas Drainage Area* | | |
| Milpas Drain | Drain to East Beach below Milpas Street. | Indicator site for |
| *Sycamore Watershed* | | |
| SC at 101 | Sycamore Creek at Railroad Br. | Downstream Integrator |
| SC at Cacique | Sycamore Creek at Cacique St. | Midstream Integrator |
| SC at APS | Sycamore Creek at Montecito St. round-about | Midstream Integrator |
| SC at Stanwood | Creek below Stanwood Dr. | Upper Watershed Integrator |

*Terms marked with an asterisk are defined in a glossary at the end of this report.

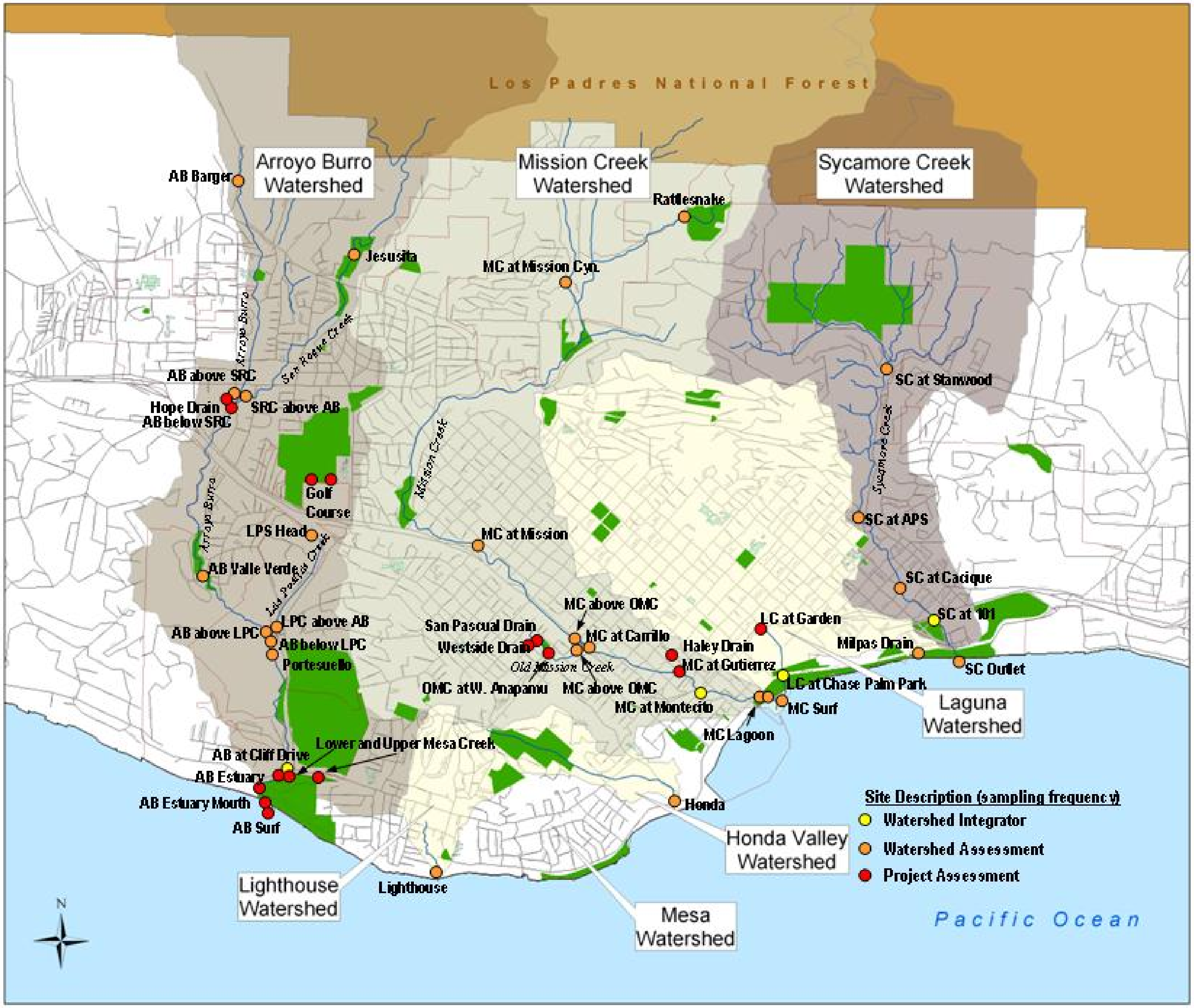


**Figure 1. Map of sampling locations throughout the City.**

*Terms marked with an asterisk are defined in a glossary at the end of this report.

## INDICATOR BACTERIA

All water samples are analyzed at the City's State-Certified Laboratory at the El Estero Wastewater Treatment Plant using the IDEXX Colilert and Enterolert methods. Results are in units of Most Probable Number (MPN) describing the statistical concentrations of indicator organisms in 100 mL of water. The MPN method is one of the prescribed techniques for the determination of these coliform bacteria from the Standard Methods for the Examination of Water and Wastewater (19th Edition, 1995) as prescribed by the EPA.

The amount of indicator organisms present (using the IDEXX Colilert and Enterolert standard methods) has maximum detection limit based on the amount of dilution per sample. Diluting the samples allows for a greater maximum detection limit when higher numbers are anticipated. In cases where the dilution is not great enough, results are reported as being some number greater than the maximum detection. Maximum detection at 1:10 dilution is 24,192 MPN for *E. coli* and enterococcus. In some cases 1:100 or 1:1000 dilutions were used for samples with anticipated higher MPN results.

Because many of the indicator bacteria data are reported as greater than, or less than, a particular number, the data are considered "censored" in statistical terms. Censored data pose challenges for calculating descriptive statistics and performing statistical tests. In some cases, more than half of the values analyzed were censored. Therefore, medians are generally used in descriptive statistics. Confidence intervals were not calculated due to advanced statistics required for censored data (Helsel, 2005).

## PHYSICOCHEMICAL PROPERTIES

Temperature, conductivity, dissolved oxygen and turbidity data are collected in the field with electrochemical probes.

## CHEMICAL CONSTITUENTS

All constituent analyses were conducted by the Zymax Envirotechnology laboratory in San Luis Obispo or Fruit Growers Laboratory in Santa Paula. Both are certified by the State of California's Department of Health Services. Data is reported for the Practical Quantitation Limit (PQL) and any known standard or limit for each constituent. The PQL is the lowest level that the lab is confident of reporting. An "ND" result means that the lab did not detect the constituent.

## CREEK WALKS

Creek walks were conducted through the months of July and August 2005 by city staff and included all watersheds within city limits. The dry period of the year allowed staff to easily identify water inputs to the creeks that may be sources of water pollution. Parcel and drainage maps were used from Public Works Browser for reference points.

Point and line data was collected using a GPS unit and data was imported to a GIS to produce maps. A subset of the data collected in 1999 for the Creeks Inventory and Assessment Study (2000) was collected. These include five main categories and their subcategories: New Side Drains, Bank Modifications, Bank Erosion, In-Stream Pollution, and Tributaries. The sub-categories are detailed in Appendix C. Every effort was used to collect the 2005 data using the same methodology that was used in 1999 in order to reduce the subjective differences that naturally occur when data is collected many years later by different people. Further discussion

*Terms marked with an asterisk are defined in a glossary at the end of this report.

confirmed that the two teams used the same criteria for determining what is considered a point or line to record.Point and Line Data Collected for 2005 Creek Walk Surveys.

All creek walks began at the beach and ended in upper reaches. Exact locations included:

- Sycamore Watershed: Beach to intersection of Stanwood and Sycamore Canyon
- Laguna Channel: Beach to Highway 101
- Mission Watershed:
    - Mission Creek: Beach to Foothill Rd
    - Old Mission Creek: Confluence to San Pasqual
- Arroyo Burro Watershed:
    - Arroyo Burro Creek: Beach to Foothill Rd
    - San Roque Creek: Confluence to Foothill Rd
- Las Positas Creek: Confluence to Highway 101

Maps were made showing five main categories that coincide with final maps from the 2000 data: Encampments and Day Use Areas, Areas of Bank Erosion, Paper Trash, Encampment, and Landscaping Waste. Photos were taken of nearly all observations that were recorded.

### BIOASSESSMENT

Biological assessment (bioassessment) has been conducted for the City by Ecology Consultants, Inc. since 2002. Prior to 2002, the program was operated by Santa Barbara County. In June 2004 and again in April 2005, the Creeks Division contracted with ECORP Consulting to conduct tidewater goby and BMI surveys at both the Mission Creek/Laguna Channel estuary and Arroyo Burro estuary. The surveys were conducted in order to obtain data on the tidewater goby and BMI populations within the estuaries and to determine how tidewater goby and BMI populations interact. The survey results provide vital baseline information for any potential future water treatment, creek restoration and lagoon management projects for Arroyo Burro, Mission Creek and Laguna Channel. In 2005 BMI surveys were conducted at eight sites in Arroyo Burro, Mission Creek, and Sycamore Creek watersheds. Detailed methods are presented in the City's 2005 Annual Report for the Bioassessment Program.

### MICROBIAL SOURCE TRACKING

The Holden Lab at UCSB began performing research for the City's Creek division in September, 2004. Phase 1, completed in 2005, was for testing DNA-based methods with creek samples that were intentionally spiked with fecal material. Based on the Phase I results, Phase II was conducted in 2005 to use the DNA-based methods for characterizing water quality at locations of interest to the City. Currently, Phase III sampling and data analysis are underway. Detailed methods will be presented in the final report for the project in early 2007.

## IV. MONITORING PROGRAM

### ROUTINE WATERSHED ASSESSMENT

**Research questions**
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).

*Terms marked with an asterisk are defined in a glossary at the end of this report.

The watershed assessment element is designed to answer the following questions for Santa Barbara's creeks:

- To what extent are indicator bacteria found and where are hot spots located?
- What is the baseline of water quality, in terms of indicator bacteria and physicochemical properties?
- Is overall water quality, in terms of indicator bacteria and physicochemical properties, getting better over time?
- Are new hot spots emerging?

**Sampling strategy**

The sampling strategy for routine watershed assessment involves obtaining sufficient data from key sites in order to identify long-term trends and test statistical hypotheses. In order to look at overall water quality, downstream integrator sites* of Arroyo Burro, Mission Creek, Laguna Channel, and Sycamore Creek watersheds are sampled most frequently at the current time (Figure 2). Weekly samples are collected at these sites in order to obtain a large enough data set, given the observed variability in the data, to identify long-term trends. Samples are also collected at upper watershed indicator* and midstream integrator sites in order to make comparisons between upstream and downstream values; these data are collected on a monthly basis. Monthly samples are also collected to obtain baseline data still needed for the smaller creeks, i.e. the outflows of Honda and Lighthouse Creeks.

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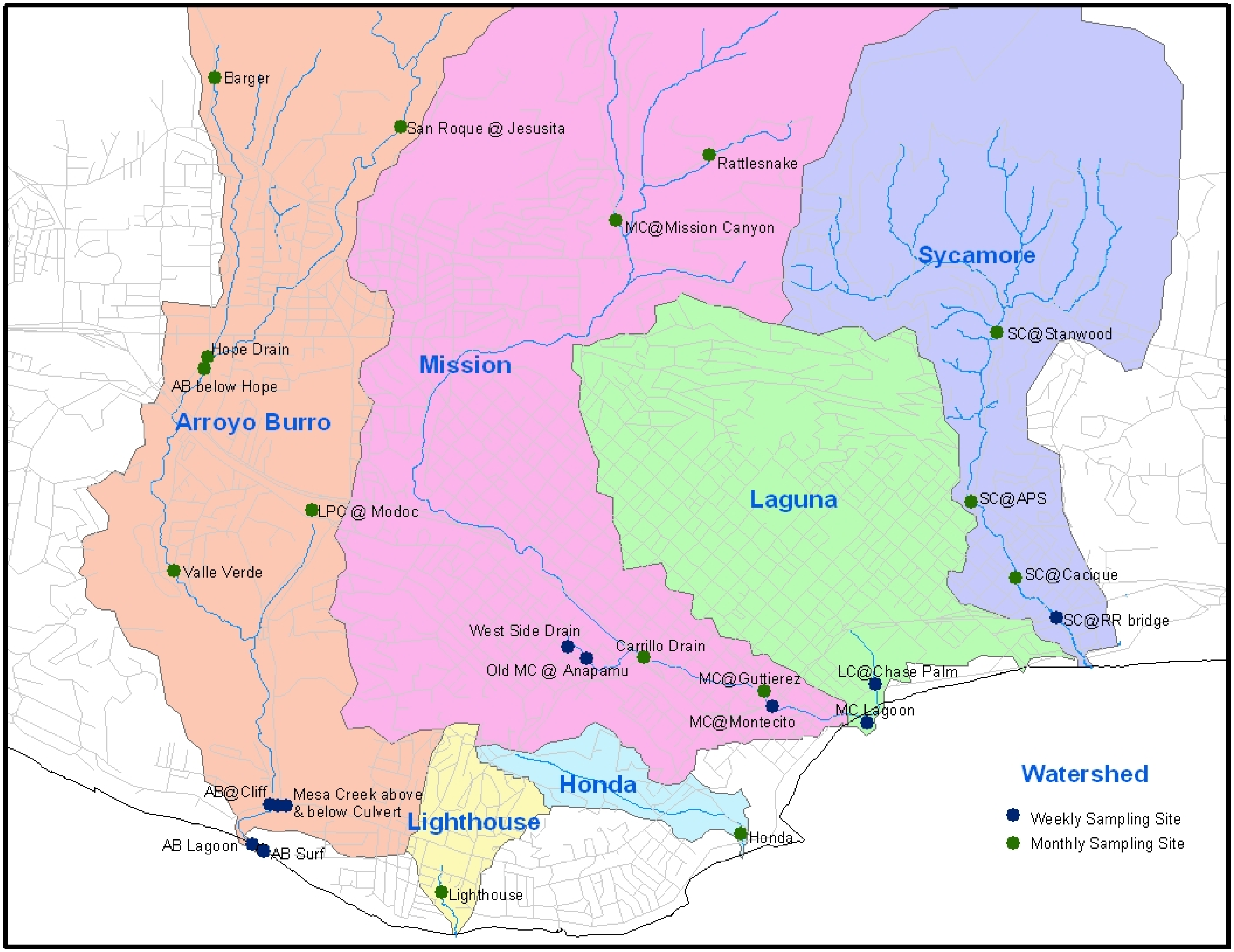


**Figure 2. Locations and frequencies sampled currently for routine watershed assessment.**

* Terms marked with an asterisk are defined in a glossary at the end of this report.

## Results and Discussion

Results from almost six years of weekly indicator bacteria sampling at the main integrator sites for Arroyo Burro, Mission Creek, Laguna, and Sycamore Creek watersheds show that all groups of indicator bacteria vary tremendously over time (Figure 3, Figure 4, Figure 5). The extreme variability seen with indicator bacteria values underlies the reason that extensive data has been collected to establish baselines and examine long-term trends. Thus far, none of the time series have demonstrated long-term changes in indicator bacteria values.

The results for *E. coli* time series show that values are consistently higher for Mission Creek (MCat Montecito) than the other three sites (Figure 3). Enterococcus results do not show as much variability among sites based on the time series. Because of its use in discerning degrees of microbial pollution, the City has continued to test for *E. coli* to examine microbial pollution in urban watersheds. The total coliform time series show the high proportion of samples that are "censored data," i.e., the larger number of samples that are >24,192 MPN/100 ml.

For all sites and all indicator bacteria, the highest values are typically seen in winter months, but there are many instances of high spikes in low-flow and summer conditions. Identifying the sources of low-flow spikes is the subject of extensive scientific research and best management practice* (BMP) implementation throughout the state. The Creeks Division is using microbial source tracking to examine reasons for high indicator bacteria levels in summer months (see Microbial Sources Tracking below).

Looking at the time series grouped by season (Figure 6) shows that the median values are not always highest in winter. Results show that seasonal medians of *E. coli* are highest in Mission Creek and lowest in Arroyo Burro. Enterococcus is highest in Sycamore Creek, during the wet season.

* Terms marked with an asterisk are defined in a glossary at the end of this report.

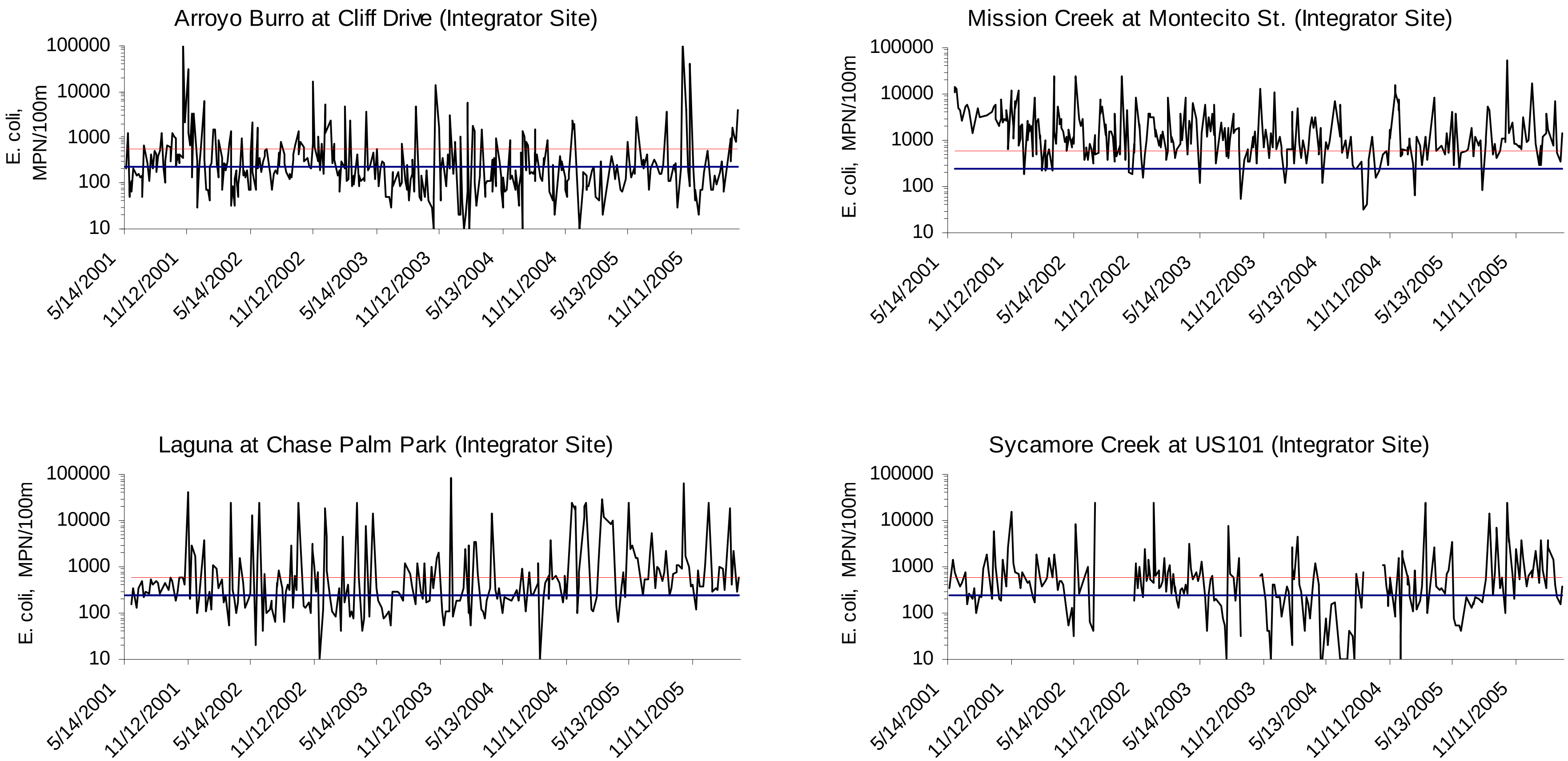


**Figure 3. Weekly *E. coli* concentrations at integrator sites* from May 2001 to March 2006. For reference, the red line shows the US EPA's single sample maximum criterion (576 MPN/100ml), and the blue line shows the RWQCB's Draft Amendment criterion (235 MPN/100ml) for fresh water.**

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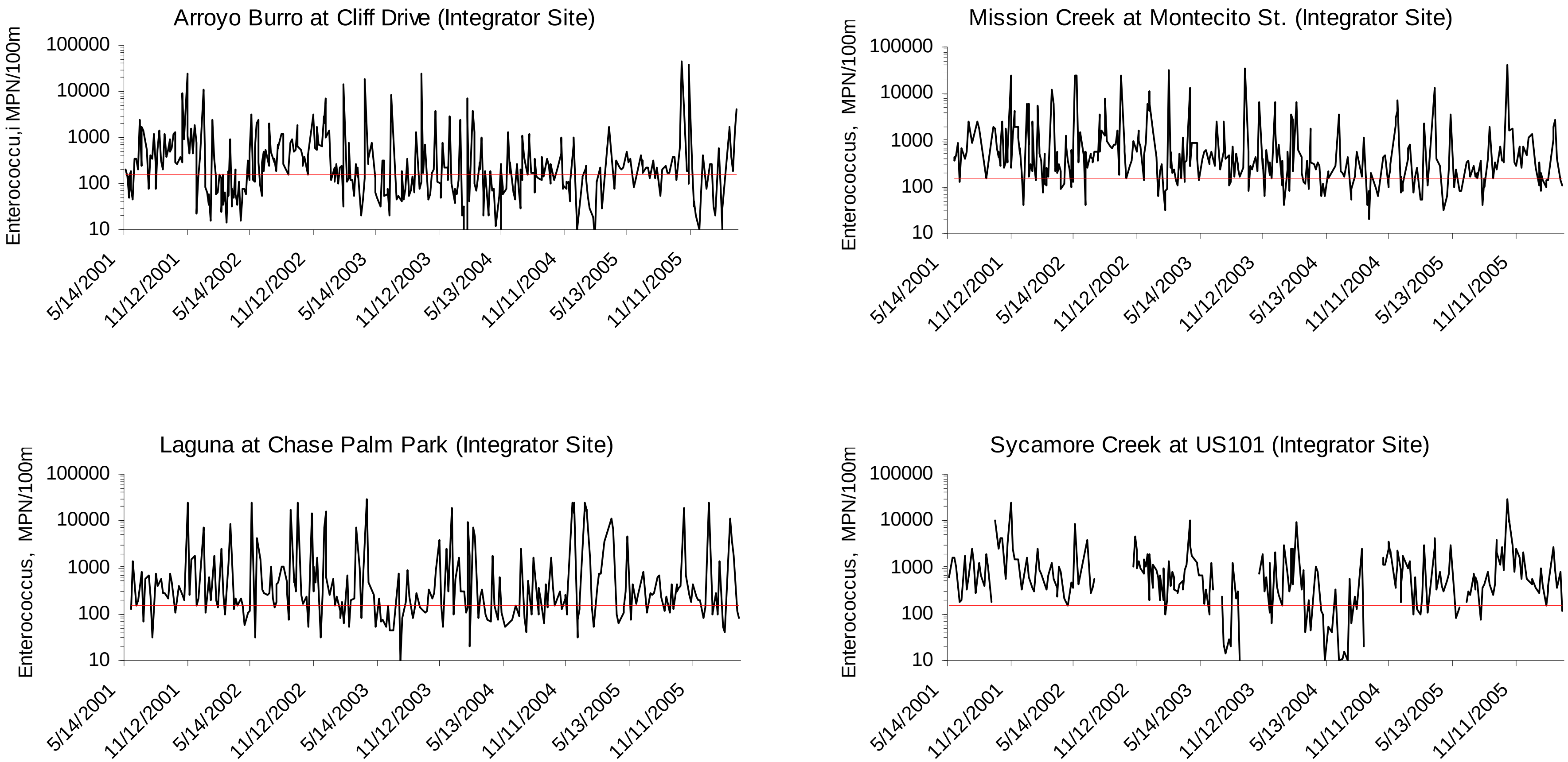


**Figure 4. Weekly enterococcus concentrations at Arroyo Burro, Mission Creek, Laguna, and Sycamore Creek integrator sites* from May 2001 to March 2006. For reference, the red line shows the US EPA criteria for enterococcus (151 MPN/100ml).**

* Terms marked with an asterisk are defined in a glossary at the end of this report.

