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WATERSHED CHARACTERIZATION STRATEGIES AND MONITORING GOALS

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[•] From USEPA 1996.

Watershed Characterization Strategies and Monitoring Goals

INTRODUCTION

More than two dozen federal and state agencies, in addition to numerous local governments, special districts, utilities, flood control agencies, and sanitation districts in the San Francisco Bay Area have some jurisdiction over watershed resources of one kind or another. In addition, a growing number of private organizations and regional partnerships are becoming involved in watershed stewardship issues that all require a framework of operation in order to understand human impacts on valued environmental resources, and ultimately to harmonize competing uses.

The objective of this paper was to review watershed characterization strategies in the San Francisco Bay Area (from the confluence of the Sacramento and San Joaquin Rivers to Coyote Creek) and thereby come one step closer to developing a framework of operation that would facilitate dialogue between governmental agencies and community groups, identify opportunities for volunteer involvement in watershed inventories and characterization of watershed resources and processes, and establish monitoring criteria to determine the success of watershed management projects.

BACKGROUND

Because of the need to control nonpoint sources of water pollution, water quality has been added to those issues which have traditionally dominated watershed management activities, such as open space preservation, fish and wildlife protection, and managing drinking water supplies. Characterizing pollutant composition, concentrations, and loads, as well as monitoring the effectiveness of best management practices (BMPs) have become important components of any nonpoint pollution control strategy.

Typically, these management efforts have relied upon the assessment of impaired "designated uses" of a water body as set forth in both the Clean Water Act of 1972 and its amendments, and, in California, by the Porter-Cologne Water Quality Act. Watershed assessment programs have been developed, in part, to address Water Quality Amendments of 1987 which highlighted the need to control, "in an expeditious manner," both point and nonpoint sources of

pollution. Because of these problem-oriented mandates, a broader, more holistic approach to watershed understanding has only very recently become a priority for regulatory agencies. Therefore, ecosystem approaches are only now becoming incorporated into the thinking of local regulated agencies such as storm water programs and publicly owned treatment works.

In order to advance integrative programs on a watershed level, multi-disciplinary thinking is now viewed as a priority for large-scale regional watershed management. Watersheds need to be monitored to meet the goals of NEPA (National Environmental Protection Act), the Clean Water Act, state and regional legislation, and for the protection of existing and future beneficial uses. Undisturbed watersheds need monitoring to provide baselines for environmental quality; disturbed watersheds need monitoring to evaluate the condition and the status of recovery strategies.

Because environmental management with an integrative watershed perspective is a relatively new concept for most agencies, basic data to describe watershed conditions and to evaluate cumulative effects and success or failure of management actions are rare. Watersheds will have to be characterized first - physically and geographically, as well as with respect to impacts on natural resources and incompatibilities of current activities with general societal goals and concerns. Subsequent to this inventory process, issues can be identified and goals can be set for water quality, habitat, and biodiversity that are specific enough to be evaluated and reasonable and appropriate in a local and regional context (e.g. mass emission goals for certain chemical parameters, presence of certain desirable species at specific densities; maximum allowable water temperatures, etc.). These environmental goals need to be reconciled with other societal goals, and then translated into environmental policy to provide the basis for monitoring progress toward these goals.

While community groups are becoming increasingly involved in measuring watershed conditions, the need for connecting their own watershed information-gathering activities to those of public agencies and their management mandates is becoming more obvious. Bay Area watershed residents are asking for the tools to inventory their watersheds, to determine problem causes, and to take care of valued natural resources. This demand has produced a number of protocols for assessing resources and taking measurements that volunteers are capable of collecting. However, a framework or “infrastructure” for placing monitoring information and integrating individual elements of a watershed picture generated from a variety of sources is still missing at this time. Scientific review, establishment of performance standards, and training are other identified needs.

An issue paper on the developing relationship between public agencies and volunteer groups (SFEI, 1996) discussed results of a regional survey of various local, regional, state, and federal agencies as well as a variety of community groups. One part of the survey was intended to identify information needs of

agencies managing natural resources, land use, or water quality. Another focus of the survey was to query these agencies with respect to their readiness to involve the interested public in collecting data to meet some of their information needs. Community groups were asked, among other things, to describe what kinds of data collection activities they were involved in and for what purposes.

Results of this survey indicate that in most cases a wide gap appears to exists between the fairly general agency missions and mandates and tracking progress and success of resource stewardship actions. From an outside perspective, it is very difficult to follow a hierarchical line of increasing specificity that would help determine if mandates, missions, and program priorities are actually achieved as in on-the-ground projects. Although monitoring activities are currently being conducted by both agency personnel and volunteers, it is unclear how the information is used or will be used to adjust projects and programs, or if tracking the success of watershed management actions could be conducted more efficiently.

This apparent gap between data gathering and data use prompted a search for watershed characterization strategies and an attempt to review available monitoring objectives, parameters, and sampling designs. As a next step, potential environmental indicators were to be identified that might be suitable in tracking the achievement of agency goals and those expressed by communities within any given watershed. Existing protocols that either had already been developed for volunteers or were planned could then be adjusted and reviewed in the context of what kinds of questions they were intended to answer. We envisioned that by connecting higher-level questions with information-gathering protocols designed to answer these questions, an efficient prioritization of data-gathering efforts could be achieved.

WATERSHED CHARACTERIZATION STRATEGIES, MANAGEMENT GOALS, AND MONITORING GOALS

A number of guidance documents for storm water management agencies have been issued that outline the necessary steps for problem characterization and remediation (see resource guide below). Perhaps because it is almost too obvious, none explicitly stresses the establishment of quantifiable resource management goals that are essential to the successful development and implementation of a watershed management plan. However, without scientifically defensible goals, implementing programs and monitoring is like dieting with no target weight or assessment of overall health. It is possible to diet to death, and to monitor that process as well.

A review of the missions and mandates of a variety of agencies that are involved in some aspects of watershed management in a regulatory, natural resource protection, public health, planning, or land use decision-making

capacity revealed that currently no overarching "watershed characterization strategy" is available for the San Francisco Bay Area. Several individual agencies and organizations have developed their own approaches to obtaining data on water quality, the status of natural resources, or land use changes, and those agencies are beginning to relate these data to whether or not they are accomplishing their public mandates or management goals. Others are not yet clear about what role they should play in watershed management, other than meeting regulatory mandates. A conceptual model, such as the one outlined below in Table 1, may assist in identifying specific needs of both volunteer groups and agencies before volunteer inventory, assessment, and monitoring activities can effectively be utilized in better decision-making processes.

