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A Water Quality Monitoring Plan for Santa Barbara's Urban Creeks

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Background Information

The City of Santa Barbara, under Measure B, established the Creeks Restoration and Water Quality Improvement Division (Creeks Division) to address water quality concerns within the city watersheds and coastal waters. The mission of the Creeks Division is to "improve creek and ocean water quality and restore natural creek systems through storm water and urban runoff pollution-reduction, creek restoration, and community education programs". Effective management for water quality improvement requires knowing the current state of the watersheds, and being able to measure the performance of management actions over time. An important step in achieving the goals of the Creeks Division is a water quality monitoring plan that measures pollutant patterns and provides insights into possible sources of identified pollution.

Problem Statement

Since 1995, the City of Santa Barbara has collected extensive data on levels of indicator bacteria in the following urban stream channels: Arroyo Burro, Mission, Laguna, and Sycamore. Elevated bacteria concentrations have been consistently detected in parts of each watershed. The cause has not been definitively established although several source characterization studies are underway.

Figure 1: Sampling Site at Sycamore Creek directly north of Highway 101

Little data has been collected that characterizes the presence or distribution of other types of pollution, such as elevated nutrient concentrations, toxicants, or sedimentation. Therefore, the Creeks Division desires a monitoring protocol to acquire the data needed to support decisions for protecting human and ecological health. The monitoring plan must address the following fundamental questions:

- What types and concentrations of pollution are in the creeks that could threaten ecological and human health?
- What are the spatial and temporal patterns of the constituents of concern?
- How does different land use impact creek water quality?
- What other correlating factors might be important?

Significance of Project

By identifying spatial and temporal patterns of pollutants, management approaches can be targeted to areas which will yield the most improvement of water quality. Overall, data generated from the monitoring plan will provide the information to support water quality management decisions, and then evaluate whether the policies are achieving their goals over time.

Methods

First, an analysis of the watersheds in the City of Santa Barbara characterized specific drainage basins based on topographic contours and storm drain infrastructure. Using a GIS geodatabase, the hydrologic flow delineation for each watershed was overlain by a land use map which followed a commonly used classification scheme developed by Anderson et al. in 1976. Land use designations were verified using the City of Santa Barbara's geospatial

browser and, when further accuracy was necessary, site visits. Site visits and creek walks assisted with the determination of sampling locations and identifying where urban impacts could be greatest (**Figure 1).** In addition, estimates of impervious surfaces in each drainage area were completed, as literature research revealed the significance of connections between water quality and impermeable surfaces.

The group conducted a literature survey and case studies of other monitoring programs in Southern California. The literature review focused on studies that evaluated the connection of pollutant sources with specific types of land use. The case studies looked at which constituents were included in other monitoring programs and the detection rates of each pollutant. This information was important for the selection of constituents of concern for this monitoring plan.

As a supplement to develop expectations about pollutants present in the creeks, and to further evaluate watershed conditions, a modeling exercise was completed. The Soil and Water Assessment Tool (SWAT) model in the Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) modeling framework was selected for this purpose (**Figure 2)**. The SWAT model was used to predict the impact of land management practices on hydrology, sediments and water quality in the region. The analysis was performed only for Arroyo Burro Creek. The model was calibrated for the prediction of stream flow and nitrate concentration using data for the water year 2003.