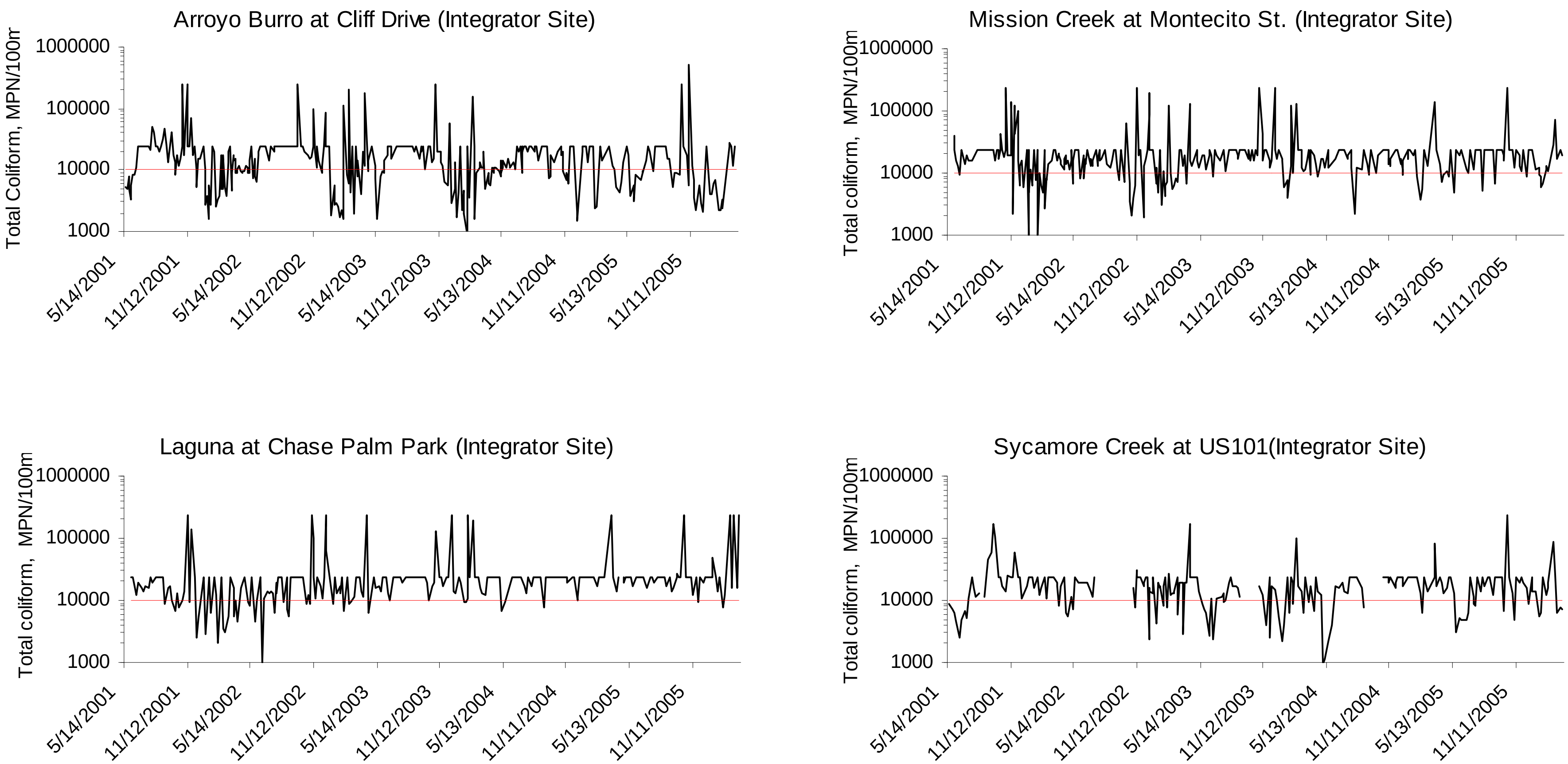


**Figure 5. Weekly total coliform concentrations at integrator sites* from May 2001 to March 2006. For reference, the red line shows the AB411 marine criteria of 10,000 MPN/100 ml.**

* Terms marked with an asterisk are defined in a glossary at the end of this report.

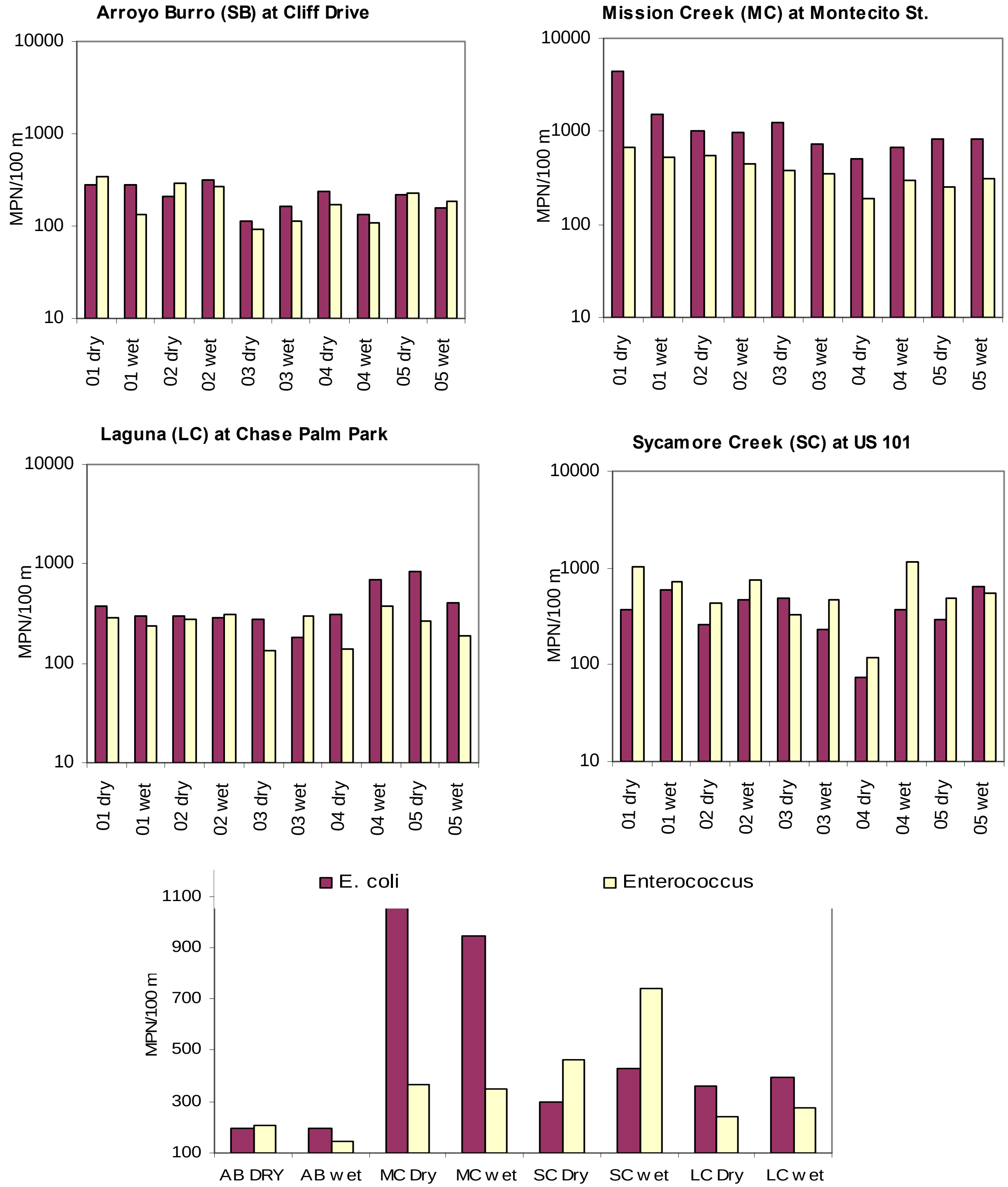


**Figure 6. Seasonal medians of total *E. coli* and enterococcus at the Arroyo Burro, Mission Creek, Laguna, and Sycamore Creek integrator sites (May 2001-March 2006). Note the log axes, which dampen the differences among groups. Lower panel compares medians of dry (April 1-October 31) and wet season (November 1- March 31) for all years combined.**

* Terms marked with an asterisk are defined in a glossary at the end of this report.

The main goal of the Creeks Division in tackling indicator bacteria problems is to reduce beach warnings and decrease the risk to human health from swimming at the beach. Throughout the state, it has been shown that water quality improved from 2001 to 2004 due to low rain years. High rains in 2005 caused water quality to worsen, even into the following summer. As shown in Figure 7, beach enterococcus levels at East Beach (collected by the County of Santa Barbara) relate to both concentration of enterococcus at the Mission Creek integrator site (Mission Creek at Montecito St.) and to discharge rates from Mission Creek (Rocky Nook data is used here as a proxy for flow out of the creek). Multiplying flow at Rocky Nook and concentration at MC at Montecito provides an approximation of flux, or load, of enterococcus discharged per minute. This analysis is preliminary and will be improved with use of additional flow data and sampling locations, along with additional watersheds. See Appendix B for additional climate data.

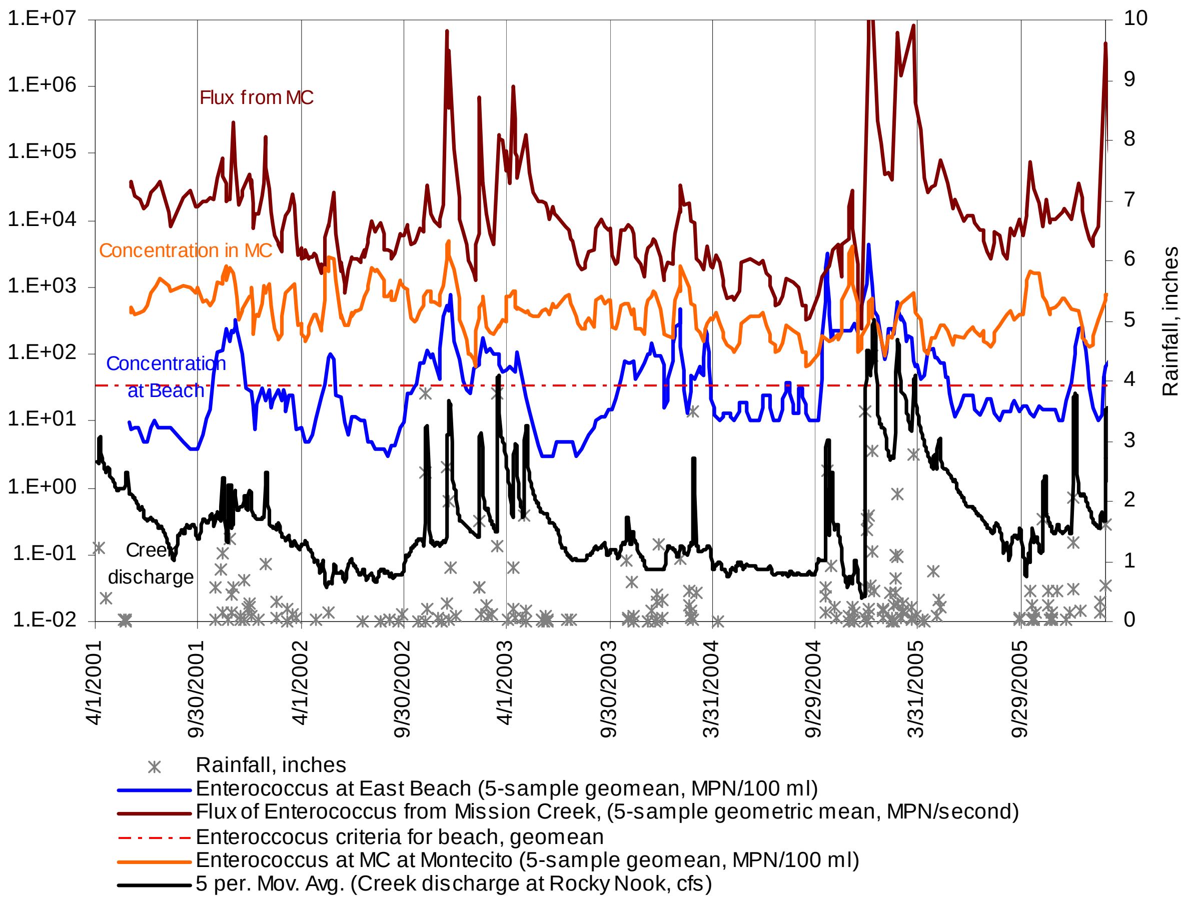


**Figure 7. Time series of enterococcus and creek discharge for Mission Creek Watershed. Vertical lines denote approximate dry season/wet season divisions.**

With the relationship between flux of indicator bacteria from creeks and beach indicator bacteria levels established, the next step is to understand where indicator bacteria enter the creeks. As shown in Table 6, the geometric means of the indicator bacteria levels are low in the upper watersheds, increase considerably in the urban corridor due to discharge from drains, and then decrease again at the lower stations, perhaps to input from uncontaminated groundwater.

* Terms marked with an asterisk are defined in a glossary at the end of this report.

**Table 6. Geometric means of indicator bacteria in Mission Creek Watershed.**

| Site | N | *E. coli*, geomean | Enterococcus, geomean |
|---|---|---|---|
| MC Rattlesnake | 69 | 30 | 72 |
| MC at Mission Canyon | 78 | 42 | 108 |
| MC at Foothill | 53 | 57 | 104 |
| MC at Alamar | 15 | 328 | 268 |
| MC at Pedregosa | 35 | 737 | 590 |
| MC at Carrillo | 93 | 367 | 539 |
| MC above OMC | 38 | 700 | 376 |
| MC at Haley | 39 | 2980 | 966 |
| MC at Guiterrez | 104 | 1283 | 613 |
| MC at Montecito St. | 346 | 1201 | 441 |
| MC Lagoon | 103 | 1635 | 368 |
| OMC above MC | 103 | 424 | 628 |
| Bohnett Park | 105 | 437 | 815 |
| Westside Drain | 204 | 415 | 543 |
| Haley Drain | 45 | 3554 | 2453 |
| Carrillo Drain | 54 | 30185 | 7823 |

Hot spots were also identified in the 2003 Water Quality Report by ranking the medians at each station, within a watershed. However, there was not way to see whether the pattern was consistent from day to day. Here we present graphical data to help explore how various stations relate to one other on the sample collection day (Figure 8, Figure 9). In general, the patterns are more variable than the grouped data. See Appendix D for graphs of additional years

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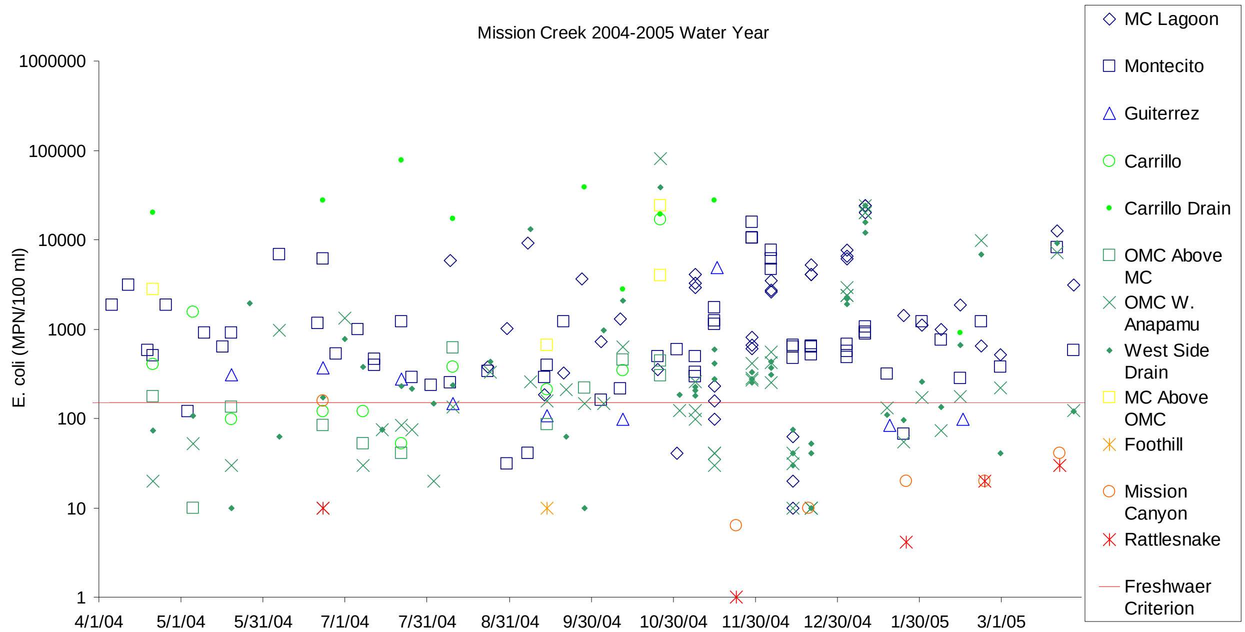


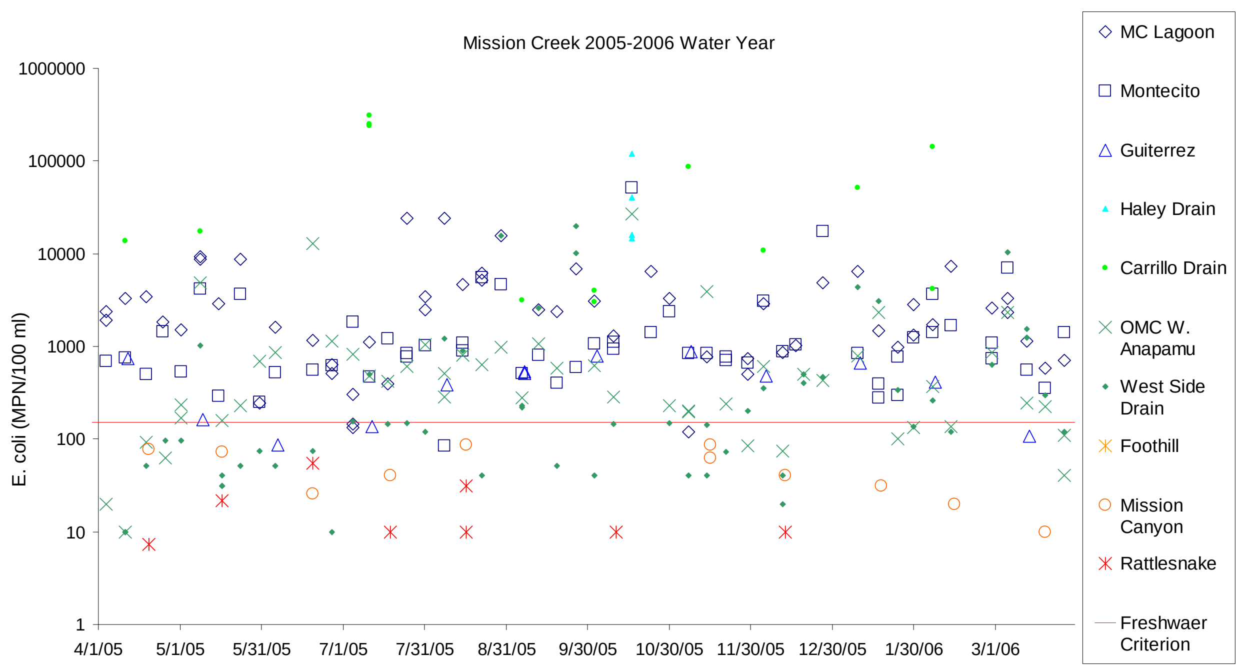


**Figure 8. *E. coli* values throughout Mission Creek Watershed. Data are presented for dates where several samples were collected throughout the watershed on the same day.**

* Terms marked with an asterisk are defined in a glossary at the end of this report.

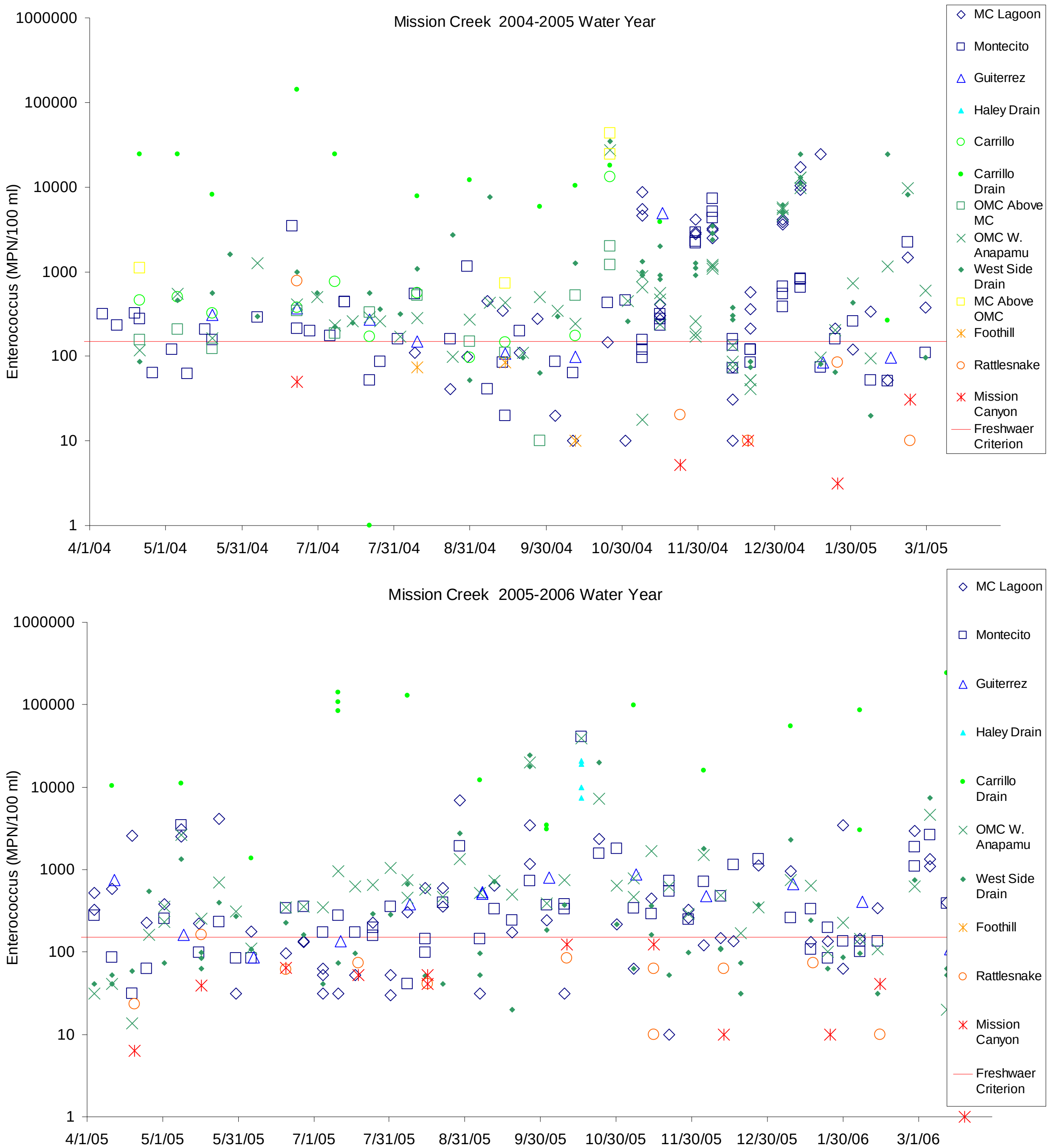


**Figure 9 Enterococcus levels throughout Mission Creek Watershed. Data are presented for dates where several samples were collected throughout the watershed on the same day.**

* Terms marked with an asterisk are defined in a glossary at the end of this report.

**Physicochemical Parameters**

Physicochemical parameters have been collected less extensively than indicator bacteria in Santa Barbara watersheds. Results show that most creek sites meet water quality objectives (Table 1) most of the time. Hotspots are defined arbitrarily as those locations that fail to meet the objective more than 15% of the sample dates.

Arroyo Burro has several dissolved oxygen hotspots, including sites near the confluence of San Roque Creek and Arroyo Burro, where the creeks are channelized through the commercial zone. Las Positas Creek headwaters are also frequently low in dissolved oxygen, as are the samples take from the bottom of Arroyo Burro Estuary. Mission Creek at Montecito does not meet the objective for dissolved oxygen approximately half of the time. Drain samples are low in dissolved oxygen on nearly all of the sample dates, as is Laguna Channel at Chase Palm Park. Lighthouse and Honda are consistently low in dissolved oxygen, whereas Sycamore Creek does not have any dissolved oxygen hot spots.

Overall, temperatures are suitable for the beneficial uses of the creeks. Hotspots are seen at AB Estuary near the bottom. Hotspots for pH include the estuary sites at depth and drain samples. Hot spots for habitat-impacting turbidity during summer months include Las Positas Creek Head, Carrillo Drain, and one of the Arroyo Burro Estuary sites at depth.

**Table 7. Summary of field parameters in the Arroyo Burro Watershed.**

| Parameter | N | No. Not Meeting Objective | Median (Range) | Hotspots (%of Samples Not Meeting Objective) |
|---|---|---|---|---|
| Conductivity | 1236 | – | 2395.5 uS<br>(12.86 – 51816) | – |
| Dissolved Oxygen | 1222 | 156 | 9.53 mg/L<br>(0.01 – 63.6) | SRC above AB (86%)<br>LPC Head (74%)<br>AB above SRC (56%)<br>AB Up Est – Depth (42%)<br>Barger (22%)<br>AB Mid Est – Depth (21%) |
| pH | 1210 | 24 | 7.89<br>(5.23 – 8.74) | AB Up Est – Depth (23%)<br>AB Estuary – Depth (22%) |
| Temp. | 1240 | 17 | 15.4 ˚C<br>(4.8 – 29.5) | AB Estuary - Depth (56%)<br>AB Mid Est – Depth (20%) |
| Turbidity | 584 | [1] 362<br>[2] 67 | 3.19 NTU<br>(0.26 – 1054) | *For criterion [2] 25:*<br>LPC Head (63%)<br>AB Up Est.– Depth (27%) |

* Terms marked with an asterisk are defined in a glossary at the end of this report.

