SAN FRANCISCO ESTUARY INSTITUTE

WATERSHED PROGRAM

A Watershed Monitoring Strategy for Napa County

Rainer Hoenicke and Jennifer Hayworth
San Francisco Estuary Institute

Prepared for the
Watershed Information Center & Conservancy (WICC) Board

CONTRIBUTION NO. 428
DECEMBER 2005

A Watershed Monitoring Strategy for Napa County

Prepared for

Watershed Information Center & Conservancy (WICC) Board

Prepared by

Jennifer Hayworth, Assistant Environmental Scientist, and Rainer Hoenicke, Senior Scientist
San Francisco Estuary Institute

December 2005

Contribution No. 428

Table of Contents

Acknowledgments

Production of this document was possible through support and funding from the following: the Napa County Board of Supervisors, the Napa County Watershed Information Center & Conservancy (WICC) Board, and members of the WICC Technical Advisory Committee (TAC) including WICC Board Monitoring Sub-Committee members Phillip Blake (NRCS), Jeff Reichel (Land Trust of Napa County), Richard Camera (Hess Collection), Don Gasser and Kate Dargan (Assistant State Fire Marshall), and Patrick Lowe (Deputy Director, Napa County Conservation, Development, and Planning Department). In particular, we would like to thank Jeff Sharp (Watershed Coordinator, Napa County Conservation, Development, and Planning Department) for his coordination efforts, technical guidance and editorial review. We thank Linda Wanczyk (San Francisco Estuary Institute) for graphic design work on the document.

This plan draws on elements from other on-going efforts to develop sound watershed and monitoring implementation plans, and we gratefully acknowledge those resources including the USEPA and the California State Water Resources Control Board.

Executive Summary

MONITORING STRATEGY PURPOSE

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

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.

1. Management Goals and Monitoring Objectives

The WICC has begun to identify conservation and planning goals based on community needs and interests for the county's watersheds, including broad goals established for the Napa River watershed and the watersheds of upper Putah and Suisun Creeks. The San Francisco Bay Regional Water Quality Control Board (RWQCB) is proposing pollution allocations for the

Napa River watershed in the form of Total Maximum Daily Loads (TMDLs) for sediment, pathogens (nutrients have also been proposed or are being developed) to meet State water quality attainment guidelines. Each TMDL implementation plan is based on adaptive and performance-based management principles, and monitoring information provides the basis for selecting the most flexible and the most cost-effective implementation measures for achieving allocation targets. In consideration of proposed TMDL target allocations and the community's current concerns for watershed health and management, the WICC proposed a fundamental set of candidate watershed goals that were derived from a broader assortment of watershed objectives. Those fundamental watershed goals include:

- Protection and enhancement of watershed lands and natural processes,
- Achievement of improved watershed health,
- Protection and restoration of water quality and beneficial uses, and
- Continuous application of new information and lessons learned from management action or inaction to adjust future next-steps.

A broader set of watershed monitoring objectives specific to support the above goals are also proposed:

- Characterize watershed conditions and trends using appropriate indicators of "healthy" watershed processes and valued ecosystem components,
- Improve the condition of the county's water bodies recognized as having beneficial use impairment problems,
- Prevent degradation of intact water bodies throughout Napa County,
- Prioritize beneficial use protection and restoration activities, and
- Insure monitoring information is used in decision-making.

2. Assessment Questions

The next step in implementing a county-wide monitoring program is to derive assessment questions related to each goal and objective that are designed to provide answers relevant to the specific needs of Napa County watershed protection. These assessment questions can be developed on several scales and arranged in hierarchical order into an increasingly specific set of questions that range from the very general to very explicit. Appropriate assessment questions help guide the design of the monitoring program and can focus monitoring expenditures commensurate with the level of community interest, management uncertainty, potential implementation costs, and risks of inaction.

3. Monitoring Program Design

A carefully planned monitoring program saves management time and money. An effective monitoring program design must consider many factors, including available resources (budget, personnel resources), current and past data gathering efforts (what have learned from those efforts, and do they address our assessment needs?), design adaptability, data quality issues, (such as comparability and scientific robustness) and suitable design approaches that can yield data for all levels of assessment questions posed by the community. The program design should allow for monitoring at various spatial and temporal scales utilizing multiple indicators, as this provides greater weight of evidence for decision-making. An integrative design approach is recommended to accomplish this; one that incorporates three principal levels:

1) inventory of watershed resources (e.g., habitat types, water body types),
2) rapid assessment of conditions using appropriate indicators, and
3) more detailed or intensive monitoring and assessment of relationships between watershed management actions and watershed health indicators.

This three-level framework would ensure that local monitoring is comparable on a regional and statewide level. This type of framework was recently incorporated into a California monitoring strategy for surface waters under the State Water Resource Control Board's Surface Water Monitoring and Assessment Program (SWAMP). The methodology is currently applied to wetlands and riparian habitat under the California Wetlands Inventory Program and the California Rapid Assessment Methodology.

Local prioritization of data collection efforts will need to be governed by the community's prioritization of the assessment questions through use of the WICC and its Technical Advisory Committee (TAC). Given recent efforts by the RWQCB to develop TMDLs for the Napa River watershed, there may be particular interest in addressing the protection and prevention of healthy, intact water bodies, as well as defining the potential progress toward delisting impaired water bodies in the county.

4. Watershed Indicator Selection

An important element of monitoring implementation is to identify watershed health indicators that correspond with prioritized assessment questions, and are chosen to balance cost and achievable/effective results. A list of preliminary watershed indicators specific to Napa County should be chosen so that they reflect representative geographic areas, ecosystem functions and their component parts.

5. Quality Assurance

A watershed monitoring program will include the development of data quality objectives for chosen watershed indicators/parameters, data verification, as well as validation and audit procedures for laboratory testing and field sampling.

6. Data Management

A WICC goal is to make credible watershed monitoring data and information available to all stakeholders in the community in a timely and accessible manner. The WICC WebCenter (**www.napawatersheds.org**) will be the foundation for a cooperative information management system to capture geospatial data for every indicator sample collected throughout the county.. Several key elements must be considered in the data management process, including developing guidelines to maintain data quality and comparability, data verification and validation, and development of and training on data tools for effective information sharing and use in decision making.

7. Data Analysis and Assessment

An effective watershed monitoring program achieves the goal of providing a consistent, defensible framework for the evaluation of monitoring data relative to state and countywide standards and supplies a methodology for assessing watershed conditions relative to various benchmarks and guidelines. The methodology must incorporate key elements that identify the available data and procedures used to collect it, document requirements relating to data quality issues, include or reference procedures for evaluating the quality of datasets, and explain data

reduction procedures that are appropriate for comparing data to applicable water quality standards and land use goals. Data from different sources need to be in a consistent format and of known quality .

8. Program Reporting and Communication

The WICC WebCenter (www.napawatersheds.org) provides one tool for a variety of users to access data for reporting purposes and general assessment. However, continual summary reports and condition assessments require considerable long-term resources to maintain and additional tools that may not be available at the local level. Monitoring implementation also requires thought on the frequency of reporting required for timely management intervention for critical parameters or for policy refinement, as well as appropriate reporting media and venues.

9. Programmatic Evaluation

A successful watershed monitoring should incorporate periodic external scientific and administrative reviews to obtain feedback on the program's validity and the effectiveness of its implementation to meet the community's needs. Approximately five years of data collection and interpretation are required to effectively evaluate lessons learned, to determine the degree of which questions have been answered that formed the rationale for the monitoring program, and to propose effectual adjustments to improve the monitoring effort.