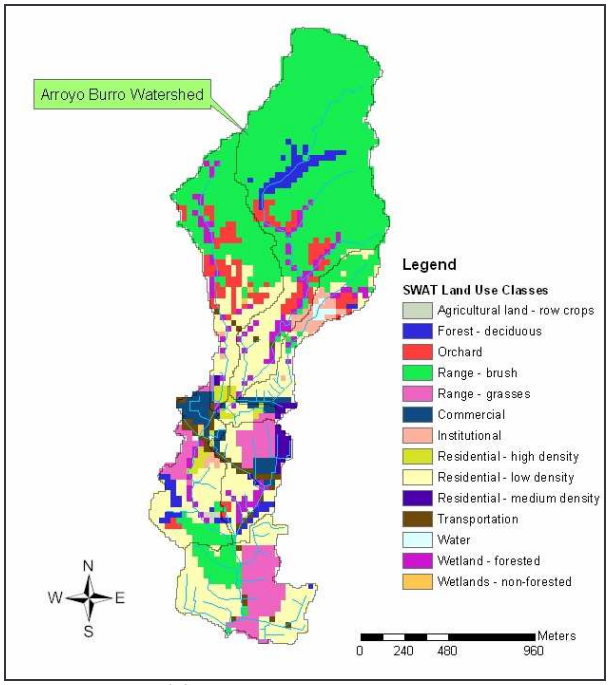

Figure 2: SWAT Land Use Classes in the Arroyo Burro Watershed

Monitoring Plan

The monitoring plan outlines recommended sampling sites, constituents of concern, and sampling frequency during dry weather and storm events. The design of the monitoring plan is adapted from the US Geological Survey's National Ambient Water Quality Assessment (NAWQA) program, which has been created "to develop long-term consistent and comparable information on streams, ground water, and aquatic ecosystems to support sound management and policy decisions". The purposes of the NAWQA program are closely related to the objectives of the proposed monitoring plan, and the use of NAWQA protocols provides a nationally recognized methodology that allows for data to be compared to other regions and across time-scales.

The pattern of water quality conditions is evaluated with a combination of integrator and indicator sites. Integrator sites are located in heterogeneous large basins, affected by a wide range of land use and hydrologic settings. Indicator sites, in contrast, are chosen at the base of smaller, specific, drainage basins with homogeneous land use and hydrologic conditions. Indicator sites are designed to capture areas predominantly influenced by a particular land use, while integrator sites are meant to be more representative of the overall conditions at key points in the watershed. **Figure 3** is a flowchart representation of the primary questions and actions required to utilize the proposed monitoring plan and effectively apply indicator and integrator sampling schemes. Integrator sites are useful to identify constituents that are problematic in the watersheds and indicator sites provide further insights on sources and pollutant hot spots. The goal of indicator sampling is to obtain a mean concentration of pollutants emanating from a particular land use type during storms, with a set goal for the confidence interval. **Figure 4** is an example of a detailed indicator sampling location profile, which is provided for each recommended sampling location in the report.