**Table 8. Summary of field parameters measured within the Mission Creek Watershed.**

| Parameter | N | No. Not Meeting Objective | Median (Range) | Hotspots (%of Samples Not Meeting Objective) |
|---|---|---|---|---|
| Conductivity | 974 | – | 1341 uS<br>(46.71–50160) | – |
| DO | 973 | 240 | 8.82 mg/L<br>(1.61 – 37.54) | Haley Drain (83%)<br>Carrillo Drain (67%)<br>MC at Montecito (48%)<br>MC at Haley (47%)<br>MC at Gutierrez (31%)<br>OMC at Anapamu (27%) |
| pH | 994 | 39 | 7.9<br>(4.20 – 9.26) | Haley Drain (21%)<br>MC Lagoon (19%)<br>Haley (15%) |
| Temp. | 994 | 5 | 17.72 ˚C<br>(2.8 – 28.5) | |
| Turbidity | 420 | [2] 44 | 0.99 NTU<br>(0.01 – 1180) | *For criterion [2] 25:*<br>Carrillo Drain (75%) |

**Table 9. Summary of field parameters in the Laguna Channel Watershed.**

| Parameter | N | No. Not Meeting Objective | Median (Range) | Hotspots (%of Samples Not Meeting Objective) |
|---|---|---|---|---|
| Conductivity | 256 | – | 1585 uS<br>(264.5 – 41980) | – |
| Dissolved Oxygen | 248 | 232 | 4.12 mg/L<br>(0.28 – 17.90) | Chase Palm Park (95%)<br>Garden Ramp (85%) |
| pH | 255 | 2 | 7.61<br>(6.79 – 8.16) | |
| Temp. | 255 | 0 | 17.9 ˚C<br>(11.1 – 23.3) | |
| Turbidity | 85 | [1] 82<br>[2] 4 | 5.29 NTU<br>(0.8 – 195) | |

**Table 10. Summary of field parameters in the Sycamore Creek Watershed.**

| Parameter | N | No. Not Meeting Objective | Median (Range) | Hotspots (%of Samples Not Meeting Objective) |
|---|---|---|---|---|
| Conductivity | 364 | – | 1289 uS<br>(374–29060) | |
| DO | 356 | 27 | 10.85 mg/L<br>(3.72 – 31.20) | |
| pH | 361 | 25 | 8.21<br>(6.90 – 9.01) | |
| Temp. | 363 | 1 | 15 ˚C<br>(5.33 – 25.3) | |
| Turbidity | 127 | [1] 46<br>[2] 15 | 1.16 NTU<br>(0.29 – 1106) | |

* Terms marked with an asterisk are defined in a glossary at the end of this report.

**Table 11. Summary of field parameters in Lighthouse and Honda Creeks.**

| Parameter | N | No. Not Meeting Objective | Median (Range) | Hotspots (%of Samples Not Meeting Objective) |
|---|---|---|---|---|
| Conductivit y | 70 | – | 3113 uS (674 – 8762) | – |
| DO | 70 | 31 | 9.50 mg/L (2.54 – 19.46) | Lighthouse Creek (86%) |
| pH | 69 | 2 | 8.01 (6.82 – 8.56) | |
| Temp. | 70 | 0 | 15.4 ˚C (8.2 – 22.5) | |
| Turbidity | 30 | [1] 8<br>[2] 0 | 3.75 NTU (0.54 – 90.80) | |

Dissolved oxygen and temperature are important to steelhead reproduction, and will become of more interest as steelhead restoration efforts continue. As shown in Figure 10, dissolved oxygen is usually above the objective during the winter months, partly because colder water holds more oxygen and partly because colder water is less conducive to algal blooms and microbial decomposition, which depletes oxygen.

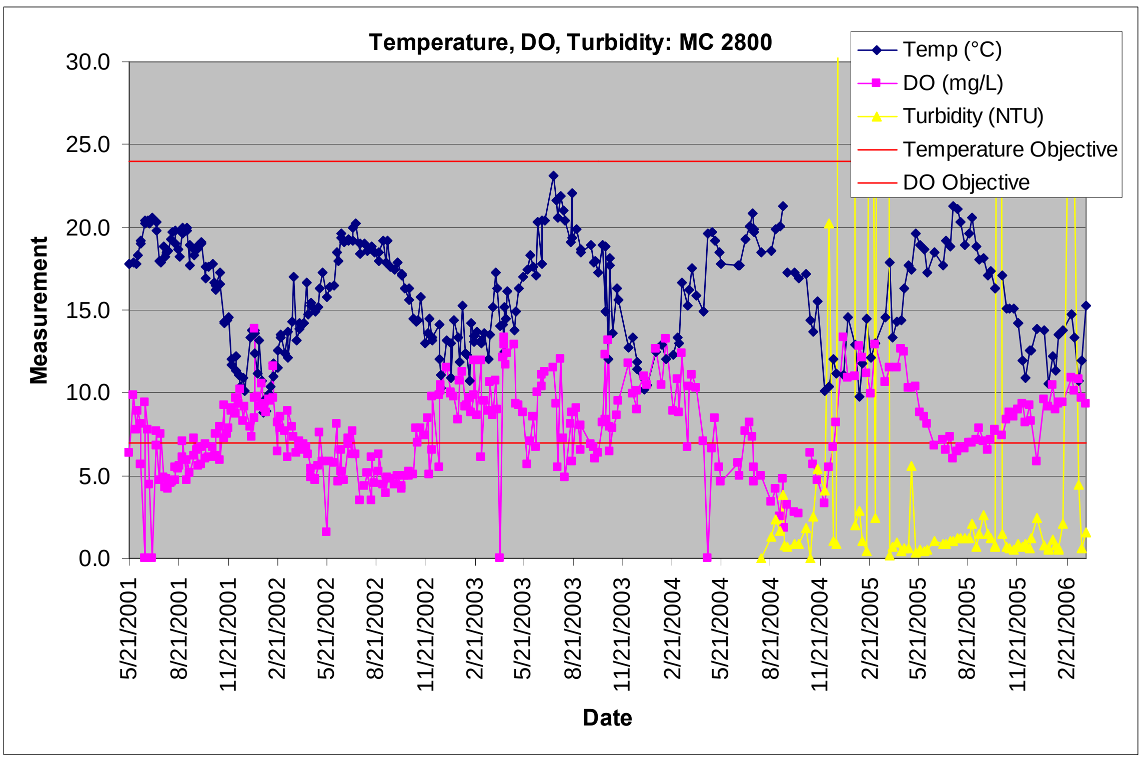


**Figure 10. Dissolved oxygen and water temperature at Mission Creek at Montecito St., showing the seasonal change in dissolved oxygen and the relationship with temperature.**

* Terms marked with an asterisk are defined in a glossary at the end of this report.

## STORM MONITORING

### Research Questions

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. Storm monitoring is designed to answer the following questions:

- Which chemical pollutants are seen at high levels during storm events?
- How do these answers vary throughout a storm?
- How do restoration/treatment projects impact water quality during storm events?

### Sampling strategy

This report provides data on storm monitoring from November 2002-January 2006 (Table 12). In the 2002/2003 and 2003/2004 wet seasons, storm monitoring was focused mostly on assessing the performance of street sweeping. Samples were collected primarily in the lower Mission Creek watershed. In 2004 the focus expanded to examine a wider range of chemical pollutants in storm water throughout Santa Barbara's watersheds. *Sampling was designed to maximize the likelihood that pollutants would be detected*. The goal of the 2004/2005 wet season was to sample two storms, including the first flush* and a large event chosen to investigate the effect of sheet flow over saturated ground over multiple time points. The goal of sampling a large event over multiple time points is to identify any pollutants, particularly herbicides and pesticides, which are transported to creeks after extensive saturation of soils. In early October 2004 a small rain event was sampled at select sites by the UCSB Bren school graduate project sponsored by the City (Aguinaga et al. 2005); the Bren results are included in the analysis presented in this report (Table 12). Because of the lack of runoff during this small storm in larger drains and creek sites, the City collected first flush samples during the next event in mid October (Table 12). Due to the lack of staff availability when the largest storms arrived (over the holiday season), a large event was not sampled in the 2004/2005 wet season. Because only the first flush event(s) were sampled in the 2004/2005 wet season, the same sampling goals were maintained for 2005/2006.

Storm monitoring of the 2005/2006 wet season began on 9/26/05 when a small drizzle event prior to the first flush was sampled at a few locations (Table 12). In October 2005 the first flush was sampled at many sites in the City. A large event extending from 12/31/05 – 1/2/06 was sampled to test the hypothesis of different pollutants or concentrations arising late in a rain storm, after flow over saturated ground developed.

Several modifications were made to the collection methods, analytical methods, and locations for storm sampling in the 2005/2006 wet season. Composite sampling*, in which samples are taken at multiple time points and combined prior to laboratory analysis, was undertaken in order to expand the likelihood of detecting pollutants over a longer period of time, without being cost-prohibitive. Because previous tests of dissolved metals were primarily below detection limits, total metals were analyzed in order to increase the understanding of pollutant loading in Santa Barbara creeks (see discussion on trace metals below). For the large event sampled, the locations were reduced to three sites in order to capture pollutant levels throughout the entire storm hydrograph. Further, samples were collected nearly every hour through the rain period and composited to reduce analytical expense. The Old Mission Creek Site (OMC) was chosen as the most likely site to find pesticides and/or herbicides based on the large amount of

* Terms marked with an asterisk are defined in a glossary at the end of this report.

residential land use in the drainage.  Haley Drain was sampled as a commercial indicator site, and also because the City, UCSB, and USGS have conducted previous research there, and Laguna Channel was sampled as an indicator site of industrial development.  In addition, samples were taken early in the hydrograph at the Mission Creek indicator site (MC at Montecito) as part of a collaborative study with the UCSB and USGS Microbial Source Tracking projects (see below).

**Table 12.  Summary of storm events sampled 2002-2005.**

| Date | Rainfall, inches | First Flush? | Samples Collected | Samples Analyzed | Sites |
|---|---|---|---|---|---|
| 11/07/2002 | 3.9 | yes | 8 | 8 | HLDa, HLDb, MC at Montecito, MLD, SPD, SRD, VCD, WSD |
| 12/16/2002 | 2.6 | no | 8 | 8 | HLDa, HLDb, MC at Montecito, MLD, SPD, SRD, VCD, WSD |
| 12/23/2003 | 0.47 | no | 5 | 5 | MC at Montecito, MLD, SRD, VCD, WSD |
| 02/02/2004 | 1.04 | no | 6 | 6 | MC at Montecito, MLD, SRD, VCD, SPD, WSD |
| 10/16/04[a] | 0.57 | yes | 3 | 3 | Hope Drain, San Roque Drain, LC @ El Estero |
| 10/19/2004 | 1.36 | no | 11 | 11 | ABH, ABL, AB at Cliff, LCC, LPM, MAC, MC at Montecito, MLD, OMC, SRD, SC 1645 |
| 12/7/04 | 0.42 | no | 3 | 3 | Hope Drain, San Roque Drain, LC @ El Estero |
| 09/26/2005 | 0.11 | trace | 3 | 3 | LCC, MLD, WSD |
| 10/17/2005 | 0.85 | yes | 27 | 12 | ABH, ABL, AB at Cliff, HLDb LCC, LPM, MAC, MC at Montecito, MLD, OMC, SRD, SC 1645 |
| 12/31/2005 -01/02/06 | 4.2 | no | 41 | 12 | HLDa, LCC, OMC |

[a] Samples collected by Bren graduate group (Aguinaga et al., 2005)

* Terms marked with an asterisk are defined in a glossary at the end of this report.

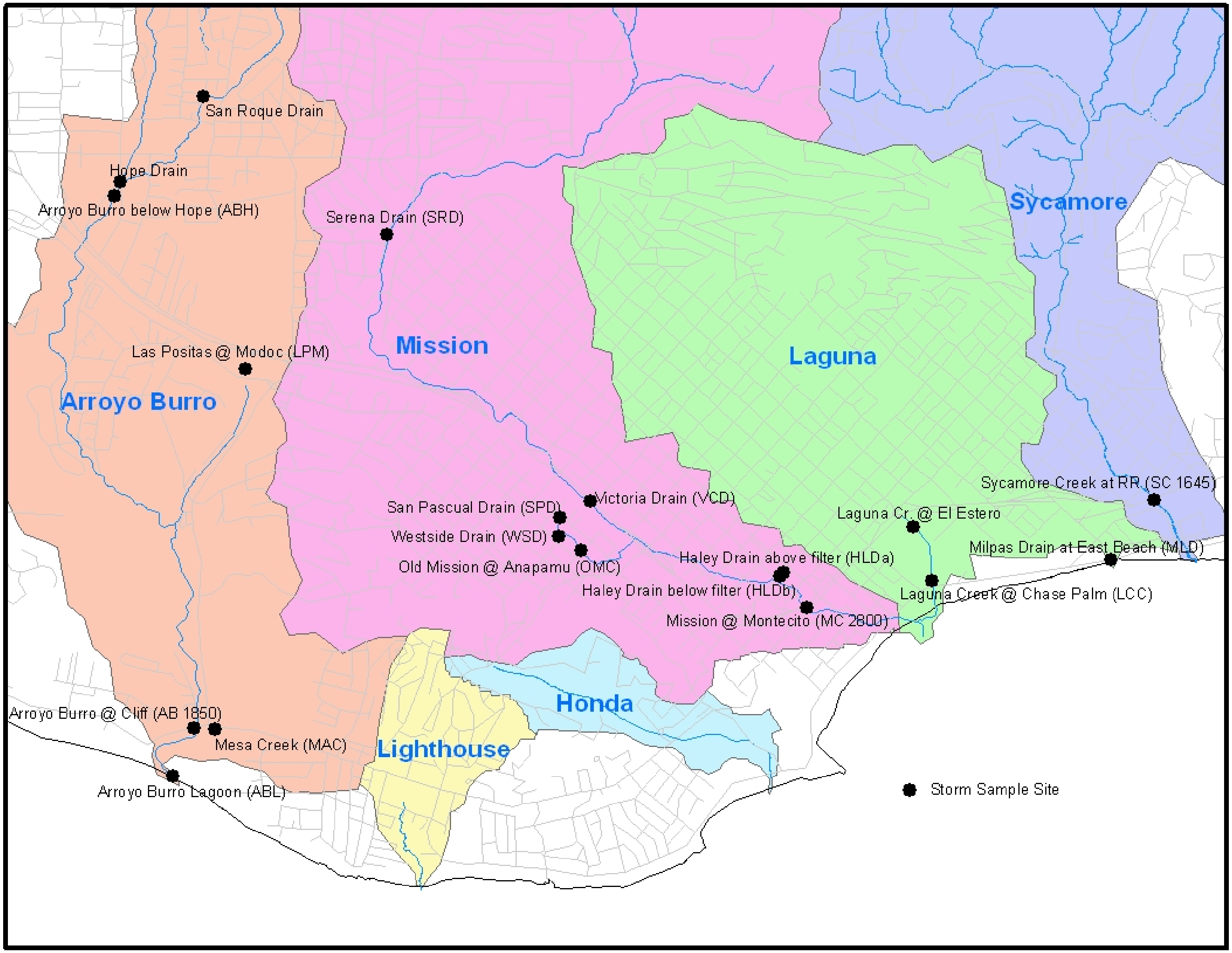


**Figure 11. Sampling locations for storm sampling.**

* Terms marked with an asterisk are defined in a glossary at the end of this report.

## Results and Discussion – Storm Monitoring

In the following discussion, summarized results are presented for trace metals, herbicides and pesticides, and additional organic pollutants. Additional data are contained in Appendix E.

*Trace Metals*

Over the past four wet seasons, storm water measurement of dissolved metals, including cadmium (III), chromium, mercury, nickel, silver, zinc, and lead have never exceeded the appropriate criteria for aquatic life toxicity except in the case of copper (Table 13). In fact, most of the dissolved metal results have been below detection limits in the majority of the samples. Measurements of total metals have exceeded the appropriate criteria for cadmium (III), copper, chromium, zinc and lead (Table 13).

The results obtained thus far suggest that copper may be problematic in Santa Barbara watersheds. Copper can be extremely toxic to aquatic organisms and is a common constituent found in urban runoff. Sources of copper include brake pads, runoff from copper roofs, and corrosion of pipes and solder. These sources have been targeted by other municipalities using appropriate best management practices* (BMPs). However, there is also mounting evidence that the current analytical methods and criteria do not relate to the toxic forms of copper. Some waters that test high for copper do not test high for toxicity in copper-sensitive species. The EPA is currently developing updated guidance for copper in surface waters.

* Terms marked with an asterisk are defined in a glossary at the end of this report.

**Table 13. Summary of trace metals in storm water from 2002-2006. Shading represents constituents that have exceeded current criteria.**

| Metal | Samples Collected | Samples Analyzed[a] | Detections, > PQL* | Exceedances, > Criteria | Criteria, mg/L (Source) |
|---|---|---|---|---|---|
| Arsenic | | | | | |
| *Total* | 68 | 24 | 3 | 0 | 0.15 (EPA CCC) |
| *Dissolved* | 91 | 62 | 6 | 0 | 0.15 (CTR CCC) |
| Cadmium (III) | | | | | |
| *Total* | 79 | 35 | 8 | 8 | 0.000275 (EPA CCC) |
| *Dissolved* | 99 | 60 | 0 | 0 | 0.0022 (CTR CCC) |
| Copper | | | | | |
| *Total* | 73 | 29 | 23 | 23 | 0.0094 (EPA CCC) |
| *Dissolved* | 99 | 70 | 23 | 13 | 0.009 (CTR CCC) |
| Chromium | | | | | |
| *Total* | 73 | 29 | 9 | 2 | 0.086 (EPA CCC) |
| *Dissolved* | 97 | 68 | 6 | 0 | 0.05 (BP WARM, Hard) |
| Mercury | | | | | |
| *Total* | 73 | 29 | 7 | 0 | 0.00091 (EPA CCC) |
| *Dissolved* | 88 | 59 | 6 | 1 | 0.0002 (BP WARM, Hard) |
| Nickel | | | | | |
| *Total* | 69 | 25 | 10 | 2 | 0.052(EPA CCC) |
| *Dissolved* | 88 | 59 | 10 | 0 | 0.4 (BP) |
| Silver | | | | | |
| *Total* | 68 | 24 | 0 | 0 | 0.0038 (EPA CMC)[b] |
| *Dissolved* | 86 | 57 | 0 | 0 | 0.003 (CTR CMC)[b] |
| Zinc | | | | | |
| *Total* | 72 | 28 | 28 | 13 | 0.12 (EPA CCC) |
| *Dissolved* | 101 | 72 | 59 | 4 | 0.12 (CTR CCC) |
| Lead | | | | | |
| *Total* | 72 | 28 | 10 | 10 | 0.0053 (EPA CCC) |

[a] The difference between the number of samples collected and analyzed reflects compositing* of some samples prior to analysis.
[b] There are no criteria available for continuous exposure.
EPA –US EPA'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
WARM – Warm aquatic habitat as a beneficial use designated by the RWQCB (CA EPA 1994).
Hard – Basin Plan criteria are broken into categories based on soft or hard water. Santa Barbara creeks generally have hard water.

* Terms marked with an asterisk are defined in a glossary at the end of this report.

**Table 14. Summary statistics of trace metals lacking criteria in storm water from 2000-2006.**

| Constituent | Samples Collected | Samples Analyzed [a] | Detections, n > PQL* | Median (Range), mg/L |
|---|---|---|---|---|
| Iron | | | | |
| *Total* | 71 | 27 | 27 | 2.03 (0.27–38.10) |
| *Dissolved* | 52 | 23 | 13 | <0.01 (<0.05–1.20) |
| Manganese | | | | |
| *Total* | 72 | 28 | 28 | 0.20 (0.01–2.60) |
| *Dissolved* | 52 | 23 | 2 | <0.05 (<0.01–0.28) |
| Potassium | | | | |
| *Total* | 71 | 27 | 27 | 5.0 (2.0–63.0) |
| *Dissolved* | 52 | 23 | 23 | 3.10 (2.0–6.0) |

[a] The difference between the number of samples collected and analyzed reflects compositing* of some samples prior to analysis.

Total cadmium (III), total copper, total chromium, total zinc and total lead may also prove to be pollutants of concern in Santa Barbara creeks. However, State and EPA regulations have moved away from quantifying total recoverable metals in order to assess harmful impacts to aquatic organisms. Additional research is needed to evaluate these compounds, including understanding the contribution of mineral erosion by testing storm samples higher in the watersheds. Furthermore, the toxicity of the storm water could be analyzed in order to determine if the total metals are leading to aquatic organism toxicity in our creeks.

*Pesticides/Herbicides*

Storm monitoring over the past four wet seasons also detected little evidence of herbicide and pesticide loading to the creeks. The herbicide glyphosate was detected in two of 46 samples analyzed (89 collected). The glyphosate levels were well below the available criterion (EPA maximum contaminant level for drinking water). However, some products containing glyphosate also contain other toxic compounds. In particular, most contain surfactants known as polyoxyethyleneamines (POEA) and some of these are much more toxic than glyphosate. The Creeks Division will investigate the possibility of testing for these compounds directly. None of the herbicides permitted for aquatic use contain POEA.

The OP pesticides were never detected in creek or drain samples. It is important to note that the aquatic life criteria available for OP pesticides (malathion, parathion, and chlorpyrifos) are lower than the practical quantification limits* (PQL) currently available. Therefore, results obtained thus far are not conclusive about the possibility of OP pesticide toxicity in Santa Barbara watersheds. Additional compounds that may be tested in the future include chlorinated herbicides, as recommended in the Basin Plan* (CA EPA 1994).

*Additional organic pollutants*

MBAS was rarely detected in storm samples (see below for sub study on MBAS in foam). Oil and grease was detected in approximately half of the storm samples and TRPH in approximately a third of the storm samples. A visible oil sheen was observed at one location; “visible sheen” is the current criterion for oil and grease under the Basin Plan*. Interestingly, samples collected when the sheen was observed were below detection limits. Because there are no numerical criteria for oil and grease and TRPH, the magnitude of the hydrocarbon

* Terms marked with an asterisk are defined in a glossary at the end of this report.

problem remains unclear. In order to provide a better understanding of potential toxicity from hydrocarbons at the levels observed in storm water, the Creeks Division will provide additional literature review in the 5-year Water Quality Report. Furthermore, the Creeks Division will investigate testing other hydrocarbon groups, including polycyclic aromatic hydrocarbons, as suggested by the Bren land use report (Aguinaga et al. 2005).

**Table 15. Summary of herbicides and pesticides in storm water from 2000-2006. Shading represents constituents that have exceeded appropriate criteria.**

| Compound | Samples Collected | Samples Analyzed[a] | Detections, > PQL* | Exceedances, > Criteria | Criterion, µg/L (source) |
|---|---|---|---|---|---|
| Herbicides | | | | | |
| *Glyphosate* | 90 | 46 | 2 | 0 | 700 (MCL) [b] |
| Organophosphorus (OP) Pesticides | | | | | |
| *Malathion* | 82 | 38 | 0 | Unknown [c] | 0.1 (EPA CCC) |
| *Parathion* | 71 | 27 | 0 | Unknown [c] | 0.013 (EPA CCC) |
| *Chlorpyrifos* | 71 | 27 | 0 | Unknown [c] | 0.041 (EPA CCC) |
| *Additional OP Pesticides (24)* | 71 | 27 | 0 | No criteria | |

[a] The difference between the number of samples collected and analyzed reflects compositing* of some samples before analysis.
[b] The only criterion identified for glyphosate is the US EPA criteroon for drinking water.
EPA –US EPA's Current National Recommended Water Quality Criteria (US EPA, 2005)
CCC- Continuous Concentration Criteria

**Table 16. Summary of additional organic pollutants in storm water from 2000-2006. Shading represents constituents that have exceeded appropriate criteria, where available.** [a]

| Compound | Samples Collected | Samples Analyzed[a] | Detections, n > PQL* | Median (Range), mg/L |
|---|---|---|---|---|
| MBAS | 41 | 26 | 4 | <0.1 (<1.0–1.8)[b] |
| COD | 91 | 47 | | 120 (28 – 630) |
| Oil and Grease (O&G) | 140 | 96 | 39 | <5.0 (<1.0–10.0)[c,d] |
| TRPH | 137 | 93 | 32 | <1.0 (<1.0–11.0)[c] |
| TOC | 133 | 89 | | 15 (3.1–188) |
| TDS | 142 | 98 | | 160 (24–6100) |

[a] The difference between the number of samples collected and analyzed reflects compositing of some samples prior to analysis.
[b] The Basin Plan* criterion for MBAS is 0.2 mg/L (CA EPA 1994); storm water samples exceeded this criteria on 4 separate occasions.
[c] The Basin Plan* criterion for Oil & Grease is described as the presence of a visible sheen (CA EPA 1994). Observation of sheen is difficult or impossible during most storm sampling efforts and is usually not recorded. However, a visible sheen which was present in all samples collected during storm events between 1/1/06 and 1/2/06 at LC @ Chase Palm, despite laboratory results indicating no detection of either O&G or TRPH. The O&G criterion was not used and/or observed before August 2004.
[d] The PQL* for O&G varied between 1 and 5 mg/L.

*Spatial and Temporal Patterns*

Although the storm monitoring results from 2002-2006 do not point to any particular hotspots for chemical pollution, several interesting trends were seen in the data from the 2005/2006 wet season. Results from the subset of constituents that had the most detectable concentrations and/or exceedances are shown (Figure 12). The first flush samples contained higher levels of total metals than the samples from the large event, supporting the paradigm that first flush storms do provide the greatest load of pollutants to urban creeks. The large event was sampled at multiple time points at three locations. The Haley Drain had consistently higher levels of most

* Terms marked with an asterisk are defined in a glossary at the end of this report.

pollutants than the Laguna Channel and Old Mission Creek, as would be expected for a storm drain compared to creek water. Furthermore, for several pollutants, the first sample collected contained the highest concentration recorded during the storm, supporting the idea that the early runoff of storms subsequent to the first flush also carry pollutants to the creeks.

