WATERSHEDS SCIENCE PROGRAM

Cost-Effective, Applicable Monitoring Approaches to Address the Resource Objectives of the North Bay Watershed Association

A report prepared by San Francisco Estuary Institute for North Bay Watershed Association

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Introduction

In 2005, the North Bay Watershed Association (NBWA), in cooperation with its member agencies, completed an Integrated Regional Water Management Plan (IRWMP) in order to more effectively manage water resources and enhance habitat in the North Bay region. As part of the IRWMP development process, a diverse group of stakeholders representing drinking water, wastewater, agricultural, environmental and flood protection interests were brought together in the form of a Technical Committee to collectively establish regional planning objectives. These planning objectives were subdivided into "Resource Objectives" which pertained to the management of water resources, and "Prioritization Objectives" which were established to help the NBWA to prioritize projects for funding and implementation. Based on these objectives and the mission statement of the NBWA, the Technical Committee subsequently established a set of IRWMP policies. The policies were thought through carefully to help guide the future direction of the NBWA in its implementation of the IRWMP and to help member agencies work collaboratively to meet the objectives in their projects.

One of the policies of the North Bay IRWMP is to *support effective surface water monitoring of the region's source and receiving waters*. SFEI was asked to develop a water quality monitoring strategy for the North Bay region and in so doing, help the NBWA implement this policy. Although there are four other major resource objectives that address water supply, flood protection, habitat enhancement and recreation and public involvement issues, the monitoring strategy will focus mainly on the objective to improve water quality since it relates most directly to the aforementioned policy. However, it is important to note that these other objectives address factors which directly or indirectly impact water quality. Therefore, although outside of scope of the present effort, it may be useful to collate datasets associated with the other policies as part of a future project. The NBWA set forth five implementation steps in order to achieve the IRWMP policy of supporting effective monitoring of the region's source and receiving waters, two of which were slated for implementation in 2006:

a) Research cost-effective, applicable monitoring approaches and identify resources needed for implementation
b) Develop a consistent approach to monitoring water quality and quantity in the region's streams and rivers

Presently, member agencies of the NBWA are expending significant resources annually to carry out monitoring activities. The objective of this report is to present an analysis of existing monitoring efforts, to determine duplication or redundancy, and to recommend a cost-effective applicable monitoring approach (summarized conceptually in Figure 1) that is capable of addressing broader objectives common to multiple agencies, as expressed in the Stewardship and IRWM Plans.

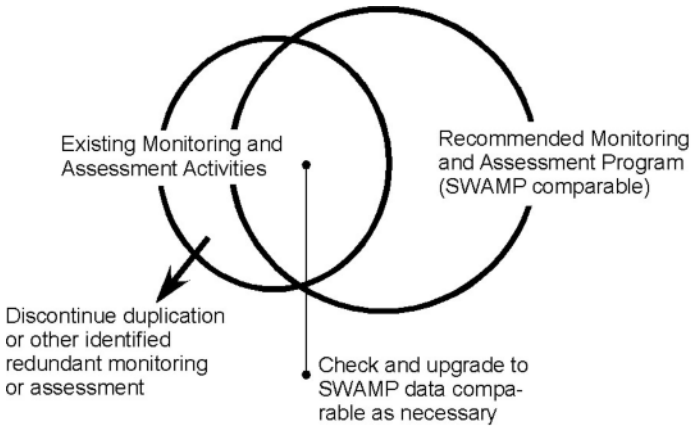

Figure 1. Conceptual model that describes the objectives of this report.

Methods

Definitions

In order to communicate effectively, it is important to establish clear and comprehensive definitions for several key terms.

Monitoring
The terms "monitoring" and "water quality monitoring" have been defined in the US EPA's Watershed Academy glossary website. The EPA defines "monitoring" as "Periodic collection of data (measured parameters) using consistent methods to determine the status (or condition) and trends of environmental or socio-economic characteristics." "Water quality monitoring" is described as an integrated activity for evaluating the physical, chemical, and/or biological characteristics of water in relation to human health, ecological conditions, and designated water uses.

> For the purpose of this report, we will elaborate on both of these definitions and define **water quality monitoring** as "the *periodic* and *systematic* collection and recording of physical, chemical, and/or biological data using consistent methods to evaluate the status or condition of a given water body in order to observe and measure trends of environmental characteristics as they relate to human health, ecological conditions, designated water uses, and system management."

As part of our review and evaluation, however, we included studies and assessments that do not necessarily meet the criterion of "periodic and systematic collection…", but which could serve as "baseline" against which conditions in the future could be compared if the

NBWA decided to extend a one-time "snapshot" into a time series of periodic measurements.

Source waters and receiving waters
It also essential that the terms "source waters" and "receiving waters" be defined for the purposes of this report.

> **Source waters** include first order streams and rivers, groundwater resources, natural lakes and reservoirs that supply water for a variety of beneficial uses but primarily for drinking water supply.

> **Receiving waters** refer to bodies of water that are located downstream from an outfall and include any rivers, creeks, tidal sloughs and portions of San Francisco Bay that receive urban runoff, treated wastewater, seepage from septic systems, industrial discharge, and agricultural return water or waste.

Data and information sources

The first step toward developing a consistent approach to monitoring water quality and quantity in the region's streams and rivers is to collate information on existing monitoring programs and studies that have assembled multiple data points over a specific time period, including those where data collection is not sustained over extended periods (see "baseline" reference above). A number of documents and websites were scanned (Table 1).

Evaluation methods

Existing monitoring and assessment activities were evaluated to determine how well they are providing data and information that would aid management decisions on how to improve and protect water quality. The primary objective was to determine if there is duplication across agencies or interest groups. The secondary objective was to assess in more detail those monitoring and assessment activities that are useful for tracking whether resource objectives are being met and should therefore continue. The activities were assessed under the following basic categories: Geographic coverage, 303(d) list pollutants, adherence to NBWA resource management goals, and cost effectiveness. In addition, we characterized activities according to which ones fit the strict definition of "periodic and systematic collection of physical, chemical, and biological data," and which ones could form a nucleus for future trend analyses (i.e., representing some kind of "baseline" condition assessment for comparison with future measurements). We subsequently derived a set of assessment questions that correspond with the water quality and quantity management objectives directly expressed or implied in the Stewardship or IRWM Plans.

Table 1. Sources of information on existing monitoring programs within the jurisdictions of the NBWA member agencies.

Agency or data base	Website or document
California Data Exchange Center	http://cdec.water.ca.gov/staInfo.html
City of Petaluma	Phase II Stormwater Management Plan
Integrated Regional Watershed Management Plan	IRWMP doc
KRIS for East Marin-Sonoma	http://www.krisweb.com/kris_ems/krisdb/webbuilder/selecttopic.htm
Marin County (MCSTPPP)	Phase II Stormwater Management Plan
Marin Municipal Water District	http://www.marinwater.org
Napa County Flood Control and Water Conservation District	Phase II Stormwater Management Plan
Napa Resource Conservation District	http://www.naparcd.org/data.htm
Napa Watershed Information Center and Conservancy	www.napawatersheds.org
National Resource Projects Inventory (NRPI database)	(http://www.ice.ucdavis.edu/nrpi/)
North Bay Watershed Association	NBWA Stewardship Plan
San Francisco Bay Regional Water Quality Control Board	Pathogen TMDL Reports: Sonoma, Napa
San Francisco Bay Regional Water Quality Control Board	Sediment TMDL Reports: Sonoma, Napa
San Francisco Bay Regional Water Quality Control Board	Nutrients TMDL Report: Napa
San Francisco Regional Water Quality Control Board	http://www.waterboards.ca.gov/sanfranciscobay/Agenda/06-18-03/06-18-03-13reportrevised.docwww.napawatersheds.org
San Francisco Regional Water Quality Control Board	http://www.waterboards.ca.gov/sanfranciscobay/TMDL/sonomacrkpathogens/staff%20report%2002-10-06.pdf
SFEI	Personal Communication
SFEI	Report on "Human influences on nitrogen and phosphorus concentrations in creek and river waters of the Napa and Sonoma watersheds
SFEI	Soda/ Carneros creek reports
Sonoma County Water Agency	http://www.scwa.ca.gov/
United State Geological Survey	http://water.usgs.gov/

Comparisons to assessment questions

The assessment questions we developed were used to identify data requirements, as illustrated in Table 2. Using this matrix, we identified in a qualitative way which data requirements should be addressed to varying degrees by current efforts, and where critical information gaps could prevent the NBWA from tracking whether or not they are meeting their water quality and water quantity objectives. The next analysis step consisted of evaluating spatial and temporal data requirements.

Table 2. IRWMP Resource management objectives, assessment questions, data requirements and recommended indicators.