Regional Monitoring Strategy

The Regional Monitoring Strategy for the San Francisco Estuary comes closest to a "watershed characterization" guidance document. It outlines the information and monitoring needs for each of the five thematic areas covered by the Comprehensive Conservation and Management Plan or "CCMP" (SFEP, 1993) - 1) pollutants, 2) dredging and waterway modification, 3) freshwater flow diversion and aquatic resources, 4) wetlands and wildlife, and 5) land use. Taken together, these five themes overlap with the most important watershed management issues. The Regional Monitoring Strategy was developed as a companion document to the CCMP prepared under sponsorship of EPA's National Estuary Program. The plan was completed in 1993, and its implementation is overseen by the San Francisco Estuary Project (SFEP). The organization designated to oversee the implementation of the Regional Monitoring Strategy is the San Francisco Estuary Institute.

The Role of Volunteer Monitors

The Regional Monitoring Strategy contains regional monitoring objectives for pollutants, dredging, freshwater flow diversion and aquatic resources, wetlands and wildlife and land use management. These objectives were reviewed to determine the role of volunteers in achieving them.

Monitoring Objectives for Pollutants

Highly technical monitoring has been conducted for some time in the Bay Area, although only with the inception of the Regional Monitoring Program for Trace Substances (RMP) in 1993 and its preceding pilot studies conducted under the Bay Protection and Toxic Cleanup Program has a comprehensive picture of "background" pollutant concentrations in the Estuary emerged. Technical monitoring has focused on identifying the status and trends of contaminants. The sampling and analysis of chemical pollutants in the Estuary water, sediment, and biota, and sediment toxicity testing are currently not feasible for volunteers. Only one volunteer organization, the San Francisco BayKeeper, focuses on pollutants in the bay waters. Therefore, the role of volunteers in

meeting these objectives will be limited. The objectives of pollutant monitoring as outlined in the Regional Monitoring Strategy are:

1. Characterize the status and trends of pollutant loads by source and their relative contribution to the Estuary.

2. Characterize the status and trends of water column and sediment pollutant concentrations in selected habitats.

3. Characterize the status and trends of bioaccumulation in selected estuarine biota.

4. Characterize the status and trends of sediment toxicity in selected habitats.

Monitoring Objectives for Dredging

The monitoring objectives for dredging are:

1. Characterize the status and trends of dredging and dredged material disposal activities and properties of disposed dredged material by source.

2. Characterize the status and trends of suspended solid concentrations in selected habitats and disposal sites.

3. Characterize the status and trends in physical characteristics of sediments in selected habitats.

4. Characterize the status and trends in physical characteristics of sediment pollutant concentrations in selected habitats.

5. Characterize the status and trends of sediment toxicity in selected habitats.

The Regional Monitoring Strategy also recommends specific monitoring actions to achieve these objectives. There is clearly a role for volunteers here. Volunteers could assist in collecting measurements of ambient suspended sediments to characterize naturally occurring levels. They could also collect measurements of substrate grain size in selected habitats. For effective volunteer participation, volunteers would need agency support for training and in determining appropriate sampling locations, times, and procedures.

Monitoring Objectives for Freshwater Flow Diversions and Aquatic Resources

The sole objective is to improve the effectiveness of the techniques and programs used to evaluate and monitor the responses of the estuarine ecosystem to water management actions. Agencies are currently monitoring the physical,

chemical and biological components of the Estuary. Because this type of monitoring generally requires a vessel and heavy sampling equipment, most volunteer groups will lack the resources to contribute to this monitoring. However, volunteers could perform nearshore monitoring such as:

- ☑ monitoring the change in plant composition in tidal and non-tidal marshes,
- ☑ monitoring the invasion of some introduced species (e.g. cordgrass and invertebrates).

Monitoring Objectives for Wetlands and Wildlife

This is the arena for the greatest involvement by volunteers. The monitoring objectives are extensive so they are not included here (see the Regional Monitoring Strategy). Volunteers can characterize the status and trends of wetland species. Biological inventories in wetland and riparian habitat would establish baseline conditions, and provide information to evaluate the trends in species abundance, distribution, and composition. The citizen's monitoring group, Coyote Creek Riparian Station, has proven that volunteers can conduct useful inventories of birds, reptiles and amphibians. Regional protocols have been developed for these inventories. There is a need to determine whether these protocols are suitable for tidal and non-tidal marshes, as they were developed for riparian corridors. The Regional Monitoring Strategy also notes that monitoring should focus on special status species and ecologically important/representative insects, amphibians, reptiles, birds, and estuarine mammals. Determining the most appropriate indicator species and habitat conditions would help focus limited resources on the most important monitoring.

Monitoring Objectives for Land Use

Volunteers can help meet the following monitoring objectives.

1. Quantifying the distribution of existing land uses.
2. Identifying and mapping critical estuarine resources.
3. Collecting and analyzing data that will enable more comprehensive and accurate analyses of potential impacts of projected land use changes on the integrity of riparian, wetland and estuarine resources.
4. Quantifying the impacts of existing and planned land use on biological resources.

Volunteer monitoring groups currently collect information to support these objectives. This information includes land use classifications, illegal dumping and discharge reporting, riparian habitat evaluation, conventional water

chemistry and bank condition/low flow channel profiles. To ensure effective monitoring, the most appropriate monitoring parameters need to be identified.

The Regional Monitoring Program's Sampling Design

The program monitors 24 open water stations along the spine of the San Francisco Estuary. Samples are collected two or three times a year to characterize the wet period, the period of declining Delta outflow, and the dry period. Five different types of sampling are conducted.

1. Conventional water quality parameters and chemistry. The conventional parameters include temperature, D.O., conductivity, salinity, hardness, pH and nutrients. Trace elements, metals, and organic compounds are measured. Four major groups of organic compounds are analyzed: PAHs, PCBs, alkanes, and selected pesticides.
2. Aquatic bioassays.
3. Sediment quality characteristics and chemistry.
4. Sediment bioassays.
5. Transplanted, bagged bivalve bioaccumulation and condition.