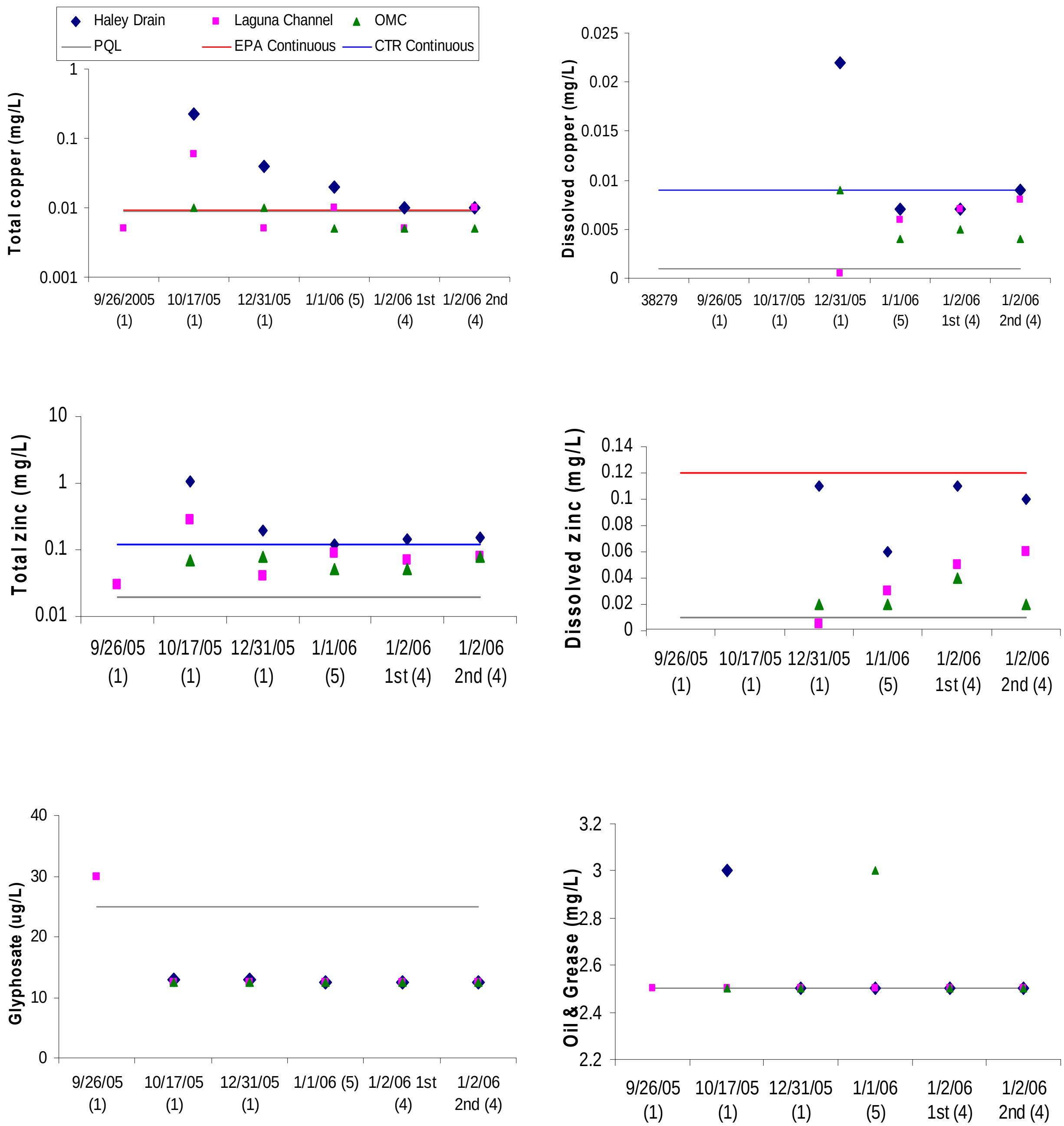


**Figure 12. Selected chemical constituents from storm monitoring in the 2005/2006 wet season. The gray line indicates the Practical Quantitative Limit* (PQL), the red line indicates the EPA criteria for protection of aquatic life (continuous concentration), and the blue line indicates the CTR criteria for protection of aquatic life (continuous concentration). Dissolved copper and dissolved zinc were not tested on 9/26/05 and 10/17/05. For clarification on graphs with overlapping data points, all constituents were tested on the remaining dates.**

* Terms marked with an asterisk are defined in a glossary at the end of this report.

## RESTORATION AND WATER QUALITY TREATMENT PROJECT ASSESSMENT

Restoration and water quality treatment assessment is used to determine the success or projects in lowering microbial and chemical pollution levels and improving water quality for aquatic organisms.

### Research Questions

The project assessment element seeks to answer the following questions for Santa Barbara creeks:

- Do Creeks Division projects result in improved water quality, as reflected in pre- and post-project conditions?
- Do completed creeks projects result in improved water quality, as reflected in upstream and downstream conditions?
- What is the baseline water quality at future restoration/treatment sites?

### Sampling Strategy

The Creeks Division is examining the effectiveness of several creek restoration and water quality improvement projects that should result in decreased pollution levels and/or improved water quality parameters (Figure 13). Many projects are in development and baseline data is being collected presently for pre- and post-project comparisons.

Restoration projects are typically designed to improve habitat for aquatic organisms and lower pollutant levels, whereas water quality treatment projects are focused more narrowly on lowering pollutant levels. Often, restoration features designed for habitat improvement also lead to decreased pollutant levels. The Old Mission Creek Restoration at Bohnett Park, including the bioswale and creek bed improvements, are predicted to reduce trash, turbidity, and levels of sediment-associated pollutants, such as metals and indicator bacteria, in low flow conditions. The Arroyo Burro Estuary project is expected have a similar outcome in low flow conditions.

Creeks Division water quality treatment projects include diversions of low-flow runoff in storm drains to the sanitary sewer, treatment of low flow runoff in storm drains by ultraviolet (UV) disinfection, and treatment of storm water in detention basins. Low flow diversions of storm drains to sewers at Hope and Haley are predicted to reduce all pollutant/ constituent levels when the diversions are operating, beginning in the 2006 dry season. The diversions will not operate in the wet season. The UV treatment at the Westside SURF project, which will be completed in summer 2006, should reduce bacteria, turbidity*, trash, and total suspended solids in dry season flows into Old Mission Creek. The Las Positas Storm Water Management Project at the Santa Barbara Golf Course, which is in the preliminary design phase, should lower sediment loads and sediment associated pollutants, and indicator bacteria.

Analysis of project effectiveness involves quarterly sampling of upstream and downstream locations for indicator bacteria, water quality parameters, and chemical pollutants. Intensive spatial monitoring of select sites several times during the year will also provide a more detailed understanding of project effectiveness.

* Terms marked with an asterisk are defined in a glossary at the end of this report.

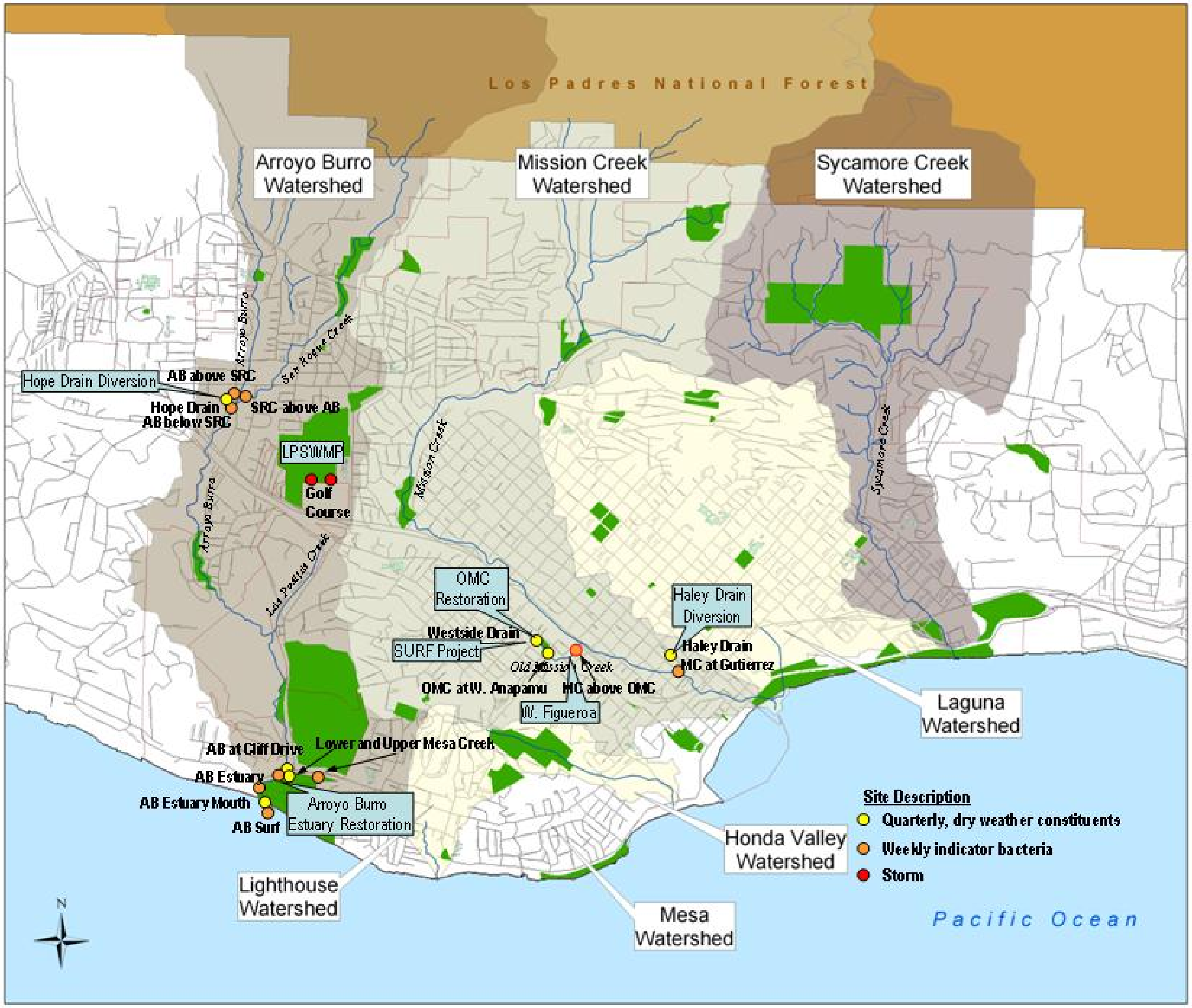


**Figure 13. Map of project site and sampling locations.**

* Terms marked with an asterisk are defined in a glossary at the end of this report.

## Results and Discussion – Baseline Chemistry Data

Although sampling has not been conducted for a long enough period to test before-and after-differences with project sites, the sampling provides a good baseline of dry season chemistry levels in creeks and drains. Table 17 provides a summary of sampling that has been conducted for chemical constituents during dry weather.

**Table 17. Summary of dry weather constituent samples taken 2002-2006.**

| Year | Days Sampled | Samples Analyzed | Sites Sampled Check Codes | Sample Collection History |
|---|---|---|---|---|
| 2004 | 7 | 23 | ABL, AB at Cliff, Mesa, OMC, WSD | Monthly and quarterly samples collected 9/26 – 12/10/04 |
| 2005 | 16 | 88 | ABL, AB at Cliff, Mesa, OMC, WSD, HLDb, Hope Drain | Monthy and quarterly samples collected 1/13 – 12/22/05 |
| 2006 | 4 | 29 [a] | ABL, AB at Cliff, Mesa, OMC, WSD, HLDb, Hope Drain | Monthly and quarterly samples collected 1/12/06 – present |

[a] Not all samples taken in spring 2006 were analyzed in time for inclusion of those results in this report.

Results show that pollutant levels are lower in dry weather than in storm samples. No dissolved metals have exceeded criteria, and in fact, dissolved metals are usually not detected. Total metals are frequently detected and will be more useful in assessing project performance in the future (Table 18). High levels of total copper, zinc, and lead were found occasionally (Table 19)

**Table 18. Summary of trace metals in dry-weather water samples from 2002-2006. No metals have exceeded current criteria (dissolved metals).**

| Metal | Samples Analyzed | Detections, > PQL* | Exceedances, > Criteria | Criteria, mg/L (source) |
|---|---|---|---|---|
| Arsenic | | | | |
| *Total* | 12 | 2 | 0 | 0.15 (EPA CCC) |
| *Dissolved* | 7 | 0 | 0 | 0.15 (CTR CCC) |
| Cadmium (III) | | | | |
| *Total* | 7 | 0 | 0 | 0.000275 (EPA CCC) |
| *Dissolved* | 7 | 0 | 0 | 0.0022 (CTR CCC) |
| Copper | | | | |
| *Total* | 29 | 17 | 4 | 0.0094 (EPA CCC) |
| *Dissolved* | 9 | 2 | 0 | 0.009 (CTR CCC) |
| Chromium | | | | |
| *Total* | 29 | 12 | 0 | 0.086 (EPA CCC) |
| *Dissolved* | 7 | 0 | 0 | 0.05 (BP WARM, Hard) |
| Mercury | | | | |
| *Total* | 7 | 5 | 0 | 0.00091 (EPA CCC) |
| *Dissolved* | 5 | 0 | 0 | 0.0002 (BP WARM, Hard) |
| Nickel | | | | |
| *Total* | 7 | 7 | 0 | 0.052(EPA CCC) |
| *Dissolved* | 5 | 1 | 0 | 0.4 (BP) |
| Silver | | | | |
| *Total* | 7 | 0 | 0 | 0.0038 (EPA CMC)[a] |
| *Dissolved* | 5 | 0 | 0 | 0.003 (CTR CMC)[a] |
| Zinc | | | | |
| *Total* | 29 | 18 | 1 | 0.12 (EPA CCC) |
| *Dissolved* | 7 | 2 | 0 | 0.12 (CTR CCC) |
| Lead | | | | |
| *Total* | 29 | 9 | 1 | 0.0053 (EPA CCC) |
| *Dissolved* | 9 | 0 | 0 | 0.0025 (CTR CCC) |

[a] There are no criteria available for continuous exposure.

* Terms marked with an asterisk are defined in a glossary at the end of this report.

Footnotes, cont'd:
EPA – US EPA'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
WARM – Warm aquatic habitat as a beneficial use designated by the RWQCB (CA EPA 1994).
Hard – Basin Plan criteria are broken into categories based on soft or hard water. Santa Barbara creeks generally have hard water.

**Table 19. Frequency, date, and location of high trace metals during dry-weather 2002-2006.**

| Metal | Date | Site | Concentration, mg/L |
|---|---|---|---|
| Copper, *total* | 4/26/05 | AB Lagoon Mouth | 0.057 |
| Copper, *total* | 11/03/05 | Hope Drain | 0.4 |
| Copper, *total* | 2/8/06 | Hope Drain | 0.017 |
| Copper, *total* | 2/8/06 | OMC @ Anapamu | 0.014 |
| Zinc, *total* | 11/03/05 | Hope Drain | 0.34 |
| Lead, *total* | 2/8/06 | OMC @ Anapamu | 0.0102 |

**Table 20. Summary statistics of trace metals lacking criteria in dry-weather water samples from 2002-2006.**

| Constituent | Samples Analyzed | Detections, n > PQL* | Median (Range), mg/L |
|---|---|---|---|
| Iron,*Total* | 29 | 24 | 0.16 (<.05–17.5) |
| Manganese, *Total* | 29 | 27 | 0.047 (<0.0005–0.36) |
| Potassium, *Total* | 29 | 26 | 4.0 (<1.0–364.0) |

No herbicides or pesticides were detected in dry weather samples, although it should be noted that criteria for some pesticides are below the current detection limits (Table 21). Oil and grease was detected in approximately 10% of samples (Table 22).

**Table 21. Summary of herbicides and pesticides in dry-weather water samples from 2002-2006.**

| Compound | Samples Analyzed | Detections, > PQL* | Exceedances, > Criteria | Criterion, µg/L (source) |
|---|---|---|---|---|
| Herbicides | | | | |
| *Glyphosate* | 32 | 0 | 0 | 700 (MCL) [a] |
| OP Pesticides | | | | |
| *Malathion* | 30 | 0 | Unknown [b] | 0.1 (EPA CCC) |
| *Parathion* | 23 | 0 | Unknown [b] | 0.013 (EPA CCC) |
| *Chlorpyrifos* | 23 | 0 | Unknown [b] | 0.041 (EPA CCC) |
| *Additional OP Pesticides (24)* | 23 | 0 | No criteria | |

[a] The only criterion identified for glyphosate is the US EPA criterion for drinking water.
[b] For these pesticides, it is not possible to observe all values in exceedance, given that the established criteria are less than the PQLs* of current laboratory techniques.
EPA – US EPA's Current National Recommended Water Quality Criteria (US EPA 2005)
CCC – Continuous Concentration Criteria

**Table 22. Summary of additional organic pollutants in dry-weather samples from 2002-2006. No exceedances were found.**

| Compound | Samples Analyzed | Detections, n > PQL* | Median (Range), mg/L |
|---|---|---|---|
| Oil and Grease | 36 | 4 | 3.1 (<3.0 - 4.0)[a] |
| TRPH | 31 | 1 | <1.0 (<1.0 - 45.0) |

* Terms marked with an asterisk are defined in a glossary at the end of this report.

## CREEK WALKS

Yearly 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

The Creek Walk element is designed to answer the following questions for Santa Barbara's creeks:

- What are current physical sources of water pollution that need to be addressed?
- How have the number and location of water pollution sources changed?
- What areas in the City may have pollution problems that can be addressed through targeted outreach?

### Sampling Strategy

Creek walks were conducted during the summer of 2005 on all watersheds within city limits. Survey methodology was derived from the City's 2000 Inventory and Assessment Study (Creeks Inventory) so that results from 2000 and 2005 can be compared. In 2005, a subset of the locations and impairment categories from the Creeks Inventory was used to collect data. Impairments catalogued in 2005 included in-stream pollution, recent bank modifications, side drains, and banks with excessive erosion. Theses categories were selected from the Creeks Inventory as the most dynamic and critical to assessing water and habitat quality.

### Selected Results and Discussion

Maps showing the distribution of water quality concerns are shown in Figure 14, Figure 15 , Figure 16, Figure 17, and Figure 18.

**Table 23. Number of pollution sources recorded in 1999 and 2005**

| | Encampments | | Day Use Areas | | Paper Trash | | Bulk Trash | | Construction Rubble | | Discarded Paint | | Green Waste | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Watershed** | **1999** | **2005** | **1999** | **2005** | **1999** | **2005** | **1999** | **2005** | **1999** | **2005** | **1999** | **2005** | **1999** | **2005** |
| Arroyo Burro | 1 | 1 | 6 | 2 | 88 | 4 | 33 | 5 | 1 | 1 | 0 | 0 | 36 | 7 |
| Lighthouse | 0 | 0 | 0 | 0 | 5 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Honda | 0 | 0 | 0 | 0 | 17 | 0 | 5 | 1 | 0 | 0 | 0 | 0 | 2 | 0 |
| Mission | 17 | 18 | 4 | 20 | 80 | 24 | 28 | 11 | 2 | 1 | 1 | 2 | 15 | 5 |
| Laguna | 3 | 5 | 0 | 4 | 13 | 6 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| Sycamore | 2 | 5 | 4 | 6 | 38 | 0 | 33 | 4 | 1 | 1 | 1 | 0 | 10 | 6 |
| **City Wide Total** | **23** | **29** | **14** | **32** | **241** | **34** | **102** | **22** | **4** | **3** | **2** | **2** | **63** | **19** |

The highest densities of pollution items in the City creeks were found in the Mission Creek and Laguna Watersheds. Laguna Creek is above ground for a short length between the freeway and the estuary, so while it does not appear that high levels of pollution items were found, concentrations were very high.

* Terms marked with an asterisk are defined in a glossary at the end of this report.

When comparing 1999 and 2005 data, there was a decrease by at least 30% in 2005 of paper trash, bulk trash, and green waste. There were two observations of discarded paint in both years. The amount of encampments increased from 23 to 29 and day use areas increased from 14 to 32 from 1999 to 2005.

The difference in the amount of trash and bulk items found in the creeks between the two different years is substantial. There were many more of these items found in 1999 than in 2005. There are several factors that may have contributed to the recorded decrease in the amount of trash in the creeks, but first, it should be noted that creek walk data represents a snapshot of the conditions in the creeks on the day of the walks, and the conditions likely change somewhat every week.

One factor that may explain the reduction in trash is the difference in the amount of rain received in the two wet seasons prior to the different creek walks. The 1998-1999 wet season produced a total of 10.99 inches of rain downtown while the 2004-2005 wet season produced 36.94 inches. The high flows in early 2005 could have scoured the creeks and their banks of trash debris so the creek corridors only had several months to accumulate trash items in high water areas. In contrast, the 1998-1999 wet season might not have "cleaned" the banks as well as the 2004-2005 season, perhaps allowing trash to accumulate over a longer time.

Another factor affecting trash loads in the creeks is the implementation of several City programs: City wide street sweeping, installation of catch-basin debris screens and filters, weekly creek clean-ups, and outreach to the community. The Streets Division has expanded the street sweeping program since 1999 to cover a large percentage of the City's streets. Since trash deposited on the streets can be carried by wind or water to storm drains which flow to creeks, the increase in street sweeping areas has the potential to greatly reduce the amount of light trash items in the creeks. The installation by the Creeks Division of debris screens along State Street and the lower West Side and catch basin filters throughout the City in various known hotspots also has the potential to keep trash items from entering the creeks via the storm drains. Since 1999, the Creeks Division has contracted clean-up crews to regularly remove items from the creeks left by people who access the creeks from bridges or parks. Items such as trash, furniture, bicycles, batteries, and feces are removed on a weekly basis from different sites as needed. This program has the potential to greatly reduce the amount of these items from the creeks that would not have been removed prior to 1999 on a regular basis. Another factor to consider are the various outreach programs by the Creeks Division to the community that aim to make people more aware of the importance of clean waterways and encourage community members to change their behaviors in order to achieve this.

It is likely that all of these factors have had a cumulative effect on the apparent reduction in trash loads in the creeks. Creek walk data provides an important tool in helping to understand the effect of these natural and programmatic factors on the creeks and riparian corridors.

* Terms marked with an asterisk are defined in a glossary at the end of this report.

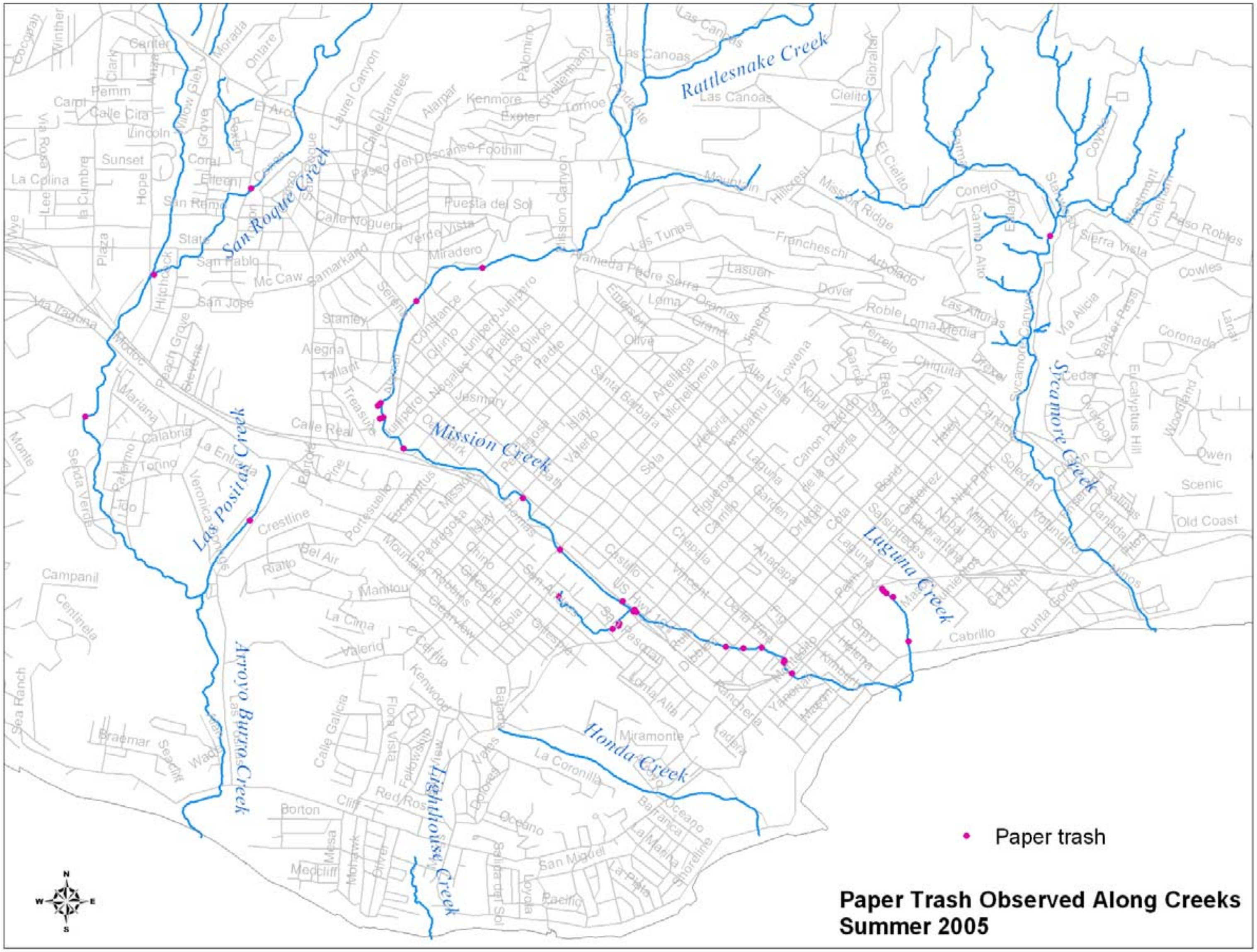


**Figure 14. Paper trash found during Creek Walks, Summer 2005.**

* Terms marked with an asterisk are defined in a glossary at the end of this report.