10. General Support and Infrastructure Planning

Several key infrastructure and planning elements must be considered to sustain a watershed monitoring program and foster institutional collaborations and coordination. Some of the most important structural/operational needs include: staff personnel and training to run and oversee the monitoring program, scientific laboratory needs, necessary funding and potential funding mechanisms to support the program and carry-out various required forms of grant writing and other locally based funding activities. A successful program will likely be implemented with support from a wide variety of funding sources, examples of which may range from federal, state, and private foundation grants to voluntary contributions, General Fund allocations, impact fees on products or activities that diminish watershed health, or fines imposed on violators of land use regulations. However varied the funding arrangement, a minimum level of locally based long-term and reliable funding is required to maintain a basic trend record and understanding of changes in core watershed health indicators.

Introduction

Background

The Watershed Information Center & Conservancy (WICC) Board was convened in 2002 by the Napa County Board of Supervisors. The WICC is governed by a 14-member Board of Directors representing a broad range of stakeholder interests. The mission of the WICC is to educate and support the community in its efforts to maintain and improve the health of Napa County's watershed lands. The WICC supports and promotes activities of watershed restoration and enhancement by: facilitating and coordinating partnerships among the individuals, agencies, and organizations involved in improving watershed health; supporting watershed research activities; and providing watershed information and education.

In 2005 the WICC Board adopted an updated strategic plan that included five thematic goal categories: (1) Watershed Conservation and Management; (2) Watershed Information Center and Conservancy Website; (3) Communication, Coordination, and Partnerships; (4) Education; and (5) Organizational Structure and Funding (PMC Conservation and Resource Planning Group, 2005). One of the specific goals in the first category is to: *Coordinate and facilitate watershed planning, research, and monitoring efforts among Napa County organizations, agencies, landowners, and citizens*. The development of a monitoring strategy is a necessary first step towards this goal.

Monitoring in the most general sense is the periodic or continuous collection of data (measured parameters) using consistent methods. 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 the Napa County's watershed lands. Where public expenditures are used for watershed management activities, good information based on monitoring data is also a requirement for gaining and maintaining public confidence. Because ecosystems are complex, monitoring information is needed for adaptive watershed management.

Adaptive Management

Adaptive management is a process that employs research and monitoring to allow certain projects and activities to proceed despite some uncertainties and risks regarding their success or consequences. Adaptive management approaches decision-making as a structured process to reduce the costs of management experiments/activities with increasing opportunities for social learning. Adaptive management increases understanding why certain actions work and others do not. Expressed differently, adaptive management is the opposite of the usual trial and error approach, where decisions are made without the required information to evaluate risks of failure (wasted expenditures) or risks of inaction (and the possibility of continued declines in quality of life issues and/or watershed health). The informative feedback concepts embedded in the adaptive management approach should be used to help reduce the inherent uncertainty and continually revise and update the goals and methods associated with watershed enhancement and protection activities.

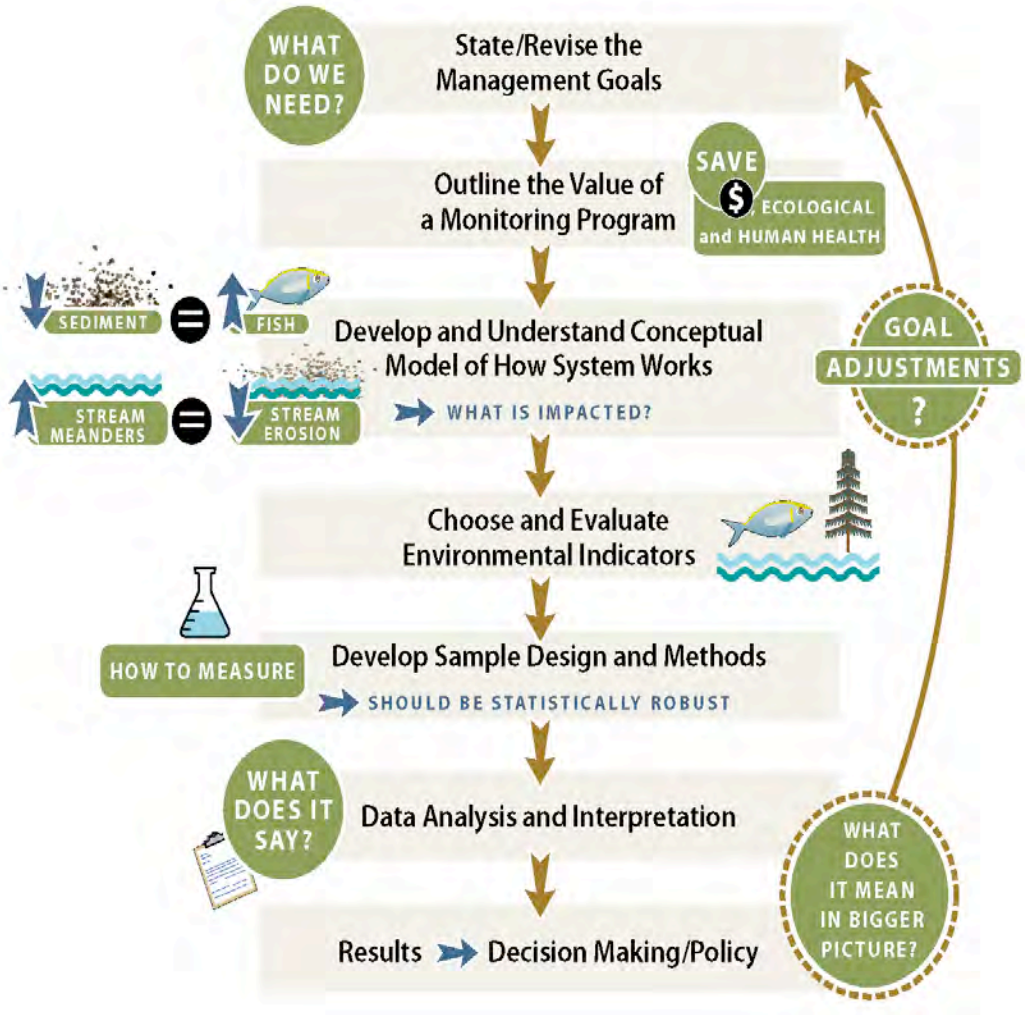
Monitoring represents an important element in a feedback loop to insure that human activities (watershed management activities) intended to achieve a desired set of conditions

actually perform in the most socially efficient manner. Proper monitoring provides adaptive management the required feedback and assessment information. Informative monitoring insures that management systems respond to changing watershed conditions and processes, including the human communities that affect and are affected by them.

Essential Elements of a Monitoring Strategy

Napa County and the WICC Board are fortunate to be able to build on numerous similar monitoring strategy development efforts throughout the nation. Figure 1 provides a sketch of the required elements, beginning with an assemblage of management goals and objectives that can be used to develop assessment questions at increasing levels of specificity.

Figure 1. Strategy for Development and Implementation of a Monitoring Plan



Several challenges exist in developing a meaningful and sustainable monitoring program. One challenge lies in the selection of an appropriate mix of monitored parameters (vital watershed components or elements) that can be combined into a set of key indicators that are representative of environmental conditions and are responsive to changes in management actions. In most cases, it is unclear what key indicators should represent progress toward broad watershed goals (e.g., "protect sensitive lands"). Furthermore, watersheds, including their social, cultural, and economic elements, are complex systems with a large number of variables. Complete certainty about the desired effects of a specific management practice on environmental conditions is in most cases impossible at best. The correct mix of monitored parameters providing just the right weight of evidence can help improve the likelihood of moving ahead with sound decisions. What the "right weight of evidence" is depends on the risks of inaction or business as usual (e.g. possible species extinction, periodic flood damage, continued declines in water quality) and the investment necessary to implement a set of management actions.

