Monitoring Recommendations 9

The purpose of this section is to provide general guidance on proposed monitoring activities to provide information for several of the recommended indicators and key uncertainties / data gaps identified in this report, and to support the next phase of model development. A more detailed Laguna monitoring and quality assurance plan will need to be prepared as part of the next steps in this process.

Key hydrologic, geomorphic, water quality, and ecosystem data to understand the Laguna de Santa Rosa system are either absent or sparse. Expanding the data set will support future TMDL studies and will assist in achieving management goals. Table 9-1 lists our recommendations for future hydrologic and geomorphic monitoring efforts.

Table 9-1
Monitoring recommendation summary

Indicator	Method	Frequency of Analysis
Channel cross sections	Identify and monument cross sections that would best reflect geomorphic change without being affected by hydraulic conditions. Resurvey the cross sections periodically.	Once every 5 years or before and after dredging if applicable
Floodplain cross sections	Field surveys of cross-sections using a total station or survey floodplain topography using ground-based LIDAR.	Once every 10 years or after major (1:100) flood events
Longitudinal profiles	Detailed field surveys using a total station.	Once every five years if no future dredging activity; otherwise before each dredging activity
Bankfull flow	Identify bankfull conditions in the field and estimate the associated discharge based on flow calculations.	Once every 10 years or after major (1:100) flood events
Rates of bed and bank erosion and aggradation	Baseline channel reconnaissance survey to locate and record bed and bank erosion and aggradation locations. Resurvey periodically to measure bank rates of change.	Once every 10 years or after major (1:100) flood events
Dredge removal volumes	Clearly identify the extent of the dredged reach. Record timing of the dredging. Estimate the magnitude of dredged volume.	Undetermined; based on dredging

Indicator	Method	Frequency of Analysis
Macrophytes	Determine the area covered by macrophytic growth using walking GPS surveys, grids and photographic documentation – calculate percent of the area covered by aquatic plants. Samples from representative locations to quantify biomass.	Minimum: once at peak of growing season (summer) and again during the winter when growth is minimal
Chlorophyll-a	Several locations -- Standard Methods 10200-I, or equivalent	Minimum: once at peak of growing season (summer) and again during the winter when growth is minimal
Minimum DO/ % Sat / REDOX	Several locations - Electronic probe – multiple depths	Continuous at 15 minute increments
Temperature/ Temperature stratification	Several location - Electronic probe – multiple depths	Continuous at 15 minute increments
Sediment	Grain size: wet-sieve/laser diffraction TOC: ASTM D4129-82M (or equivalent) Embeddedness: Survey ring/grid method Nutrients: Total P (EPA 365.3) Total N (EPA 351.3)	Grain size/TOC during high & low flow conditions. Embeddedness during low flow as conditions allow.
Benthic Macroinvertebrate Diversity Index	Rapid Bioassessment in both upper reaches of watershed and reaches within cities	Initial five years every Spring, then every other year
Warm and Cold Water Fish	Electro-shock and release, initial detailed community surveys in main stem and reaches not yet surveyed, then monitor communities at set locations within watershed at regular intervals	Low and high flow conditions (as conditions allow)
Unionized ammonia pH	Calculated from temperature, pH, and total ammonia Electronic probe	TBD Continuous at 15 minute intervals
Nutrient (e.g., PO4, TP, NO3, NO2, TN, Total ammonia)concentrations	EPA 365.3/EPA 351.3	TBD
Organic carbon/BOD concentrations	Organic Carbon: ASTM D4129-82M (or equivalent) BOD5day: SM5210B	TBD
Atmospheric deposition	USGS Method described in: Water-Resources Investigations Report 03–4241	During the wet season
Run-off from dairies, pastures, vineyards, and land application of tertiary treated wastewater	Collection of runoff from drainage ditches, culverts, and storm water drains and analysis for nutrient constituents and BOD. This monitoring should also include shallow wells to monitor infiltration rates from irrigated fields to the streams.	Ditches and culverts should include three samples, each, during the wet and dry seasons. Shallow wells sampling regime to be determined.

Indicator	Method	Frequency of Analysis
Riparian buffer habitat condition	GIS mapping and regular geographic survey to identify alterations to buffer width and habitat connectivity; shade cover / density; on the ground assessments of vegetation & fauna condition throughout watershed, including determination of non-native/invasive components. Riparian Buffer study should also include monitoring of uptake and trapping efficiency of various buffer types and widths.	Once every 5 years
Amphibians	Calling and Crossing surveys	Yearly during spring
Birds	Area search, point count and nesting surveys in riparian zones and along waterways	Summer and spring

In addition, we recommend the installation of an acoustic Doppler sensor at the River Road Bridge to record flow direction and velocity so that inflows form the Russian River can be quantified. This would provide a greater understanding of sediment and water movement and would be key to verify and calibrate a hydrodynamic model of the Laguna and the Russian River confluence.

If there is a desire to develop a more complete hydrologic and sediment budget of the system, future monitoring and analysis of the Laguna de Santa Rosa should also include:

- Discharge data at more locations over a longer period of record;
- Approximate amount of sediment contributed by each type of sediment source in each subwatershed;
- Grain size distribution along the Laguna;
- Grain size distribution of sediment contributed from each tributary;
- Approximate volume and grain sizes of sediment stored along streams; and
- Approximate transport rate of sediment through stream channels and valley floors.

In terms of water quality and ecosystem parameters, we recommend the following special studies to be performed.