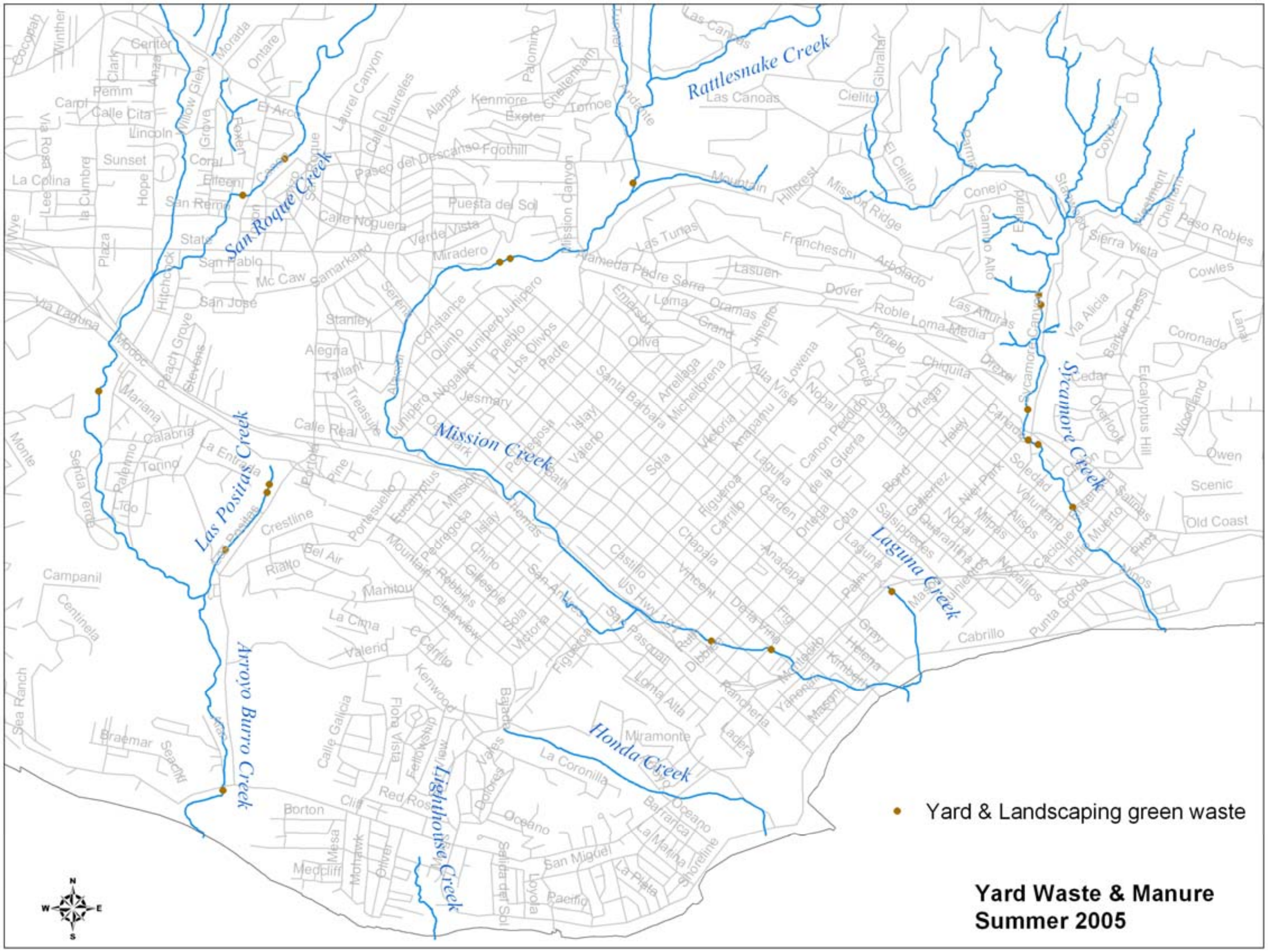


**Figure 15. Yard waste and manure found during Creek Walks, Summer 2005.**

* Terms marked with an asterisk are defined in a glossary at the end of this report.

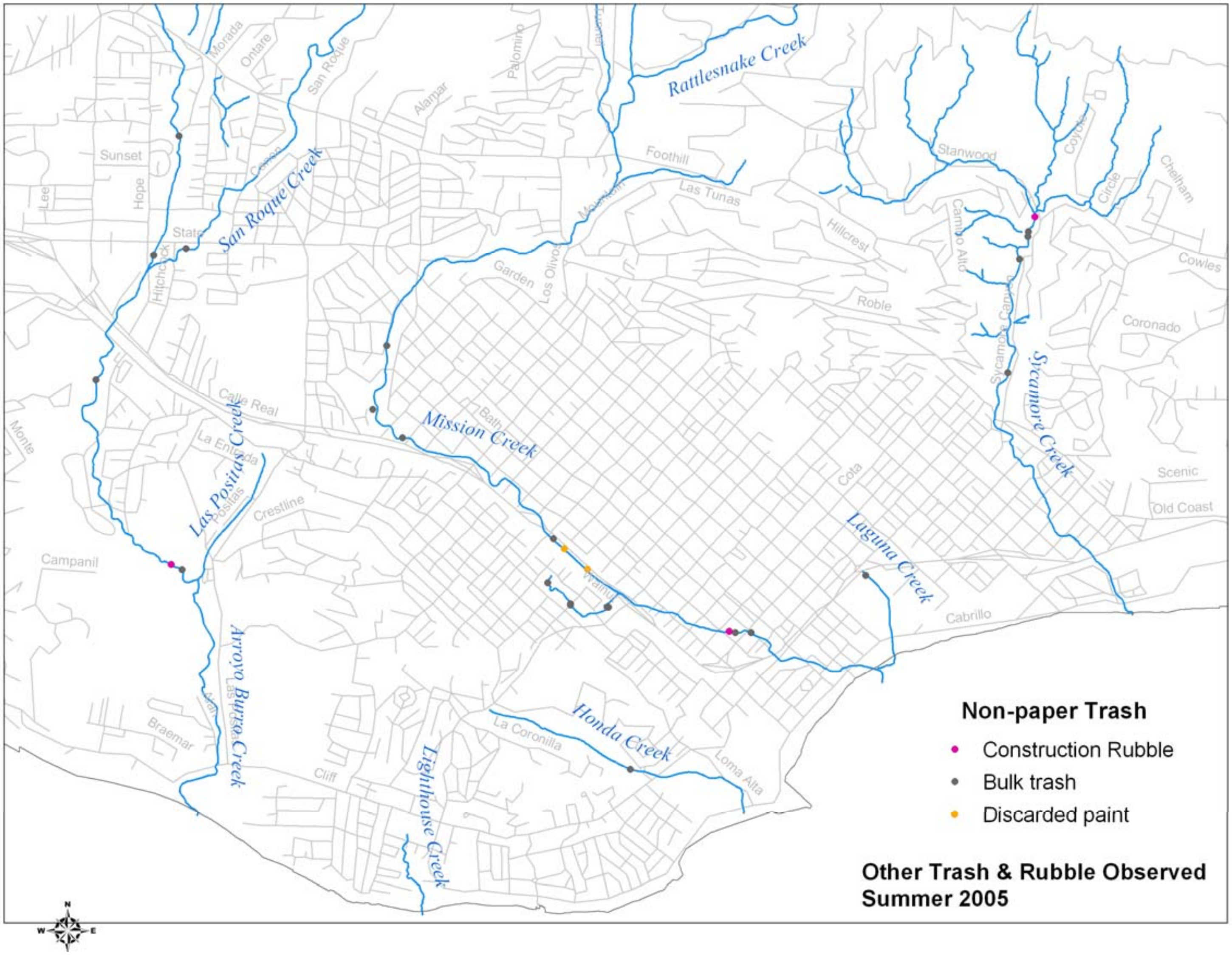


**Figure 16. Trash and rubble observed in Creek Walks, Summer 2005.**

* Terms marked with an asterisk are defined in a glossary at the end of this report.

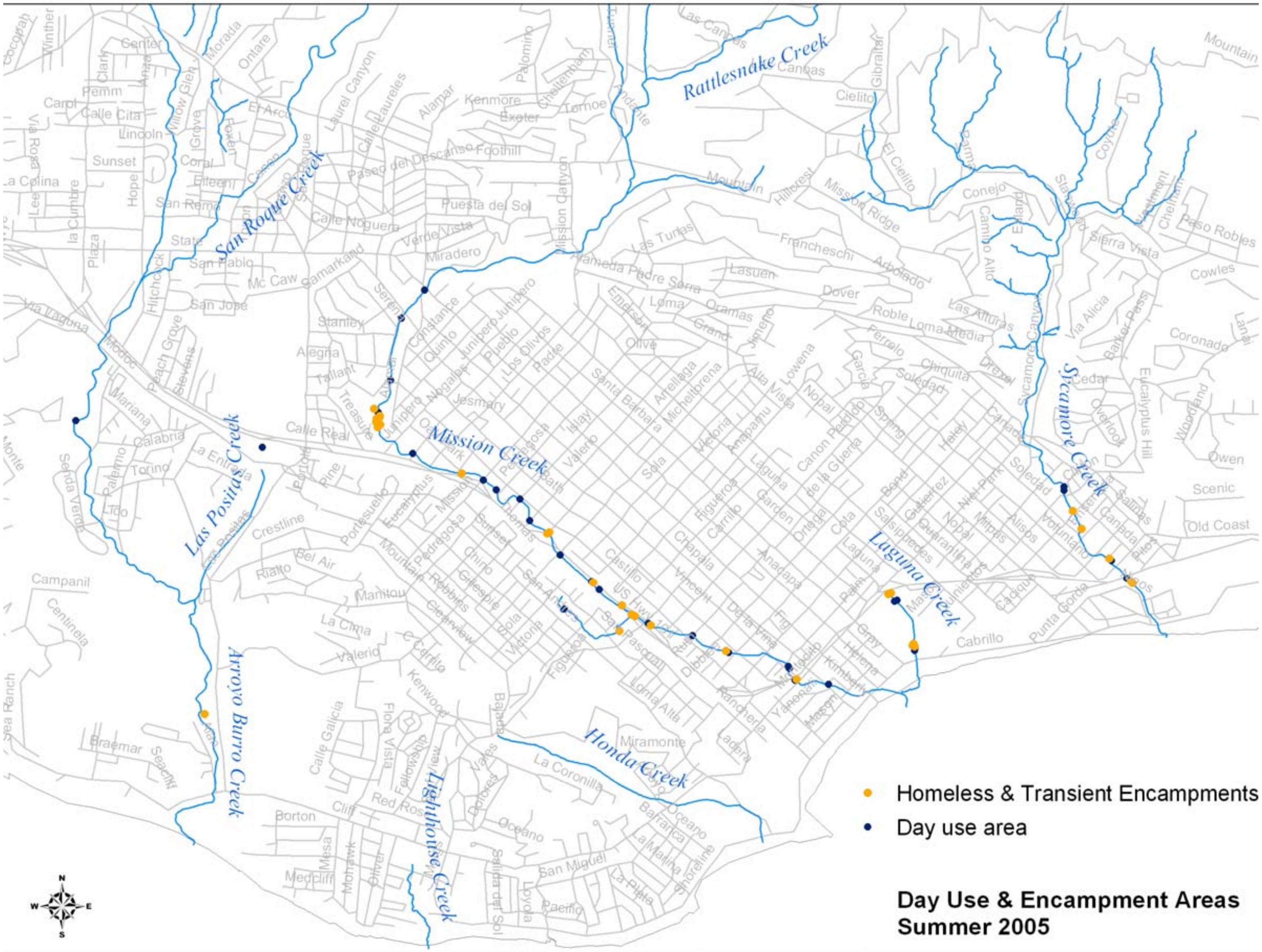


**Figure 17. Day use and encampment areas observed during Creek Walks, Summer 2005.**

* Terms marked with an asterisk are defined in a glossary at the end of this report.

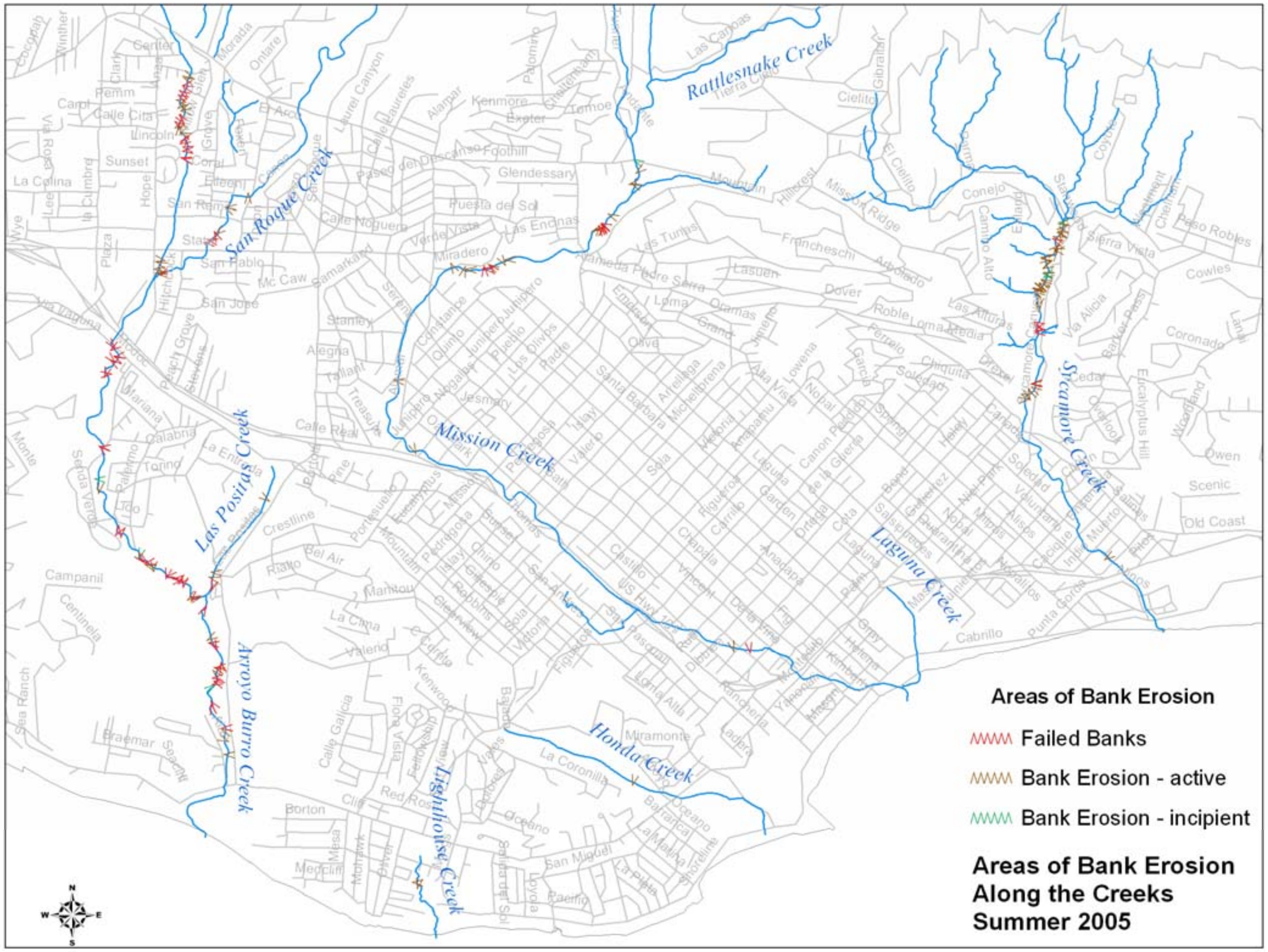


**Figure 18. Areas of bank erosion observed during Creek Walks, Summer 2005.**

* Terms marked with an asterisk are defined in a glossary at the end of this report.

## MICROBIAL SOURCE TRACKING RESEARCH.

Microbial source tracking* is used to develop better tools for tracking fecal pollution in creeks and to identify sources of indicator bacteria. The Creeks Program 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. As discussed above, indicator bacteria may come from soils, plants, and human and animal waste (see above discussion on indicator bacteria).

### Research Questions

The microbial source tracking element seeks to answer the following questions for Santa Barbara watersheds:

- Can DNA-based techniques be used successfully to identify signals of human and/or animal waste in creek water, sediment, and/or soil samples?
- Which locations in creeks and lagoons have signals of human and/or animal waste?
- What happens to the signals of human waste and indicator bacteria levels as water moves downstream away from the source?

### Summary

Due to the many limitations with indicator bacteria data, the City sought to work with Dr. Holden at the University of California, Santa Barbara (UCSB) in order to develop DNA-based methods that can be used for microbial source tracking. The project began in 2004 with Phase I, which involves the development and application of new methodologies that can be used for discovering human waste in urban watersheds. Phase II involves the identification of potential upstream and intermediate sources of contamination, and the assessment of the fates of contamination during transport in the creek, through the lagoons, and into the ocean during summer low-flow conditions. Phase III involves applying the methodology to storm samples to investigate the high numbers of indicator bacteria that are seen during in creeks, lagoons, and ocean waters during high runoff conditions. Phase III also involves tracking further upstream in the Hope and Haley storm drain systems to locate sources of human waste/sewage.

Project Rationale

Since May 2001, the Creeks Division has gathered extensive data on the presence of indicator bacteria throughout its watersheds. Although the City now has a much better understanding about the presence of indicator bacteria throughout its creeks, the specific sources of pollution and the degree to which the recreational waters are harmful to human health are not known. Due to the many limitations with indicator bacteria data, the City sought to work with Dr. Holden in order to develop DNA-based methods that can be used to determine if human waste is present in creek, lagoon, and ocean samples.

In the last two decades significant progress has been made in the biological sciences using DNA-based techniques (also called “molecular” methods) to answer long-standing research questions. Only in the last several years have environmental scientists tried to apply molecular methods to water quality problems, and methods development is still underway.

* Terms marked with an asterisk are defined in a glossary at the end of this report.

Results from Phase I

In Phase I of this project, Dr. Holden determined that two promising DNA-based methods, *Bacteroides* PCR and Community Profile, are suitable for use in Santa Barbara's watersheds (see the attached report to the Creeks Committee in June 2005). The *Bacteroides* PCR technique can be used to identify the presence of human waste, and the Community Profile can be used to determine if human and/or animal waste signals are present in samples. In the past year, Dr. Holden has successfully added quantitative approach (qPCR) to the *Bacteroides* technique. This effort has improved the method by providing numerical results, rather than presence/absence data, to the research effort.

Results from Phase II

*Phase IIA:* A "snapshot" of lower Mission Creek and the Laguna Channel was conducted to survey human waste indicators in sampled waters. These studies were replicated over 3 days (June 28-June 30, 2005) to better understand temporal variability in the signals. Results showed evidence of human fecal contamination in runoff from the Haley Street storm drain on each of the three days. Evidence of contamination was found in Laguna Channel on two days. Human waste was not detected in runoff from the Westside Drain.

*Phase IIB:* Based on the results from Phase IIA, the fate and transport study was focused on the Haley Street storm drain. Samples were collected on the first day (August 4, 2006) from two creek sites downstream of the Haley Street storm drain, the drain itself, and two manholes upstream in the storm drain. On the second day, samples were collected from the two creek sites downstream of the storm drain, the drain itself, and a creek site upstream of the storm drain. This scheme was replicated three times throughout the day. Results confirmed the presence of human waste in the Haley Street storm drain, demonstrated temporal variability in the signal, and provided data for the transport model, which is still being analyzed.

*Phase IIIC:* A "snapshot" of lower Arroyo Burro watershed was conducted. This snapshot was replicated over 3 days (August 22-25, 2005). Results showed consistent contamination in runoff from Hope Avenue storm drain and transient contamination in other sites.

Hope and Haley Drain Water Quality

Results from Dr. Holden's research points to consistent contamination of the Haley Street storm drain with human waste during June and August, 2005. The Hope Avenue storm drain was also contaminated when it was sampled in August 2005. Indicator bacteria values obtained from these samples were also high, which is not surprising given the direct evidence of human waste or sewage. Table 24 summarizes historical indicator bacteria data from the Hope and Haley Street storm drains, with data from the downstream creek sites and the EPA recreational contact criteria for comparison:

* Terms marked with an asterisk are defined in a glossary at the end of this report.

**Table 24. Indicator bacteria values from Hope and Haley Storm Drains.**

| Site | Median *E. Coli,* MPN/100 mL | Median Enterococcus MPN/100 mL |
|---|---|---|
| *Hope Avenue Storm Drain* | | |
| Phase II Data (n=3) | 8,600 | 10,140 |
| Creeks Data (n=78) | >24,192 | 8,182 |
| Creeks Data - Summer (n=36) | >24,192 | 7,976 |
| *Haley Street Storm Drain* | | |
| Phase II Data (n=7) | 5,476 | 17,329 |
| Creeks Data (n=46) | 3,090 | 2,351 |
| Creeks Data - Summer (n=20) | 4,301 | >2,419 |
| *Arroyo Burro at Cliff Drive* | | |
| Creeks Data (n= 360) | 199 | 197 |
| *Mission Creek at Montecito* | | |
| Creeks Data, (n= 295) | 1,201 | 408 |
| *EPA Criteria* | 576 | 151 |

The median represents the point at which half of the values are above, and half are below, the value. These data suggest that most of the indicator bacteria concentrations measured during Dr. Holden's research were not anomalous and that historical levels of indicator bacteria at the storm drains may have signaled the presence of human waste. Although the median value for Enterococcus values at Haley Street storm drain was substantially higher during Phase II sampling compared to the long-term medians, 30% of summer data are higher than the Phase II median.

Creeks Staff requested that Public Works televise the Haley Street storm drain upstream of the outflow to Chapala Street and Ortega Street to look for potential sources of contaminated flow to the storm drain. No clear sources of input were seen.

## BIOLOGICAL ASSESSMENT

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. The program involves annual collection and analysis of benthic macroinvertebrate* (BMI) samples and other pertinent physiochemical and biological data in study creek reaches using US EPA endorsed rapid biological assessment* (or bioassessment*) techniques.

### Research Questions

The biological assessment element seeks to answer the following questions for Santa Barbara creeks:

- 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?

### Summary

In 2000, the County of Santa Barbara's Project Clean Water partnered with Ecology Consultants

* Terms marked with an asterisk are defined in a glossary at the end of this report.

Inc. to develop a bioassessment program for assessing the health of creeks within the South Coast. During the winter of 2002, the City was asked to participate in the County's Bioassessment Program. The City participates in the County's bioassessment program by funding bioassessment surveys for Mission, Arroyo Burro and Sycamore Creeks.

Bioassessment surveys consist of sampling creek water for benthic macroinvertebrates (bugs) and general plant and animal surveys along specific reaches of each creek. Water chemistry measurements such as temperature and dissolved oxygen are also taken as well as measurements of the stream flow and channel characteristics (width, substrate, gradient, etc.) The results of the survey are then complied in a report, which includes raw data, statistical analysis and conclusions concerning various indicator bug species and creek health.

Benthic macroinvertebrate species have been shown in various studies to be indicator species for water quality and general creek health. Certain bug species thrive in undisturbed creeks with clean water while other specific bug species thrive in dirty water within highly disturbed/modified creeks. The primary reason to conduct testing is to provide objective data for measuring improvements to creek health as a result of water quality and restoration projects. We are planning to participate in the bioassessment program for another year in order to establish a more complete baseline of data for measuring changes in creek health overtime.

Ecology Consultants Inc. with assistance from City staff conduct the bioassessment surveys. As shown in other creeks within the County, the surveys indicate that the creek reaches within the urban areas of the City (lower watershed) are unhealthy and have poor water quality while those creek reaches within the more rural areas (upper watershed) of the City are generally healthy and have better water quality. See the Ecology Consultants' 2006 report for additional information.

## SPECIAL STUDIES

### Indicator Bacteria Precision

Because indicator bacterial sampling is highly variable in samples collected from the surf zone, in 2005 the Creeks Division undertook a substudy in order to assess whether creek samples were also highly variable. In early 2005, indicator bacteria samples were collected in triplicate and the variability was examined. In summary, the data from creeks were surprisingly consistent and do not warrants further collection of triplicate samples. It is possible that the higher turbulence in surf-zone samples creates the strong gradients in ocean conditions.

### Foam and MBAS

Following a rain event from 12/31/05 to 1/2/06, large amounts of foam were seen at Arroyo Burro Beach and surrounding areas. Foam is often a natural phenomenon that results from the breakdown of fats and proteins of soil and aquatic organisms facilitating the production of bubbles in agitated water. Foam also can be the result of soaps from household and automotive products entering the watershed. Because of the large amount of foam on the beach following the storm, the Creeks Division analyzed some samples from Arroyo Burro Creek and beach for MBAS.

Methylene Blue Activated Substances (MBAS) are substances found in household detergents and possibly other products for domestic and commercial use. Current lab tests can detect MBAS in samples at a concentration of 0.1 mg/l or 0.1 parts per million). In its Basin Plan, the

* Terms marked with an asterisk are defined in a glossary at the end of this report.

Central Coast Regional Water Quality Control Board has set a water quality objective of 0.2 mg/l for MBAS.

Sampling for MBAS has taken place on six different dates and 20 different sites since October 2004. Not every site was sampled on every date, so a total of 29 samples have been tested for MBAS. Sampling took place during rain events on three of these dates and during dry weather for the other three. Results have not yet been received from an outside lab from the last dry weather date which was sampled this month.

On 1/11/06 during dry weather, the Creeks Division collected some foam that had accumulated in Arroyo Burro Creek above the lagoon outfall and MBAS was detected at 1.8 mg/l. This sample does not represent a true concentration in the creek because the foam was targeted when sampling. MBAS was not detected (<0.1mg/l) in samples taken on the same day from the creek, which represent true concentrations. Bubbles were visible in the creek when sampled. On 2/1/06 at Arroyo Burro Beach, samples were taken from targeted beach foam (not a true concentration) and samples from the surf zone and the lagoon mouth (true concentrations). MBAS was not detected in these samples. Foam was abundant in the surf zone when sampled.