Investment in monitoring, as part of the adaptive management cycle, needs to be commensurate with the potential costs of course corrections toward more sustainable practices and the magnitude of short- and long-term risks to the environment and society if no action is taken. A well-established tool for dealing with monitoring challenges is to begin with broad goal statements and develop appropriate monitoring objectives. From the developed goals and objectives, specific assessment questions relating to each goal are then derived.

1. Management Goals

1.1'Community Goals' for Napa County's Watershed Lands

Through the WICC, the community has begun to identify conservation and planning goals based on various needs and interests for the county's watersheds. Broad goals have first been established for the Napa River Watershed and expanded to encompass the watersheds of upper Putah and Suisun Creeks. These broad goals are:

- Protect sensitive lands;
- Facilitate restoration of priority habitats;
- Support existing watershed stewardship programs;
- Partner with municipalities to address urban impacts and cost sharing;
- Conduct fundraising to support monitoring;
- Coordinate research, monitoring and data management;
- Conduct public outreach and education; and
- Coordinate compilation of baseline watershed conditions.

In addition to the goals above, the upper Putah Creek agricultural community (as part of a larger coalition group under specific surface water runoff requirements) has signed on to goals in order to protect the beneficial uses of water bodies in the Putah Creek watershed. A critical goal of that effort is to determine the existing ecological conditions of agriculturally dominated water bodies by:

- Assessing the impacts of waste/polluted discharges of surface run-off from irrigated lands to receiving surface waters;
- Determining the degree of implementation of management practices to reduce discharge of specific pollutants that impact surface water quality;
- Determine the effectiveness of management practices and strategies to reduce discharges that impact water quality;
- Determine concentration and loading of pollution in these discharges to surface waters; and
- Evaluate compliance with existing narrative and numeric water quality objectives to determine if additional implementation of management practices is necessary to improve and/or protect water quality.

In addition to the broad WICC goals above, specific environmental endpoints or targets have been proposed in draft form by the RWQCB for the Napa River watershed that relate to the restoration of impaired beneficial uses through proposed implementation of a "Total Maximum Daily Load" (TMDL) for sediment, pathogens, and nutrients under Section 303(d) of the Clean Water Act. California water quality objectives designed to protect cold and warm freshwater habitat, fish migration and spawning, preservation of rare and endangered species, wildlife habitat, and human health/recreation are currently not met in the Napa River watershed.. The currently proposed pathogen TMDL for Napa River is based on bacterial density targets (geometric mean and ninetieth percentile of E. coli density of 126 and 406 CFU/100mL, respectively), as well as zero discharge of untreated human waste to the river, its tributaries, or connected groundwater flows (Krottje and Tuden 2005). Future numeric water quality targets for nutrient TMDLs will be based on water column nutrient concentrations (using draft objectives of 0.025 mg-N/L, annual median) for un-ionized ammonia and 10 mg-N/L for nitrate), algal densities, and water column dissolved oxygen concentrations (draft objectives of 5.0 mg/L minimum for warm water habitat and 7.0 mg/L for cold water habitat) (Krottje and Whyte 2003). TMDL allocation targets for sediment have been proposed using anadromous fish species (steelhead and Chinook salmon) and the endangered California freshwater shrimp as indicator species of watershed health, primarily because land and water use practices that restore these species are also likely to be protective of other valued ecosystem components (Napolitano et al. 2005). Attainment of these proposed targets will require a reduction in human-caused sediment inputs by 50%.

The Implementation Plan for the proposed TMDLs will include: (1) a description of the types of management actions needed to achieve state water quality objectives and recommendations for all responsible parties, public and private; (2) an action time schedule; and (3) descriptions of the compliance monitoring and surveillance measures to ensure successful implementation of management practices. Each TMDL implementation plan will be based on the adaptive and performance-based management principles outlined in the introduction to this report, and monitoring information will provide the basis for flexible and most cost-effective implementation for reductions in human-induced pollutant inputs. Monitoring will also allow managers to determine if

they have reached their goal or if the goal needs to be adjusted based upon newly collected and more robust information and data about the watershed and how it functions.

1.2 Proposed Goals and Monitoring Objectives

In June 2005, the WICC formed an ad-hoc sub-committee to refine management goals and to guide development of a countywide watershed monitoring strategy. In consideration of proposed TMDL target allocations and the community's current concerns for watershed health and management, the WICC proposed a fundamental set of candidate watershed goals that were derived from a broader assortment of watershed objectives. Those fundamental watershed goals include:

- Protection and enhancement watershed lands and natural processes,
- Achieving improved watershed health,
- Protection and restoration of water quality and beneficial uses, and
- Continuous application of new information and lessons learned from management action or inaction to adjust future steps.

A broader set of watershed monitoring objectives specific to support the above goals are also proposed and will need to be reviewed by the WICC's Technical Advisory Committee (TAC), agreed upon by WICC Board and accepted by the community before a monitoring program can developed and ultimately implemented. Those more specific monitoring objectives are:

- Characterize watershed conditions and trends using appropriate indicators of "healthy" watershed processes and natural resources associated with both aquatic and terrestrial components of the watershed,
- Improve the condition of the county's waterbodies recognized as having beneficial use impairment (e.g. water quality) problems,
- Prevent degradation of intact (i.e. unimpaired) waterbodies throughout the county,
- Prioritize potential activities designed to protect and restore beneficial uses ranging from the project specific level all the way up to the larger landscape-scale watershed level, and
- Insure monitoring information is available and used in decision-making.

2. Assessment Questions

The next step in developing and implementing a watershed monitoring program is to derive a set of assessment questions related to each goal and objective that are designed to provide answers relevant to the specific needs of local watershed protection. These questions can be developed on several scales and arranged in hierarchical order into an increasingly specific set of questions that range from the very general to very explicit. Appropriate assessment questions help guide the design of the monitoring program and can focus monitoring expenditures commensurate with the level of uncertainty, potential implementation costs, and risks of inaction. In addition, previously collected watershed

data and information can be evaluated as to their relevance to the newly identified set of assessment questions and combined into representative watershed indicators suitable for planning and project design or performance evaluation after implementation. Based on the above goals and objectives, a set of initial assessment questions was developed to determine possible data needs and to focus a monitoring strategy that is relevant for the community and local decision-makers (Appendix A). These types of assessment questions need to be agreed on and prioritized before a monitoring program responsive to the needs of the community can be successfully designed.

3. Monitoring Program Design

3.1 Key Elements

The design of the monitoring program is crucial and should be guided by several principles, including budget affordability and design adaptability. The design must provide data that meet specific informational needs, are comparable within all of the county's watersheds, and are scientifically robust enough to draw accurate conclusions. The design should allow for monitoring at various spatial and temporal scales as expressed by the different range of the assessment questions identified. An integrative design approach is necessary to accomplish this. For example, some assessment questions may target environmental trends through time for each watershed, which would require a probabilistic sampling design that generates data representative of watershed conditions. If an assessment question pertains to monitoring the success of a particular restoration project or management action within one watershed, a non-random, 'targeted' design would be more appropriate. The incorporation of both designs within the larger monitoring strategy is necessary to answer the variety of assessment questions. The merits of such an integrative approach are described in more detail in the United States Geological Service's staff testimony to the US Senate on February 2005 concerning monitoring designs (Appendix B). Additionally, a watershed monitoring design should utilize multiple indicators at varying spatial and temporal scales to provide a greater weight of evidence in the data acquired. A suitable framework that incorporates these principles consists of three levels: 1) inventory of watershed resources (e.g., habitat types, water body types); 2) rapid assessment of condition using appropriate indicators; and 3) more detailed or intensive monitoring and assessment of relationships between watershed management actions and watershed health indicators.