Chemical results can be compared to water quality objectives to determine the health of the Estuary. Bioassays determine if waters and sediment are toxic to aquatic life. Sampling of bivalves indicates the potential contamination of shellfish and bioavailability of contaminants. Results also suggest potential hot spots or sources of pollutants. For example, if diazinon concentrations peak near the outlet of the Petaluma River, additional sampling might be conducted to determine the sources of diazinon in the Petaluma River watershed. Source identification could be enhanced by volunteer involvement, as volunteers can collect samples over a wide area more effectively and in a less costly manner than professionals.

Proposed Role of Volunteers in the Regional Monitoring Strategy

Volunteer monitoring groups support the objectives of the Regional Monitoring Strategy by:

- ☑ establishing baseline conditions of riparian habitat and species,
- ☑ mapping land uses,
- ☑ mapping critical estuarine resources, and
- ☑ reporting illegal dumping and discharges.

Volunteer monitoring groups could further support the objectives of the Regional Monitoring Strategy by:

- ☑ expanding their monitoring to include tidal and non-tidal marshes,
- ☑ characterizing suspended sediments or another measure of sediment load,
- ☑ characterizing physical conditions in riparian corridors (e.g. flow, water temperature, shading)
- ☑ collecting water samples in riverine systems for professional analysis of trace elements, metals or organic compounds,
- ☑ conducting aquatic toxicity testing of creeks and rivers, and
- ☑ coordinating sampling locations, times and procedures with professionals.

How to Dovetail Volunteer Monitoring with the Regional Monitoring Strategy

Currently there is a clear separation between the professional monitoring conducted in the Estuary and volunteer monitoring efforts in the watersheds contributing to the Estuary. Better communication between these groups and information synthesis stemming from individual data-gathering efforts are necessary to improve our understanding of the health of the whole Estuary. No agreement even exists among the different agencies pursuing their mandates that cover only small parts of watershed management of how to integrate professionally collected data on a system-wide basis. No mechanisms exist to date for assessing data from the five different CCMP program areas, whose monitoring objectives are listed above, in a coherent way. Also, no agreement exists for where monitoring information should reside and who the recipients ought to be that may act on this information. One potential vehicle for communication is to organize a planning session at a conference reviewing the implementation of the Regional Monitoring Strategy. The purpose of the planning session would be to coordinate upcoming sampling schedules and designs of professional and volunteer monitoring programs and agree on the appropriate management actions that new information and scientific data may suggest.

The Stormwater Monitoring Programs and the Role of Volunteer Monitors

Until recently, the three largest storm water programs in the Bay area were required to monitor a suite of storm water related pollutants at two fixed stations each for five storm events per year. The objectives of this monitoring were to determine levels of pollutants in storm water discharge and to assess attainment of water quality objectives in the receiving waters. Trends in storm

water quality were also to be evaluated. A monitoring strategy for storm water building on the findings of pollutant characterization efforts is now under development. The San Francisco Bay Regional Water Quality Control Board has requested the Bay Area storm water agencies to modify their monitoring program. They were requested to consider characterization of drainage areas by land use, and to consider monitoring of physical, biological and chemical indicators. Using community members to monitor was strongly encouraged.

Current volunteer monitoring supports the goals of the stormwater programs. These current activities include:

- ☑ land use classification,
- ☑ monitoring of conventional water chemistry,
- ☑ characterization of riparian habitat and species,
- ☑ aquatic toxicity testing,
- ☑ macroinvertebrate sampling,
- ☑ and reporting of illegal dumping and discharges.

The stormwater agencies should consider involving volunteer program leaders in the process of developing a new monitoring strategy. Common objectives need to be identified. Depending on the strategy (e.g. emphasis on toxicity testing or macroinvertebrate sampling), additional training of volunteers may be necessary.

Framework for Use of Volunteer Data

The survey paper (SFEI, 1996) indicated that the demand exists for watershed-related information, and that a framework for the scientific and organizational foundation of watershed inventories, assessments, and monitoring activities is sorely needed. Responses to the survey did not directly reveal at the necessary level of detail, however, why a specific suite of parameters is being collected, and how these data could answer specific management questions. Although more than 200 monitoring activities are currently undertaken by various agencies and volunteer organizations, in most cases, it is not immediately apparent what kinds of purposes these activities are supporting.

The following hypothetical example (Table 1) illustrates how monitoring parameters and environmental measurements that could be used to characterize watershed conditions can be derived from very general questions concerning watershed resources. This example provides a stylized picture of a monitoring design process that moves from lesser to greater degrees of technical and scientific specificity. The informed public's vision for their watershed and general issues related to water quality, "health" of a riparian corridor, absence of certain fish, wildlife, or plant species of concern, etc., form the basis of

assessment questions, which in turn lead to management goals, monitoring objectives, and measurements that can determine if management goals have been achieved. By placing existing measurements and indicators into this matrix, an evaluation of their usefulness and cost effectiveness is facilitated and organized.

Table 1

HYPOTHETICAL WATERSHED CHARACTERIZATION AND MONITORING DESIGN FRAMEWORK

PUBLIC CONCERNS	ASSESSMENT ISSUES	MANAGEMENT GOALS	MONITORING OBJECTIVES	POTENTIAL MEASUREMENTS
Are stream resources adequately protected?	- reduced abundance of key fish and amphibian species - decrease in riparian habitat acreage and quality	- restore anadromous fisheries - eliminate exotic species - protect species of concern - protect riparian habitats	- increase steelhead spawning habitat by 50% by the year 2000 in creek X - remove priority exotic species by 70% by the year 2000 along riparian corridor of creek X - Monitor tree cover	- acreage of gravel beds in creek X - dissolved oxygen levels 2x/day - temperature 2x/day - recovery of native plant species - percent tree cover at creek X
Is water quality good?	- contaminant loads - changes in aquatic invertebrate species composition and diversity - number of toxicity events - improvement in water quality	- prevent and reduce pollutant inputs into waterways - restore and protect biological resources - eliminate toxic runoff events	- reduce copper loads in creek X by 20% by year 2000 - reduce occurrences of toxicity in selected indicator spp. by 50% by year 2000 - increase oil recycling by 200% by year 2000	- Cu concentrations at selected sites - flow - toxicity tests at predetermined intervals, based on identified pollutant use - invertebrate index for creek X - mass balance of oil in watershed X
Are recreational opportunities available?	- decreased access - visual impairment - lack of safety - overfishing	- improve public access - increase acreage of public lands - enhance fishing opportunities	- increase riparian trails and interpretive centers by 200% by year 2000 - monitor recreational use of trails and interpretive centers - catch per unit effort	- miles of riparian trails - visitor hours per year - user surveys - angler surveys
Are certain fish and wildlife species present?	- historical records - habitat loss - water quality impairment	- restore conditions suitable for critical species - protect critical habitat	- monitor habitat conditions - monitor reproductive success	- total suspended sediment load - erosion and sedimentation - vegetative cover - dissolved oxygen