Resource Mgt. Objectives	Assessment Questions	Data Requirements	Current Data Collection Activities	Recommended Indicators
Protect receiving waters from pollution to comply with current and future water quality regulations and maintain healthy aquatic systems	1. What are the likely pollutants that could impact surface waters and what are their sources? 2. What factors are causing potential impairment? 3. What areas are at greatest risk? 4. What is the current status and tends of water quality? 5. How effective are management actions [and policy decisions] in protecting and restoring beneficial uses?	• Land use/cover, animal facilities, intensive ag, industrial parks • Hydrology • Historic land use practices • Waste discharge locations • Soil erodibility • IBI • Toxicity tests • Basic water quality parameters • Septic tank locations	• Benthic macroinvertebrate sampling • Basic water quality parameter sampling • Sediment loading analysis	• Tissue Residues (e.g. small fish, bird eggs) • Toxicity • Benthic community abnormalities • Sediment source analysis, trends, and transport processes
Protect the quality of drinking water supplies	1. Are any drinking water sources impaired? 2. What are the likely pollutants that could impact drinking water supplies and what are their sources? 3. What is the current status and tends of water quality? 4. How effective are management actions [and policy decisions] in protecting drinking water resources?	• Septic tank locations • Waste discharge locations • Maintaining data base of target pollutants and drinking water standards • Land use/land cover • Hydrology • Historic land use practices • Soil erodibility	• Microbiological testing • Standard drinking water target physiochemical testing • Vegetation cover, landslide risk, rainfall duration, frequency and magnitude, soil saturation	• Existing suite of parameters • Periodic pharmaceutical and personal care products scan
Maintain and restore streams to geomorphic equilibrium	1. To what extent has sediment supply to streams been increased and land capability been decreased through shallow landslides and gully erosion over the past? 2. To what extent have hydrologic processes been modified over the past? 3. Where is it feasible to restore hydrologic processes to meet multiple goals of flood protection, habitat restoration, water use efficiency, supply and storage improvements? 4. How effective are land and water management [and policy decisions] in protecting or restoring geomorphic processes on hillslopes and in streams?	• Land use/land cover • Hydrology • Historic land use practices, soils and erodibility • Historic landslide and gully frequency / drainage density • Historic channel and floodplain locations • Bank, bed, and terrace erosion • Monumented X-sections • Revetment condition • Bankfull width and depth • Sediment storage and sediment size and distribution • Pool spacing and causes • LWD survey and supply mechanisms • Riparian cover • Longitudinal profile, dams, culverts, and migration barriers	• Channel cross section analysis • Sediment loading analysis • TSS/ SSC sampling	• Magnitude and duration of turbidity in response to floods of greater than bankfull stage • Meander belt width • Longitudinal profile • Channel X-section stability • Embeddedness • Pool-riffle sequence abnormalities • Pool quality and spacing abnormalities • Drainage density change • Flood duration and extent • Flow magnitude
Maintain sufficient stream flow for aquatic and wildlife habitat	1. What are the natural seasonal changes in flow (magnitude and spatial extent)? 2. What were the historic sources of base flow? 3. What is the current state of riparian habitat? 4. How can land management and water management be modified to improve low flow hydrology and maintain appropriate seasonal storm flushes for spawning, rearing, and migration?	• Flow • Hydrology • Precipitation • Plant and animal community composition • Land use/cover • Water rights • Water withdrawals and discharges	• Stream gauging • Precipitation records • Well depth and trends • Historic extent and distribution of aquatic habitat (in several watersheds)	• Flow magnitude (magnitude and spatial extent) • Plant and animal community abnormalities • Pool temperature and DO • Food resource / biomass

Geographic coverage

All water bodies in the NBWA member area (Figure 2) have designated uses that reflect environmental and socioeconomic needs. In addition, the Clean Water Act requires that waters of the State meet certain water and habitat quality requirements. Thus, it was necessary to to assess whether each watershed was being monitored sufficiently and for the appropriate pollutants.

Figure 2. Locations of watersheds in the NBWA member area (source NBWA website: http://www.nbwatershed.org/pages/maps.php.

303(d) pollutants

Section 303(d) of the Clean Water Act requires that impaired water bodies be identified. Impaired water bodies are those where water quality standards are not expected to be met after implementation of best available technological controls, with respect to permitted wastewater. Water quality standards include: (1) beneficial uses (such as fish and wildlife habitat and recreational use); (2) any narrative or numeric water quality objectives; and (3) anti-degradation or maintenance of ambient water quality. Napa River, Sonoma Creek, and Petaluma River are all listed as impaired for sediments, nutrients and pathogens by the State of California in compliance with Section 303(d) of the Clean Water Act administered by the U.S. Environmental Protection Agency (Table 3). In addition, all creeks in the NBWA member agencies area are listed for diazinon, the tidal area of Petaluma River is listed for nickel and nutrients, Richardson Bay is listed for fecal coliform, and San Pablo Bay is listed for a whole range of contaminants (Table 3). The existing monitoring and assessment activities were evaluated to determine if these parameters are being monitored sufficiently to develop a basis for delisting or choosing management alternatives.

Table 3. Status of TMDLs and 303(d) listing.

Water body	Pollutant	2002 303(d) Listing Status	2006 303(d) Listing Status
All	Diazinon	Approved by RWQCB 2005	Complete
Napa River	Nutrients	Estimated completion 2008	Complete
	Pathogens	Approved by RWQCB 2006	Complete
	Sediment	Approved by RWQCB 2006	Complete
Petaluma River	Nutrients	Listed	Estimated completion 2019
	Pathogens	Listed	Estimated completion 2019
	Sediment	Listed	Estimated completion 2019
Petaluma River (tidal area)	Nickel	Listed	Estimated completion 2019
	Nutrients	Listed	Estimated completion 2019
Richardson Bay	Fecal Coliform	Listed	Estimated completion 2019
San Pablo Bay	Chlordane	Listed	Estimated completion 2008
	Dieldrin	Listed	Estimated completion 2008
	Dioxin	Listed	Estimated completion 2019
	DDT	Listed	Estimated completion 2008
	Exotic Species	Listed	Estimated completion 2019
	Furan compounds	Listed	Estimated completion 2019
	Mercury	Completed 2006	Complete
	Nickel	Listed	Estimated completion 2019
	PCBs (non dioxin-like)	Approved by RWQCB 2006	Complete
	PCBs (dioxin-like)	Listed	Estimated completion 2019
	Selenium	Listed	Estimated completion 2019
Sonoma Creek	Nutrients	Estimated completion 2008	Estimated completion 2008
	Pathogens	Estimated completion 2008	Completed 2005
	Sediment	Estimated Completion 2008	Estimated completion 2008

NBWA Resource Management Goals

The North Bay Watershed Stewardship Plan identified five sets of goals and objectives for resource areas as mentioned above. The existing monitoring and assessment activities were evaluated to see if they were striving to meet all five sets of goals, and if not, where more attention is needed.

Cost effectiveness

Lastly, existing monitoring and assessment activities were evaluated according to an estimated cost for each project. They were broken into three categories for analysis:

1) Short-term activities, useful for baseline data
2) Multi-year activities that are now suspended due to lack of funding or because the project goals have already been met
3) Sustained, multi-year activities with consistent funding

This analysis was based on past experience with developing monitoring efforts, most notably, the proposed Napa County Watershed Monitoring Program. This level of analysis is necessary for stakeholders to see not only where and how pollutants and water bodies are being monitored, but also at what level of effort (monetary and temporally). All levels of effort are important for different reasons: sustained monitoring efforts are the most useful for establishing trends and tracking management responses. However, shorter term projects are also useful for establishing baseline data and providing "snapshots" of current states of water bodies. It is important to determine the existing distribution of each type of monitoring to make recommendations for future efforts based on resource needs, assessment questions, data gaps, and funding resources.

Results

Geographic coverage

The monitoring and assessment efforts cover a variety of geographical areas. At the county level, 38% of all programs (32 out of 84) are located in Napa County portion of the NBWA geographic coverage area shown in Figure 2. Marin and Sonoma are almost equally represented (21 and 23, respectively), while there are 8 projects that cover parts of two or more counties (Table 4).

Table 4. Assessment and Monitoring Efforts by County.

Location	# Assessment and Monitoring Efforts
Marin County	21
Sonoma County	23
[1]Napa County	32
Sonoma/Marin	1
Napa/Sonoma	1
All 3 (North Bay)	6
Total	*84*

[1] Note only included projects within the NBWA member agency boundary (See Figure 2).

At the watershed scale, the activities are again not very equally distributed spatially. Again, the Napa River watershed has the most projects (28), and when grouped with Sonoma Creek, they account for over half of all the current efforts in the NBWA service area (43 out of 84; Table 5). The Petaluma River watershed, which is roughly the same size as Sonoma Creek has far fewer monitoring efforts (6), despite the fact that its population is much larger. In East Marin, Novato Creek and Corte Madera Creek have the most activities for a single watershed (5), followed by Arroyo Corte Madera del Presidio (2), and Sausalito (1). In addition, there are projects that cover the entire county (5), or northern Marin only (2). There were also some projects that covered multiple watersheds: Sonoma Creek and Napa River (1), all the Sonoma and Marin watersheds (1), and the entire North Bay (6).

Table 5. Monitoring Efforts by Watershed.

Watershed	# Assessment and Monitoring Efforts
Arroyo Corte Madera del Presidio	2
Corte Madera Creek	5
Novato Creek	5
Sausalito	1
Throughout Marin	5
North Marin only	3
[1]Napa River	19
[1]Napa tribs	9
Petaluma River	4
Upper Petaluma River only	1
Petaluma tribs	1
Sonoma Creek	13
Sonoma tribs	2
Throughout Napa	4
Throughout Sonoma	2
Napa River, Petaluma River and Sonoma Creek	1
Sonoma and Marin	1
North Bay	6
Total	*84*

[1] Note only included projects within the NBWA member agency boundary (See Figure 2).

Even though there were 84 monitoring efforts throughout the NBWA service area, there are still areas that are not monitored that could benefit from more local attention. These watersheds include the smaller creeks of Marin County, Miller, San Rafael, Gallinas, and San Pedro Creek; as well as the tidal areas of Sonoma Creek (Table 6).

Table 6. Watersheds not covered in monitoring efforts.

County	Watershed not Monitored
Marin	Miller Creek
	San Rafael Creek
	Gallinas Creek
	San Pedro Creek
Sonoma	Tidal areas

303(d) Pollutants

The streams, rivers and portions of the San Francisco Bay that make up the NBWA service area are impaired by a variety of pollutants. However, monitoring activities do not necessarily match up with 303(d) listing (Table 7). Out of all the watersheds, San Pablo Bay, Sonoma Creek, and the Petaluma River were monitored for the most number of pollutants. In most cases monitoring efforts covered a wider range of pollutants than those required for regulatory purposes. Many of the non-303(d)-listed pollutants that were monitored can be tied to drinking water standards, including pathogens or pathogen indicators (e.g. crypotosporidium and giardia), ammonia, and chlorine. In contrast, there were some pollutants that were left out of monitoring efforts in San Pablo Bay and the Petaluma River even though they appear on the 2006 303(d) list (Table 8).

Table 7. Pollutants Monitored by Watershed[1].

Waterbody	Pollutant Monitored	On 303(d) list?
Novato Creek	Sediments	No
	Nutrients	No
	Crypotosporidium	No
North Marin (Novato and Miller Creeks)	Herbicides	No
All of Marin County	Crypotosporidium and Giardia	No
	Pesticides	Yes (Diazinon)
[2]Napa River	Sediments	Yes
	Pathogens	Yes
	Nutrients	Yes
Petaluma River	Ammonia	No
	Diazinon	Yes
	Chlorphyifos	No
	Nutrients	Yes
	Pathogens	Yes
	Organics	No
Richardson Bay	Fecal Coliform	Yes
San Pablo Bay	Fecal Coliform	No
	All drinking water contaminants	Some yes (Mercury, Selenium, Chlordane, Dioxin, PCBs)
Sonoma Creek	Pathogens	Yes
	Nutrients	Yes
	Sediments	Yes
	Ammonia	No
	Salinity	No
	PBDEs	No

[2]Note only included projects within the NBWA member agency boundary (See Figure 2).