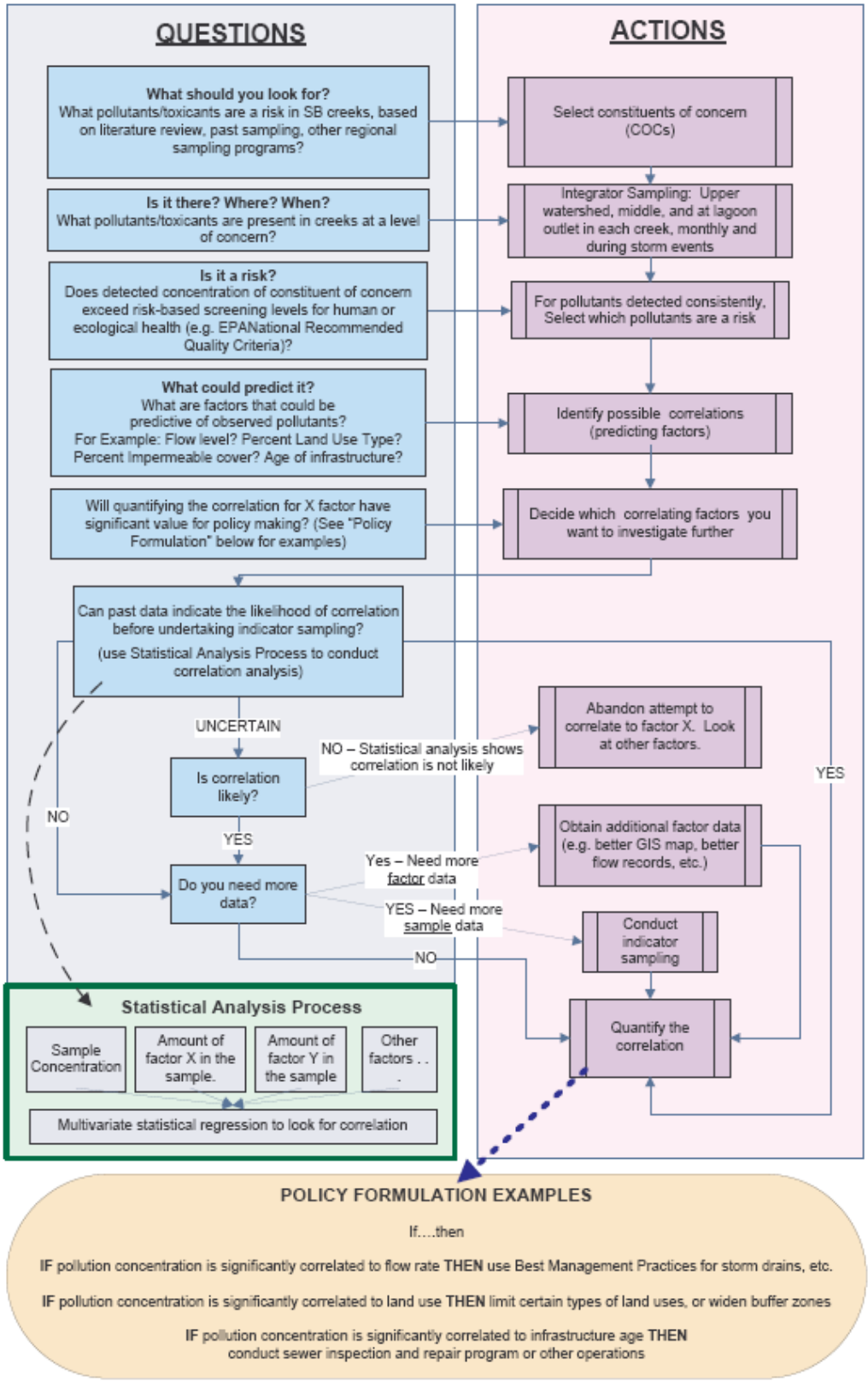

Figure 3: Flowchart for Monitoring and Data Evaluation Process

Figure 4: Indicator Sampling Location Profile for Monitoring Plan

Constituents of concern fall into the following general categories:

- suspended sediments
- pesticides and herbicides
- organic matter
- metals
- hydrocarbons
- bacteria
- nutrients

The choice of specific constituents of concern is based on literature review, results from case studies, and previous sample results in Santa Barbara.

Recommendations

The group recommends the following:

- *Integrator sampling* - Perform integrator sampling for a two year characterization period, followed by ongoing sampling at a possibly reduced period
- *Indicator sampling option#1* – Commence indicator sampling following confirmation from integrator sampling that a particular constituent is present at levels of concern.
- *Indicator sampling option#2* – Commence indicator sampling concurrent with integrator sampling in order to avoid a 2-year delay in data analysis.
- *GIS database* – Make a strong commitment to a GIS database that will enable the Creeks Division to view, query, and analyze all sample data in a unified geographic format.
- *Data management system* – Submit and store water quality data in recognized standardized formats to enable ease of data submission to regulatory agencies. This database should be GIS-linked so duplicate entry will not be required.
- *Sampling technologies* – Utilize field sample test kits to reduce sample analysis costs.
- *Storm event sampling* – Sample intensively during select storm events to gain valuable insight into the transport of pollutants off the urban landscape.
- *Bed sediment studies* – Sediment sampling during low flow conditions could provide valuable insight on the presence of sorbed pollutants when the creeks have low to no flow.
- *Quality assurance project plan* – Follow guidelines approved by regulatory agencies to ensure that data collection and analysis meet data quality objectives.
- *Predictive Modeling* – Utilize modeling software on an ongoing basis. A more developed sampling data set will allow better calibration of predictive models and potentially give the city a useful tool for Total Maximum Daily Load development.
- *Costs* – Assess costs of sampling with respect to labor and lab expenses. Consider autosampler technologies as a potential cost reducing option during intensive sampling periods such as storm events.

Conclusions

The integrator sampling outlined in this plan will provide a characterization of pollutant concentrations at key points in each watershed at different times of the year and flow conditions. Indicator sampling will provide information on which land uses contribute the most to the problem. Other correlating factors, such as the amount of impermeable area represented in a sample, should also be considered. Those factors most likely to produce predictable correlations, and also most useful in crafting policy should the correlation be quantified, should be tested for. Indicator sampling should continue until the desired precision has been obtained. After the initial two year characterization period, integrator sampling should continue into the future (although not necessarily monthly) in order to track pollutant trends over time and signal if new sources or areas of the watershed are becoming problematic.