DOCUMENTATION OF AGENCY MANAGEMENT GOALS

One of the intended tasks of this report was to recommend appropriate environmental indicators and measurements that could serve the information needs of various agencies and organizations. However, because the survey (SFEI, 1996) did not directly reveal the connection between existing measurement parameters or indicators and specific management questions, the approach to making this connection had to be changed, working backwards from existing measurements to their potential uses.

Answers to the survey question of "Why are you doing this monitoring?" only provided general answers, such as "storm water permit", "local government planning", or "beneficial use assessment." We were unable to determine the specific connection between dissolved oxygen measurements, for example, and the management goal of "...[ensuring] that there is sufficient water (quantity and quality) for wildlife." (Department of Fish and Game Strategic Plan, 1993). We therefore researched management goals of some key agencies from each category described in the survey and attempted to determine the usefulness of monitoring parameters currently collected by agencies with respect to informing their staff how and to what extent stated management goals are being achieved. In addition, measurements collected by volunteers were evaluated using the same criterion. A thorough review of existing environmental indicators and development of new ones, however, is beyond the scope of this task and is recommended as part of inventory and monitoring parameter prioritization.

MONITORING ACTIVITIES AND RELATIONSHIPS TO MANAGEMENT GOALS

In order to develop a systematic review process of existing environmental measurements and their usefulness in answering management questions, we used a subset of management goals collected from selected agencies in the categories listed in the survey (natural resources, water quality, public health, land use, parks and recreation), and identified corresponding measurements identified by agencies and non-governmental organizations. An exhaustive analysis would have been beyond the scope of this task, but a preliminary comparison between survey forms and agency strategic plans, mandates, or master plans revealed the following patterns:

1. Many agencies have overlapping mandates and goals and therefore share very similar information needs.

2. Environmental data are generally not collected in a systematic way.

3. Frequently, the same measurements are made by different organizations.

4. Large information gaps exist locally and regionally.

Table 2 summarizes a selected set of agency management goals and related measurements needed to evaluate progress toward those goals.

Table 2. AGENCY GOALS AND RELATED MEASUREMENTS

Examples of Agency Goals	Selected Inventories and Measurements Related to Goal
Create and restore habitats critical to the survival of plant and animal populations (CCMP)	- Riparian vegetation inventories - Inventory of biota - Land use inventories - Flow - Temperature - Suspended sediment loads
Attain beneficial uses of waters of the Region (Regional Water Quality Control Board).	- Concentrations of chemical constituents - Toxicity tests and evaluations - Temperature - Flow - Pathogen indicators - Conductivity
Develop and manage Reclamation projects and lands to conserve and, where appropriate, enhance fish and wildlife habitat and populations (Bureau of Reclamation).	- Riparian vegetation inventories - Inventory of biota - Land use inventories - Flow - Temperature - Suspended sediment loads
Ensure that there is sufficient water (quantity and quality) for wildlife (Department of Fish and Game).	- Monitor water diversions - Collect baseline biological information - Rapid bioassessment surveys - Flow
Maintain roads, trails, and other improvements to avoid erosion and soil failure (East Bay Regional Park District)	- Geomorphology - Soil inventories - Suspended sediment loads
Control discharge of pollutants from urban runoff (Alameda County Clean Water Program)	- Map stormdrains and creeks - Concentrations of chemical constituents - Toxicity tests and evaluations - Temperature - Flow - Land use inventories

CURRENT AND POTENTIAL VOLUNTEER EFFORTS IN WATERSHED INVENTORIES, ASSESSMENT, AND MONITORING

Monitoring activities in the Bay Area have focused on baseline characterization techniques and fall into roughly three groups; physical and chemical characteristics, habitat type and condition, and wildlife population measurements. Physical and chemical parameters include water quality, flow rate, sediment measures and channel features. Basic water quality parameters are being studied in at least eight watersheds around the San Francisco Bay Area. Data collected through these programs provide background information on dissolved oxygen, air and water temperature, watershed-specific rainfall patterns, turbidity, and conductivity. In the water quality arena, additional efforts are underway to develop uniform methods of toxicity testing as well as for suspended sediment parameters.

Habitat monitoring protocols developed thus far also focus on baseline characterization of habitat type and condition. These parameters include instream fisheries habitat classification and bank and riparian habitat condition. Some volunteer monitoring programs have begun to include surveys to track the success of restoration or exotic species eradication projects.

Hydrological and geomorphologic measurements are critical in evaluating sediment and pollutant transport, runoff coefficients, ground water recharge potential, and to forecast changes in habitat conditions. Protocols are being developed without adequate funding and have only received limited testing and review.

There is also a strong feeling among volunteer groups that inventory, monitoring and restoration activities should be integrated into educational programs at all grade levels.