9.1 Sediment Oxygen Demand

Sediment oxygen demand (SOD) is the rate of the dissolved oxygen consumption in a water body (river, lake or ocean) due to the decomposition of organic matter deposited on the bottom sediment. In shallow nutrient-rich waters where algal blooms frequently occur, very high SOD (due to the decomposition of settled algal detritus) has been measured. This may lead to severe oxygen depletion, resulting in fish kills. The SOD is often a significant component of the dissolved oxygen budget; its determination provides an important input to mathematical models used in water quality control and environmental impact assessment studies. SOD is quantified using an *in situ* SOD chamber, which continuously measures the dissolved oxygen in a chamber placed over the sediments.

The objective of this study will be to measure the SOD in the Laguna's sediments during low and high flow conditions.

9.2 Sediment nutrient flux

It is well-recognized that sediments play an important role as both a source and a sink of nutrients in lakes and reservoirs (Nürnberg 1987; James 1991). The forms and quantity of phosphorus (P) and nitrogen (N) in aquatic ecosystems are a function of such factors as the external nutrient inputs and outputs, and their interchange between the sediment and the water compartments (Reddy et al. 1996). The exchange rate of nutrients at the sediment–water interface is a highly complex phenomenon that depends on several factors and processes, including temperature, dissolved oxygen (DO), redox potential, pH and microbial activities (Bostrom et al. 1988). The organic matter content of the sediments also influences nutrient flux rates

The objective of this study will be to measure the sediment nutrient flux in the Laguna's sediments during low and high flow conditions.

9.3 N/P limitation

The ratio of nitrogen (N) to phosphorus (P) in stream water impacts lotic ecosystem structure and function. Low N:P ratios (<16) often result in N limitation of algae growth and high N:P ratios (>16) often result in P limitation of algae growth. The objective of this study will be to measure the nitrogen and phosphorus ratios in the Laguna during low and high flow conditions.

Recommended algal growth potential methodology

The bioassay method is important for a better understanding of the relation between nutrient concentration and phytoplankton dynamics in aquatic systems. Based on the concept of algal nutrient limitations, the algal assay is a responsive test designed to examine algal growth response to nutrient enrichment (Miller et al., 1978; Downing et al., 1999). Nutrient enrichment bioassays are a useful indicator as to which nutrient has the potential or is most likely to limit phytoplankton growth at a particular time and place (Diaz and Pedrozo, 1996; Ault et al. 2000). Nutrients of primary concern are nitrogen and phosphorus compounds (Verhoeven et al., 2001; Wetzel, 2001). Since the growth rate of phytoplankton in eutrophic waters is usually limited by nitrogen and/or phosphorus (Olde Venterink et al., 2002), the addition of these nutrients causes a growth response of algal cells proportional to the magnitude of limitation of the particular nutrient. Accordingly, the interpretation of the degree of algal growth response to nutrient enrichment leads to a sharper definition of the concept of nutrient limitation by providing a quantifiable definition of nutrient limitation (Downing et al. 1999). Algal biomass and overall ecosystem productivity may be controlled by the type and intensity of nutrient limitation (Dodds et al., 2002). Therefore, the magnitude of nutrient limitation has implications for population dynamics, species interactions, and ecosystem processes and thus many measures reported in published experiments can be converted to a single biologically meaningful measure of nutrient limitation that is comparable across studies (Downing et al., 1999; Osenberg et al., 1999).

Horvatić et al (2006) describes a method of nutrient addition to determine nutrient limitation. A modification of this method using a laboratory cultured green alga (Selenastrum capricornutum) and nutrient spiked/not-spiked sterile-filtered water from the Laguna could be used to determine the AGP of the Laguna. A brief overview of the method is provided below:

1. Prior to testing, laboratory cultured green alga (*S. capricornutum* or equivalent) is acquired, rinsed and starved in sterile-filtered distilled water for three days to eliminate any stored nutrient reserves that the algae have accumulated.
    - Using a single species of known health reduces the uncertainty of using "naturally" collected algae of unknown species and health.
    - Allows for an accurate initial inoculation of algal cells into the test chambers.
2. Laguna sample is collected, sterile-filtered (0.45 micron cellulose filter), analyzed for nutrient concentrations, and placed into sample flasks.
    - Removes bacteria, predators, competing algae species, and detritus.
    - Provides a test environment having known concentrations of background nutrients and water quality.
3. One set (six replicates) remains unspiked; one set contains a spike of KNO_3 (final concentration = 0.16 g-N/l); another set contains a spike of K_2HPO_4 (final concentration = 0.02 g-P/l); a control set contains algal growth media.
    - Provides control over the concentration of nutrients in solution. Nitrogen and phosphorus are added in excess so that neither nutrient becomes limiting during the experiment.
4. Inoculate each test chamber with a known number of algal cells as described in "*Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms*" (EPA/600/4-91/002 – July 1994).
    - Provides a known initial quantity of algal cells.
5. Perform test as described in EPA/600/4-91/002 – July 1994), with the following exception:
    - Quantify growth of *S. capricornutum* from one replicate from each treatment daily for 14 days (until the stationary phase of growth) [per method described by Horvatić et al (2006).
6. Calculate AGP according to Horvatić et al (2006).

This method of addition allows for the calculation of AGP by using the test indicator species' growth rather than the depletion of nutrients. This method does have uncertainties. The primary uncertainty is that it provides only an approximation of *in situ* conditions; an uncertainty that is present in all laboratory bioassay tests.

9.4 Baseline faunal surveys

In addition to surveying and regularly monitoring the above listed faunal indicators (e.g. fish, amphibians, birds), it is important to get a better idea of the full spectrum of the current faunal diversity (including invertebrates, mammals, reptiles) within selected degraded and non-degraded reaches in the watershed. This will serve as baseline information to help assess the direction and success of future restoration efforts.