One of the first steps in design development is to identify current and past inventories and monitoring efforts undertaken in the county's watersheds. Napa County is particularly rich in natural resource data that have been assembled over the past decades, and numerous individual studies have been undertaken to answer specific questions related to impacts of various land and water uses on valued ecosystem components (for a preliminary list of data sources, see Appendix C). Bringing the existing information together and understanding how past and ongoing monitoring efforts and studies can be incorporated into a long-term and successful program will be critical in making it cost-effective and insuring that we collect the right data and continuously learn from available information.

Since the creation of the WICC, significant progress has already been made on inventorying habitats, biological resources, and the factors that control them. The most significant has been the development of the Baseline Data Report (BDR) for Napa County and the impairment assessment work by the RWQCB to support their TMDL obligations under federal and state legislation. The BDR describes and documents current watershed conditions for the entire county, and the TMDL impairment assessments identify limiting factors for beneficial uses of state waters (e.g., recovery of anadromous fisheries and water contact recreation).

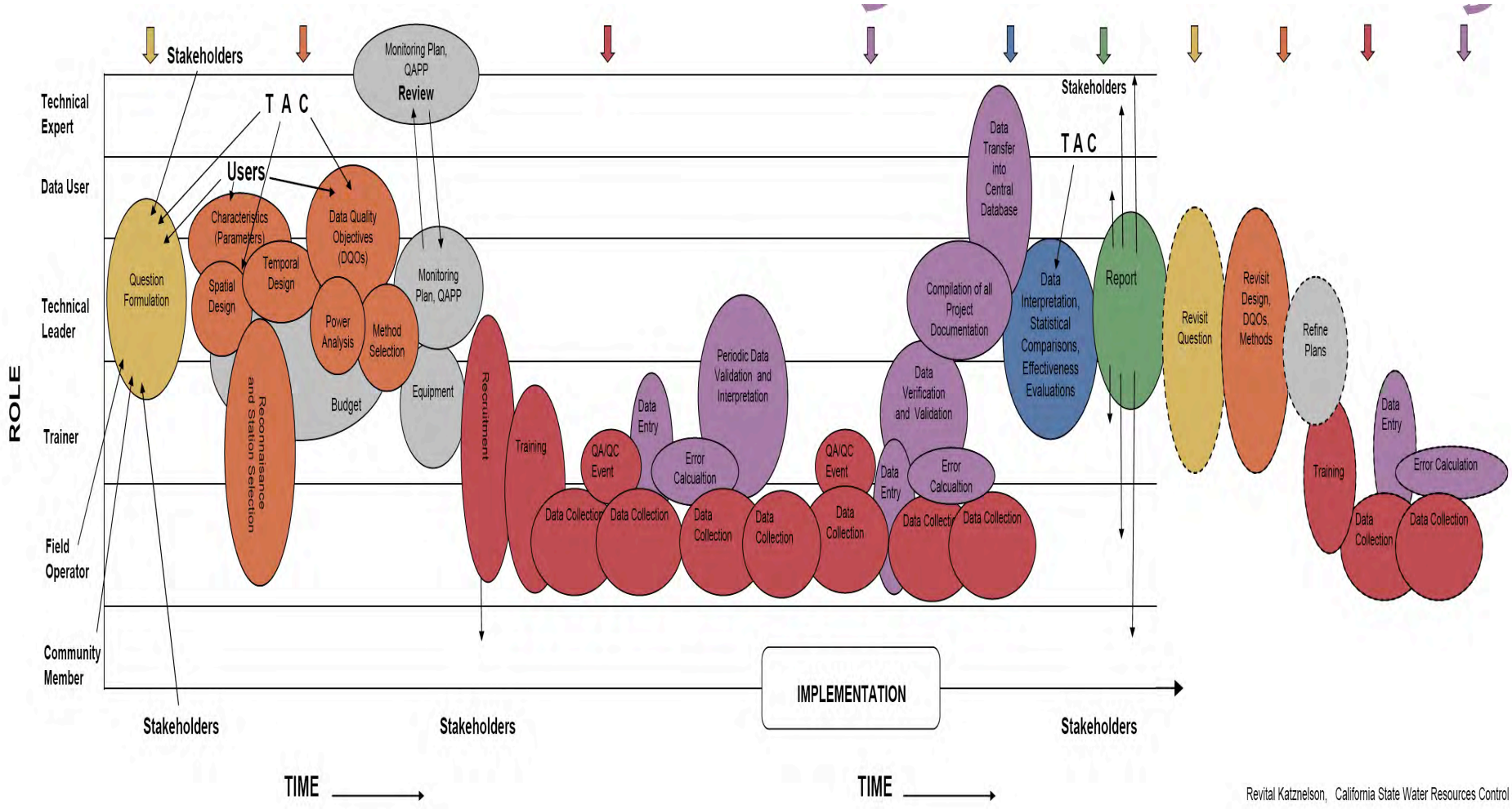
Once assessment questions are derived from the management goals and objectives and agreed upon by the community, the BDR can be used as a valuable tool in conceptual model development, for identifying data gaps that should be filled through additional watershed studies, and insuring that data are collected in a comparable manner at appropriate intervals and in the right places to track progress toward obtaining identified goals. Appendix C lists some potential sources of past and current watershed monitoring efforts in Napa County.

3.2 Implementation Prioritization

Local prioritization of data collection efforts will need to be governed by the community's prioritization of the assessment questions through use of the WICC and its Technical Advisory Committee (TAC). In some areas, landowners may be ready now to participate in monitoring, and those areas might receive higher priority consideration. The common information needs of individual landowners should be identified first, followed by higher landscape-level concerns. Prioritization criteria should be established to specifically address the protection/prevention of impairment in currently intact water bodies, as well as the potential progress toward delisting currently impaired water bodies. Prioritization will help to insure that intact and unimpaired beneficial uses can be maintained and preserved. Development and implementation of the monitoring program will require several stages through time, but progress can be easily tracked (Figure 2).

Data collection activities can be grouped into short-term research or special-studies designed to inform specific questions and long-term monitoring activities designed to track trends.

Figure 2. Roles of stakeholders and participants in monitoring program development and implementation *(from Revital Katznelson, SWRCB)*



4. Watershed Indicator Selection

An important element of monitoring implementation is to identify watershed health indicators that correspond with prioritized assessment questions, and are chosen to balance cost and achievable/effective results. A list of preliminary watershed indicators specific to Napa County should be chosen so that they reflect representative geographic areas, ecosystem functions and their component parts.

A list of preliminary watershed indicators specific to the watersheds of Napa County should be chosen so that they reflect representative geographic areas and ecosystem functions and components (Appendix D). Indicators can be organized in a variety of ways. The most broadly accepted organizational tools is the "Pressure – State – Response" (PSR) Model and variations thereof (OECD 2003, http://www.oecd.org/dataoecd/7/47/24993546.pdf). It represents an easy-to-understand organizing framework to ensure a weight of evidence can be generated that links societal responses and reductions in adverse environmental impacts (pressures) to improvements in environmental condition (improved state).

Cost also plays an important role in indicator selection, as achievable monitoring efforts must be balanced with available funding resources. Surrogate indicators that yield sufficient data to answer assessment questions may be chosen above more costly indicators. For instance, in order to assess improvement in salmonid populations, it is cheaper and just as effective to measure the quality of the spawning habitat (e.g. percent shading) rather than survey actual salmonid numbers.

5. Quality Assurance

A watershed monitoring program will include the development of data quality objectives for chosen watershed indicators/parameters, data verification, as well as validation and audit procedures for laboratory testing and field sampling. Establishing a Quality Assurance (QA) team may be appropriate to develop and guide QA procedures and review standard operating procedures (SOP), produce QA reports, and evaluate data quality from past and current monitoring efforts. A number of useful guidance documents exist and are in development that can easily be adapted to the local needs (Appendix E).