Table 8. 303(d)-listed Pollutants not Monitored.

Waterbody	Pollutant
San Pablo Bay	Exotic Species
Petaluma River	Sediment
Petaluma River (tidal area)	Nickel
	Nutrients

Resource Management Goals

To better understand what drives the monitoring efforts, they were grouped according to the resource management goal they seek to attain (Table 9). A vast majority (50) sought to meet goals and objectives of water quality, which is also the focus of this report. The second most common resource goal was habitat enhancement (19), followed by water supply (6), and lastly, flood protection (2). None of the efforts were directed at recreation and public education, but there were five efforts that sought to meet a combination of

[1]This table does not include basic constituents. Basic constituents include: pH, temperature, conductivity, dissolved oxygen, turbidity, chlorophyll A, TSS, TDS. These were not included because we wanted to show monitoring for those pollutants above and beyond the basics since they are the most commonly monitored parameters due to cost and equipment needs.

goals such as water quality and habitat enhancement or flood protection and water supply.

Table 9. Assessment and Monitoring Efforts by Goal.

Goal	# Assessment and Monitoring Efforts
Water Supply	6
Water Quality	50
Flood Protection	2
Habitat Enhancement	19
Recreation and Public Education	0
Multiple Goals	5
Total	*84*

Cost Effectiveness

The assessment and monitoring activities in the North Bay covered a wide range of watersheds and pollutants, and also varied by the length and type of funding received to produce data. For example, some projects were one-time efforts aimed at answering a specific question and did not require or have funding for any follow-up monitoring. On the other hand, many activities were prolonged efforts over many years that functioned as the core projects for the organizations or agencies that lead them. About 40% of the activities (34) fell in the former category of short-term activities, useful as baseline data describing water quality conditions ("state") in the context of possible (but unfunded) future comparisons over time. About one third of the activities (27) fell into the latter category of sustained, multi-year activities with consistent funding. The remaining activities (23) fell into a third category of multi-year activities that are now suspended due to lack of funding or because the project goals have already been met (Figures 3 and 4).

Depending on the type of pollutants, and the complexity and length of the program, the money spent on monitoring can vary dramatically. The level of effort for monitoring in the North Bay in terms of dollars spent does not necessarily coincide with the *number* of projects. Estimated costs for monitoring in the North Bay total almost $3.5 million/year, and range from $10,000-$100,000 per activity. Examining costs shifts the way in which effort exerted is perceived. For example, about 40% of the projects were short-term activities, but when cost is factored in, nearly 50% of the total amount of money spent on monitoring in the North Bay was spent on shorter-term projects that are not sustained for trend evaluations (Figure 5). The second-highest number of activities was multi-year projects with consistent funding; however, in terms of money spent on that category of monitoring, it drops to only 21% of total funding ($745,000/year). At the watershed scale, the Napa River had the most money spent for monitoring, while Sausalito had the least. This is in line with the number of projects, as Napa had by far the most (Figure 6). Next we analyzed money spent on monitoring activities according to the resource management goal. Water quality monitoring activities made up the largest portion of funds spent ($2.265 million/year), followed by Habitat Enhancement ($805,000/year), Multiple Goals ($305,000/year), Water Supply ($85,000/year) and lastly, Flood Protection ($40,000/year; Table 10). This division of costs is mostly in line with the

actual number of activities (Table 10). Water quality had the most, followed by Habitat Enhancement, multiple goal-projects and water supply (which have switched positions), and lastly, flood protection.

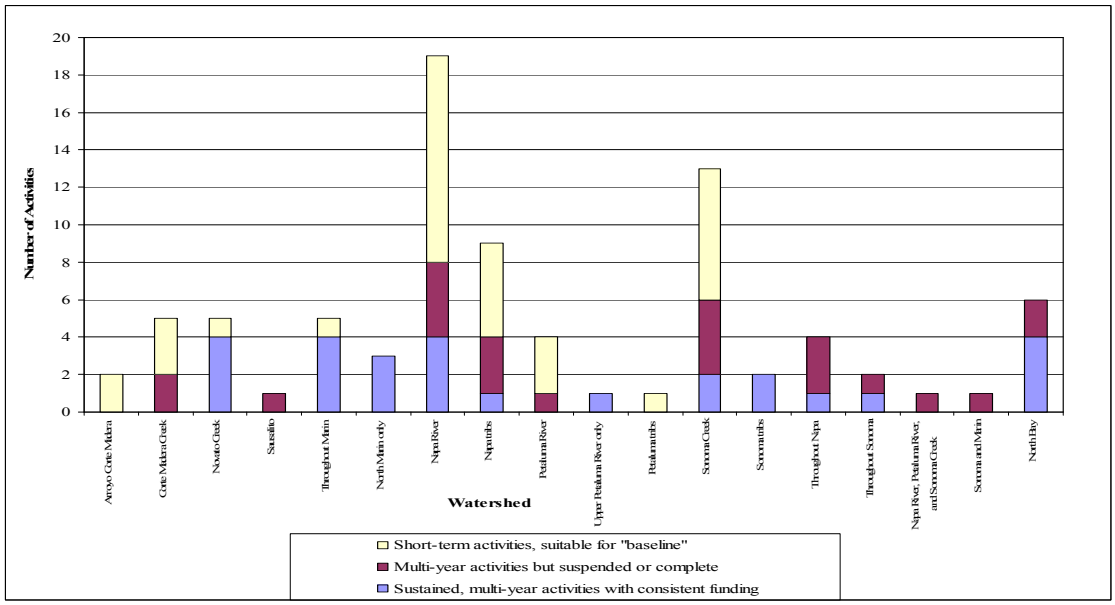

Figure 3. Type of funding and length of monitoring and assessment activities by watershed.

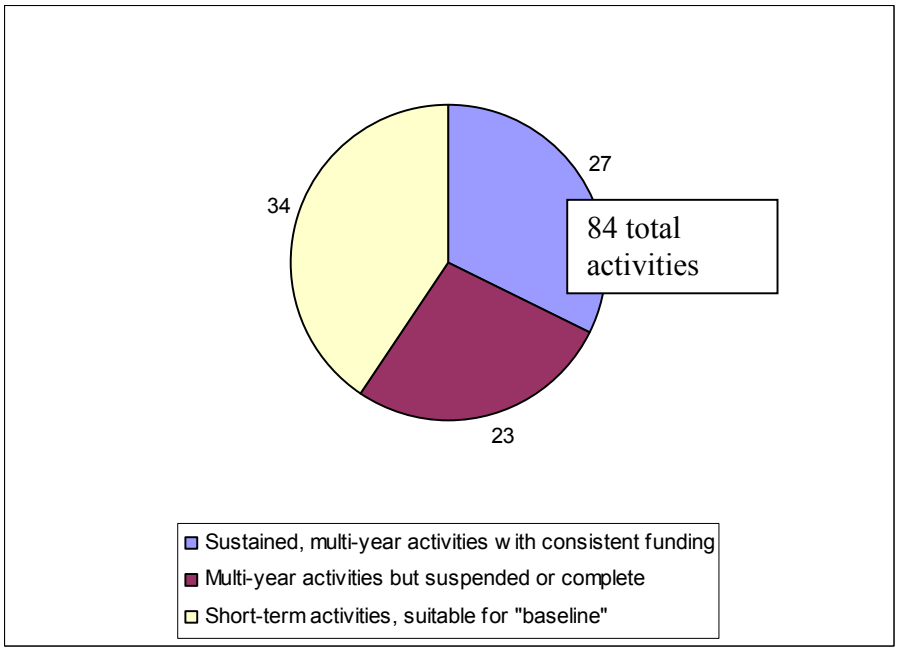

Figure 4. Summary of types of monitoring and assessment activities.

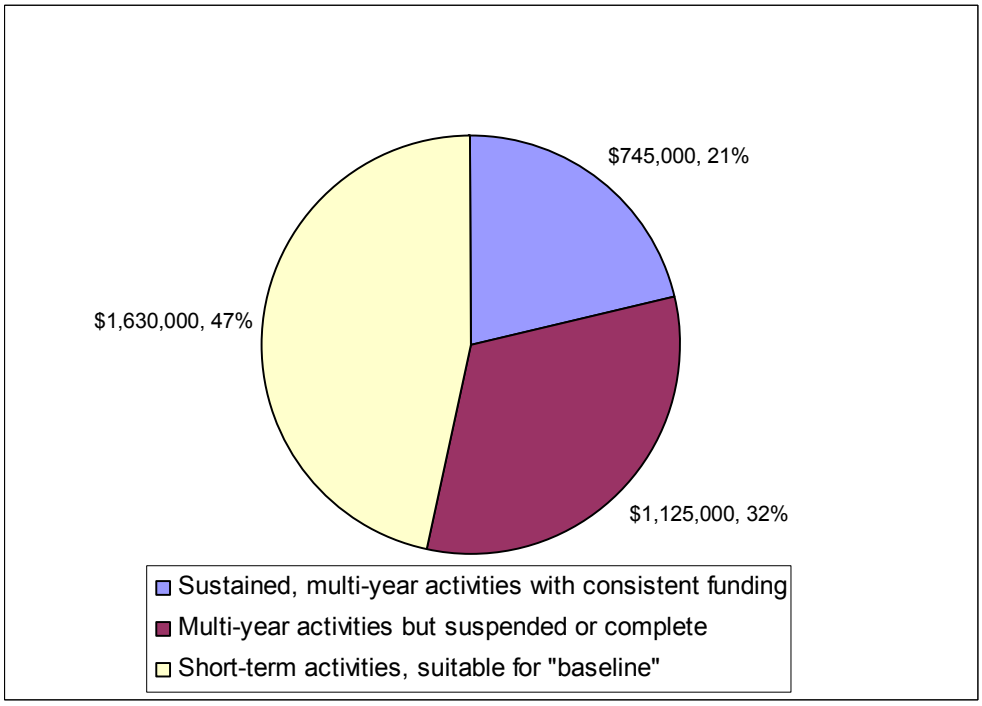

Figure 5. Summary of money spent on monitoring and assessment by type of activity.