The following is a list of monitoring objectives provided by groups surveyed throughout the San Francisco Bay Area:

- ☑ Conduct research on avian species of the San Francisco Bay National Wildlife Refuge,
- ☑ Make avian research data available for management and restoration decisions,
- ☑ Educate the public,
- ☑ Preserve remaining acres of San Francisco Bay wetlands,
- ☑ Develop a water quality monitoring program on Wildcat Creek that will provide useful baseline data,
- ☑ Train students and community members in monitoring techniques,

- ☑ Research, restore, and manage riparian corridors,
- ☑ Educate the public about the importance of riparian corridors,
- ☑ Advance our understanding of riparian corridors and promote informed decision-making,
- ☑ Integrate creek curriculum into the school curriculum,
- ☑ Integrate science and mathematics, with an emphasis on aquatic environmental studies, into the K through 12 curriculum,
- ☑ Save the Adobe Creek steelhead trout from extinction,
- ☑ Protect open spaces,
- ☑ Preserve biological diversity,
- ☑ Control pollution in the Pacific coastal zone,
- ☑ Encourage understanding of coastal resources,
- ☑ Maintain viable wetland habitat for use by permanent and transitory waterfowl,
- ☑ Monitor and improve our local surf spots,
- ☑ Protect and enhance the world's waves and beaches through conservation, research and education,
- ☑ Protect, restore and enhance the health of the Corte Madera watershed and its creeks,
- ☑ Protect and improve the ecological health of the watershed through community education and involvement,
- ☑ Preserve, restore and enhance the Sonoma Creek and its aquifer, riparian corridor and the watershed that sustains them through citizen action, involvement, public education, research and expert advocacy.

It is clear that most groups consider the protection of aquatic systems as a critical component of their mission. They have chosen to participate in informed decision-making via their monitoring programs. They see the education of their community as critical to their goals.

REGIONAL MONITORING OBJECTIVES FOR VOLUNTEER MONITORS IN THE SAN FRANCISCO ESTUARY WATERSHED

After reviewing the monitoring objectives of the volunteer monitoring groups, stormwater programs and the Regional Monitoring Strategy it is clear that the focus of monitoring is diverse and in flux. Given that the stormwater program's monitoring is under revision, it is difficult to establish specific regional volunteer monitoring objectives at this time. However, general guidance is appropriate. All the regional monitoring programs share a need for

a better understanding of the health of the watershed. In particular, there is a need to characterize the status of riparian habitat and specific important or indicator riparian species. Thus, we recommend the following common monitoring and educational goals for volunteer monitoring groups in the Bay Area.

- ☑ Characterize the status of creek water quality, riparian habitat, and riparian species,
- ☑ Characterize the distribution of important biological species or key indicators of riparian health,
- ☑ Educate the community as to the health of the watershed and to their role in managing watersheds,
- ☑ Work together with agencies and the community to provide useful information for management of the San Francisco Estuary watershed.

In recognition of the need for better understanding of watersheds, the San Francisco Estuary Institute has developed a Watersheds Science Plan (SFEI, 1997) to integrate among the various efforts of government and the public to assess and report on the health status of watersheds. The Plan can be summarized as the following three basic steps:

1. Develop an understanding of the environmental past, the present, and change.
2. Based upon the understanding of change, develop quantitative resource objectives for the future.
3. Monitor progress toward the objectives, and monitor the risk that the objectives might not be achieved.

As indicated above the public already participates in many aspects of watershed science, albeit in a non-systematic way that has not yet led to rigorous Water Quality Assessments or quantitative resource objectives (how much of what kind do we want where?) and assessing the feasibility of achieving them.

APPROPRIATE ENVIRONMENTAL INDICATORS

Before determining what should be monitored to meet our monitoring objectives, it is important to determine whether specific parameters have been identified as key environmental characteristics which, if studied, would yield the most information as to the status and trends in watershed health. Theoretically, these key characteristics, or environmental indicators, would yield more accurate information more effectively than monitoring of similar parameters. It is beyond the scope of any one volunteer monitoring program to determine suitable environmental indicators, although their data may help determine appropriate ones. Therefore, we look to scientists and resource

managers for guidance. Environmental indicators have recently been reviewed by USEPA, Regional Monitoring Program personnel, and the Center for Watershed Protection. That information is summarized below.

USEPA's Environmental Indicators for Water

USEPA recently established national environmental goals, objectives, and indicators for the waters of the United States. The goals are:

> *"America's rivers, lakes and coastal waters will support healthy communities of fish, plants, and other aquatic life, and will support uses such as fishing, swimming, and drinking water supply for people. Wetlands will be protected and rehabilitated to provide wildlife habitat, reduce floods, and improve water quality. Ground waters will be cleaner for drinking and other beneficial uses."*

USEPA stated 5 objectives to meet these goals. They also identified 18 environmental indicators that would show progress or regress towards reaching these objectives. The objectives and indicators are in Appendix A. EPA sees these indicators as providing a consistent core set of data to evaluate its goals. Since current information is insufficient, all levels of government, the public and private sector will need to work together to improve our knowledge of the health of our waters.

What is the role of riparian stations and volunteer monitors in monitoring environmental indicators? Riparian stations and volunteer monitors are well suited to collect data on the following environmental indicators:

- ☑ biological integrity,
- ☑ species at risk,
- ☑ aquatic life designated use,
- ☑ surface water pollutants, and
- ☑ estuarine eutrophication conditions.

Biological integrity can be assessed using bioassessment techniques for fish, macroinvertebrates, and plants. Volunteers can focus on the rapid bioassessment procedures for macroinvertebrates. The California Department of Fish and Game (CDFG) has developed a procedure specifically for volunteers. There are very little data in the San Francisco Bay area on the biological integrity of creeks.

The regional volunteer monitoring protocols for monitoring vegetation, birds, reptiles and amphibians can be used to census at-risk species, if surveying is not harmful to those organisms. Various groups, including CDFG, the US Fish and Wildlife Service, the Coyote Creek Riparian Station and the California Native Plant Society, evaluate the status of plant and animal species. Volunteers could

expand the scope of this information.

The appropriate indicators for determining whether water meet the aquatic life designated use are varied. When numerical water quality objectives exist, it is straightforward to determine if these objectives are being met. The parameters for which water quality objectives exist, and for which volunteers can readily monitor, are temperature, dissolved oxygen, and pH. Volunteer monitoring protocols have been developed for these parameters.

The USEPA recommends measuring six water quality parameters to detect trends in surface water pollutants. These are dissolved oxygen, dissolved solids, nitrate, total phosphorus, fecal coliform, and suspended sediment. Protocols, written for volunteers, exist for all of these parameters. However, we do not recommend that all volunteer monitoring groups monitor all of these parameters. Quality assurance concerns need to be addressed before nutrients and bacteria are monitored widely by volunteers.