6. Data Management

A goal expressed through the WICC Board is to make credible watershed monitoring data and information available to all stakeholders in the community in a timely and accessible manner. Concerns regarding privacy issues will require decisions about the scale and in what format data will be presented. It is envisioned that the WICC WebCenter (www.napawatersheds.org) will be the centralized storage database and the foundation for a cooperative information management system to capture geospatial data for every indicator sample collected throughout the county. Water quality, toxicity, sediment chemistry, microbiological, habitat, biological, fish and shellfish tissue data and metadata should be associated with geographical assessment units such as the National

Hydrography Dataset (NHD) or more finely delineated sub-watersheds within the Napa River, Putah Creek, and Suisun Basins. Implementation considerations include:

- Establishing and maintaining an electronic data management system for integrating multiple ambient watershed monitoring data types,
- Developing guidelines and technical specifications for data organization, flow and verification/validation to maintain data quality and comparability on a local and regional level,
- Data verification and validation,
- Loading historic and current monitoring data into the database,
- Providing expanded training on the WICC interactive WebCenter to expand coordination by data generators throughout the local area, and
- Facilitating intra- and inter-agency data comparability by developing and providing general use tools such as protocols and formats for electronic data transfer, procedures and tools for batch uploading of data, protocols and tools for data verification and validation and query and analytical tools for summarizing and analyzing data.

7. Data Analysis and Assessment

An effective watershed monitoring program achieves the goal of providing a consistent, defensible framework for the evaluation of monitoring data relative to state and countywide standards and supplies a methodology for assessing watershed conditions relative to various benchmarks and guidelines. The methodology must incorporate key elements that identify the available data and procedures used to collect it, document requirements relating to data quality issues, include or reference procedures for evaluating the quality of datasets, and explain data reduction procedures that are appropriate for comparing data to applicable water quality standards and land use goals. Data from different sources needs to be in a consistent format and of known quality.

The methodology must describe how existing available data and information relevant to applicable water quality standards, land use guidelines, species recovery plans, and other conservation and protection goals will be compiled and analyzed to make decisions about how these standards and goals may be attained or adjusted. The methodology should:

- Identify the likely sources of existing and available data and information and procedures for collecting or assembling them,
- Describe or reference requirements relating to data quality and descriptive accuracy, such as analytical precision, temporal and geographical representation and metadata documentation needs,
- Include or reference procedures for evaluating the quality of datasets, and
- Explain data reduction procedures (e.g., statistical analyses) appropriate for comparing data to applicable water quality standards and watershed goals.

8. Program Reporting and Communication

8.1 Data sharing: Web-based maps, graphs, standard database formats

Watershed health indicators are comprised of a wide range of parameters comprised in seven general categories:

- Landscape condition (e.g., habitat types, landscape structure, land cover),
- Biotic condition (e.g., ecosystems and communities, species and populations),
- Chemical and physical characteristics (e.g., nutrients, trace inorganic and organic chemicals, temperature, oxygen),
- Ecological processes (e.g., primary production),
- Hydrology and geomorphology (e.g., surface and groundwater flows, groundwater elevations, channel and floodplain morphology/complexity, sediment transport and storage),
- Natural disturbance regimes (e.g., frequency, intensity, extent, duration), and
- Human uses and watershed services (e.g., timber, water use, land use, recreation, food production).

Data from these kinds of categories are collected either routinely or sporadically by numerous entities from individual landowners to federal agencies. In order to combine data from different sources, they need to be of known quality and in a consistent format.

The WICC WebCenter (www.napawatersheds.org) provides one tool for a variety of users to access data for reporting purposes and general assessment. However, continual summary reports and condition assessments require considerable long-term resources to maintain and additional tools that may not be available at the local level.

8.2 Communication to identified audiences

Information derived from watershed health indicators at various spatial scales (individual parcel to whole river basin) has different audiences and requires different communication mechanisms. Individual landowners, e.g., need to know if their management measures produced certain outcomes that may not be very relevant for the general public or policy-makers. However, broad indicators at the landscape level may be of interest to a general audience interested in the "state of the watershed." Monitoring program implementation requires careful thought about:

- The frequency of reporting required for timely management intervention at the project level (e.g., real time stream flow data), or at the landscape level for larger community policy development, and
- Media and reporting venues (e.g., videos, fact sheets, newsletters, annual reports, workshops, public meetings, etc.)

9. Programmatic Evaluation

A successful watershed monitoring should incorporate periodic external scientific and administrative reviews to obtain feedback on the program's validity and the effectiveness of its implementation to meet the community's needs. Most rigorously conducted monitoring programs conduct periodic external scientific and administrative reviews to remain relevant. Approximately five years of data collection and interpretation are required to effectively evaluate lessons learned, to determine the degree of which assessment questions have been answered that formed the rationale for the monitoring program, and to propose effectual adjustments to improve the monitoring effort.

10. General Support and Infrastructure Planning

Several key infrastructure and planning elements must be considered to sustain a watershed monitoring program and foster institutional collaborations and coordination. A successful program will likely be implemented with support from a wide variety of funding sources.

10.1 Planning Coordination/Institutional collaborations

This element of the monitoring strategy deals with the support needed to implement a coordinated and comprehensive watershed health monitoring and assessment program, which includes identifying:

- The required number of staff needed for monitoring program implementation and oversight,
- Needed laboratory support to perform scientifically appropriate documented methods,
- Training needs for program implementation, including for field, laboratory, data management and data assessment staff,
- Required funding for implementing the program (e.g., for salaries, training, travel, equipment, laboratory analysis, and external scientific review of assessment reports), along with anticipated sources and amounts of funding and the effects of any shortfalls, and
- Needed support for grant-writing and other localized fundraising activities.

10.2 Funding options

A watershed monitoring program will likely be implemented with a wide variety of funding sources, examples of which may range from federal, state, and private foundation grants to voluntary contributions, local General Fund allocations, impact fees, or possible fines imposed on violators. However varied the funding arrangement might be, a minimum level of locally based long-term and reliable funding is required to maintain a basic trend record and understanding of changes in core watershed health indicators.

11. References

CVRWQCB. July 11, 2003. Conditional Waivers of Waste Discharge Requirements for Discharges from Irrigated Lands within the Central Valley Region. Resolution No. R5-2003-0105. California Regional Water Quality Control Board, Central Valley Region, Rancho Cordova, Ca.

Krottje P. and D. Whyte. 2003. Conceptual Approach for Developing Nutrient TMDLs for San Francisco Bay Waterbodies. California Regional Water Quality Control Board, San Francisco Bay Region, Oakland, CA.

Ministry of Forest and Range, Government of British Columbia. August 9, 2000. Forest Practices Branch. http://www.for.gov.bc.ca/hfp/amhome/Amdefs.htm

Napolitano, M., Potter, S. and D. Whtye. April 18, 2005. Napa River Sediment Total Maximum Daily Load Draft Technical Report. California Regional Water Quality Control Board, San Francisco Bay Region, Oakland, CA.

OECD. 2003. OECD Environmental Indicators, Development, Measurement and Use, Reference Paper. Organization for Economic Co-operation and Development (OECD). Paris, France. **http://www.oecd.org/dataoecd/7/47/24993546.pdf**

R. Katznelson. 2005. Designing an Environmental Monitoring Project (powerpoint presentation). California Regional Water Quality Control Board, San Francisco Bay Region, Oakland, CA.

PMC Conservation and Resource Planning Group. 2005. Watershed Information Center and Conservancy of Napa County. Final 2005-06 Strategic Plan.