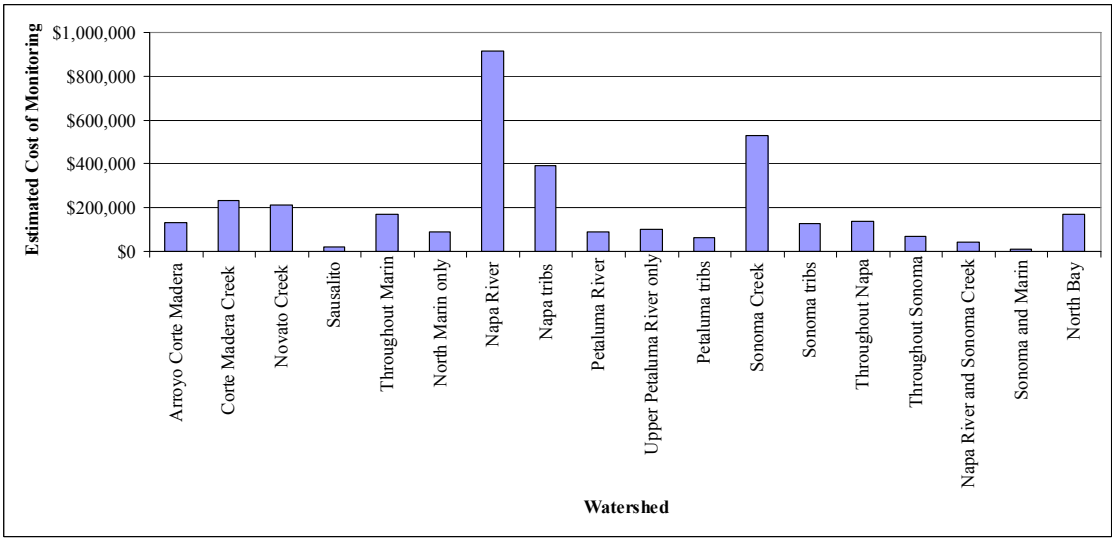

Figure 6. Estimated cost of monitoring activities by watershed.

Table 10. Estimated annual cost of monitoring activities by resource management goal.

Goal	Approximate Annual Cost for all Efforts
Water Quality	$2,250,000
Flood Protection	$40,000
Water Supply	$85,000
Multiple Goals	$305,000
Habitat	$805,000
Total	*$3,485,000*

Lastly we analyzed money spent by each Agency (Figure 7). The Napa Resource Conservation District (RCD) spent the most for a single organization ($530,000/year), followed by the Sonoma Ecology Center (SEC: $345,000/year). The remaining other NGOs spent a combined total of $955,000/year. In total, NGOs (including the Napa RCD and SEC) spent $1.47 million/year, just slightly less than the $1.97 million/year spent by local, state and federal agencies combined. This analysis demonstrates the important contribution of other groups (NGOs) who are obtaining competitively awarded funds and managing grant-funded projects. This is especially striking considering the relative size of annual budgets of local agencies compared to most local NGOs. Most data collection is aimed at addressing many of the TMDL goals. The answers to the NBWA assessment questions are not being generated by NBWA member agencies. Although data gaps still exist, there isn't much, if any, duplication or redundancy of monitoring efforts funded by the NBWA member agencies (i.e. our conceptual model described in Figure 1 is not too relevant in the present analysis or in driving recommendations for future effort).

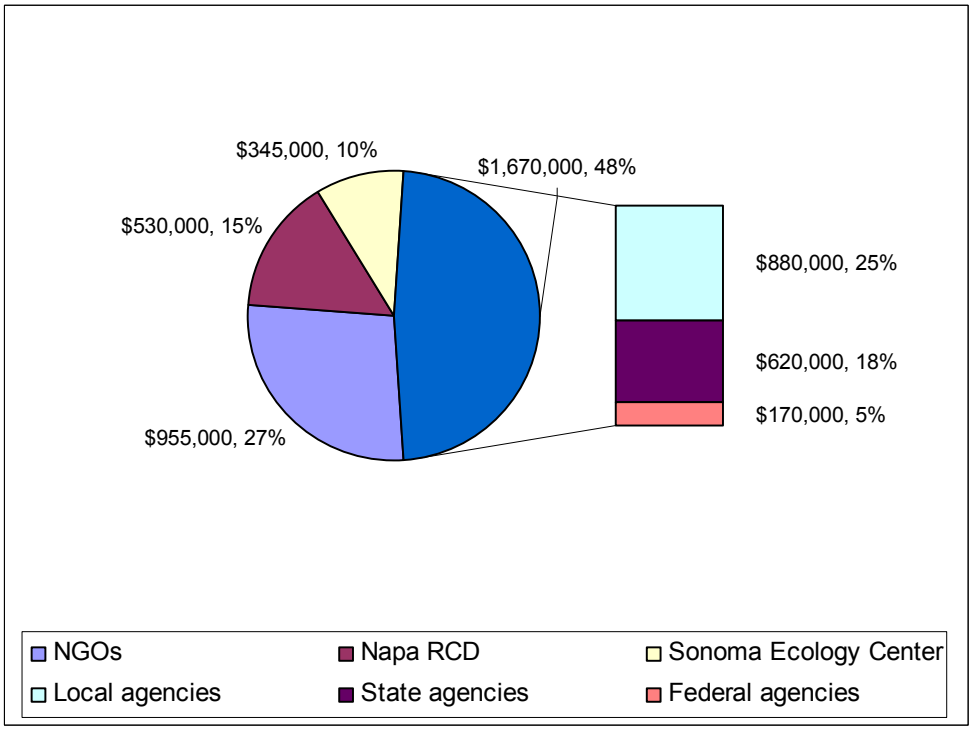

Figure 7. Estimated cost of monitoring activities by type of organization

Enhancing Data Comparability through SWAMP

One of the most vexing challenges of combining data from different sources has been the lack of appropriate data documentation that would enable the data user to evaluate their quality and appropriate uses. The initial approach to overcome this challenge was attempted via prescribing standard analytical methods for certain parameters that were included in NPDES permits. However, advances in analytical chemistry and field methods have been so rapid that the review and approval process could not keep up. The standardization approach was therefore augmented by "performance-based" measurement systems that give data generators the option of choosing from a variety of methods meeting clear data quality objectives for sensitivity, accuracy, precision, completeness, and representativeness (for more information, see http://www.waterboards.ca.gov/swamp/docs/guidelines_pbms_program.pdf). As long as the measurement system and data quality are sufficiently documented, the data user that transforms data into information and gives them meaning can evaluate to what extent data from disparate sources can be combined into broad assessments.

The statewide Surface Water Ambient Monitoring Program (SWAMP) has developed a number of guidance documents that pertain to data comparability. In order to effectively share data among disparate agencies, it is necessary to follow a select set of data business rules and formats. The SWAMP Database Management Team has established documentation to describe these business rules as well as field sampling guides, data formats, and data management processes that could be helpful in collecting and sharing data comparable to SWAMP. The guidance documents are provided at:

http://www.waterboards.ca.gov/swamp/qapp.html. All data generated by grant projects funded by the State Water Resources Control Board are required to be "SWAMP-comparable." Comparability is defined as: (1) meeting the data quality objectives outlined in the SWAMP Quality Assurance Project Plan; and (2) meeting the data formatting requirements as documented in: http://mpsl.mlml.calstate.edu/SWAMP_InformationManagementPlan_100405.doc

The SWAMP Program strongly encourages the use of "performance-based methodology" (PBM) for conducting analytical procedures and therefore recognized the use of modified standard procedures, as appropriately documented following CFR 40, Part 136.4. The use of PBM allows for approved procedures to be modified according to these guidelines, which provide results that are equal to or better than (more stringent than) the standard protocol that was modified.

Any project undertaken by SWAMP-participating entities will employ only methods and techniques which have been determined to produce measurement data of a known and verifiable quality and which are of quality sufficient to meet the overall objectives of the water quality monitoring investigation.

Fortunately, data comparability principles are beginning to take hold in every watershed stewardship group, RCD, or public agency that generates data. However, efforts to maintain momentum need to include training of monitoring staff and providing the necessary understanding that links assessment questions to required data quality objectives. This implies increased involvement and participation by resource managers and the public, because only they can specify what level of uncertainty in the data they feel comfortable with (e.g., do we want to be 60%, 75%, or 95% certain that stream buffers provide a predetermined level of reduction of sediment, zinc, polycyclic aromatic hydrocarbons, and permethrin inputs into creeks?).

Summary of Findings and Discussion

This report has described present monitoring efforts in the NBWA member agency area. The findings are summarized as follows:

1. The majority of the funding presently being spent in the NBWA member agency area is derived from competitive grants and is largely associated with trying to address data gaps related to impairment assessment and TMDL implementation. The application for and spending of grant funding is not being coordinated well regionally and there is no documented prioritization process in place at the regional level.

2. Most of the resources being expended by the member agencies are associated with permit compliance, and there is little coordination between individual permit holders or with NGOs seeking or holding competitive grant funds.

3. Funding is not being applied evenly across the region, and there is no monitoring occurring in some watersheds.

4. In general, there is little systematic study and reporting of pressures on the system. In general, there is more study of conditions or state. As a rule, changes in policies or practices are not systematically tracked to identify resulting environmental improvements as measured by appropriate "state" indicators.

5. It is difficult to recommend a cost-effective sampling program design until the broad NBWA resource objectives have been made more specific and managers have more clearly articulated and prioritized their information needs for decision-making. Prioritization of information needs can occur in an iterative fashion. For example, one of the broad objectives in the Stewardship Plan is to restore streams to dynamic equilibrium. Upcoming infrastructure maintenance and replacement projects may provide opportunities for restoring hydrologic functions in multiple creeks throughout the NBWA area, and those kinds of monitoring elements pertaining to tracking improvements in hydrologic functions can be designed to build on existing baseline conditions where data exist.

As a result of these findings, our conceptual model (expressed pictorially in Figure 1) did not play out well in the analysis. There is little duplication or redundancy of monitoring efforts funded by NBWA member agencies. Overall, member agencies are doing little to address Stewardship Plan and IRWMP objectives. More than $3 million per year are being spent on monitoring and assessment activities, but the application of the funding isn't coordinated and resulting in synergies, given the "project-by-project" approach behind these activities. It should be acknowledged that creation of an organization like the NBWA and the North Bay Watershed Network is the start of such a coordination and "synergy" mechanism. In addition, the Sonoma Ecology Center, SFEI, and RCDs (all organizations whose missions, at least in part, are to assist in the generation and coordination of scientific information for management and policy development) are involved in all of the non-NBWA member agency grant funded projects. Examples of recent projects are: (1) the development of appropriate watershed indicators and indices related to water availability for multiple uses, including identification of data gaps (Sonoma and Napa watersheds); (2) developing data and modeling approaches that could link land use decisions with water quality improvements (Sonoma Creek watershed); and (3) identification of alternative land and water management scenarios to support sediment TMDL goals in the Napa River watershed.