Some symptoms of estuarine eutrophication can be noted by volunteers. These include fish kills, extensive algal blooms, and high turbidity. Once quality assurance concerns are addressed, monitoring nutrient concentrations should help measure trends in eutrophication, as well as sources of nutrients.

Environmental Indicators for the Regional Monitoring Program

The Regional Monitoring Program conducted a workshop on environmental indicators in October of 1995. The primary goal was to determine which indicators should be used to provide assessment of the contamination of the Estuary. Three types of indicators were reviewed:

- ☑ indicators of ecological response in the open water habitat,
- ☑ indicators of the status and trends of the Estuary sediment, and
- ☑ indicators of the health of upper trophic levels.

Examples of the indicators are population densities of fish and algae, toxicity tests with shrimp, kelp or abalone, contaminant levels in bivalves, areal extent of eel grass beds, bird eggshell thickness, and molecular markers. The workshop participants ranked many indicators, but additional assessment was deemed necessary before environmental indicators are chosen. This process is expected to continue into 1997. At this time, the process of developing environmental indicators is not sufficiently advanced to guide volunteer monitors. However, most of these environmental indicators require significant technical expertise or involve significant sampling resources. Therefore, volunteer involvement will likely be limited to population level or community level indicators, such as changes in wetland area, changes in eel grass bed area,

or reproductive success of bird species.

Center for Watershed Protection's Review of Stormwater Indicators

The Center for Watershed Protection recently published a review of environmental indicators used to assess the success or failure of stormwater management efforts (Claytor and Brown, 1996). These indicators would be used by stormwater managers to track trends in the overall aquatic health due to implementation of stormwater programs. The indicators must be able to distinguish stormwater from other sources of pollution.

Six categories of environmental indicators were reviewed and rated. Ratings were based on the indicators' applicability to lakes, streams, and estuaries, and the effectiveness of evaluating land use impacts, stormwater programs, whole watershed quality, industrial sites and municipal programs. Of these six, biological indicators rated higher than water quality, physical and hydrological, social, programmatic or site indicators.

The biological indicators include bioassessment of fish and macroinvertebrates, single species indicators, and composite indicators. Of these, the fish and macroinvertebrate bioassesments as well as the composite indicators were rated slightly higher than the other indicators. Because of permitting requirements for electroshocking and seining, volunteers would need to work directly with the CDFG to conduct fish surveys. Therefore, the greatest potential for community involvement is in macroinvertebrate assessment. CDFG has developed a macroinvertebrate procedure suited for volunteers.

Other pertinent indicators that were deemed effective as stormwater indicators, and that have potential for volunteer involvement are: water quality monitoring, toxicity testing, stream widening/downcutting, physical habitat monitoring, increased flooding frequency, and stream temperature monitoring.

Monitoring Parameters to Support Regional Monitoring Objectives

A tiered monitoring approach (Table 3) has been developed that outlines the different levels of complexity or reconnaissance, inventory, and monitoring tasks volunteers with varying levels of training may become involved in. These tiers relate specifically to the effort required for training, the complexity of sampling or reconnaissance protocols, and quality assurance measures, with Tier 1 being the least complex and Tier 3 the most. Monitoring groups would begin with simple monitoring of conventional water chemistry and visual observations of the creek and adjoining land uses as part of general reconnaissance and basic data collection. Illegal dumping and discharges are reported in a standard fashion. The second phase would involve collecting

quantitative information on the geomorphology of the creek, surveying riparian vegetation, and assessing creek health through macroinvertebrate sampling. Finally, in the third phase, volunteers monitor biological resources such as birds, reptiles and amphibians. Macroinvertebrate sampling is more rigorous and toxicity testing is a potential component.

Table 3. Tiered Monitoring Approach for Volunteers.

Protocol Level	Title	Author(s)	Status	Review Status	Database Develop.	QA/QC Standards
One						
	Watershed Map	TBD	Not Started	NA	NA	NA
	Watershed Background	TBD	Draft	NA	NA	NA
	Stream Survey	Mill Valley Watershed; FS&W	Field Testing	Needed	Needed	Needed
	EPA Streamwalk	EPA	Complete	Complete	Needed	Yes
Two						
	Thalweg Profile	SFEI	Field Testing	Complete	Complete	Needed
	Bank Characteristics	SFEI	Field Testing	In Prog.	In Prog.	Needed
	Land Use Zonation	SFEI	Not Started	NA	NA	NA
	Rainfall	CCRS, Napa RCD	Complete	Complete	Complete	Complete
	Basic Water Quality	CCRS	Complete	Complete	Complete	Complete
	Beginning GIS	SFEI; GreenInfo Network	Not Started	NA	NA	NA
Three						
	Channel Crossections	Napa RCD, CCRS	Complete	Needed	Complete	Needed
	Stream Flow	Napa RCD, CCRS, SFEI	In Prog.	Needed	Needed	Needed
	Habitat Characterization					
	Birds	CCRS	Complete	Complete	Complete	Complete
	Vegetation	CCRS	Complete	Complete	Complete	Complete
	Reptiles & Amphibians	CCRS	Complete	Complete	Complete	Complete
Three	Riparian Habitat	CCRS	Complete	Complete	Complete	Complete
	Fisheries	CCRS	Complete	Partial	Complete	Complete
	Invertebrates	CCRS	Draft	In Prog.	In Prog.	In Prog.
	Land Use Inventory	TBD	Not Started	NA	NA	NA
	Full GIS	TBD	Not Started	NA	NA	NA

The Watersheds Science Plan (SFEI, 1997) is the road map that identifies all

necessary information pieces needed to characterize watersheds, whether collected by volunteers or professionals, for the purpose of 1) understanding what factors control flooding, pollution, and sediment loads, 2) inventories of habitats for species of concern, 3) inventories of potential stream and riparian restoration sites, 4) development of more efficient water quality and ecological monitoring programs, and 5) identification of Best Management Practices.

The monitoring approach is designed so that a volunteer group could initiate a program with less rigorous monitoring and then step into a more technically difficult program as their expertise grows. The monitoring approach identifies appropriate monitoring parameters and procedures. Quality assurance procedures are briefly identified in the specific procedures. Monitoring locations and times have not been identified. This is an important task that requires the input of stormwater managers and other agencies involved in the Regional Monitoring Strategy.

