Water Quality Monitoring Program Report
2001-2006

Clean Creeks
HEALTHY BEACHES
CITY OF SANTA BARBARA

Report Summary

SEAL OF THE CITY OF SANTA BARBARA
CALIFORNIA

City of Santa Barbara
Creeks Restoration and Water Quality Improvement Division
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INTRODUCTION

The Creeks Division Monitoring Program provides data for the Creeks Division to establish baselines of water quality, track long-term changes, and assess project performance. This information is needed to understand sources and routes of pollution in creeks, prioritize future projects for the Division and provide a basis for understanding the effectiveness of the current program. The Creeks Division strives to maintain a dynamic, adaptive monitoring program that is driven by specific research questions, as opposed to collecting data haphazardly.

The goals of the monitoring program are to:

- Quantify the levels of microbial contamination and chemical pollution in watersheds throughout the city in relation to human and aquatic health.
- Evaluate the effectiveness of the City's restoration and water quality treatment projects in reducing contaminant and pollutant levels and improving water quality for aquatic organisms.

The 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.

The monitoring program consists of seven key elements:

1. Routine watershed assessment
2. Storm monitoring
3. Restoration and water quality treatment assessment
4. Biological assessment
5. Creek walks
6. DNA-based microbial source tracking
7. Special studies

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.

Report Overview

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, and 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.

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.). In order to relate physical, chemical, and biological properties of water to the beneficial use, measured values from monitoring efforts are compared against criteria (standards, thresholds) that are known to be related to the beneficial use* of the water.

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.

There are several sources of criteria and/or guidance that may pertain to different pollutants and different beneficial uses, including the Regional Water Quality Control Board's (RWQCB) 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.

Indicator Bacteria

Indicator bacteria are groups of intestinal bacteria that are always found in high concentrations in human waste and sewage. The vast majority are not harmful in and of themselves. Indicator bacteria are used to predict the likelihood that human waste/sewage is present in environmental samples, leading to the inference that pathogenic microorganisms may also be present. The State regulates beach warnings based on levels of indicator bacteria in surf-zone samples collected by the County.

Unfortunately, indicator bacteria can come from soil, decaying plants, and animal waste, and they survive and even grow in the environment which means that indicator bacteria do not always indicate the presence of human waste/sewage. The City collects samples for indicator bacteria and they are processed at the State-certified El Estero Wastewater Treatment Plant lab.

Physicochemical Parameters

Physicochemical properties of water include conductivity, dissolved oxygen (DO), pH, temperature, and turbidity. These are also called "conventional water quality parameters." Many aquatic organisms are sensitive to physicochemical parameters. Analyzing them is important to understanding habitat quality for aquatic organisms. City staff measures physicochemical parameters in the field with electronic probes.

Trace 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. Metals may come from erosion of natural deposits, pesticides, industrial waste discharges, agricultural waste, or corroding metal pipes and storage tanks. Trace metals can have direct toxic effects on aquatic plants and animals. They can 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. The City contracts with a state-certified laboratory to analyze the chemical constituents.

Herbicides and 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 of herbicides and pesticides include residential and commercial landscaping. Runoff over landscaping treated with the chemicals provides a route of entry to the creeks. Herbicides and pesticides can be harmful to aquatic organisms above certain concentrations.

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. The primary reason MBAS is sampled is as a tracer of wastewater or washing processes reaching stormwater.

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.

Bioassessment

Bioassessment uses benthic macroinvertebrate surveys and an index of biological integrity to assess and track the health of creeks for aquatic organisms. The City contracts out bioassessment services.

Microbial Source Tracking

Microbial source tracking is used to develop DNA-based tools for tracking fecal pollution in creeks and to identify sources of indicator bacteria. The City contracts with the Holden Laboratory at UCSB to conduct microbial source tracking.

PROGRAM ELEMENTS: RESEARCH QUESTIONS, KEY FINDINGS, AND RECOMMENDATIONS

Routine Watershed Assessment

Routine watershed assessment focuses on microbial pollution (as defined by indicator bacteria) and water quality for aquatic organisms (physicochemical properties such as pH, temperature, dissolved oxygen, turbidity, conductivity).

Research questions

The sampling strategy for routine 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?

Key findings

- 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 2004-2006.
    - 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 are identified.
    - Baseline data is being collected for Lighthouse and Honda watersheds.

Recommendations

- Maintain routine watershed assessment in order to track long-term changes and identify new hot spots.
- Reallocate resources to conduct less frequent sampling of integrator sites and upper- and mid-watershed indicator sites. Sample at additional drains and potential hot spots.

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?

The monitoring program over the past two years has strived to sample for the "worst-case scenario" in order to identify pollutants of concern. Sampling efforts were focused on "first flush" storms and on one large storm in January 2006.

Key findings

- 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.
- 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 leading to the highest concentrations of pollutants in runoff was supported by results from storm monitoring in 2005-2006.
- The herbicide glyphosate was rarely detected in storm samples (two out of 46 samples). When glyphosate was detected, it was well below the drinking water standard, which is the only criterion 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.

Recommendations

- Maintain storm-monitoring efforts and continue to monitor first-flush storms, with a modified constituent list.
- Reduce focus of identifying pollutants of concern, as this has been accomplished.
- 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.