**Table 25. MBAS concentrations in foam substudy.**

| | *MBAS, mg/L* | |
|---|---|---|
| **Location** | **1/11/06 (no rain)** | **2/1/06 (no rain)** |
| AB @ Hope Ave | | |
| AB at Cliff @ Cliff Dr. | <0.1[a] | |
| AB at Cliff @ Cliff Dr. foam | 1.8 | |
| AB 100 yds above Cliff Dr. | <0.1 | |
| AB Beach Foam | | <0.1 |
| AB Surf | | <0.1 |
| AB Lagoon Mouth | | <0.1 |

[a] The PQL for MBAS is 0.1 mg/L.

## Beach Warning and Bacteria

An analysis of dry-season beach data was conducted in order to better understand the relationship between beach warnings and the risk to human health. The results of the analysis were presented at the Creeks Division Community Forum in October 2006.

The County of Santa Barbara is required by State Assembly Bill AB411 to collect weekly indicator bacteria data at four beaches during the AB411 dry season (April 1-October 31); the County elects to collect data all year. An analysis of the data over the past five years showed low rates of beach warnings at Arroyo Burro Beach, Leadbetter, E. Beach at Mission Creek, and E. Beach at Sycamore Creek (Table 26).

* Terms marked with an asterisk are defined in a glossary at the end of this report.

**Table 26. Number of beach warnings posted from April 1-October 31, 2002-2006.**

| | Arroyo Burro | Lead-better | E. Beach (Mission) | E. Beach (Syc.) |
|---|---|---|---|---|
| **Number of Exceedances (n≈170)** | 31 | 9 | 27 | 11 |

In an effort to better understand the connection between beach warnings and levels of indicator bacteria, we reviewed the epidemiological information that went into the determination of the criteria for indicator bacteria. The main studies were conducted in the 1970's at locations with treated sewage discharges, and based on telephone interviews with swimmers. The studies found that enterococcus correlated with most closely with gastrointestinal (GI) illness, or "stomach bugs." They found that overall, for every ten-fold increase in enterococcus levels, there was an increase of 1.2 stomach bugs per 100 swimmers. Additional studies conducted since then have found extremely variable results. Many studies have found no correlation between indicator bacteria and illness, while other have. Overall, reviews support the use of the current Enterococcus criterion, but the usefulness depends highly on the source of indicator bacteria present. There are stronger correlations between indicator bacteria and illness in children and triathletes than in the general population. In addition, there is a strong bias in self reporting of illness, based on how much information the swimmer has about water quality issues. In Southern California, a 1996 Santa Monica Bay study found higher GI illnesses in swimmers directly in front of storm drains, and a 2004 Mission Bay Study found no correlations with illness.

Serious outbreaks and illness are tracked by the CDC Surveillance system since 1978. Nationwide, no reports of swimming-related marine beach outbreaks have occurred. Outbreaks have occurred for freshwater beaches in the Great Lakes. In Santa Barbara County, medical providers and labs are required to report outbreaks and cases of serious illness (e.g. Hepatitus A), and no report of illness have been related to swimming in creeks or ocean.

Going back to the beach data, when beach warnings were posted, enterococcus levels, were usually due to levels very close to the state criterion.

**Table 27. Enterococcus levels at beaches from April 1-October 31, 2002-2006**

| | Arroyo Burro | Lead-better | E. Beach (Mission) | E. Beach (Syc.) |
|---|---|---|---|---|
| **Median Ent./100 ml** | <10 | <10 | <10 | <10 |
| **Number Exceeding (n=170)** | 13 | 9 | 18 | 9 |
| **Maximum Ent./100 ml** | 907 | 443 | 457 | 1031 |

Using the basic model to predict risk from swimming in the ocean described above, on the worst of the dry-season days the model predicted a small increase in number of stomach bugs caught by swimmers (approximately 1 per 100 swimmers). On most days at all four beaches, the enterococcus values were below the detection limit, predicting very safe swimming.

## V. SUMMARY

* Terms marked with an asterisk are defined in a glossary at the end of this report.

## KEY FINDINGS

### Routine Watershed Assessment

- The City has an excellent baseline of indicator bacteria data over five years throughout the watersheds.
  - Due to weekly-to-annual variability, no long term changes were seen in indicator bacteria values at watershed integrator sites (sites at the lower end of watersheds).
  - Among integrator sites, Mission Creek has persistently higher indicator bacteria values than Arroyo Burro, Laguna Channel, and Sycamore Creek. The lowest values are found at Sycamore Creek.
  - The impact of individual rain events on extremely high indicator bacteria values is clear; however a baseline seasonal pattern is not evident.
  - Annual variability corresponds with overall levels of precipitation. Water quality – as characterized by indicator bacteria – improved from 2001-2004. Due to a very heavy rain year, water quality worsened from 2004-2005.
  - Hot spots for indicator bacteria that were identified in the 2003 Water Quality Report remained consistent. No new locations were identified.
  - For Arroyo Burro, Mission Creek, and Sycamore Creek, indicator bacteria values typically increase from the upper watershed to the urban corridor, and then decrease in the lowermost reaches and/or lagoons. Likely causes of increase are inputs of indicator bacteria from storm drains in the urban corridor, followed by mixing with less contaminated water from groundwater input.
- Baseline data for physicochemical parameters are less comprehensive than indicator bacteria.
  - Analysis of physicochemical parameters in Arroyo Burro, Mission Creek and Sycamore Creek shows that dissolved oxygen and temperature are within guidelines for cold aquatic habitats. Exceptions are the lower reaches of Mission Creek and the upper reaches of Arroyo Burro, where dissolved oxygen is frequently below the criterion for cold species, but is usually above the criterion for warm species.
  - Dissolved oxygen is consistently low in Laguna Channel and Lighthouse Creek.
  - Turbidity is usually within guidelines during summer months, and spikes during the rainy season.
  - Hot spots for physicochemical parameters were identified.
  - Baseline data is being collected for Lighthouse and Honda watersheds.

### Storm Monitoring

- Storm monitoring has led to the identification of pollutants of concern in Santa Barbara creeks. Dissolved copper, MBAS, oil and grease, sediment, and indicator bacteria are the primary pollutants of concern identified by storm sampling.
- Dissolved copper is a frequent storm water pollutant of concern across the country. The criteria are under revision because it is not understood which dissolved forms are toxic to aquatic organisms.

* Terms marked with an asterisk are defined in a glossary at the end of this report.

- The class of surfactants called MBAS was above the criterion in several samples. MBAS is not particularly toxic and is a good tracer of wastewater (including washing) entering surface water.
- Oil and grease was detected in approximately half of all storm samples analyzed.
- Suspended sediment concentrations were also very high in storm samples, but an appropriate standard has not been identified, nor is it known what portion of the sediment load arises from natural erosive processes.
- The concept of the first flush of rainfall leading to the highest concentrations of pollutants in runoff was supported by storm monitoring in 2005-2006.
- The herbicide glyphosate was rarely detected in storm samples (2 out of 90 samples). When glyphosate was detected, it was well below the drinking water standard, which is the only standard available.
- Pesticides were never detected in storm samples. However, the levels of detection currently available are well above the criteria for protecting aquatic health, so the compounds cannot be ruled out as pollutants of concern.

**Restoration and Water Quality Project Assessment**

- Quarterly sampling of chemical constituents at select project assessment sites (upstream and downstream of current and proposed projects) showed very low concentrations of most pollutants during dry weather. There were no detections of dissolved metals, glyphosate, or pesticides in the samples.
- Total metals were detected frequently and total copper was high on occasion at Hope Drain.
- Hydrocarbons were detected at project assessment sites in approximately 10% of the samples.
- Preliminary analysis of indicator bacteria data for the Old Mission Creek Restoration Site at Bohnett Park exhibited a seasonal pattern from pre-project through post-project sampling. There is not yet enough data to determine whether this relationship has changed since the project was installed.
    - In the winter, indicator bacteria values increased from the upstream site (West Side Drain) to the downstream site (W. Anapamu Bridge), due perhaps to continuing input from runoff.
    - In the summer, indicator bacteria values decreased from between the Westside Drain and W. Anapamu, likely due to exposure to sunlight.

**Creeks Walks**

- Creek walk methodology was refined and input with GIS so that data could be compared among years.
- Creek walks were conducted on all creeks within the City in 2005. Results were compared to data collected in 1999.
- The highest densities of encampments, day use, and pollution items in City creeks were found in the Mission Creek and Laguna Channel.
- The amount of trash observed decreased substantially between 1999 and 2005. The explanation for the decrease is likely a combination of different creek flow histories and the impact of City programs such as street sweeping, curb inlet screens, and outreach efforts.

* Terms marked with an asterisk are defined in a glossary at the end of this report.

**Microbial Source Tracking**

- Two DNA-based methods developed by the Holden Laboratory at UCSB for tracking indicator bacteria sources were tested and validated for creek water using feces-spiked environmental samples from Santa Barbara Creeks.
- Preliminary analysis using the Community Profile method did not identify dog, gull, cat, or raccoon waste in samples tested.
- On multiple days, source tracking studies by UCSB confirmed the presence of human waste and/or sewage in the Haley Drain, Hope Drain, and points downstream in Mission Creek and Hope Drain, respectively.
- Both of the sites where human markers were confirmed had a history of high levels of indicator bacteria.

**Bioassessment**

- Benthic macroinvertebrate sampling suggests that communities in the lower, urbanized corridors of Arroyo Burro and Mission Creek are not as robust as aquatic communities in the upper watersheds.
- Benthic macroinvertebrate communities in the estuaries do support stable populations of the endangered tidewater goby.

**Special studies**

*Indicator Bacteria Precision*

- Despite large variations in indicator bacteria values in the surf zone, triplicate indicator bacteria measurements were very consistent in creek and drain samples in low flow.

*Foam in Arroyo Burro Winter 2006*

- The surfactant MBAS was not strongly associated with high amounts of foam observed at Arroyo Burro Beach and in the Estuary in Winter 2006.
- Visual observation suggests foam may have runoff recently sealed streets

*Beach Warning and Bacteria*

- Analysis of dry season data from the County showed low rates of beach warnings at Arroyo Burro Beach, Leadbetter, E. Beach at Mission Creek, and E. Beach at Sycamore Creek.
- Warnings due to Enterococcus levels, which are known to be the best predictor of health concerns, were usually due to levels very close to the state criterion.
- A basic model to predict risk from swimming in the ocean was identified. On the worst of the dry-season days the model predicted a small increase in number of stomach bugs caught by swimmers (approximately 1 per 100 swimmers).
- On most days at all four beaches, the Enterococcus values were below the detection limit, predicting very safe swimming.

## RECOMMENDATIONS

**General recommendations**

- • Overall, limit routine monitoring except as necessary to evaluate long-term trends.
- • Shift toward the use of using DNA-based and traditional tools to confirm contamination at hot spots and identify the geographic sources upstream (up storm drains) from hot spots.
- • Expand toolbox to be able to track loads of pollutants in drains and creeks, rather than concentration only. This will require an investment in equipment purchase and training

* Terms marked with an asterisk are defined in a glossary at the end of this report.

with autosamplers, flow gauges, rain gauge(s), and possibly remote communication equipment.

- • Maintain partnerships to continue work on DNA-based source tracking.
- • Expand focus of microbial contamination research to include wet weather flow.
- • In an effort to participate in standardized data collection for storm water in Southern California, use the Technical Steering Committee's recommendation for storm monitoring where possible.
- • Use GIS tools to better interpret spatial data.
- • Use watershed models to better analyze what-if scenarios, including installation of projects and geographically targeted outreach..
- • Use the Haley Drain drainage area as a pilot area for tracking and reducing contamination from human waste.

**Routine Watershed Assessment**

- Move to biweekly sampling of integrator sites and bi-monthly sampling of upper and mid watershed sites to evaluate long term trends.

**Storm Monitoring**

- Reduce focus of identifying pollutants of concern, as this has been accomplished.
- Continue to monitor first-flush storms, with a modified constituent list.
- After the first flush, shift focus to identifying sources, routes and fates of indicator bacteria in storm water.
- Test the toxicity of water containing high levels of dissolved copper.

**Restoration Monitoring**

- Omit dissolved metals, pesticides, and herbicides from quarterly, dry-season sampling. They were never or rarely detected and the price of analysis is considerable.
- For future projects, collected pre-project, upstream/downstream data whenever possible.
- Conduct spatial intensives to determine mechanisms of water quality changes at project sites.

The ultimate test of this report will be that is used to help inform decisions on projects and programs in the City. The report contains a wealth of information that was not analyzed extensively at this time. Much more analysis should be done with this data before it becomes archived.

* Terms marked with an asterisk are defined in a glossary at the end of this report.

## VI. GLOSSARY

**Antidegradation statement.** Declares that the existing uses of a water body must be maintained and protected, even if water quality is better than the minimum level established by the state or tribal water quality standards (see Basin Plan*).

**Basin Plan**. The federal Clean Water Act* and the California Porter-Cologne Water Quality Control Act* require that the RWQCBs* adopt water quality control plans to guide and coordinate the management of water quality in the Region. These documents are known as Basin Plans and are required to be reviewed every three years in Triennial Reviews. The Basin Plans set beneficial uses to be protected, water quality objectives*, and programs of implementation needed for achieving water quality objectives

**Beach closure**. Beaches closed when sewage releases or spills occur. The closure continues until after the spill or release has been stopped and until monitoring indicates that the contamination levels meet appropriate standards. In addition, areas those that are highly contaminated with exceedances of single sample maximum and 30-day standards for multiple indicator organisms may be closed.

**Beach warning.** If indicator bacteria criteria* are not met the beach is posted with signs warning the public to avoid body contact with the ocean water. The health warning stays in effect for the beach until water resample results are below the state bacteriological standards. Areas that are consistently contaminated may receive long-term or permanent posting. Those that are highly contaminated with exceedances of single sample maximum* and geometric mean* criteria for multiple indicator organisms may be closed (see beach closure*).

**Beneficial uses.** Legal designation of uses of the waters that should be protected, including domestic, municipal, agricultural and industrial supply, recreation (see REC-1*), navigation, and the preservation of fish and wildlife habitat (see COLD* and WARM*). The designated beneficial uses of Santa Barbara creeks are listed in the Basin Plan*.

**Benthic macroinvertebrates.** Animals without backbones that live in association with streams and lake bottom habitats. Examples are larval insects such as caddisflies and mayflies, and crustaceans such as crayfish.

**Benthic.** Refers to material, especially sediment, at the bottom of an aquatic ecosystem. It can be used to describe the organisms that live on, or in, the bottom of a waterbody.

**Best management practices (BMPs)**. Methods, measures, or practices determined to be reasonable and cost-effective means to meet certain, generally nonpoint source, pollution control needs. BMPs include structural and nonstructural controls and operation and maintenance procedures.

**Bioaccumulate**. The net uptake of a material by an organism from food, water, and/or respiration that results in elevated concentrations in tissues.

**Biological integrity**: The condition of the aquatic community that inhabits unimpaired water bodies as measured by community structure and function.

**California Ocean Plan (COP).** The California Ocean Plan establishes water quality objectives for California's ocean waters and provides the basis for regulation of wastes discharged into the State's coastal waters. The plan applies to point and nonpoint source discharges. Both the State Board and the six coastal Regional Water Boards implement and interpret the COP. The COP was first approved in 1972. The most recent edition was approved by the State in 2005 and by the US EPA in 2006.

**California Toxics Rule (CTR).** On May 18, 2000, the EPA promulgated numeric water quality criteria for priority toxic pollutants for California because the EPA determined that there

* Terms marked with an asterisk are defined in a glossary at the end of this report.

was a gap in California water quality standards created in 1994 when a state court overturned the state's water quality control plans containing water quality criteria for priority toxic pollutants. Thus, the State of California has been without numeric water quality criteria for many priority toxic pollutants as required by the Clean Water Act. According to the EPA, these federal criteria are legally applicable in the State of California for inland surface waters* and enclosed bays and estuaries* for all purposes and programs under the Clean Water Act. See storm water monitoring section for additional information.

**Clean Water Act (CWA)**. Water pollution control laws based upon the Federal Water Pollution Control Act of 1972 with amendments passed in 1977, 1981, and 1987. The main objective is to restore and maintain the "chemical, physical, and biological integrity of the Nation's waters."

**Cold Fresh Water Habitat (COLD)**. Beneficial use of water that supports cold water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish or wildlife, including invertebrates.

**Composite sampling.** A procedure that involves collecting individual samples from different time points and mixing them prior to analysis. This procedure allows for greater coverage of the sampling period with limited costs.

**Contamination.** Pollution* that creates a hazard to the public health through poisoning or through the spread of disease, e.g. microbial pathogens.

**Criterion**: Levels of water quality expected to render a body of water suitable for its designated beneficial use*, composed of numeric and/or narrative criteria. Numeric criteria are scientifically derived ambient concentrations developed by US EPA or states for various pollutants of concern to protect human health and aquatic life. Narrative criteria are statements that describe the desired water quality goal.

**Detection limit.** See practical quantification limit.

**Enclosed bays.** Indentations along the coast which enclose an area of oceanic water within distinct headlands or harbor works.

**Enterococcus.** The enterococcus group is a subgroup of the fecal streptococci. The enterococci portion of the streptococcus group is a valuable bacterial indicator for determining the extent of fecal contamination of recreational surface waters.

**Epidemiological study**. A research study that investigates the factors determining and influencing the frequency and distribution of disease, injury and other health-related events and their causes in a defined human population.

***Escherichia coli* (*E. coli*)**. A subgroup of fecal coliform bacteria that is present in the intestinal tracts and feces of warm-blooded animals. It is used as an indicator of the potential presence of pathogens. There are many different strains of *E. coli* and most are harmless and live in the intestines of healthy humans and animals. The *E. coli* O157:H7 strain, which is found in under-cooked beef, produces a powerful toxin and can cause severe illness; this strain is not generally a recreational water quality concern. In addition, *E. coli* is studied intensively by geneticists because of its small genome, normal lack of pathogenicity, and ease of growth in the laboratory.

**Estuaries and coastal lagoons.** Waters at the mouths of streams that serve as mixing zones for fresh and ocean waters during a major portion of the year. Mouths of streams that are temporarily separated from the ocean by sandbars are considered estuaries according to the California Ocean Plan*.

**Fecal coliform.** Indicator organisms (organisms indicating presence of pathogens) associated with the digestive tract.

**First flush.** The first big rain after an extended dry period (usually summer) which flushes accumulated pollutants of surfaces and out of storm drains and carries them into the creeks and ocean.

* Terms marked with an asterisk are defined in a glossary at the end of this report.

**Geographic Information System (GIS)**. A system of hardware, software, data, people, organizations and institutional arrangements for collecting, storing, analyzing and disseminating spatial information.

**Geomean**. Shorthand for geometric mean.

**Geometric mean.** A measure of the central tendency of a data set that minimizes the effects of extreme values. Mathematically, it is equivalent to the antilog of the mean of log-transformed data.

**Index of biological integrity (IBI).** A method for describing water quality using characteristics of aquatic communities, such as the types of fish and invertebrates found in the water body. See biological integrity.

**Indicator bacteria.** Groups of bacteria that are used as indicator organisms* for human waste and/or pathogens.

**Indicator organism.** An organism used to indicate the potential presence of other (usually pathogenic) organisms. Indicator organisms are usually associated with the other organisms, but are usually more easily sampled and measured.

**Indicator site**. Stream sampling sites located at or near outlets of drainage basins with near homogeneous land use.

**Indicator.** A measurable quantity that can be used to evaluate the relationship between pollutant sources and their impact on water quality.

**Inland surface waters.** Freshwater or brackish rivers, streams, creeks and lakes.

**Integrator site.** Stream sampling sites located in drainage basins that are large and complex and often contain multiple environmental settings.

**Load.** The total amount of material (pollutants) entering the system from one or multiple sources; measured as a rate in weight per unit time.

**Microbial source tracking (MST).** A collection of scientific methods used to track sources of fecal contamination.

**Narrative criteria.** Non-quantitative guidelines that describe a desired water quality goal or goals, e.g. the Basin Plan criterion for oil and grease is “no visible sheen.”

**Physicochemical parameters.** Relating to both physical and chemical properties. For example, dissolved oxygen concentrations depend on the supply of oxygen and the temperature of the water.

**Pollution.** Generally refers to alteration of the water quality to a degree which unreasonably affects beneficial uses*, e.g. recreation or aquatic habitat.

**Porter-Cologne Water Quality Act.** State water code that regulates water quality issues and gives ultimate jurisdiction of water rights to the SWRCB.

**Practical quantification limit (PQL).** The lowest chemical analysis level that can be reliably achieved within specified limits of precision and accuracy during routine operating conditions.

**REC 1 (Water Recreation Contact in the Basin Plan)**: A beneficial use defined as the use of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, white water activities, fishing, or use of natural hot springs.

**Receiving waters.** Creeks, streams, rivers, lakes, estuaries, ground-water formations, or other bodies of water into which surface water and/or treated or untreated waste are discharged, either naturally or in man-made systems.

**Recreational contact standards.** The minimum protective indicator bacteria criteria for waters adjacent to public beaches and public water-contact sports areas.

**Regional Water Quality Control Board (RWQCB, or “Regional Board”).** Nine regional boards oversee Basin Plans, permitting, storm water management plans, and regional ambient monitoring. Under the auspices of the U.S. Environmental Protection Agency,

* Terms marked with an asterisk are defined in a glossary at the end of this report.

the State Board and Regional Boards also have the responsibility of granting Clean Water Act National Pollutant Discharge Elimination System (NPDES) permits. The nine Regional Boards differ somewhat in the extent they choose to apply waste discharge requirements and other regulatory actions. Santa Barbara falls in the jurisdiction areas of the Central Coast RWQCB, or Region 3.

**Single sample maximum (SSM).** The maximum acceptable indicator bacteria concentration for a single sample.

**State Water Resources Control Board (SWRCB, or "State Board").** An agency within the California Environmental Protection Agency whose mission is to preserve, enhance and restore the quality of California's water resources, and ensure their proper allocation and efficient use for the benefit of present and future generations. Under the Porter-Cologne Water Quality Control Act*, the State Board has the ultimate authority over State water rights and water quality policy. However, Porter-Cologne also establishes nine Regional Water Quality Control Boards* to oversee water quality on a day-to-day basis at the local/regional level.

**Total coliforms.** A measure all forms of coliform bacteria present in a sample.

**Turbidity**. "Cloudiness" of water due to suspended sediment or organic matter, and is expressed as nephelometric turbidity units (NTU).

**Upper watershed indicator site.** Indicator site* used to assess the watershed conditions upstream of the urbanized corridor.

**Warm Fresh Water Habitat (WARM)**. Beneficial use of water that supports warm water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.

**Water quality objective.** Term used by Basin Plan and some state laws that is synonymous with criterion*. The legal definition is "limits or levels of water quality constituents or characteristics which are established for the reasonable protection of beneficial uses."

**Water quality standard.** Law or regulation that consists of the beneficial designated use or uses of a waterbody, the numeric and narrative water quality criteria that are necessary to protect the use or uses of that particular waterbody, and an antidegradation* statement.

**Watershed.** A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

* Terms marked with an asterisk are defined in a glossary at the end of this report.

## VII. REFERENCES


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* Terms marked with an asterisk are defined in a glossary at the end of this report.

# APPENDIX A

# DEFINITIONS OF BENEFICIAL USES

The following is taken from the State Water Resources Control Board's Basin Plan (1994)

Beneficial uses for surface and ground waters are divided into the twenty standard categories listed below. One of the principal purposes of this standardization is to facilitate establishment of both qualitative and numerical water quality objectives that will be compatible on a statewide basis.

Municipal and Domestic Supply (MUN)
Uses of water for community, military, or individual water supply systems including, but not limited to, drinking water supply. According to State Board Resolution No. 88-63, "Sources of Drinking Water Policy" all surface waters are considered suitable, or potentially suitable, for municipal or domestic water supply except where:

a. TDS exceeds 3000 mg/l (5000 uS/cm electrical conductivity);
b. Contamination exists, that cannot reasonably be treated for domestic use;
c. The source is not sufficient to supply an average sustained yield of 200 gallons per day;
d. The water is in collection or treatment systems of municipal or industrial wastewaters, process waters, mining wastewaters, or storm water runoff; and;
e. The water is in systems for conveying or holding agricultural drainage waters.

Agricultural Supply (AGR)
Uses of water for farming, horticulture, or ranching including, but not limited to, irrigation, stock watering, or support of vegetation for range grazing.

Industrial Process Supply (PROC)
Uses of water for industrial activities that depend primarily on water quality (i.e., waters used for manufacturing, food processing, etc.).

Industrial Service Supply (IND)
Uses of water for industrial activities that do not depend primarily on water quality including, but not limited to, mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, or oil well repressurization.

Ground Water Recharge (GWR)
Uses of water for natural or artificial recharge of ground water for purposes of future extraction, maintenance of water quality, or halting of saltwater intrusion into freshwater aquifers. Ground water recharge includes recharge of surface water underflow.

Freshwater Replenishment (FRSH)
Uses of water for natural or artificial maintenance of surface water quantity or quality (e.g., salinity) which includes a water body that supplies water to a different type of water body, such as, streams that supply reservoirs and lakes, or estuaries; or reservoirs and lakes that supply streams. This includes only immediate upstream water bodies and not their tributaries.

Navigation (NAV)
Uses of water for shipping, travel, or other transportation by private, military, or commercial vessels. This Board interprets NAV as, "Any stream, lake, arm of the sea, or other natural body of water that is actually navigable and that, by itself, or by its connections with other waters, for a period long enough to be of commercial value, is of sufficient capacity to float watercraft for the purposes of commerce, trade, transportation, and including pleasure; or any waters that have been declared navigable by the Congress of the United States" and/or the California State Lands Commission.

Hydropower Generation (POW)
Uses of water for hydropower generation.

Water Contact Recreation (REC-1)
Uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, white water activities, fishing, or use of natural hot springs.

Non-Contact Water Recreation (REC-2)
Uses of water for recreational activities involving proximity to water, but not normally involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating tidepool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities.