USEPA. 2005. Watershed Academy's Distance Learning Program - Watershed Academy Web. United States Environmental Protection Agency, Washington, DC. http://www.epa.gov/watertrain/index.htm

USEPA. 2000. Principles for the Ecological Restoration of Aquatic Resources. EPA841-F-00-003. Office of Water (4501F), United States Environmental Protection Agency, Washington, DC.

USEPA. 1977 (amended). Clean Water Act, Federal Water Pollution Control Act Amendments of 1972. United States Environmental Protection Agency, Washington, DC.

Wikipedia Simple English Online Encyclopedia. 2005. http://simple.wikipedia.org/wiki/Main_Page

Appendix A. Examples of Assessment Questions based on Management Goals (MG) and Monitoring Objectives (MO)

MG 1. Protect and enhance watershed lands and natural processes

MO 1. Characterize watershed conditions and trends using appropriate indicators of "healthy" watershed processes and valued ecosystem components

A1. Which watershed lands should be protected and enhanced?

- Where are the sensitive lands and priority habitats within each watershed?
- What are the social and economic factors associated with the use of those resources/lands?

A2. To what extent have natural processes been disturbed, and where do they need to be restored and protected?

- Where are current restoration projects?
- What are the urban and rural pollutant sources within each watershed, and what are their relative contributions to impairments in sensitive and priority habitats?
- What management practices are in place to prevent and reduce pollution in impaired waterbodies?
- What further efforts are needed to reduce impacts from urban and rural runoff?

A3. What are appropriate indicators of success?

- What indicators are reasonable representations of surface water condition?

MG 2. Achieve improved watershed health

MO 2. Improve the condition of the county's waterbodies recognized as having beneficial use impairment

A1. How do we want to define watershed health?

A2. What conditions do we consider desirable?

A3. What are existing trends of appropriate indicators of watershed health?

- What is the condition of representative habitats over time - improving, degrading, staying the same? Conditions in the past, present, and future?
- How are pollution patterns and trends affected by management actions (BMPs, source control)?
- What watershed segments in each watershed have the most concern over current and future social and economic pressures impacting environmental resources?

MG 3. Protect water quality and beneficial uses

MO 3. Prioritize beneficial use protection and restoration activities

A1. What is the present condition of water quality?

- Are aquatic beneficial uses (cold and warm freshwater habitat, fish migration and spawning, wildlife habitat, and preservation of rare & endangered species) impaired in identified sensitive habitats?
- Where are draft TMDL targets being exceeded? At several scales – watershed, project site.

A2. What are appropriate indicators of beneficial use condition and trends?

- What indicators show a signal relative to implemented management measures?

MO 4. Prevent degradation of intact (e.g. unimpaired) waterbodies throughout the county

- Which stewardship programs exist?
- What are the criteria for prioritizing support to these programs?
- What programs/efforts would benefit the most from fundraising?
- Where are significant research studies occurring in each watershed that can be used to evaluate the relative environmental and social benefits of various management options?
- What are current monitoring methodologies employed within each watershed by various agencies/organizations, and where are areas of intersection and/or gaps?
- Where are significant individual and watershed-based management actions/ projects?

MG 4. Continuously apply new information and lessons learned from actions to adjust future steps

MO 5. Insure monitoring information is used in decision-making

- What baseline data are necessary to promote standardization and robust science-based decision-making?

Appendix B. USGS Testimony to Congress on Water Quality Monitoring

Monitoring in the 21st Century to Address our Nation's Water-Resource Questions

By Timothy L. Miller, USGS
February 25, 2005

A time of increasing complexity

Water-quality monitoring has become a high priority across the Nation, in large part because the issues are more complex and money is tighter. The demand for high-quality water is increasing in order to support a complex web of human activities and fishery and wildlife needs. This increasing demand for water, along with population growth and point and nonpoint sources of pollution, threatens the quality *and* quantity—and therefore the availability—of all our water resources.

This is a challenge all across the country. Areas once thought of as "water rich"—mostly in terms of limitless availability—are now considered "water challenged," such as in southern Florida, where available water must support 6 million people along their coasts, extensive agriculture south of Lake Okeechobee, and ecosystems in the Everglades and the Florida Bay. No longer is only the arid western U.S. challenged to manage its water needs for drinking, irrigation, aquatic ecosystems, and recreation.

As was acknowledged more than 30 years ago when the Clean Water Act was implemented, monitoring is fundamental to successful management of water resources. However, the nature of monitoring must adapt to increasingly complex water demands and issues. Monitoring is no longer limited to "end of pipe" site-specific data on dissolved oxygen or suspended solids, collected for day-to-day evaluations of compliance or decisions about permitting. Three specific challenges force a shift in monitoring since the implementation of the Clean Water Act.

- Most water-quality problems are caused by diffuse "nonpoint" sources of pollution from agricultural land, urban development, forest harvesting, and the atmosphere. These sources are more difficult to monitor, evaluate, and control than point sources, such as discharges of sewage and industrial waste. The amount of pollution from nonpoint sources varies from hour-to-hour and season-to-season, making it difficult to monitor and quantify the sources over time.
- Water-quality issues themselves have become more complex. Forty years ago, concerns about water quality focused largely on the sanitary quality of rivers and streams—in bacteria counts, nutrients, dissolved oxygen for fish, and a few measures like temperature and salinity. While these factors are still important, new and more complex issues have emerged. Hundreds of synthetic organic compounds, like pesticides and volatile organic compounds (VOCs) in solvents and gasoline have been introduced into the environment. Over the last 10 years, improved laboratory techniques have led to the "discovery" in our waters of microbial and viral contaminants, pharmaceuticals, and hormones that weren't measured before.
- Evaluation and monitoring of pollution sources and of the condition of our water resources have been limited because available information is fragmented. Inconsistency in the types of data collected, the standards and analytical methods used, and the selection of monitoring sites makes it difficult to integrate the findings.

Different questions require different kinds of monitoring. It's important to understand that one monitoring design cannot solve all of our water-resource issues or questions. For example, depending on specific interests or responsibilities, one might ask:

- Is the water meeting beneficial uses; that is, is it acceptable for drinking or swimming or irrigation or for sustaining aquatic habitat?
    - What percentage of streams is impaired within a State?
- Are regulatory requirements being met? Are concentrations or loads below those allowed in discharge permits?
- How does the water quality of one water body compare with those nearby or across the Nation?
- Is water quality getting better or worse? Does water quality change during certain times of the year?
- What are the sources of contaminants and causes of the problems?
- How do changes in land use or management practices affect water quality?

None of these questions is easy to answer, and each requires a different kind of monitoring—a specific set of data collected in certain places and at certain times. So, undoubtedly, monitoring designs end up being unique or different—varying in the timescales and spatial scales covered. The process, however, is always the same. The process begins with clearly defining the water-resource questions; outlining the decisions that will be made from the data; and then identifying the data (or monitoring) needed to make the decision.

Water-resource issues or questions determine monitoring objectives. And the objectives determine the monitoring design. No design, therefore, is "better" or "more successful" than another. Success is measured by whether the monitoring design addresses the specific objectives. Different types of monitoring—such as "probabilistic" and "targeted" designs—answer different sets of questions. Although both of these designs can contribute to statewide, regional, or national assessments, and improve understanding of the general or "ambient" water resource, they provide different types of information. Both types of monitoring are important, and therefore, should not be viewed as competitive or duplicative, and both need support with adequate funding. In fact, these designs are so different that discussions should not focus on whether one design can substitute for another but on how to integrate the two in order to go beyond what each can provide individually, particularly in predicting conditions in unmonitored areas. This can be illustrated by addressing an overarching question driving many discussions "What is the quality of our Nation's waters?"