NEED FOR QUALITY ASSURANCE PLANS AND GUIDANCE ON DATA MANAGEMENT

The survey responses from volunteer monitoring groups indicated that agencies are concerned about the quality of volunteers' data. Many of the volunteer monitoring groups address components of quality assurance (e.g. training, duplicate sampling, concurrent sampling by professionals, instrument calibration), but only a minority have written quality assurance plans. To ensure the collection of useful data, we recommend that all volunteer monitoring groups which want their data to be used for environmental decision-making must follow a quality assurance plan. The regional monitoring procedures do not currently contain QA plans. We recommend that the San Francisco Estuary Volunteer Monitoring Steering Committee develop boiler plate QA plans that could be tailored by individual groups. We also recommend that they develop this boiler plate QA plan using USEPA's guidance on developing QA plans for volunteers. Our review of the Coyote Creek Riparian Station's QA plan indicates it is a good template to evaluate for developing the boiler plate plan.

The regional monitoring procedures contain datasheets that should assist groups in developing their own databases. However, there is a need to identify how to transfer data between groups, or between agencies and volunteer groups. There is also a need to identify appropriate data analysis. USEPA has indicated it will fund a regional workshop on data analysis, storage and retrieval.

PROPOSED ADAPTIVE WATERSHED MANAGEMENT MODEL

As a means of placing volunteer monitoring in a context of watershed management, an adaptive model was developed. This model proposes an approach to regional watershed management which bases continuous

adjustment of policy decisions on a sound scientific foundation of local inventories, assessment, and monitoring. It is not meant to supersede activities within any watershed in the Bay Area that are accomplishing locally derived management goals or effective resource protection policies. However, this model attempts to provide a general framework for citizens, agency personnel, scientists, technical experts, and policy makers which will help them initiate a dynamic process of environmental understanding. Successfully applied through a process of community consensus and thoughtful policy development, it is hoped that this model will support local and regional improvement of ecosystem condition.

It is clear also that an understanding of watershed functioning is necessary to realize the Comprehensive Conservation and Management Plan's (CCMP) goal of "restoring and monitoring the...integrity of shellfish, fish and wildlife and recreational activities in the estuary, and assuring that the designated uses of the estuary are protected." The basic physical and ecological processes which connect the estuary to the streams and upland habitats dictate that successful long-term management decisions need to take these processes into account.

In many parts of the San Francisco Estuary, major watersheds which drain to the Bay encompass diverse political, social, economic and ecological characteristics. These varied situations require that any acceptable model be capable of dealing with the wide range of possibilities within any particular watershed and must be capable of dynamic adaptations as these factors change. Many feedback loops and opportunities for adjustment need to built into this process.

The major components of the model and a diagrammatic representation are described below:

Public Concerns, Issues or Goals

In some cases, the communities within a particular watershed have defined resource issues which have caused the community to organize to bring about change. Typically, residents become aware of declines in "beneficial uses" of water or watersheds, such as water quality, fish and wildlife populations, the loss of outdoor recreational opportunities. Or they are concerned about issues such as flooding, ground water pollution or water supply. Less often, communities engage in a directed process of "visioning" watershed condition at some point in the future, setting interim goals and instituting policies to achieve their collective vision. Improved definition of these issues, and the development of operational solutions, will result in inventory and assessment.

Inventory / Assessment

Although communities may become aware of certain problems or desire a certain set of environmental conditions to exist, frequently much more

information is needed about current and past conditions before appropriate resource goals can be set. Information can be gathered from a variety of sources and displayed to the public, resource managers, and elected officials in a number of ways. Background data and biological inventories help to focus attention on specific issues, highlight cause-and-effect relationships, and educate the public that must support management decisions and policy adjustments.