To develop a monitoring strategy for individual agencies or the entire North Bay region and improve the current suite of combined monitoring efforts, it is necessary to use a conceptual framework to organize the analysis of existing monitoring programs and provide a rationale for changes. This same framework also provides a tool to inform stakeholders about how a watershed may react to natural factors and management actions, so that they can continue to adapt the monitoring strategy as needs change in the future. The conceptual framework for this project is based on the "Pressure-State-

Response" (PSR) model developed by the Organization for Economic Cooperation and Development (OECD). This model describes how human activities (Pressure), that provide force to or alter the natural conditions of the North Bay watershed and its receiving waters, such as land use, water and chemical use, and agricultural practices affect water quality and associated beneficial uses (State). In turn, unsatisfactory "state" conditions (e.g., noncompliance with regulatory standards or biological objectives) drive changes in management of these human activities (Response) designed to affect the types and magnitudes of the "pressures" and the resultant water quality and beneficial use "state". This PSR model can be used for a variety of contaminants in different sub-watersheds with multiple landscape uses and at different geographic scales. While the PSR framework is simplistic, often too linear, and not always capable of taking interactions among pressures into account, it is very useful for structuring monitoring programs and communicating the rationale behind data collection efforts. Figure 8 shows an example application of the PSR framework and how it could be used to select appropriate indicators of water quality and watershed health.

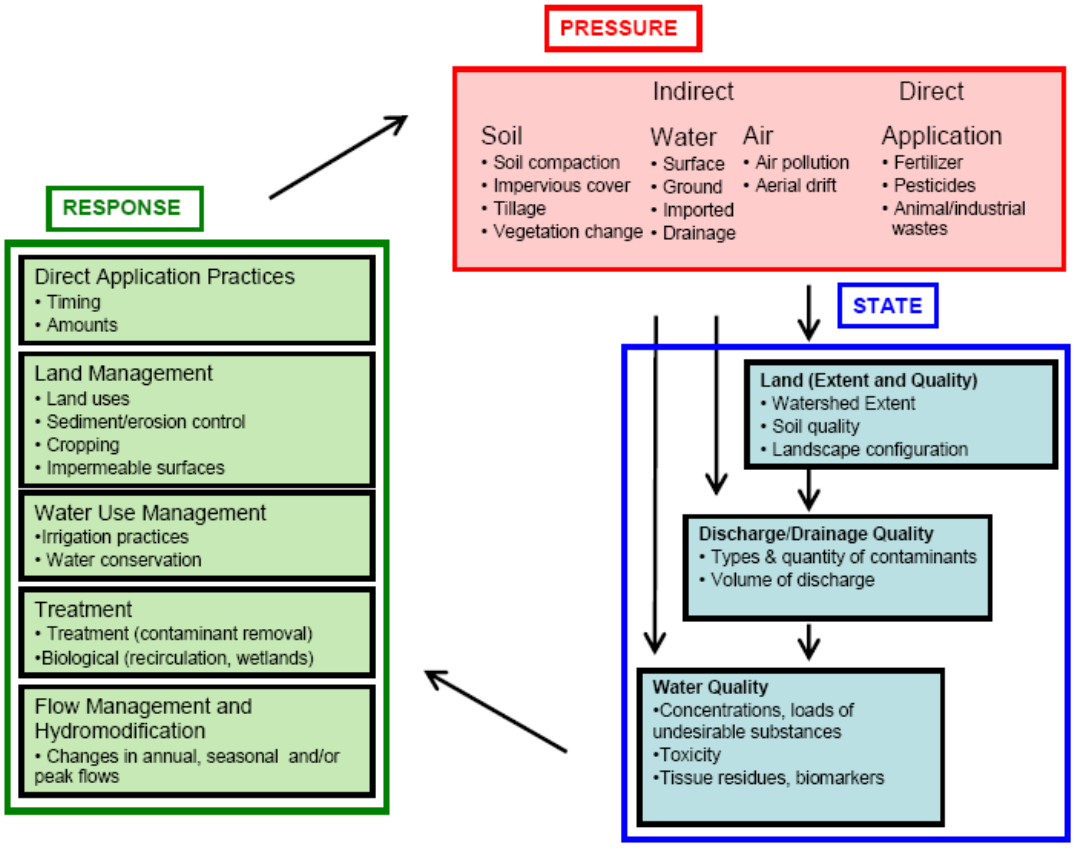

Figure 8. Pressure-State-Response: A monitoring framework diagram.

Despite all of the efforts by NGO and member agencies, a series of critical information gaps remains. These can be divided into three categories based on the pressure-state-response model (See Figure 8). Below are a few suggested data collection needs (for pressures on and states of the area's streams) and questions that, if answered, would help

to improve decisions on how to manage and reduce human impacts (responses) in the NBWA member agency area (Table 11)

Table 11. Data gaps and suggested questions for more effective monitoring and management

Pressure	State	Response
How is impervious land cover changing over time?	What is the flow regime in NBWA streams? (base flow persistence; peak flow)[2]	How well are management initiatives are changing the pressure on or state of each watershed system including: road management? • Riparian management • Reductions in grazing intensity • Choices of cover crops and tillage practices • Irrigation practices • Runoff management • Timing of chemical applications and other measures on agricultural lands addressing upland sediment supply, runoff, and downstream water chemistry
How does urban drainage infrastructure contribute to undesirable changes in the hydrograph?	What upland sediment supply is associated with landslides, earth flows, and increased drainage density and connectivity (roads, ditches, gullies)	
What are the application rates per watershed of nutrients or manures, and chemicals such as fungicides, herbicides and insecticides?	What is the level of bed and bank erosion?	
	What is the composition of in-channel bed substrates?	How well are agricultural and urban water conservation measures helping to maintain minimum base flows during the summer months?
	What is the habitat quantity and quality for endangered species?	
What is the discharge or runoff from areas of high livestock use	How are recreation opportunities for humans distributed?	
	What changes in channel geometry have occurred over the past 100 years?	How well are low-impact design principles and erosion control measures during development applied, maintaining or improving off-site impacts?
	What are the changes in width, extent and quality of riparian buffers?	
	What are the concentrations of nutrients and toxics in water or sediment	
	What are biological resources including macro-invertebrates and fish species?	

.Doing projects to fill critical information gaps is only part of the solution. The greatest opportunities for obtaining greater overall benefits from existing types of monitoring activities exist by:

[2] Only the Novato Ck., Petaluma R., Napa River, and Sonoma Ck. mainstems are currently being gauged

1) Prioritizing monitoring and assessment needs based on identified risks and coordinating fund-raising efforts to obtain the greatest degree of coordination possible (several working models of coordination exist – among them the Napa Watershed Information Center and Conservancy);

2) Strategically augmenting and leveraging state funds allocated via the State's Surface Water Ambient Monitoring Program to intensify data collection to meet NBWA needs;

3) Enhancing and helping to maintain valuable established monitoring efforts by watershed stewardship organizations that primarily rely on limited-term grant funding (e.g., benthic macroinvertebrate monitoring, anadromous fish spawning and survival success, etc.);

4) Systematically keeping track of management measures and practices designed to de-list certain pollutants or restore and protect beneficial uses.

Effective monitoring of the region's source and receiving waters is best facilitated through collaboration among multiple agency partners and NGOs. This presents challenges, some of which can be overcome by carefully thought-out inclusion of the most important or relevant monitoring elements only, and thorough program planning and multi-year funding allocation. The area that is most lacking is the systematic monitoring of how a system changes in response to management initiatives (except in the wastewater arena where it is often an immediate reduction in a chemical stressor that is easily predicted and measured). There is a variety of reasons for the lack of monitoring associated with management actions. Perhaps the most obvious is that there is limited local funding assigned, and state and federal grant funding is rarely available for projects that last more then three years. However, a system may take many years or even decades to respond to changes to management. An effective monitoring program will respond to assessment questions specially formulated to generate data to describe pressures on desirable attributes, state, and change through time in response to management. This is not an easy prospect given that one institution is unlikely to bring all the necessary resources to the table, and given the slow response time of many system attributes to management. These difficulties can be overcome by combining the resources of multiple agencies and choosing indicators that track progress toward multiple objectives. Data comparability is perhaps an easier issue to deal with (made possible through SWAMP guidance) than institutional issues and the need for sustained funding. Employing comparable methods and clearly documenting data quality objectives will ensure a greater level of data comparability and aggregating individual project data for broader landscape-scale assessments.

It is difficult at this time to propose a specific monitoring program until the NBWA has reviewed, agreed to, and prioritized a basic set of questions or issues for which appropriate measurements, indicators, and sampling designs can be identified. Also, quantifiable goals or benchmarks at various scales (Whole NBWA area, county,

watershed, reach) will assist in tracking how pressures on and the state of each environmental attribute are changing over time. The NBWA has made a start at identifying performance measures in the IRWMP that relate to the resource management objectives and to policy implementation. These policy performance measures are best adjusted in concert with selecting appropriate indicators of environmental conditions and the pressures affecting them. For example, regarding the suggested performance measures for supporting effective surface water monitoring, it's not necessarily the % of total streams that is being monitored that counts, or the number of parameters, but rather the degree to which questions relevant to managers can be answered. If we increase our monitoring parameters from 15-30, but only five of them are useful for adjusting policies and programs or individual management practices, our "performance" will have actually decreased. Similarly, if a key question is whether or not stream conditions or health is getting better (as measured by an effective set of condition indicators), member agencies and collaborators do not need to, nor can afford to sample EVERY stream. A representative subset of streams will allow us to draw conclusions about the population of streams as a whole. Table 12 provides an example of how broad resource management objectives can be broken down into increasingly specific management or assessment questions, which in turn point out suitable environmental indicators of watershed health. Where and at what frequency data should be collected will depnd on a number of criteria, among them:

- Level of risk to desired environmental conditions (the higher the risk/threat posed by specific land or water uses, the more frequently data need to be collected to assess change)
- Locations and intensity of management responses (are actions and restoration investments paying off?)
- Level of measurement uncertainty that can be tolerated.