Commercial and Sport Fishing (COMM)
Uses of water for commercial or recreational collection of fish, shellfish, or other organisms including, but not limited to, uses involving organisms intended for human consumption or bait purposes.

Aquaculture (AQUA)
Uses of water for aquaculture or mariculture operations including, but not limited to, propagation, cultivation, maintenance, or harvesting of aquatic plants and animals for human consumption or bait purposes.

Warm Fresh Water Habitat (WARM)
Uses of water that support warm water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.

Cold Fresh Water Habitat (COLD)
Uses of water that support cold water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish or wildlife, including invertebrates.

Inland Saline Water Habitat (SAL)
Uses of water that support inland saline water ecosystems including, but not limited to, preservation or enhancement of aquatic saline habitats, vegetation, fish, or wildlife, including invertebrates. Soda Lake is a saline habitat typical of desert lakes in inland sinks.

Estuarine Habitat (EST)
Uses of water that support estuarine ecosystems including, but not limited to, preservation or enhancement of estuarine habitats, vegetation, fish, shellfish, or wildlife (e.g., estuarine mammals, waterfowl, shorebirds). An estuary is generally described as a semi-enclosed body of water having a free connection with the open sea, at least part of the year and within which the seawater is diluted at least seasonally with fresh water drained from the land. Included are water bodies which would naturally fit the definition if not controlled by tidegates or other such devices.

Marine Habitat (MAR)
Uses of water that support marine ecosystems including, but not limited to, preservation or enhancement of marine habitats, vegetation such as kelp, fish, shellfish, or wildlife (e.g., marine mammals, shorebirds).

Wildlife Habitat (WILD)
Uses of water that support terrestrial ecosystems including, but not limited to, preservation and enhancement of terrestrial habitats, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.

Preservation of Biological Habitats of Special Significance (BIOL)
Uses of water that support designated areas or habitats, such as established refuges, parks, sanctuaries, ecological reserves, or Areas of Special Biological Significance (ASBS), where the preservation or enhancement of natural resources requires special protection.

Rare, Threatened, or Endangered Species (RARE)
Uses of water that support habitats necessary, at least in part, for the survival and successful maintenance of plant or animal species established under state or federal law as rare, threatened, or endangered.

Migration of Aquatic Organisms (MIGR)
Uses of water that support habitats necessary for migration or other temporary activities by aquatic organisms, such as anadromous fish.

Spawning, Reproduction, and/or Early Development (SPWN)
Uses of water that support high quality aquatic habitats suitable for reproduction and early development of fish.

Shellfish Harvesting (SHELL)
Uses of water that support habitats suitable for the collection of filter-feeding shellfish (e.g., clams, oysters, and mussels) for human consumption, commercial, or sport purposes. This includes waters that have in the past, or may in the future, contain significant shellfisheries.

Areas of Special Biological Significance (ASBS)
are those areas designated by the State Water Resources Control Board as requiring protection of species or biological communities to the extent that alteration of natural water quality is undesirable.

The following areas have been designated Areas of Special Biological Significance in the Central Coastal Basin:

1. Ano Nuevo Point and Island, San Mateo County

2 Pacific Grove Marine Gardens Fish Refuge and Hopkins Marine Life Refuge, Monterey County

3. Point Lobos Ecological Reserve, Monterey County

4. Carmel Bay, Monterey County

5 Julia Pfeiffer Burns Underwater Park, Monterey County

6. Ocean area surrounding the mouth of Salmon Creek, Monterey County

7. Channel Islands, Santa Barbara County - San Miguel, Santa Rosa, Santa Cruz

An ASBS designation implies the following requirements:

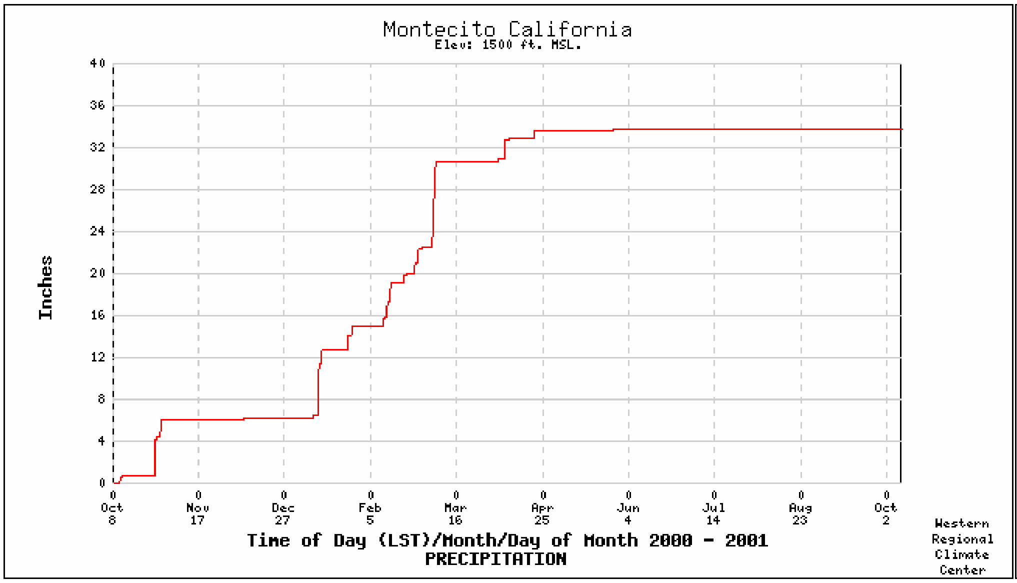
Discharge of elevated temperature wastes in a manner that would alter water quality conditions from those occurring naturally will be prohibited.

Discharge of discrete, point source sewage or industrial process wastes in a manner that would alter water quality conditions from those occurring naturally will be prohibited.

Discharge of waste from nonpoint sources, including but not limited to storm water runoff, silt, and urban runoff, will be controlled to the extent practicable. In control programs for waste from nonpoint sources, Regional Boards will give high priority to areas tributary to ASBS.

# APPENDIX B

# CLIMATE AND HYDROLOGY DATA




Statistics

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Oct. 8, 2000
:00 LST

**End Date/Time**
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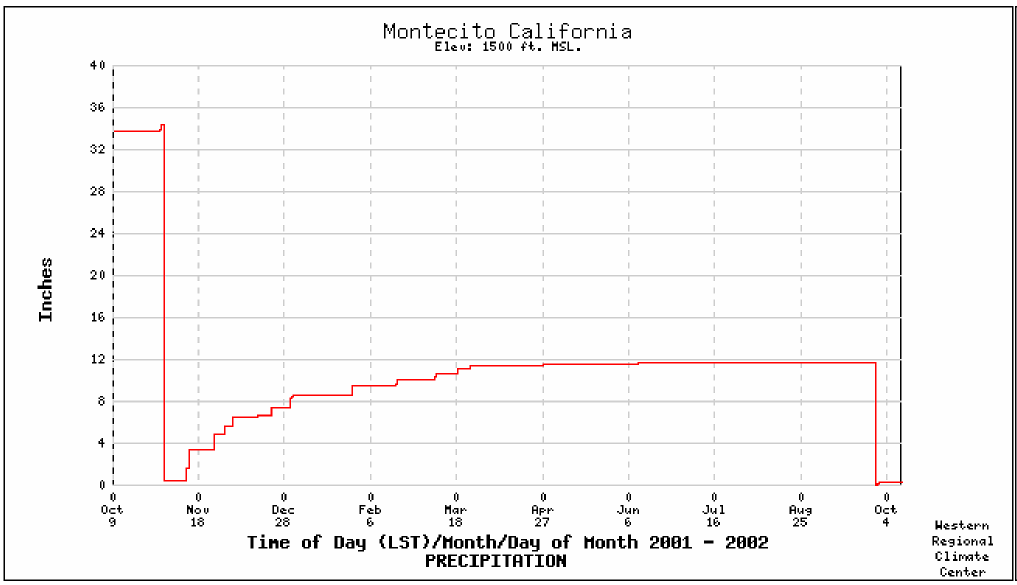
23:00 LST

**PRECIPITATION**
Inches

**Average**
23.48

**Max. | Min.**
33.84 | 0




Statistics

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:00 LST

**End Date/Time**
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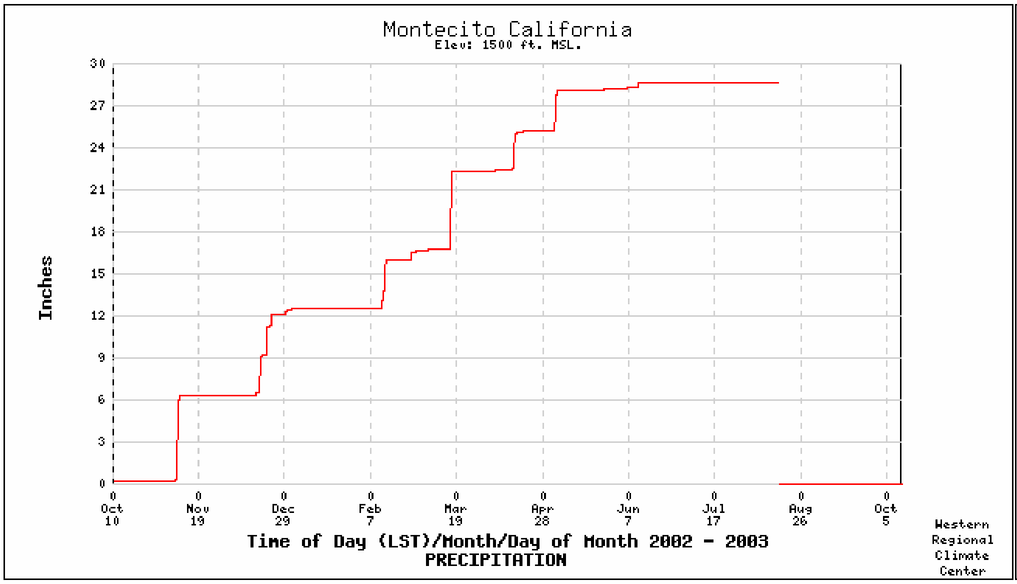
23:00 LST

**PRECIPITATION**
Inches

**Average**
11.07

**Max. | Min.**
34.34 | 0.06




Statistics

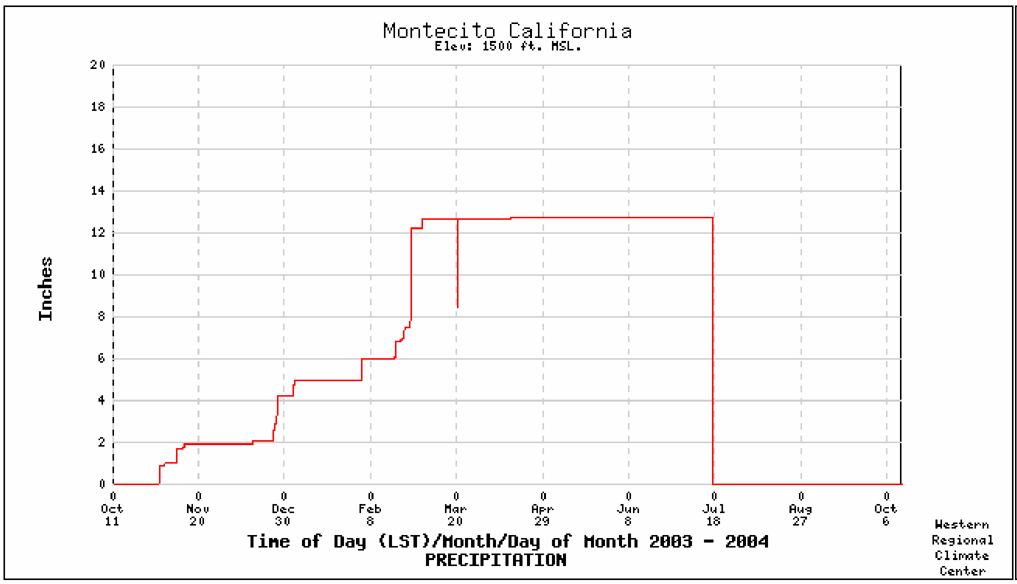
**Begin Date/Time**
Oct. 10, 2002
:00 LST

**End Date/Time**
Oct. 10, 2003
23:00 LST

**PRECIPITATION**
Inches

**Average**
15.19

**Max. | Min.**
28.63 | 0.02




Statistics

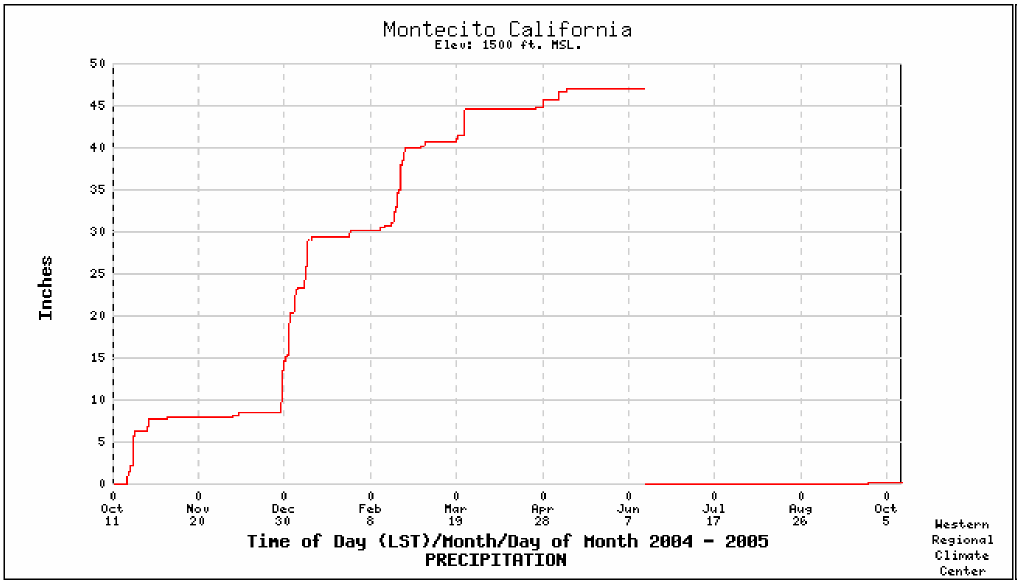
**Begin Date/Time**
Oct. 11, 2003
:00 LST

**End Date/Time**
Oct. 10, 2004
23:00 LST

**PRECIPITATION**
Inches

**Average**
6.02

**Max. | Min.**
12.75 | 0




Statistics

**Begin Date/Time**
Oct. 11, 2004
:00 LST

**End Date/Time**
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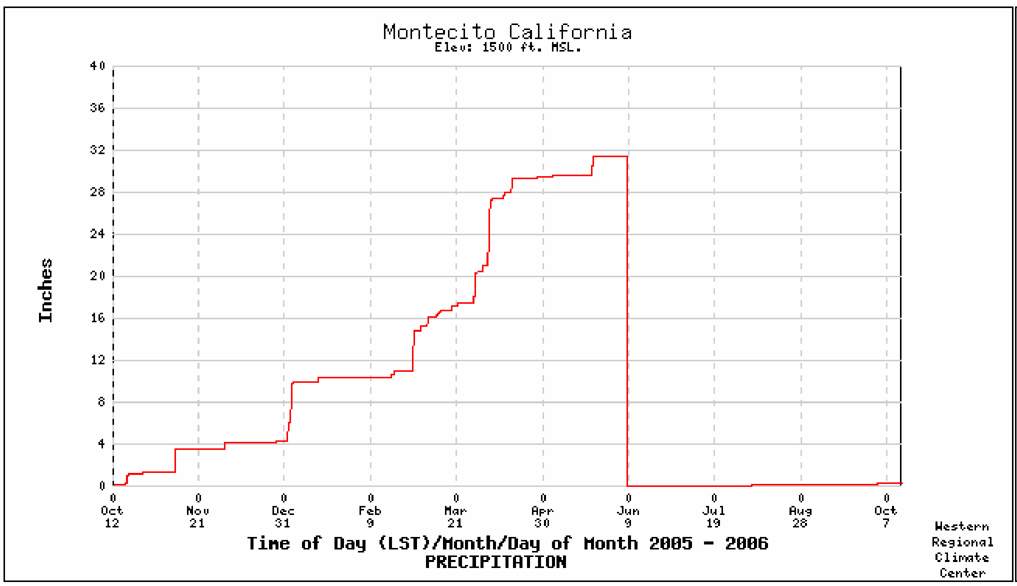
23:00 LST

**PRECIPITATION**
Inches

**Average**
19.5

**Max. | Min.**
47.04 | 0




Statistics

**Begin Date/Time**
Oct. 12, 2005
:00 LST

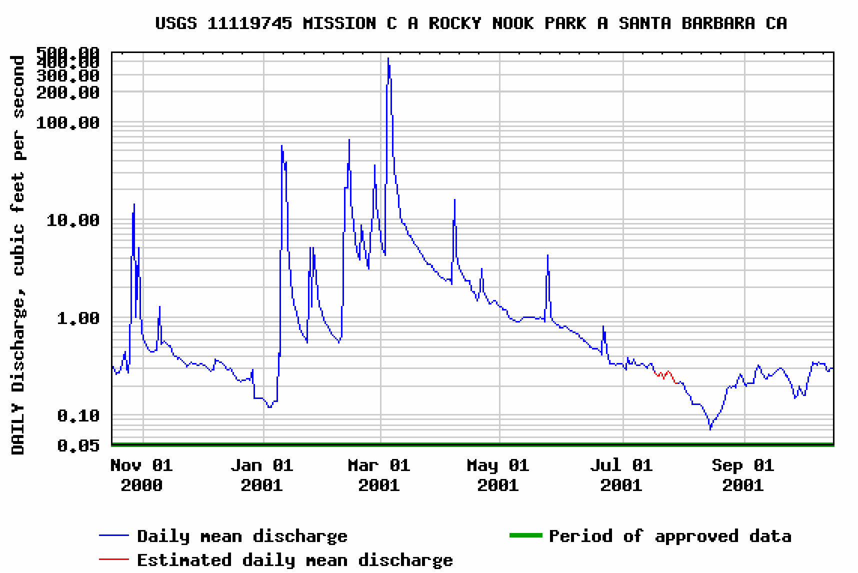
**End Date/Time**
Oct. 12, 2006
23:00 LST

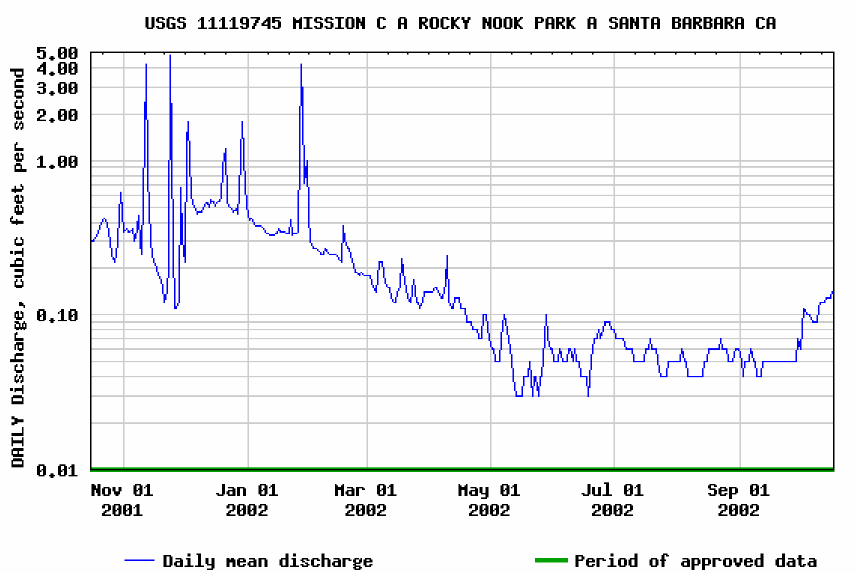
**PRECIPITATION**
Inches

**Average**
9.2

**Max. | Min.**
31.34 | 0.02

# Table 1


USGS 11119745 MISSION C A ROCKY NOOK PARK A SANTA BARBARA CA
DAILY Discharge, cubic feet per second
500.00
400.00
300.00
200.00
100.00
10.00
1.00
0.10
0.05
Nov 01 2000
Jan 01 2001
Mar 01 2001
May 01 2001
Jul 01 2001
Sep 01 2001
Daily mean discharge
Estimated daily mean discharge
Period of approved data


USGS 11119745 MISSION C A ROCKY NOOK PARK A SANTA BARBARA CA
DAILY Discharge, cubic feet per second
5.00
4.00
3.00
2.00
1.00
0.10
0.01
Nov 01 2001
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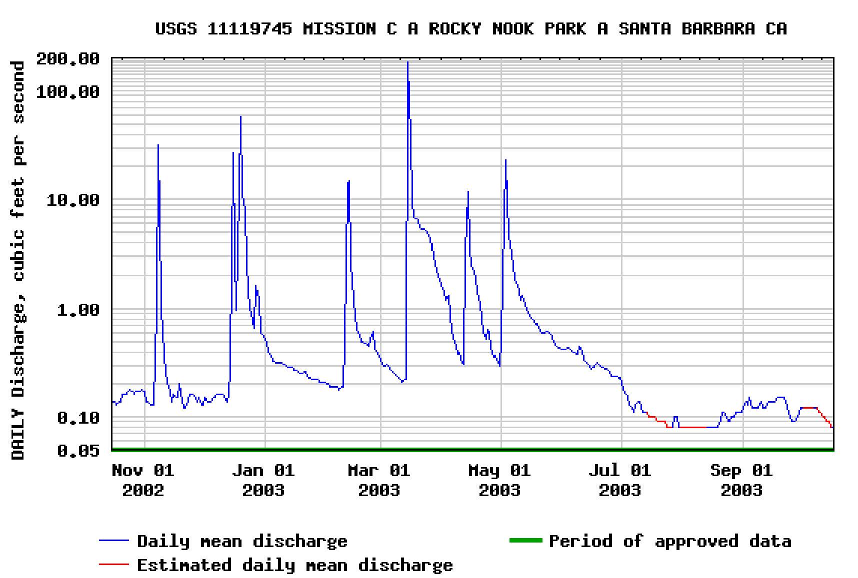
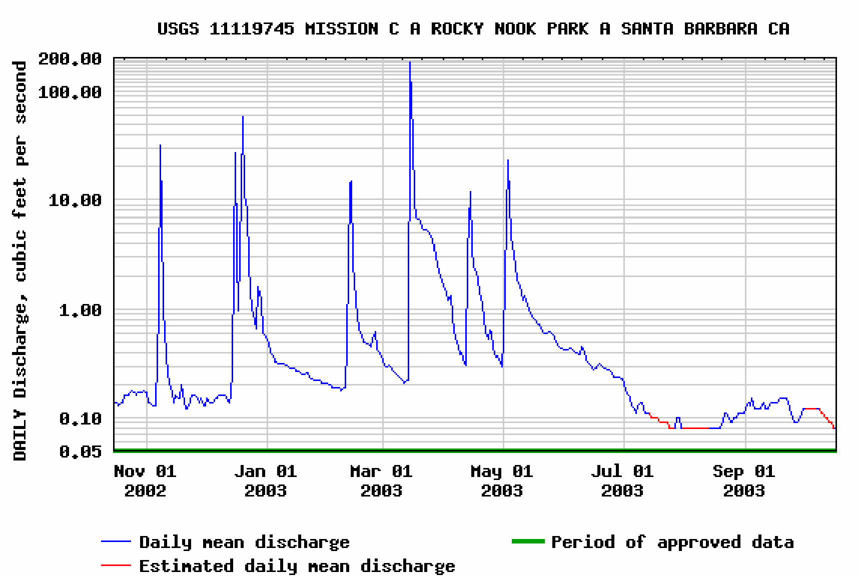
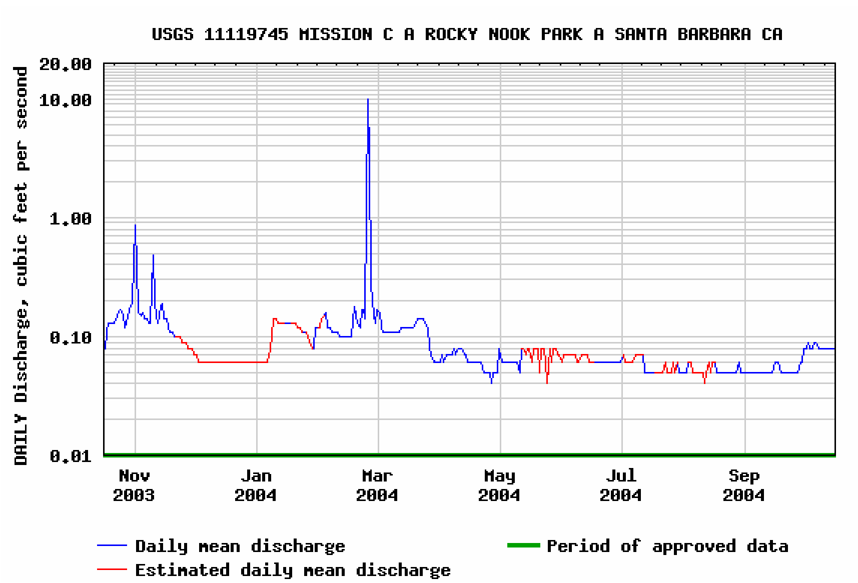
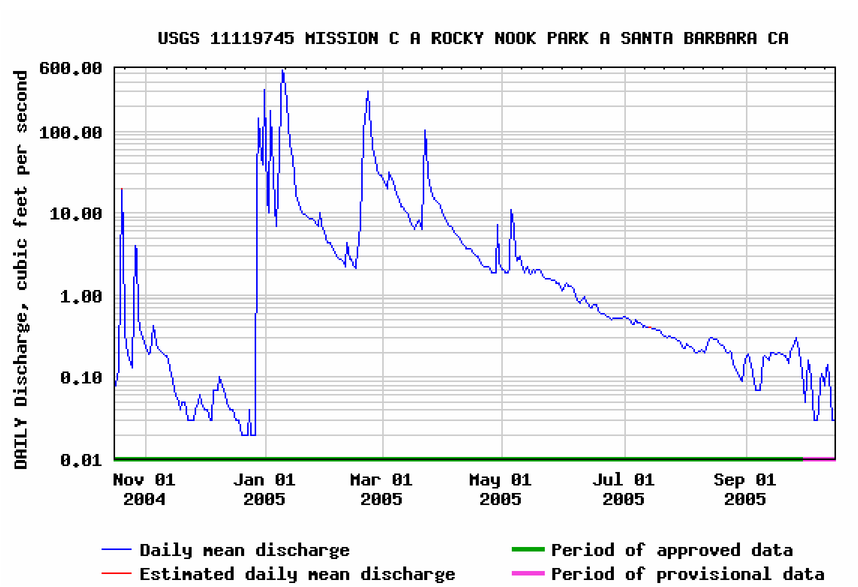
Mar 01 2002
May 01 2002
Jul 01 2002
Sep 01 2002
Daily mean discharge
Period of approved data