What monitoring design best answers "What is the quality of our Nation's waters?" Again, it depends on specific objectives and questions. To some, this may reflect an overall assessment of the resource as required in the Clean Water Act section 305(b): "What percentage of the Nation's waters is impaired? What percentage is in good condition? What percentage of streams is meeting their beneficial uses?" Such questions require a broad-based probabilistic monitoring design, in which sites are chosen randomly and are distributed across a certain region. This type of monitoring provides a quantitative, statistically valid estimate of, for example, the number of impaired stream miles within a region or State. Probabilistic monitoring and assessments help to document what is going well (how much of the resource is in good condition) and what is not (how much is in poor condition). The data collected help decision makers prioritize regions having the most degraded waters and assess which stressors—such as nutrients, sedimentation, and habitat disturbance—are of most importance in that region or State. Many probabilistic monitoring programs are currently implemented by States and within the U.S. Environmental Protection Agency, such as the Environmental Monitoring and Assessment Program (EMAP).

Probabilistic monitoring is a useful and cost-effective method for getting an unbiased, broad geographic snapshot of "whether there is a problem" and "how big the problem is." To others, "assessing the Nation's waters" leads to other questions, including "Why are water-quality conditions happening and when? Do certain natural features, land uses, or human activities, and management actions affect the occurrence and movement of certain contaminants? Are water conditions changing over time? "
These are equally important questions, but require a "targeted" monitoring design that focuses on understanding the relations between water-quality conditions and the natural and human factors that cause those conditions. Monitoring sites are therefore not selected randomly within a grid, but because they represent certain human activities, environmental settings, or hydrologic conditions during different seasons or times of year. For example, sites may be selected to assess the effects of agriculture and urban development on pesticide and nutrient contamination in streams.
A "targeted" monitoring design requires data collection:

- Over different seasons. This is important because, for example, USGS assessments generally show low concentrations of contaminants, such as pesticides, in streams for most of the year—lower than most standards and guidelines established to protect aquatic life and human health. However, the assessments also show pulses of elevated concentrations—often 100 to 1,000 times greater in magnitude, exceeding standards and guidelines—during times of the year associated with rainfall and applications of chemicals. Such pulses could affect aquatic life at critical points in the life cycle and also could affect drinking water.
- In different land uses, including agricultural, urban, and more pristine land-use settings. USGS assessments show that water conditions are very different among the different settings; insecticides, for example, are more frequently detected at higher concentrations in urban streams than in agricultural streams. Water conditions also are different among different land-use practices; phosphorus, sediment, and selected pesticides, for example, are at higher concentrations in streams draining agricultural fields with furrow irrigation than in agricultural fields with sprinkler irrigation.
- In different geologic settings. The setting—whether it is sand and gravel or volcanic rock, for example—affects how readily water moves over the land and into the ground.
- During different hydrologic conditions. The amount of streamflow and the timing of high and low flows determine how contaminants are carried in streams, and the connections between streams and ground water determine how the ground water will be affected.
- Over the long term. Without comparable data collected over time, assessments cannot distinguish long-term trends from short-term fluctuations and natural fluctuations from effects of human activities. USGS assessments show that water quality continually changes. The changes can be relatively quick—within days, weeks, or months, such as in streams in the Midwest where types of herbicides used on corn and soybeans have changed, or relatively slow, such as in ground water beneath the Delmarva Peninsula where nitrate concentrations are beginning to decrease after 10 years of improved management of nitrogen fertilizers.

Targeted sampling brings an understanding of the causes of water-quality conditions. It establishes relations between water quality and the natural and human factors that affect water quality. Targeted monitoring and assessments help decision makers to (1) identify streams, aquifers, and watersheds most vulnerable to contamination; (2) target management actions based on causes and sources of pollution; and (3) monitor and measure the effectiveness of those actions over time. Such monitoring would not be necessary if all streams and watersheds responded the same over time. But they are different. As shown by targeted assessments across the Nation, such as through the USGS National Water-Quality Assessment (NAWQA) Program,

even among similar land uses, the differences in sources, land-use practices, hydrology and other natural factors make one watershed more vulnerable to contamination than another and result in different ways that management strategies can improve water quality.

Integrating the two designs

Neither probabilistic nor targeted monitoring designs answer all questions about the Nation's water resources. While the targeted design cannot provide a quantified estimate of, for example, percentage of streams impaired within a broad geographic region, a probabilistic design cannot account for sources, seasonal differences, varying streamflow and ground-water contributions, or processes that control the movement and quality of water.

Ideally, data collection and monitoring should be consistent and comparable so that the findings can be integrated. National investments and partnerships must commit to increasing the comparability and integration of monitoring in order to enhance our ability to answer critical questions about water resources and understand the quality of the Nation's waters.

Appendix C. Potential sources of past and current Napa County watershed monitoring

- Resource Conservation District (RCD) turbidity and stage data at some stations
- Friends of Napa River fish surveys
- Friends of Napa River, RCD macroinvertebrate studies
- US Army Corps of Engineers (USACE) - Lower Napa River Flood Control
- US Geological Survey (USGS) stage and sediment data for Napa River
- San Francisco Estuary Institute (SFEI) nutrient and pathogen studies in Napa; also, historical ecology work
- National Wetlands Inventory (NWI) – wetland and riparian habitat mapping
- Stillwater Sciences' work on temp, turbidity, permeability, pool filling
- Robert Leidy and Jonathon Koehler fish surveys
- City of Napa water quality data
- Reservoirs – rainfall, storage, release
- California Department of Fish and Game (CDFG), Region 3
- Rutherford Dust Society
- WICC Baseline data report
- California Department of Water Resources (DWR) well data
- State Water Resources Control Board (SWRCB) water rights database

Appendix D. Potential Indicators: Matrix relating broad and specific level indicators to proposed Management Objectives

Management Objectives	Indicators Broad Level (Watershed)	Indicators Specific Level (Project, Stream)
Characterize watershed conditions and trends	• Current and Planned Land Management Activities • % Landscape Composition/ Landuse • Road density • Drainage density • Hydrological modifications of surface waters • Topography and soil type • Rainfall measures • Extent and diversity of habitat types • % Fragmentation of habitat patches • Biological community extent and composition • Surface water extent	• Connectivity to floodplain • % Riparian cover and buffer extent • Pool/Riffle composition • Species population size and diversity • Presence/Absence of sensitive species • Nutrient concentrations • Pathogen counts • Sediment quality characteristics • Water quality characteristics • Rates of bed and bank erosion • Scour potential • Bed permeability • Incision Rate
Improve the condition of the county's waterbodies recognized as having beneficial use impairment problems	• Change over time in watershed segments of concern (decreased erosion & incision, increased biological usage) • Trends in gravel permeability, scour depth, and meander wavelength • Trends in meeting numeric nutrient and pathogen targets • Increase of restoration activities (# permits) associated with impaired watersheds • % Decrease in fish barriers • % Decreases in drainage density • Decrease in # of swim advisories	• Sustained increase in salmonid numbers and diversity • Sustained decrease in nutrient concentrations and pathogen counts • Increase in riparian cover and composition • Sustained decrease in water temperatures • Increase in stream miles in channel equilibrium
Prevent degradation of intact (e.g. unimpaired) waterbodies throughout the county	• Available funding • Watershed permitting activities • Number of stewardship programs' activities in areas of concern • Current research and monitoring activities in areas of concern • Population growth patterns	• Road number and type • BMPs onsite and impacts • Riparian buffer changes (extent and composition) • Specific water quality parameters (including nutrients & pathogens) • Changes in chemical water quality • Bed scour and permeability

	• Land use changes (development pressure) • % Wetlands • % Riparian Corridor • BMPs applied • Change in % unimpaired vs. impaired	• Incision rate • Biological assemblage abundance and diversity
Prioritize beneficial use protection and restoration activities	• Available funding • % Watershed with TMDL targets exceeded • Land use changes (development pressure) • Population growth patterns • Permitted watershed restoration activities • % Coverage and overlap by stewardship groups	• Increased use of waterbodies by swimmers/fishermen • Riparian buffer changes (extent and composition) • BMPs onsite and impacts • Increased use of waterbodies by wildlife • Water quality monitoring (including nutrients & pathogens) • Biological assemblage abundance and diversity
Insure monitoring information is used in decision-making	• WICC meetings to review data and monitoring recommendations • # Policy documents referencing Strategic Plan • Monitoring information referenced in project review	• Data comparability among current studies • Communication between WICC Board, stakeholders, and monitoring entities

Appendix E. List of Existing QA/QC Guidance Documents

Lowe, S, Hoenicke, R and J. Davis. May 1999. Quality Assurance Project Plan for the Regional Monitoring Program for Trace Substances. San Francisco Estuary Institute (SFEI), Oakland, CA.