Table 12. Recommended Monitoring Strategy. Note preliminary cost estimates filled in where information was readily available.

Resource Mgt. Objectives	Assessment Questions	Recommended Indicators	Measurement Frequency	Estimated Cost (per tributary per year)
Protect receiving waters from pollution to comply with current and future water quality regulations and maintain healthy aquatic systems.	1. What are the likely pollutants that could impact surface waters and what are their sources? 2. What factors are causing potential impairment? 3. What areas are at greatest risk? 4. What is the current status and tends of water quality? 5. How effective are management actions [and policy decisions] in protecting and restoring beneficial uses?	Tissue Residues (e.g. small fish, bird eggs)	Every 5-10 years (fish only)	?
		Toxicity		
		Benthic community abnormalities	Every 5 years	$50,000
		Sediment source analysis, trends, and transport processes		
Protect the quality of drinking water supplies.	1. Are any drinking water sources impaired? 2. What are the likely pollutants that could impact drinking water supplies and what are their sources? 3. What is the current status and tends of water quality? 4. How effective are management actions [and policy decisions] in protecting drinking water resources?	Existing suite of parameters		
		Periodic pharmaceutical and personal care products scan		
Maintain and restore streams to geomorphic equilibrium.	1. To what extent has sediment supply to streams been increased and land capability been decreased through shallow landslides and gully erosion over the past? 2. To what extent have hydrologic processes been modified over the past? 3. Where is it feasible to restore hydrologic processes to meet multiple goals of flood protection, habitat restoration, water use efficiency, supply and storage improvements? 4. How effective are land and water management [and policy decisions] in protecting or restoring geomorphic processes on hillslopes and in streams?	Magnitude and duration of turbidity in response to floods of greater than bankfull stage	10 times per year (for TSS)	$50,000 (for TSS)
		Drainage density change	Every 5-10 years	$20,000 for first assessment, $5,000 after that
		Flood duration and extent		
		Flow magnitude	Every year	$20,000
		Meander belt width		
		Longitudinal profile	Every 3 years (or after channel-shaping flow)	$25,000
		Channel X-section stability	Every 3 years (or after channel-shaping flow)	$30,000
		Embeddedness	Every 3 years	$40,000
		Pool-riffle sequence abnormalities		
		Pool quality and spacing abnormalities		
		Plant and animal community abnormalities	Every 5 years	$30,000
		Pool temperature and DO	Every 3 years (temp only)	$20,000 (temp only)
		Food resource / biomass		

Possible Next Steps

Based on these findings we suggest the following steps:

1. Explore more formal communication and coordination mechanisms with the broad community of watershed stewards (NGOs, RCDs, and other associations) to coordinate and prioritize proposals designed to fill data gaps and implement projects on a landscape level. This and the other suggestions would also help with several other implementation steps in the Policies Section of the IRWMP.

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Note: The other implementation steps for the monitoring policy included:

* Identify North Bay region streams, rivers, and bay locations where monitoring is needed (this was done in this SFEI study and SFEI is now involved in a project on Miller Creek that may lead to specific monitoring)

*Coordinate with other agencies and groups currently monitoring source and receiving water quality and quantity within the region.

*Meet with member agencies to discuss potential monitoring approaches and coordinate an implementation plan

2. Identify to what extent monitoring, assessment, and implementation activities conducted under the county stormwater management programs and various TMDL implementation plans can be prioritized and adjusted in collaboration with Regional Water Board staff in a manner that brings these activities in closer alignment with the Stewardship and Integrated Regional Water Management Plans. It appears as though the stormwater management programs of the Sonoma County Water Agency (covering Petaluma and the Valley of the Moon), Napa County, and Marin County could achieve greater benefits in terms of information outcomes if they jointly approached Regional Board staff with a coordinated proposal. The NBWA and the North Bay Watershed Network could be appropriate conveners and facilitators of this approach. Also, TMDL implementation requires a monitoring component that could be negotiated with Regional Board staff in a manner that integrates it into a comprehensive monitoring program in modular fashion. The anticipated stream and wetland protection policy, currently under development by the North Coast and San Francisco Bay Regional Water Quality Control Boards, will be yet another vehicle for collaborative and coordinated implementation efforts, including monitoring the effectiveness of these efforts.

3. Evaluate appropriate options for organizational mechanisms for better monitoring coordination and fundraising.

4. Napa County could serve as a model for the other NBWA member agencies for coordinating and integrating monitoring and assessment activities on a watershed basis (Napa County has three – with Putah Creek discharging into the Central Valley Region, and both the Napa River and Suisun Creek watersheds contained in Region 2). By setting up similar structures capable of coordinating and integrating grant-funded assessment projects with permit-driven monitoring requirements in Marin and Sonoma Counties,

monitoring designs and activities could be scaled appropriately in a manner where many of the objectives common to all NWBA participants could be met. Napa County's Watershed Information Center and Conservancy (WICC), representing the coordination and integration mechanism, is in the process of being re-structured at this time to create greater efficiencies for decision-making and fundraising. The opportunity exists to learn from this process. The Appendix excerpted language from a draft report for building an appropriate monitoring infrastructure and evaluating funding options. This report has not yet been approved by the WICC Board (comprised of elected officials, landowners, and other non-governmental entities) and therefore should only serve as illustration.

5. While the development and implementation of a comprehensive monitoring program may appear as a prohibitively expensive undertaking, improved source and receiving water monitoring can be implemented in step-wise fashion. Individual NBWA member agencies, RCDs, and other grant recipients may consider jointly prioritizing information needs based on risk to valued resources and planned investments in restoration and other management activities that require performance assessments. The NBWA could be the appropriate facilitator of this process. Initially, indicators could be chosen that address multiple questions at relatively low cost. Specific monitoring designs (mix of indicators, sampling locations, and frequency) can be developed after targets or benchmarks for desired conditions have been agreed to. A minimum "baseline" effort to determine progress toward desirable conditions (e.g. "maintain healthy aquatic systems" or "restore streams to geomorphic equilibrium") will be required that may be sponsored at the County level.

Note: This effort on "indicators" overlaps with the NBWA effort to develop "Performance Measures" for IRWMP Policy No.4- Support effective surface water monitoring of the region's surface waters and receiving waters. The 2005 IRWMP suggested the following performance measures: (1) Percent of rivers and streams fully monitored. (2) Increase in the type and amount of data collected (parameters, schedule)

The IRWMP also states "The NBWA and its members will further define the performance measures into measurable targets or numeric objectives."

In 2006 the Habitat/ Floodplain Technical Committee suggested modifying the first measure-- *Number of streams being monitored* and further suggested NBWA revisit this measure after the SFEI study.

In addition, this effort will help with two other policies and their respective performance measures: Policy No.6 - Support efforts to restore habitat for special status species within the NBWA region with associated performance measures of: (1) Restored riparian habitat (acres) and (2) restored wetlands (acres).

The Habitat/Floodplain Technical Committee suggested the following modifications in 2006: *Restored wetlands (acres)*

Need baseline for both-total riparian habitat existing and wetlands.

Policy No.7 - Support efforts to reduce erosion and sedimentation in streams, with associated performance measures of: (1) Level of sediment in streams (turbidity); and (2) Number of stream restoration projects

The Habitat/Floodplain Technical Committee suggested the following modifications in 2006: *Number of erosion control projects (not yet ready to identify targets – revisit after SFEI study on Water Quality)*

Appendix 1

Excerpts from the Napa County Watershed Monitoring Strategy and Options for Infrastructure Planning and Funding Options

The Napa County Watershed Information Center & Conservancy (WICC) updated its Strategic Plan in the summer of 2005. A key goal of the Plan is to *improve watershed health throughout Napa County by supporting community efforts to protect and enhance watershed lands and natural processes with an emphasis on riparian corridors and native species and their habitats.* A key strategy towards achieving this goal is to identify, conduct and coordinate watershed studies and monitoring that will prioritize watershed areas for restoration, enhancement and/or permanent protection. Development of a watershed monitoring strategy is a necessary first step toward this goal. Within the context of the WICC Strategic Plan, monitoring is a key management action for tracking success of natural resource protection and restoration efforts and assessing and reporting on the long-term environmental health and socio-economic well being of Napa County's watershed lands. Where public expenditures are used for watershed management activities, good information based on monitoring data is a requirement for gaining and maintaining public confidence. Because ecosystems are complex, monitoring information is also a key component needed for adaptive watershed management, a systematic process of continually improving watershed management policies and practices by learning from their outcomes.. As monitoring data are being used to inform management practices and policies, the monitoring program itself will also be adjusted on a regular basis as part of the adaptive management feedback loop.

Essential Elements of a Monitoring Program

Development and implementation of a monitoring program follow a logical progression, and contain ten essential elements:

1. Clear management goals and monitoring objectives,
2. Assessment questions formulated directly from goals,
3. Monitoring program design,
4. Indicator selection,
5. Quality assurance,
6. Data management,
7. Data analysis and assessment,
8. Program reporting,
9. Programmatic evaluation, and
10. General support and infrastructure planning.

General support and infrastructure planning

Option A: Expand any existing 501 (c)(3) non-profit organization or create an independent, non-advocacy, not-for-profit organization capable of receiving private and public funds to

sustain a baseline program, governed by the WICC Board, the creation of a Technical Advisory Committee, and expert workgroups, either formalized or as needed.

Option B: Expand the WICC to enhance and formalize capability in the areas of scientific and technical oversight, communication, and business management.

This option avoids the initial start-up efforts associated with developing a new organization or expanding the mandate of an existing one. However, several potential disadvantages include lack of impartiality and being able to maneuver through politically contentious issues and power imbalances associated with levels of funding from each entity. This could lead to the potential for "forgotten areas" within the geographic NBWA coverage despite high biological or social value. The option of using an existing governmental agency would limit certain funding sources.

Option C: A blend of Options A and B.

This option may avoid some of the real or perceived disadvantages of Option A and B, and could use already established infrastructure, joined together with a not-for-profit subdivision under a broad stakeholder governance structure. The not-for-profit subdivision/arm would facilitate fundraising from both private and governmental entities, could act as fiduciary agent, and could be staffed with capable personnel from existing organizations with appropriate expertise, assigned to the new entity through a variety of formal or informal mechanisms (e.g., interagency personnel agreements, Memoranda of Agreement, time-limited contract employees, Joint Power Agreements.