USGS 11119745 MISSION C A ROCKY NOOK PARK A SANTA BARBARA CA
DAILY Discharge, cubic feet per second
200.00
100.00
10.00
1.00
0.10
0.05
Nov 01 2002
Jan 01 2003
Mar 01 2003
May 01 2003
Jul 01 2003
Sep 01 2003
Daily mean discharge
Estimated daily mean discharge
Period of approved data


USGS 11119745 MISSION C A ROCKY NOOK PARK A SANTA BARBARA CA
DAILY Discharge, cubic feet per second
200.00
100.00
10.00
1.00
0.10
0.05
Nov 01 2002
Jan 01 2003
Mar 01 2003
May 01 2003
Jul 01 2003
Sep 01 2003
Daily mean discharge
Estimated daily mean discharge
Period of approved data


USGS 11119745 MISSION C A ROCKY NOOK PARK A SANTA BARBARA CA
DAILY Discharge, cubic feet per second
20.00
10.00
1.00
0.10
0.01
Nov 2003
Jan 2004
Mar 2004
May 2004
Jul 2004
Sep 2004
Daily mean discharge
Estimated daily mean discharge
Period of approved data


USGS 11119745 MISSION C A ROCKY NOOK PARK A SANTA BARBARA CA
DAILY Discharge, cubic feet per second
600.00
100.00
10.00
1.00
0.10
0.01
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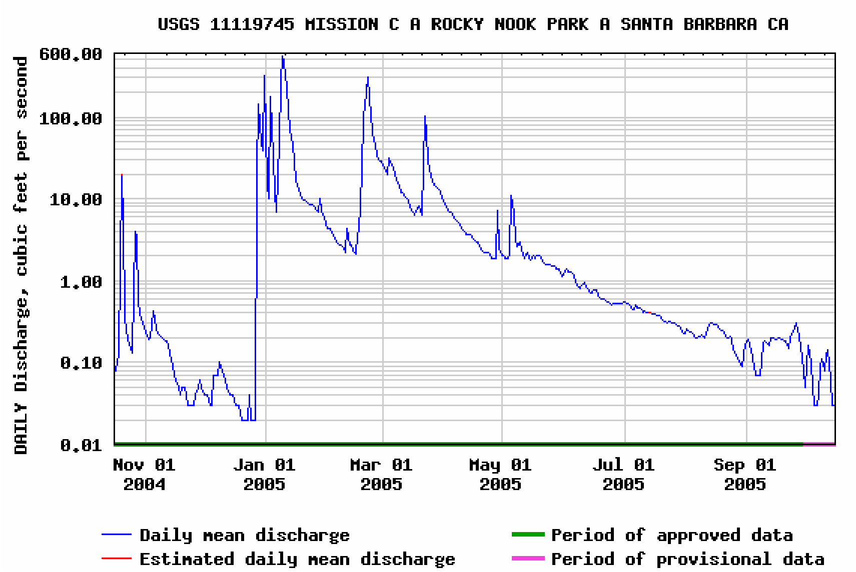
Jul 01 2005
Sep 01 2005
Daily mean discharge
Estimated daily mean discharge
Period of approved data
Period of provisional data


USGS 11119745 MISSION C A ROCKY NOOK PARK A SANTA BARBARA CA
DAILY Discharge, cubic feet per second
600.00
100.00
10.00
1.00
0.10
0.01
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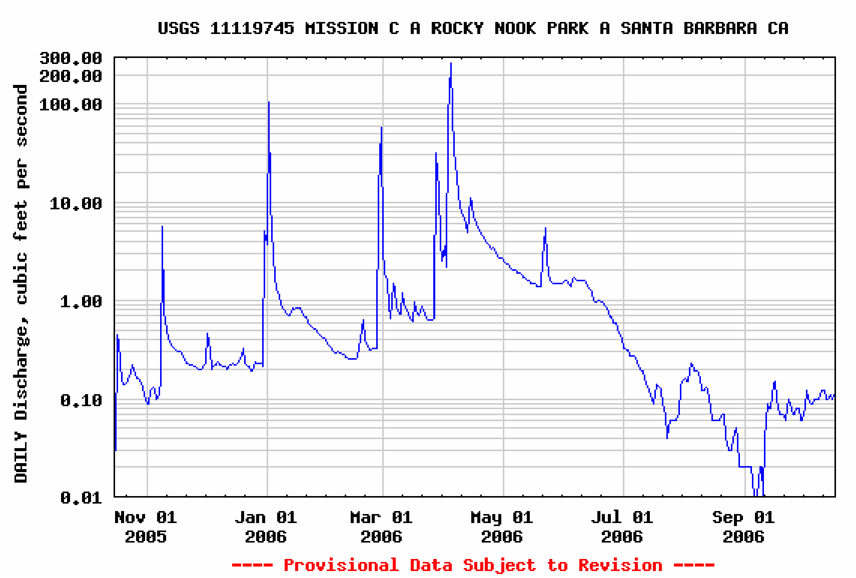
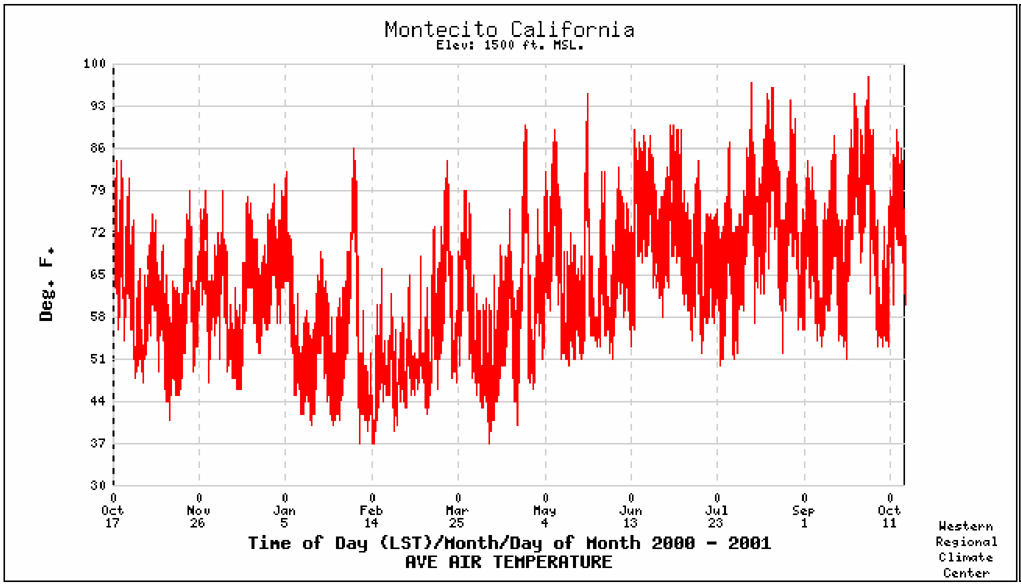
Jan 01 2005
Mar 01 2005
May 01 2005
Jul 01 2005
Sep 01 2005
Daily mean discharge
Estimated daily mean discharge
Period of approved data
Period of provisional data


USGS 11119745 MISSION C A ROCKY NOOK PARK A SANTA BARBARA CA
DAILY Discharge, cubic feet per second
300.00
200.00
100.00
10.00
1.00
0.10
0.01
Nov 01 2005
Jan 01 2006
Mar 01 2006
May 01 2006
Jul 01 2006
Sep 01 2006
---- Provisional Data Subject to Revision ----




Statistics

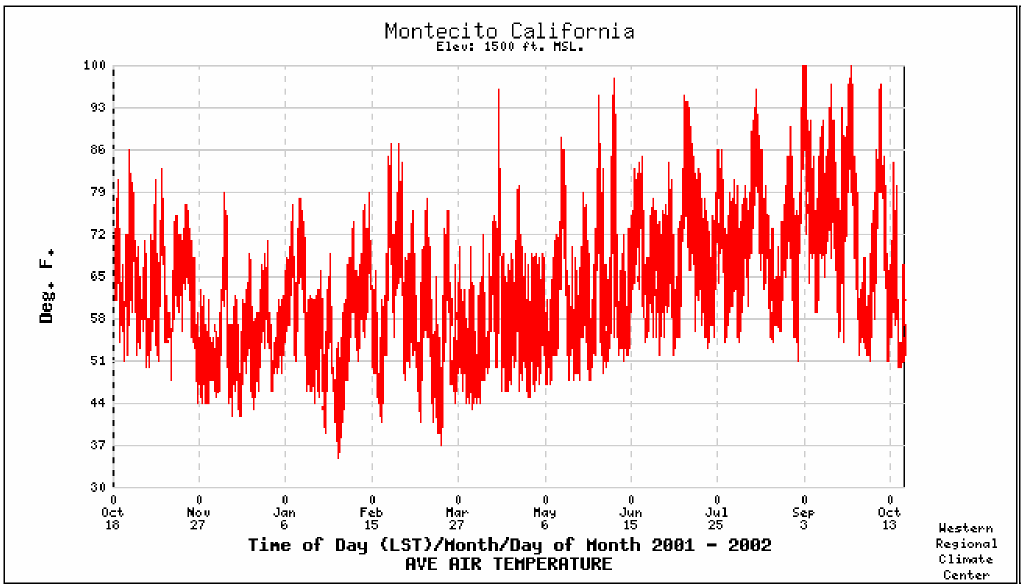
**Begin Date/Time**
Oct. 17, 2000
:00 LST

**End Date/Time**
Oct. 17, 2001
23:00 LST

**AVE AIR TEMPERATURE**
Deg. F.

**Average**
62.8

**Max. | Min.**
97.9 | 36.9




Statistics

**Begin Date/Time**
Oct. 18, 2001
:00 LST

**End Date/Time**
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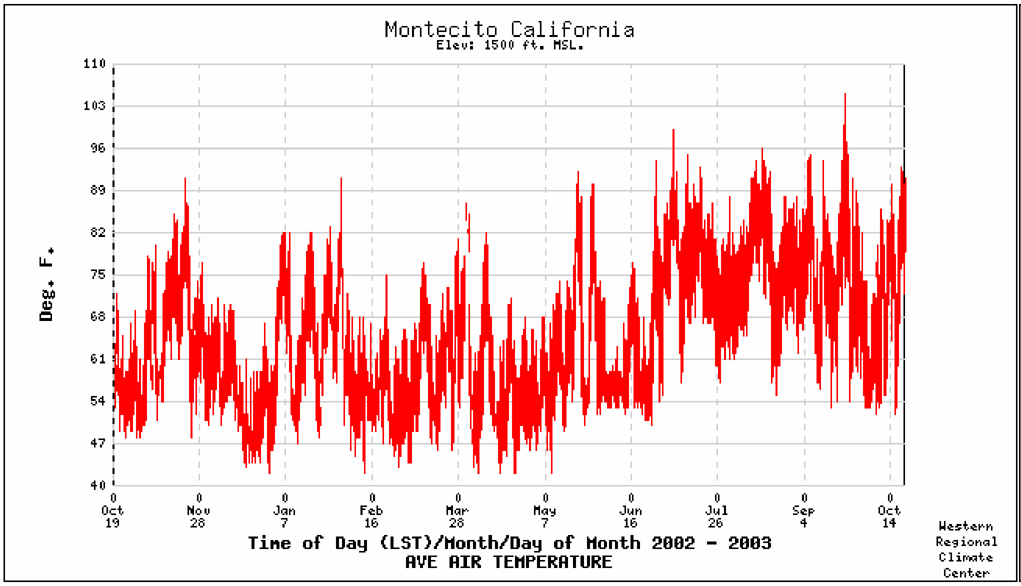
23:00 LST

**AVE AIR TEMPERATURE**
Deg. F.

**Average**
62.7

**Max. | Min.**
99.9 | 34.9




Statistics

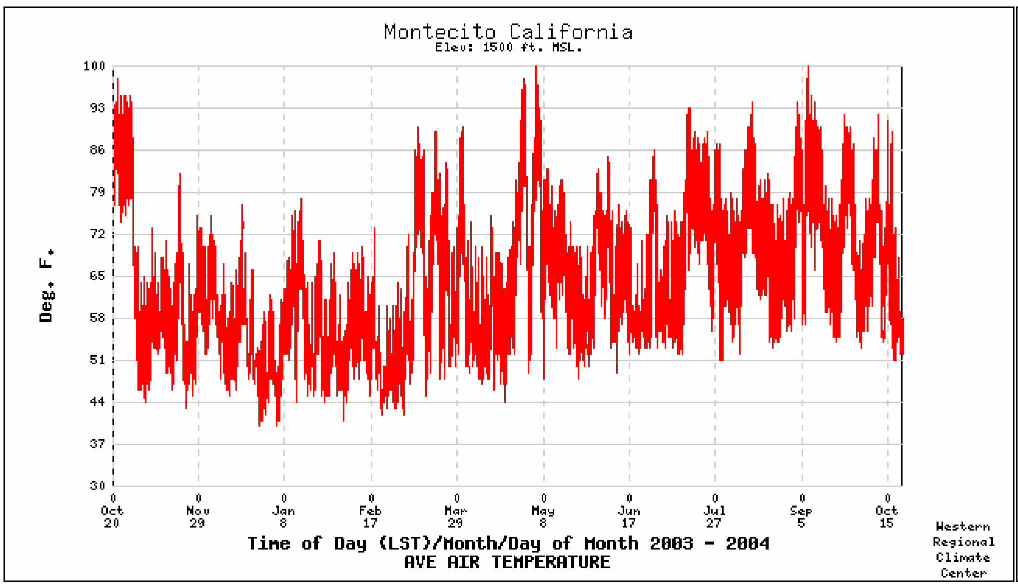
**Begin Date/Time**
Oct. 19, 2002
:00 LST

**End Date/Time**
Oct. 19, 2003
23:00 LST

**AVE AIR TEMPERATURE**
Deg. F.

**Average**
64.5

**Max. | Min.**
104.9 | 41.9




Statistics

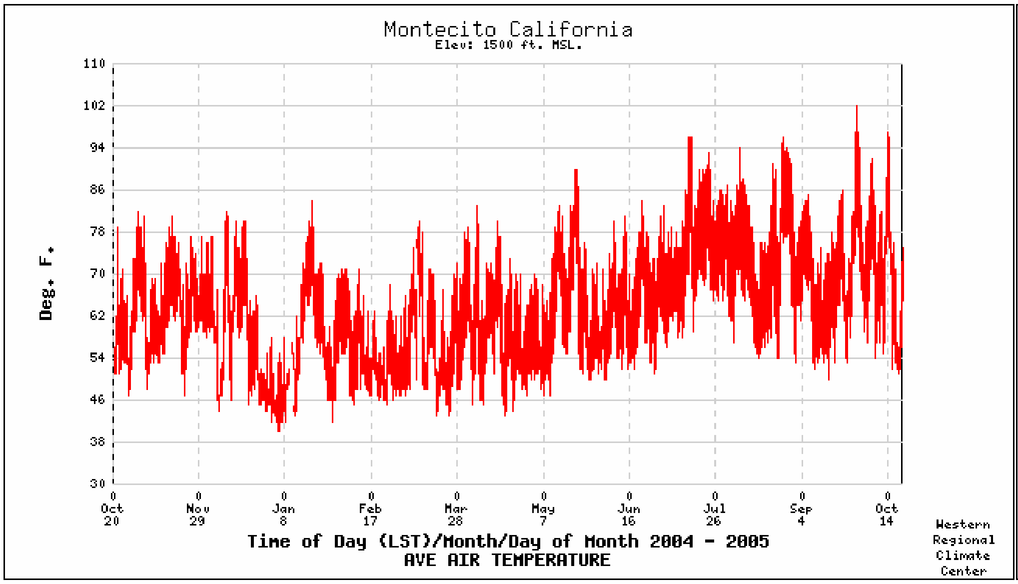
**Begin Date/Time**
Oct. 20, 2003
:00 LST

**End Date/Time**
Oct. 19, 2004
23:00 LST

**AVE AIR TEMPERATURE**
Deg. F.

**Average**
63.8

**Max. | Min.**
99.9 | 39.9




Statistics

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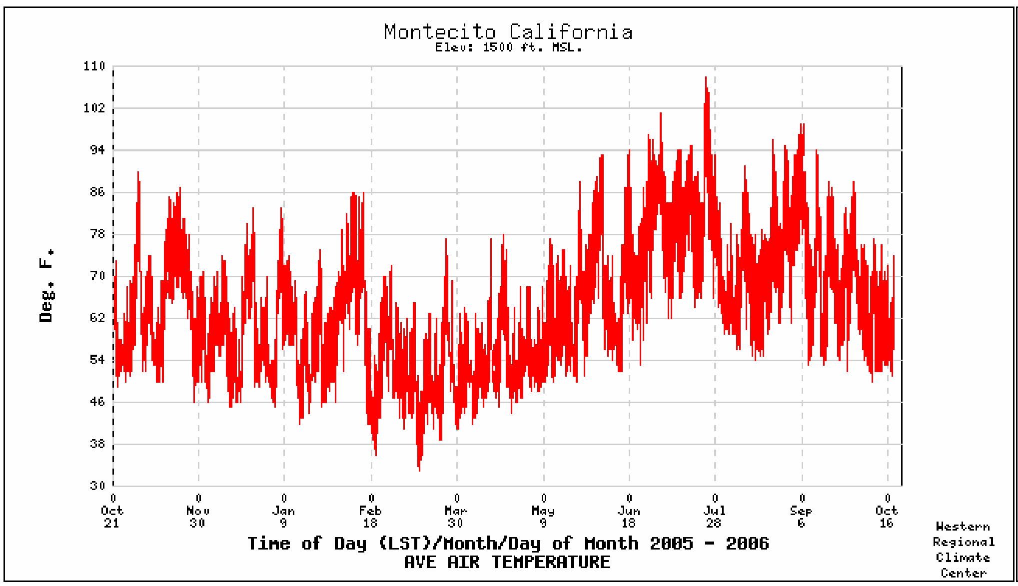
Oct. 20, 2004
:00 LST

**End Date/Time**
Oct. 20, 2005
23:00 LST

**AVE AIR TEMPERATURE**
Deg. F.

**Average**
63.2

**Max. | Min.**
101.9 | 39.9




Statistics

**Begin Date/Time**
Oct. 21, 2005
:00 LST

**End Date/Time**
Oct. 21, 2006
23:00 LST

**AVE AIR TEMPERATURE**
Deg. F.

**Average**
63.7

**Max. | Min.**
107.9 | 32.9

# APPENDIX C

# CREEK WALK METHODS

**Point and Line Data Collected for 2005 Creek Walk Surveys.**

**Side Drains (DR- mapped as point)**
Side drains that appeared new to the creek were mapped along with estimated diameter. Materials consisted of:

**DR-me**: metal;

**DR-co**: concrete- often seen as an opening in a concrete wall (i.e. under a bridge or culvert, or coming out of a vertical or sloped concrete wall;

**DR-pv**: poly vinyl chloride (PVC) or other plastic polymer compound;

**DR-oc**: open culvert where instead of the stormflow coming directly out of a pipe, water runs through or atop a reinforced (generally with concrete or asphalt) surface which directs flows.

**Bank Modifications (BM- mapped as line)**
Bank modifications are any anthropogenically modified structure on or along the creek bank. Each BM line is unique for each side of the creek bank. Principally utilized for bank stabilization during high water flows, the modifications are generally made of the following materials and with the following bank angles:

**BM-rr:** large boulders, concrete or other rock construction debris, consolidated along the bank normally in a steep angle just shy of vertical, to protect property (structures, etc.) or bridges, etc.;

**BM-gv:** vertically stacked gabion protecting wall, comprised of rock cages, stacked like bricks/building blocks;

**BM-gs:** gabion protecting wall, configured like BM-gv, but angled/sloped;

**BM-ne:** an erosion preventing blanket in form of a net, often made of natural fibers (i.e., jute) or synthetic (i.e., plastic) materials, laid atop and/or staked upon the bank;

**BM-pr:** pipe and rail bank stabilizer, essentially comprised of vertical 3" to 6" diameter metal pipes, covered with metal wire fence, and with rocks/cobble between the fence and the bank;

**BM-rw:** retaining wall for bank stabilization, where any type of substrate (normally wood timbers) are lain down to ultimately comprise a vertical wall;

**BM-ss:** sloped sand bags, which are concrete-filled bags, stacked like bricks or rocks in an angled configuration;

**BM-sv:** same substrate as BM-ss, but the vertical sand bags are stacked vertically;

**BM-sc:** spray concrete, which is created by spraying a concrete mixture along the surface (i.e., the bank) to form a protective shell;

**BM-tc:** sloped concrete wall, generally smooth and trapezoidal in shape, and often created by flood control purposes to facilitate rapid passing and evacuation of water;

**BM-vc:** vertical concrete wall, also smooth like BM-tc, but vertical, not angled;

**BM-wf:** wire fence, much like BM-pr, or more simple construction, but without rocks/cobbles between the fence and the bank.

**BM-il:** Illegal bank modification, usually done around residences. (Tim added).

**BM-fu:** bank modification failing where undercutting has occurred. (Tim added).

**BM-fl:** bank modification failing where BM is leaning into stream channel, sometimes happens with pipe and rail.

**Bank Erosion (BE- mapped as a line)**
Bank erosion occurs mostly through alluvial processes (water derived forces), but sometimes through colluvial (gravity induced) forces, where the degree of erosion was defined and described as:

**BE-in:** incipient erosion, where the creek bank shows visible signs of instability with high potential for erosion, such as pressure sags, slumps, or the bank is
devoid of protective vegetation (with stabilizing roots) coupled with high bank angle;

**BE-ac:** active erosion, where the creek bank not only shows measurable signs of slumping and sagging coupled with high bank angle, but where fallen or missing sections of the bank have left scars, barren earth, or exposed roots, and the process is ongoing;

**BE-fa:** bank failure, where the creek bank has eroded to such extent that not only are the erosion scars prominent, but protective vegetation is exposed to such extent that roots and often tree trunks are exposed and overhung, massive slope failure has occurred, and the erosive process will undoubtedly continue.

**In-stream Pollution (IP-map as point)**
In-stream pollution is defined as any type of anthropogenic substance that is nonnative or unnatural to the creek corridor/system, assumed largely responsible for water quality problems and beach closures, such as:

**IP-fe:** human feces, where it is isolated;

**IP-fc:** human feces, where it is concentrated and thus suspected to be a frequented "bathroom" location;

**IP-ma:** manure, where feces from any livestock animal was identified;

**IP-st:** stable, where a corral or permanent residence of livestock (i.e., horse) was identified, and visual amounts of solid and liquid waste were observed potentially or directly flowing towards the creek;

**IP-an:** animal, where small animal scat was identified, either isolated or concentrated "hotspots";

**IP-en:** human encampment, visible either by the human or his/her bedding and miscellaneous paraphernalia;

**IP-da:** day use area, defined as a spot for recreation or similar activity in the creek corridor-graffiti was commonly observed on the bank/channel walls in these locations;

**IP-gr:** green waste, where homeowners or contracted employees have collected and deposited yard/landscape cuttings/trimmings, etc., either onto the creek bank or in the creek;

**IP-tr:** paper trash, defined as small paper, glass and plastic or other items, such as cups, bags, bottles, cans, boxes, wrappers, etc.  **Note, since high water flows redistribute these light/floatable trash materials, not every piece of trash was

mapped, only areas where much trash was observed, or where the source was (i.e., picnic bench, bridge, drain, etc.), or where clean-up efforts could be concentrated;

**IP-bu:** bulk trash, defined as heavy or large objects that were deposited in the creek corridor, but could not easily be cleaned up in a public creek clean-up session-these items were commonly large metal pipes, water heaters, car parts, sofas, and/or other undetermined large trash objects;

**IP-ru:** construction rubble, commonly comprised of medium to large sized concrete or asphalt chunks/debris-pushed onto the creek bank or into the creek channel;

**IP-gw:** grey water discharge, where non stormflow or dry water discharge was evident- commonly from laundering or other washing operations;

**IP-pa:** house paint, observed as dumped oil-based or water-based paint;

**IP-cs:** concrete slurry, containing tremendously detrimental compounds to aquatic life- observed as liquid waste from unused concrete applications often dumped into the creek or splattered along the bank;

**IP-hi:** hazardous industrial waste, identified as hazardous materials used in industrial applications, such as solvents, lubricants, or other petroleum hydrocarbon compounds- commonly contained in drums or observed as stains;

**IP-hm:** hazardous medical waste, identified as any "Sharps" type object used in the medical profession or for personal medical use, such as syringes or needles.

**Tributary (TR mapped as point).**

Source of visible water flow into creek.  This data was added to the 2005 Creek Walk Survey.

**TR-sw:** surface water such as a contributing stream or other water flow.

**TR-gw:** ground water coming out of bank into stream.