Nichol, G and E. Reyes. March 24, 2004. Surface Water Ambient Monitoring Program (SWAMP) - Compatible Quality Assurance Project Plans (Version 1.0). State Water Resources Control Board (SWRCB), Dept of Water Quality, Sacramento, CA.

US EPA. September 1996. The Volunteer Monitor's Guide To Quality Assurance Project Plans. EPA 841-B-96-003. Office of Wetlands, Oceans and Watersheds (4503F), United States Environmental Protection Agency, Washington D.C.

Appendix F. Glossary of Watershed Monitoring Terms
**** Denotes definitions from EPA Watershed Academy***

Adaptive Management - Adaptive management is a systematic process for continually improving management policies and practices by learning from the outcomes of operational programs. Its most effective form–"active" adaptive management–employs management programs that are designed to experimentally compare selected policies or practices, by evaluating alternative hypotheses about the system being managed. (From Ministry of Forests and Range 2000)

***Ambient monitoring -** All forms of monitoring conducted beyond the immediate influence of a discharge pipe or injection well and may include sampling of sediments and living resources.

***Assessment -** The translation of scientific data into policy-relevant information that is suitable for supporting decision-making and action.

Assessment Questions – Questions developed to focus monitoring data on environmental management issues that clearly relate to ecological components or processes deemed important in ecological condition.

***Biological parameters -** Include measures related to the plant and animal life of the water body, such as fish species diversity and abundance, or the presence or absence of indicator fishes, aquatic invertebrates, or aquatic plants.

***Chemical parameters -** Include contaminants such as metals, dissolved nutrients, oils, and pesticides, and also include chemical properties of the aquatic system such as dissolved oxygen, chemical oxygen demand, and acid neutralizing capacity.

Conceptual Model - Visual or textual characterization of an ecosystem or watershed that defines problems, identifies the type of solutions needed, and provide logical steps in the development of a strategy and goals. (US EPA 2000)

***Data Quality Objectives (DQOs) -** In the context of water quality monitoring, the characteristics or goals that are determined by a monitoring or interpretive program to be essential to the usefulness of the data. They would include, but not be limited to, the specification of delineation of the limits of precision and bias of measurements, the completeness of sampling and measurements, the representativeness of sites relative to program objectives, the validity of data, and so forth.

Ecosystem - A naturally occurring assemblage of organisms (plant, animal and other living organisms—also referred to as a biotic community) living together with their environment, functioning as a loose unit. (From Wikipedia Encyclopedia)

***Effectiveness monitoring -** Documents how well the management practices meet intended objectives. Monitoring evaluates the cause and effect relations between management

activities and conditions of the riparian dependent resources. Terrestrial and in-stream methods constitute monitoring that evaluates and documents the total effectiveness of site-specific actions.

***Environmental indicator -** A measurable feature or features that provide managerially and scientifically useful evidence of environmental and ecosystem quality or reliable evidence of trends in quality. The selection of relevant indicators should be derived directly from the assessment question and from professional judgment.

***Environmental restoration** - The return of a degraded ecosystem to a close approximation of its remaining natural potential.

Habitat - The physical environment that surrounds (influences and is utilized by) a species population. (From Wikipedia)

***Implementation monitoring -** Documents whether or not management practices were applied as designed. Project and contract administration is a part of implementation monitoring.

***Implementation Plan** - Developing a step-by-step plan for addressing management objectives, selecting the best watershed management alternatives, listing strategies for implementing selected management alternatives, and determining how to measure progress and evaluate efforts. The plan specifically identifies funding mechanisms, prioritizes management actions, and outlines plan review and stakeholder feedback process.

Management Goals and Objectives - Goals direct implementation actions and provide standards for measuring success. The chosen goals should be achievable ecologically, given the natural potential of the area, and socioeconomically, given the available resources and the extent of community support, and should have stakeholder consensus. Good goals provide focus and increase project efficiency. (US EPA 2000)

***Monitoring -** Periodic or continuous collection of data (measured parameters) using consistent methods to determine the status (the condition of the ecological resources) of a water body and watershed and the changes in those measurements over time.

***Physical parameters -** Include general conditions such as temperature, flow, sediment characteristics, water color, and within-channel habitat structure.

***Probability-based sampling** (Probabilistic Sampling Design) - A sampling method in which randomness is built into the design so that properties of the sampled population can be assessed in terms of their likelihood of occurrence or existence.

***Quality assurance/quality control (QA/QC) -**A system of procedures, checks, audits, and corrective actions to ensure that all EPA research design and performance, environmental monitoring and sampling, and other technical and reporting activities are of the highest achievable quality.

***Random sampling -** A sampling method in which every possible sample has the same chance of being selected.

***Sampling design -** All of the details concerning sampling units, sample selection, timing, spatial distribution and other issues involved in gaining sufficient sampling data for a monitoring and assessment program.

***Statistically significant results -** Sampling data that collectively meet or exceed data quality objectives or pass a statistical testing method, and therefore can support or disprove a hypothesis or other inference.

***Systematic sampling -** A sampling method in which sample selection begins at a random starting point but subsequently selects additional sampling units at equal intervals along a stated gradient or numbered list; for example, sampling a river channel's width and depth at 1-kilometer intervals along its full length.

***Trends and changes -** A trend is the consistent directional change in a population's characteristics documented by a minimum of three sampling events over a period of time (or sometimes distance); a change is a difference in a characteristic between just two sampling events.

***Total Maximum Daily Load (TMDL) -** A calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources. Water quality standards are set by States, Territories, and Tribes, and identify the uses for each waterbody, for example, drinking water supply, contact recreation (swimming), and aquatic life support (fishing), and the scientific criteria to support that use. A TMDL is the sum of the allowable loads of a single pollutant from all contributing point and non-point sources. The calculation must include a margin of safety to ensure that the waterbody can be used for the purposes the State has designated. The calculation must also account for seasonal variation in water quality. (From Clean Water Act 1987)

***Water quality assessment -** The determination whether a water body is attaining its designated uses for such purposes as drinking, contact recreation, fisheries, and irrigation, based on state Water Quality Standards as provided for in the Clean Water Act of 1987.

***Water quality monitoring -** An integrated activity for evaluating the physical, chemical, and biological characteristics of water in relation to human health, ecological conditions, and designated water uses.

Watershed - A region of land where water flows into a specified body of water, such as a river, lake, sea, or ocean. Also a topographical boundary between catchment basins. (From Wikipedia)

***Watershed monitoring -** Monitoring primarily designed to sample and assess the characteristics and/or condition of a watershed or watersheds, or to sample and assess

specific entities on a watershed basis (i.e. as a geographic unit for sampling). For example, water quality monitoring conducted on a watershed basis would include monitoring physical, chemical, and biological condition of the water body as well as specific watershed characteristics (e.g., stream corridor traits, wetlands, and watershed land use/land cover patterns) that may be related to observed water quality.