Future Funding Options

Funding a systematic monitoring program is a difficult prospect given present institutional arrangements, state budget deficits, and limited federal funding. There will be a number of challenges. For a monitoring program to be effective, it must have a critical mass (enough funding so that there is flexibility to respond to new information and the ability to answer many questions in parallel so that the program participants remain engaged and so that there are ongoing successes or millstones being reached). Financing agreements and resource allocations for a sustainable monitoring program need to be equitable, affordable, and durable. Resource allocations should not result in the likelihood of other programs failing to meet their goals. In this context, funding is best accomplished via pooling of resources from a variety of sources, yet with a minimum predictable threshold that must be maintained if the program is to succeed and be sustained over the long term. It is important that generation of information (not just data) and communication mechanisms be an integral part of the monitoring program so that participants can respond quickly through management or redesign. Lastly, it is important to allocate a portion of the funds to periodic external peer-review. The following funding options seem plausible:

Option 1: Include appropriate level of funding for performance evaluations of locally-funded restoration projects, such as those implemented through local bond measures or local environmental/project mitigation requirements. This option would require the establishment of performance evaluation guidelines and a mechanism for pooling funds from multiple projects for future watershed assessment and cumulative performance evaluations.

Option 2: Provide mechanisms to apply fines and penalties to violators of local statutes towards funding watershed monitoring and information program requirements. No formal arrangements have been made nor guidelines established between local agencies protecting the public's interest in environmental resources and well-functioning watershed processes.

Option 3: Inventory and evaluate existing long-term watershed monitoring and information needs by a variety of public and private entities under non-point source pollution (NPDES) permits, project (CEQA) mitigation and monitoring requirements, and other agency permit conditions (e.g., Section 401 certification, agricultural waiver conditions, Section 1600 Stream Bed Alteration Agreements, etc.). Identify to what extent individual agency needs/programs are addressing very similar resource questions and where efficiencies can be collaboratively achieved. Integration and enhancement of existing resources could provide the basic long-term financial foundation for sustaining a watershed monitoring and information program. Regulatory oversight agencies acting in the public trust will have to collaboratively agree to modify permit conditions.

Option 4: Develop consistent monitoring, reporting and performance evaluation requirements (i.e., language) for permitting and certification under Clean Water Act (CWA) Sections 404, 401, Waste Discharge Requirements/Waiver Conditions, Fish and Game Code Section 1600, and Endangered Species Act (ESA) Section 7, and local permitting programs and explore the incorporation of requirements in a consistent and equitable manner among all permitting programs. Build on Joint Aquatic Resource Permit Application (JARPA) and other 'stream-line' permitting efforts. Include conditions during project review and permitting to contribute a small percentage of fees towards a watershed scale "performance evaluation and monitoring fund." This approach would require consensus and significant permit coordination between water quality and land use permitting, and natural resource trustee agencies having review and permitting authority at the federal, state, and local level (e.g., County and City Planning Departments, Regional Water Quality Control Boards, NOAA Fisheries, California Department of Fish and Game, Bay Conservation and Development Commission, and others).

Option 5: Dedicate personnel to identifying grant and foundational funding opportunities, prepare successful applications and manage managing funding contracts and reporting requirements. However, only a limited number of local organizations have the capacity and dedicated resources available to effectively pursue grant/foundational funding and it tends to be sporadic and associated with the Granting organizations visions not local visions.

Option 6: Explore voluntary (tax deductible) contributions by land owners and industry (e.g., possibly linked to a small percentage of harvest proceeds (e.g., 0.1%) or gross revenue). The watershed monitoring and information program would have to demonstrate clear linkages to improved environmental management decisions and

other benefits to growers, land managers and property owners (either immediate returns or demonstrated long term returns).

Option 7: Provide voluntary opportunities on property tax payment stubs (or other recurrent billing) for watershed protection contributions with a specific amount dedicated to the watershed monitoring and information program.

Option 8: The Air Resources Board collects $4 per year from vehicle registration fees for air quality-related projects - 40% of those fees are transferred to each county. Explore feasibility of utilizing some of these funds for overlapping information needs regarding air quality impacts and watershed information and monitoring needs (e.g., aerial imagery interpretation and vegetation surveys, surface water quality adjacent to roadways).

Option 9: Attach a watershed monitoring and information funding provision to any proposed regional or local initiative for environmental restoration and/or protection (e.g., proposed environmental license plate fund for the nine-county San Francisco Bay Area, legislative proposals on a vehicle registration surcharge, legislative line-items, specific allocations in grants/RFPs, propositions, bonds and other mechanisms).

Option 10: Explore means of incorporating environmental impact costs of certain products into their price structure (e.g., surcharge on invasive non-native plant material sold locally, or on household pesticides, fertilizers etc.) and dedicating a portion of the program's proceeds to fund a watershed monitoring and information program.

Option 11 (added to this Appendix and not contained in the Napa WICC draft)**:** Track competitive grant proposal solicitations and participate with matching funds to augment grant funds being developed by NGOs in the following manner:

a) Expanding the spatial coverage of data and information generation described in the grant
b) Expanding the time period of data and information generation described in the grant
c) Expanding the scope of work described in the grant
d) Allowing for post-grant project appraisal
e) Building better bridging between local management questions and the objectives of the granting agencies and influencing proposals to granting organizations being developed by NGOs
f) Increasing the likelihood of success on competitive grant applications

In these ways, monitoring and assessment to address goals can be expanded using the existing local scientific and planning expertise provided by NGOs and state and federal funds.

Appendix 2

Workshop Synopsis

On February 27, the NBWA sponsored a workshop to discuss findings and outcomes of the work effort undertaken by the San Francisco Estuary Institute to address cost-effective monitoring approaches. The agenda questions for the guided discussion at the workshop and a list of attendees are included below. The final report reflects feedback and suggestions received at the workshop.

North Bay Watershed Association Workshop
February 27, 2007, 4pm-6pm
Novato

Draft Agenda

4:00 – 4:30 pm Summary of key findings from the draft report	Lester McKee and Rainer Hoenicke
4:30 – 5:30 pm Guided Discussion (see attached questions)	Harry Seraydarian
5:30 – 6:00 pm Suggestions for NBWA involvement in facilitating joint steps	All

QUESTIONS FOR GUIDED DISCUSSION:

1) Is our way of defining "monitoring" too inclusive or not inclusive enough, i.e. are we capturing all pertinent activities and projects using our definitions?
2) Did we miss any key information sources or overlook major existing or past monitoring efforts?
3) Is the Pressure-State-Response framework appropriate as an organizing tool to select meaningful indicators? If not, what other framework(s) are you using to organize or prioritize monitoring activities?
4) Does our suggested tiered/hierarchical approach make sense (see pages 5-7 in draft report):
   (a) Starting with broad landscape and land use characterization and periodic assessments of change over time of key indicators
   (b) Stratifying areas by "risk" of water quality and beneficial use degradation, to place appropriate monitoring stations for pro-active, low-intensity, surveillance purposes using integrative measurements, such as Indices of Biological Integrity, sediment and water toxicity during times of potential impact, etc.
   (c) Short-term cause-and-effect investigations to narrow down options for management response/intervention, and

(d) Keeping track of appropriate quantifiable management response indicators (e.g., percent area under certain BMPs; % dry-season base-flows restored to historical hydrograph, etc.)

5) Are recommended steps useful in generating appropriate support for "change agents" to move forward in meaningful ways?
6) Could Napa County serve as a suitable model for monitoring program development?

Attendees:

Wil Bruhns, SF Bay Regional Water Quality Control Board
Caitlin Cornwall, Sonoma Ecology Center
Steve Zeiger, City of San Rafael
Terri Fashing, Marin County Department of Public Works
Liz Lewis, Marin County DPW
Andy Rogers, Petaluma Watershed Council
Sue Lattanzio, Friends of Novato Creek
Carole Dillon-Knutson, Novato City Council
Arthur Knutson, Novato Sanitary District
Cindy Lowney, Friends of Corte Madera Creek
Sandy Guldman, Friends of Corte Madera Creek
Jeff Sharp, Napa County, Watershed Information Center and Conservancy
Jason Sweeney, Southern Sonoma County Resource Conservation District
Pable Ramudo, North Marin Water District
Shari Gardner, Friends of the Napa River
Sue Brown, ross Valley Sanitary District
Don McEnhill, Watershed Council
Marc Holmes, The Bay Institute
Michael Bowers, Southern Sonoma County RCD
Kevin Booker, Sonoma County Water Agency
Bev James, Novato Sanitary District

Appendix 3

[see attached Project List]