- Maintain flexibility to collect additional samples based on monitoring results or additional research questions.

Restoration and Water Quality Project Assessment

Restoration and water quality treatment assessment is used to determine the success of 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 projects result in improved water quality, as reflected in upstream and downstream conditions?
- What is the baseline water quality at future restoration/treatment sites?

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. Many projects are in development and baseline data is being collected presently for pre- and post-project comparisons.

Key Findings

- 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 the Hope Avenue Storm 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 at Bohnett Park project site 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 increase from the upstream site (Westside Drain) to the downstream site (W. Anapamu Bridge), due perhaps to continuing input from runoff.
    - In the summer, indicator bacteria values decrease from between the Westside Drain and W. Anapamu, likely due to exposure to sunlight.

Recommendations

- Maintain project assessment sampling, focusing on pre- and post-project, upstream/downstream sampling wherever possible. Sample with a modified list of constituents.

- Conduct spatial intensives to determine mechanisms of water quality changes at project sites.

Creeks Walks

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

Research Questions

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?

Key Findings

- 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 encampment and day-use related creek pollution were found in Mission Creek and the 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 community outreach efforts.

Recommendation

- Continue creek walks and collect data such that it can be used to make quantitative comparisons over time.

Microbial Source Tracking

Microbial source tracking* is used to develop better tools for tracking fecal pollution in creeks and to identify sources of indicator bacteria. The Creeks Division has gathered extensive data on the presence of indicator bacteria throughout its watersheds, the specific sources of pollution and the degree to which the recreational waters are harmful to human health are not known. As discussed above, indicator bacteria may come from soils, plants, and human and animal waste (see above discussion on indicator bacteria).

Research Questions

- 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?

Key Findings

- 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 Street Storm Drain, Hope Avenue 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.

Recommendation

- Continue research efforts in microbial source tracking.

Bioassessment

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

Research Questions

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?

The biological assessment element is contracted to Ecology Consultants, Inc., and 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) technique.

Key Findings

- 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.
- Intense storms in 2005 led to the scouring of all sites and resulted in changes in community composition at all sampling sites.
- The indexes of biological integrity for each site did not change due to the intense storm flows.

Recommendation

- Maintain bioassessment research for two to three additional years to establish a good baseline of data.

Special studies

Key Findings

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 that recently sealed streets may be a source of foam.

Beach Warning and Bacteria

- Analysis of dry-season data from the County showed low rates of beach warnings at Arroyo Burro Beach, Leadbetter Beach, East Beach at Mission Creek, and East Beach at Sycamore Creek.
- Warnings due to Enterococcus levels, which are known to be the best predictor of health concerns, were usually based on 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 ailments 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.

GENERAL RECOMMENDATIONS

Based on findings from the monitoring program and current research developments in the water quality field, the following general recommendations for the monitoring program are identified for implementation over the next one to five years:

- Reallocate resources to limit routine watershed monitoring except as necessary to evaluate long-term trends.
- Shift toward the use of DNA-based and traditional tools to confirm human contamination at hot spots and locate sources upstream, i.e., up storm drains.
- Expand toolbox to be able to track loads, in addition to concentration, of pollutants in creeks and drains. This will require an investment in equipment and training with autosamplers, flow gauges, rain gauge(s), and possibly remote communication equipment.
- Maintain partnerships to continue work on DNA-based microbial 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, use the Model Monitoring Technical Committee's (Southern California Coastal Water Research Project) recommendations for storm monitoring where possible.
- Use the Haley Street Storm Drain drainage area as a pilot area for tracking and reducing contamination from human waste.
- Investigate the use of GIS tools to better interpret spatial data and to focus monitoring efforts.
- Investigate the use of watershed models to better analyze what-if scenarios.
- Continue to stay abreast of current developments in sediment quality objectives and develop a research plan for sediment testing that is based on appropriate questions, methods, and objectives (criteria). The State Water Board is currently developing objectives and monitoring recommendations for sediments in enclosed bays and estuaries.
- Continue to stay abreast of developments in pathogen testing and pursue testing when questions about infectivity and epidemiology have been addressed. Recent literature suggests that majority of human viruses in creeks and oceans may not be infective. Furthermore, epidemiological relationships (dose vs. health impact) have not yet been established.

The Water Quality Monitoring Program has provided a solid baseline for understanding water quality issues. Routine watershed assessment, bioassessment, and creek walks have provided a baseline of water quality data. Routine watershed assessment has demonstrated the seasonal and inter-annual variability of indicator bacteria values and provided evidence for hot spots of bacterial contamination. Hot spots for physicochemical parameters have also been identified. Storm monitoring has identified constituents of concern and has confirmed that first-flush storms carry higher concentrations of pollutants to creeks, compared to later, larger storms. Based on project assessment monitoring, it is known that the dry-season values of most chemical constituents are low. Microbial source tracking has confirmed that hot spots based on indicator bacteria data can be sites where human waste is present.

The program now has sufficient baseline data in many categories and can move in a direction that focuses more on identifying loads and routes of pollutants to creeks in dry and wet weather. 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. Additional analysis should be considered before this is archived.