Appendix 3: Monitoring Activities
North Bay Watershed Association

Monitoring Program/ Project	County	Watershed	Organization/ Agency(ies)	Other Participants
Clean Marina Project	All Counties	All watersheds	Baykeeper	State Water Resources Control Board/CA Coastal Commission/SF Bay Regional Water Quality Control Board/BCDC
Drinking water quality monitoring	All Counties	All watersheds	Water Agencies	District/Municipal Utilities Districts
Precipitation data	All Counties	North Bay	CDEC	Department of Water Resources
Reservoir data	All Counties	North Bay	CDEC	Department of Water Resources
Marin County Stormwater Pollution Prevention Program - NPDES Phase II Permit monitoring	All Counties	North Bay	State Water Resources Control Board/Publicly Owned Treatment Works (POTWs)/SF Bay	
The National Pollutant Discharge Elimination System (NPDES) requires self monitoring of wastewater	All Counties	North Bay	State Water Resources Control Board/Publicly Owned Treatment Works (POTWs)/SF Bay Regional Water Quality Control Board	
Rapid bioassessment techniques in order to determine the distribution and population counts for macroinvertebrates in the Bay Area.	All Counties	North Bay	State Water Resources Control Board; Stormwater programs for each municipality in the Bay Area	The Bay Area Macroinvertebrate Bioassessment Information Network (BAMBI)
Maximum Pool Depths in Old Mill Creek 1994	Marin County	Arroyo Corte Madera del Presidio	Mill Valley Stream Keepers	
Study of Arroyo Corte Madera del Presidio Watershed	Marin County	Arroyo Corte Madera del Presidio	Mill Valley Stream Keepers	A.A. Rich & Associates
Geomorphic Assessment of the Corte Madera Creek Watershed, Marin County, California , December	Marin County	Corte Madera Creek	Friends of Corte Madera Creek	
Fishery Resource Conditions of the Corte Madera Creek Watershed, Marin County	Marin County	Corte Madera Creek	Friends of Corte Madera Creek Watershed	A.A. Rich & Associates
Bacteria (e coli) sampling	Marin County	Corte Madera Creek	Friends of Corte Madera Creek Watershed	
Corte Madera Creek Watershed Plan	Marin County	Corte Madera Creek	Marin County Flood Control and Water Conservation District (lead), EPA, SWRCB, SF Bay RWQCB	
Corte Madera Watershed Report, Field Methods and Results of Sampling Study Conducted in 6/92 & 2/93	Marin County	Corte Madera Creek: Assessments were performed on Cascade, Corte Madera, Fairfax,	S.F. Bay Regional Water Quality Control Board	
Valley Golf Course Monitoring	Marin County	North Marin	North Marin Water District	
Water Treatment Plant Monitoring	Marin County	North Marin	North Marin Water District	
Aquatic Macroinvertebrate Sampling Program	Marin County	North Marin: Miller Creek, Corte Madera, Ross, Bill Williams, San Anselmo, Sleepy Hollow, and Cascade creeks; Also Novato Creek	MCSTOPPP	
Novato Creek Watershed Citizen's Water Quality Monitoring Program	Marin County	Novato Creek	Friends of Novato Creek	MCSTOPPP
Sediment Sources and Fluvial Geomorphic Processes of Lower Novato Creek Watershed	Marin County	Novato Creek	Marin County Department of Public Works	Laurel Collins
Fishery Resource Conditions of Novato Creek	Marin County	Novato Creek	MPW (Marin Public Works?)	A.A. Rich & Associates
1 Streamflow gauge	Marin County	Novato Creek	USGS	Marin County Department of Public Works
Stafford Lake Monitoring	Marin County	Novato Creek: Stafford Lake	North Marin Water District	
Pathogen TMDL	Marin County	Sausalito	SF Bay Regional Water Quality Control Board	
Continuously monitoring of constituents for which there are drinking water standards	Marin County	Throughout Marin County	Marin Municipal Water District	
Monitoring for crypotosporidium and giardia in drinking water supply	Marin County	Throughout Marin County	Marin Municipal Water District	
Drinking Water Source Assessment for MMWD Surface Water Reservoirs to identify potential sources of contamination	Marin County	Throughout Marin County	Marin Municipal Water District	
Program to monitor pesticide use around MMWD facilities	Marin County		Marin Municipal Water District	Integrated Pest Management Program
Marin-Sonoma Counties Agricultural Runoff Influence Investigation	Marin County/Sonoma County	Petaluma River; Ellis Creek and San Antonio Creek	CA Department of Fish and Game	Marin County/Sonoma County

Appendix 3: Monitoring Activities
North Bay Watershed Association

Monitoring Program/ Project	County	Watershed	Organization/ Agency(ies)	Other Participants
Benthic Macro Invertebrate Project	Napa County	Napa River	Friends of Napa RiverSFEP,	State Water Resources Control Board/San Francisco Estuary Project
Cross sectional survey to develop model to better understand watershed dynamics	Napa County	Napa River	Napa County RCD	
Napa Creek Fisheries/Habitat Assessment	Napa County	Napa River	Napa County RCD	
Napa River Watershed Sediment TMDL Study	Napa County	Napa River	Napa County RCD	SF Bay Regional Water Quality Control Board/State Water Resources Control Board/EPA
Carneros Creek Tributary Watershed Assessments	Napa County	Napa River	Napa County RCD	CALFED
Southern Napa River Waterhed Project- Final Phase of the Complete Napa River Restoration Plan	Napa County	Napa River	Napa County RCD	
Central Napa River Assessment Project	Napa County	Napa River	Napa County RCD	
Napa River Volunteer Monitoring Program	Napa County	Napa River	Napa County RCD	
Napa River Ambient Background Study	Napa County	Napa River	Napa Sanitation District	City of American Canyon/City of Calistoga
Napa River Sediment TMDL Report	Napa County	Napa River	SF Bay Regional Water Quality Control Board	
Napa River Habitat Assessment	Napa County	Napa River	SF Regional Water Quality Control Board	State Coastal Conservancy/Regents of the University of California
Napa River Basin Limiting Factors Analysis	Napa County	Napa River	Stillwater Sciences	University of California, Berkeley
Lower Watershed Fisheries Monitoring Project	Napa County	Napa River	Stillwater Sciences	US Army Corps. Of Engineers
Analysis of fish habitat of the Napa River and tributaries	Napa County	Napa River	U.S. Fish and Wildlife Service	
2 Streamflow gauges	Napa County	Napa River	USGS	
Napa River Sediment TMDL Report	Napa County	Napa River		
Napa River Pathogens TMDL Report	Napa County	Napa River	SF Bay Regional Water Quality Control Board	San Francisco Estuary Institute
Napa River Pathogens TMDL Report	Napa County	Napa River	University of California, Berkeley	
Napa River Pathogens TMDL Report	Napa County	Napa River from Oak Knoll Road, north of Napa, to Kennedy Park, upstream of the Highway 29 bridge	Napa County, Department of Environmental Management	
Napa River Pathogens TMDL Report	Napa County	Napa River: Browns Valley Creek, Murphy Creek, Napa Creek, and Salvador Channel, Sheedy Creek and a few sites on the mainstem Napa River	SF Bay Regional Water Quality Control Board	
Water level measuring equipment and performs streamgaging and suspended sediment sampling at select sites on several Napa River tributaries	Napa County	Napa River: Salvador Creek, Huichica Creek, Carneros Creek, and Murphy Creek	Napa County RCD	
Napa River Pathogens TMDL Report	Napa County	Napa River; Browns Valley Creek, Murphy Creek, and Salvador Channel.	SF Bay Regional Water Quality Control Board	
Napa River Sediment TMDL Report	Napa County	Napa River; Carneros Creek Watershed	Pacific Watershed Associates	
Sulphur Creek Fish Habitat Assessment	Napa County	Sulphur Creek	Napa County Resource Conservation District	
Sulphur Creek Tributary Watershed Assessments	Napa County	Sulphur Creek	Napa County Resource Conservation District	
Sulphur Creek Water Quality Study	Napa County	Sulphur Creek	Napa County Resource Conservation District	
Sulphur Creek Channel Geomorphology Assessment	Napa County	Sulphur Creek	San Francisco Estuary Institute	
Habitat Inventory Report, Wooden Valley & White Creeks	Napa County	Wooden Valley and White Creeks, Napa	Napa County Resource Conservation District	
(Volunteer) Stream Flow Monitoring Program	Napa County		Napa County RCD	

Appendix 3: Monitoring Activities
North Bay Watershed Association

Monitoring Program/ Project	County	Watershed	Organization/ Agency(ies)	Other Participants
Sediment and Stewardship Project	Napa County		Napa County RCD	SF Bay Regional Water Quality Control Board
Fecal Coliform Study	Napa County		Napa Sanitation District	
Copper Translator Study	Napa County		Napa Sanitation District	
Nutrient TMDL	Napa County, Sonoma County	Napa River, Sonoma Creek, Petaluma River	SF Bay Regional Water Quality Control Board	
Fishery Resource Conditions of Adobe Creek	Sonoma County	Adobe Creek, Petaluma	City of Petaluma	A.A. Rich & Associates
Stream guages	Sonoma County	Petaluma River	CDEC	City of Petaluma
Diazinon/Chlorpyrifos in Upper Petaluma River Watershed 1998	Sonoma County	Petaluma River	Petaluma Tree Planters	
Groundwater testing program on seven wells for nitrates, salts, boron, TDS, hardness, coliforms, and organic constituents	Sonoma County	Petaluma River	Sonoma County Water Agency	
Toxic Fire Retardants in San Francisco Bay Fish	Sonoma County	Sonoma Creek	Environmental Working Group	SF Bay Fund/San Francisco Foundation
Pollution through Improved Management at Equestrian Facilities	Sonoma County	Sonoma Creek	EPA	
Sonoma Creek Pathogens TMDL Report	Sonoma County	Sonoma Creek	SF Bay Regional Water Quality Control Board	San Francisco Estuary Institute
TMDL Study for Sonoma Creek	Sonoma County	Sonoma Creek	Sonoma County Water Agency	
Stream Stewards (citizen monitoring in Sonoma Creek watershed)	Sonoma County	Sonoma Creek	Sonoma Ecology Center	Sonoma Creek
Erosion Inventory and Sediment Control Recommendations for Jack London State Historic	Sonoma County	Sonoma Creek	Sonoma Ecology Center	CA Department of Parks and Recreation
Spawning Gravel Suitability Assessment, Sonoma Creek Watershed	Sonoma County	Sonoma Creek	Sonoma Ecology Center	
measures peak flows/stream flows in Sonoma Creek and tributaries.	Sonoma County	Sonoma Creek	Sonoma Ecology Center	Stream Stewards Program
Sonoma Creek Habitat Survey	Sonoma County	Sonoma Creek	Southern Sonoma County Resource Conservation District	Private Landowners
Sonoma Creek Watershed Enhancement Plan	Sonoma County	Sonoma Creek	Southern Sonoma County Resource Conservation District	
1 Streamflow gauge	Sonoma County	Sonoma Creek	USGS	
Limiting Factors Analysis	Sonoma County	Sonoma Creek and major tributaries	Sonoma Ecology Center	
Complete Fish Habitat Inventory in Sonoma Creek Watershed	Sonoma County	Sonoma Creek and Tributaries	Sonoma Ecology Center	
Geomorphic Changes in the Lower Reaches of Carriger Creek, Sonoma County	Sonoma County	Sonoma Creek trib:Carriger Creek	Laurel Collins	
City of Sonoma Stream Monitoring Program	Sonoma County	Sonoma Creek, Fryar Creek and Nathanson Creek	Sonoma Ecology Center	City of Sonoma
Hydrologic/Hydraulic Analysis of the Petaluma River Watershed	Sonoma County	Upper Petaluma River watershed	Sonoma County Water Agency	County of Sonoma/City of Petaluma
Water Quality Monitoring of receiving waters of Sonoma Valley Treatment Plant	Sonoma County		Sonoma County Water Agency	
Water Quality Monitoring: Suspended Sediment, Benthic Macroinvertebrates, and Summer Stream Flow	Sonoma County		Sonoma Ecology Center	Citizen Volunteers
San Francisco Area Reduction of Nonpoint Source Pollution through Improved Management at Equestrian Facilities	Sonoma County, Marin County		State Water Resources Control Board	Marin County RCD/Southern Sonoma County RCD/EPA