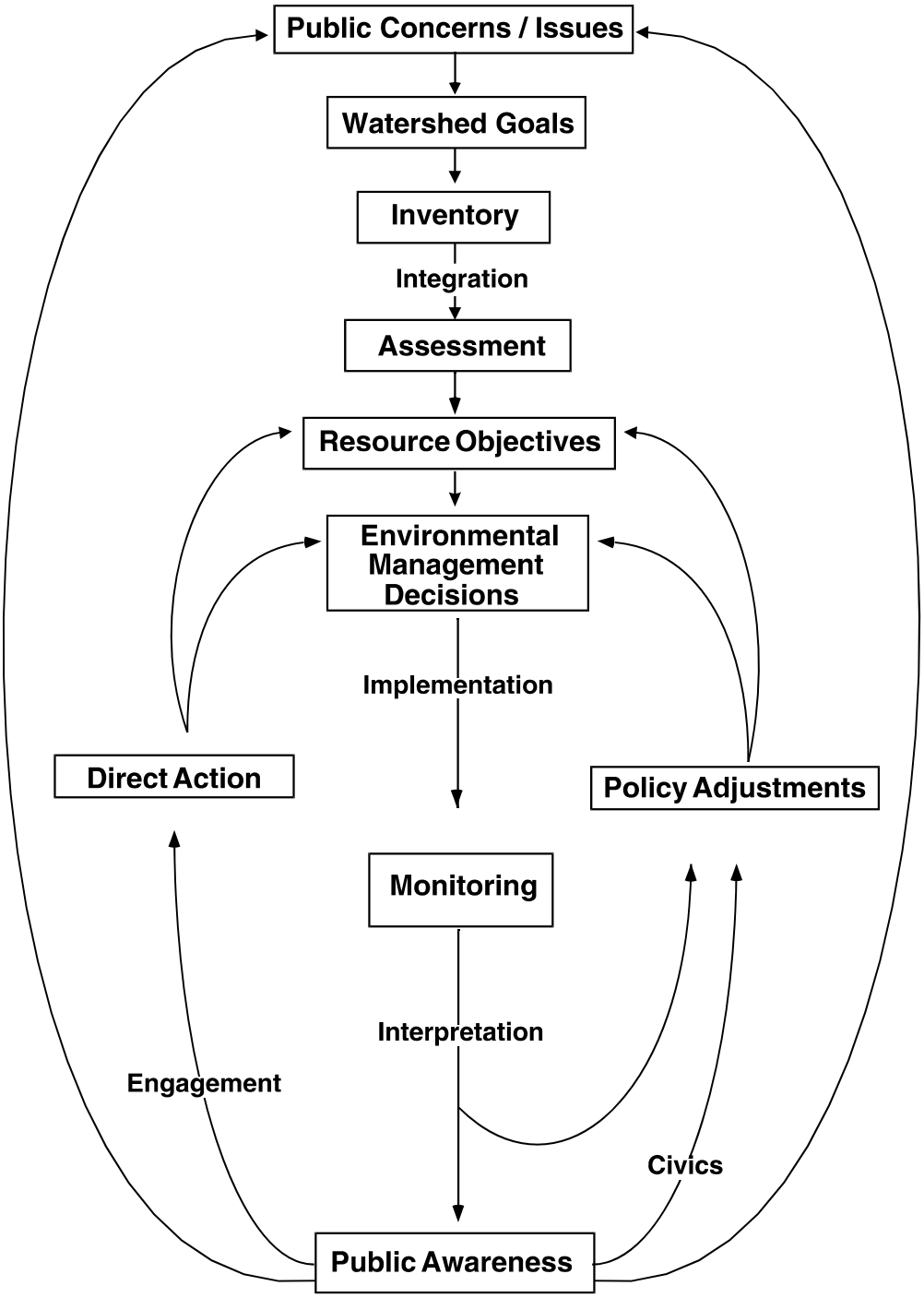
Integration

Integration means the use of the inventory results to identify, and perhaps quantify, the natural processes or human operations that control changes in local conditions.

Assessments

Assessments are based upon the integration of watershed inventories to understand the relative influences of natural processes and human operations on historical changes within the watershed. The result is a better understanding of how existing concerns and issues have evolved, a better public appreciation of the watershed approach to solutions for environmental problems, and a justifiable selection of environmental conditions that can and should be improved. Watershed assessments also provide estimates of the limits of what watershed management can achieve as solutions to the major concerns and issues.

Adaptive Watershed Management



Resource Objectives

Resource objectives are quantitative statements that describe what environmental conditions should be achieved and sustained by watershed management. The objectives should be broadly shared by the watershed residents, including the local government agencies. The most probable sources of risk that the objectives will not be achieved should also be identified.

Environmental Management Decisions

Environmental management decisions translate the resource objectives into specific activities or instruments that individually or together have a measurable influence on local watershed conditions, relative to the objectives, or that significantly affect the risk that the objectives will not be achieved. These decisions must be communicated effectively to the watersheds residents.

Implementation

Once management decisions have been made, they must be carried out to benefit the targeted resource. After proper consideration has been given to problems and their solutions, often, because of ineffective or non-existent implementation of good management decisions, resource values are declining further. Funding must be allocated and staffing levels must be sufficient to carry the best management decisions forward into action.

Monitoring

Monitoring is a scheme of successive inventories through time that describe changes in a watershed, including the ordinary diurnal, seasonal, or annual variations due to natural causes, and the effects of human operations. Monitoring begins with the initial inventory of present conditions. It continues indefinitely, with modifications to account for changes in public concerns and issues, and to reflect increases in scientific understanding. Watershed responses to management actions must be monitored to determine if the actions can achieve the resource objectives. Monitoring programs must be planned to yield information that directly addresses the topic of management efficacy. SFEI could play a major role in local and regional watershed monitoring, as outlined in the following section of this concept plan.

The resource objectives and the identified sources of risk that the objectives will not be achieved have special meanings in the context of monitoring. Each resource objective is a performance indicator for watershed management. The progress or regress of management is measured as the condition of the watershed relative to the resource objectives. The sources of risk are stressor indicators. They are monitored to forecast management problems and to help

account for success. Stressors can be natural or anthropogenic. Rainfall, channel form, predation, and disease are common natural stressors. Funding, staffing, engineering design, and policy conflicts are examples of anthropogenic stressors.

There will also be needs to monitor watershed conditions that do no necessarily pertain to the achievement of local resource objectives. Integration of local inventories will encourage the development of objectives for the region as a whole. These will be consistent, but not necessarily the same, as the resource objectives for local watersheds. For example, while a local objective might be to support a certain population of anadromous fish, a regional objective might be to complete comparable, initial inventories among all major watersheds in the region, or to achieve a certain percentage of local resource objectives.

Interpretation

At this position in the flow chart, interpretation means clear and accurate measures of progress or regress, relative to the resource objectives, based upon the monitoring results. The measures must be provided to all participants in watershed management, including the watershed residents. Effective communication of monitoring results is the key to community support and appropriate policy adjustments.

Public Awareness

Public awareness must be generally increased to achieve local or regional resource objectives. More public awareness is required for watershed residents to support watershed management. Most resource objectives will not be achievable without adjustments in the behavior of watershed residents, and the need for such adjustments must be clearly understood by the watershed residents. Increases in public awareness will improve the definition of public concerns and issues, causing them to be more consistent with the scientific understanding of the watershed, and in this way improve watershed management. It is therefore incumbent upon watershed managers to develop and maintain public awareness programs that engage the local community.

Civics

A successful public awareness program will challenge the community to become involved in the governmental process which must help guide and direct the attainment of resource goals. An environmentally aware public will be an instrument of ecological change through constructive participation in the government.

Policy Adjustment

Changes in public policy must initially be made in order to rectify the causes of

ecological health impairment or to bring about the community's watershed vision. Additionally, as the community gains more insight through monitoring and public awareness, changes in the course of watershed management will likely be necessary.

Feedback mechanisms at this point should foster changes in both the community's perception of appropriate resource goals and any necessary changes in environmental management strategies.

Engagement

Engagement means that watershed residents are personally involved in the watershed management decisions to help achieve the shared resource objectives.

Direct Action

Direct action by watershed residents will increase the social meaning of the resource objectives, and may be required to assure that the objectives are cost-effective. Direct actions can include staffing public awareness programs, participation in authorized ecological restoration projects, and volunteer monitoring. The latter type of direct action may be most important. The proposed model will involve more environmental monitoring than has previously been accomplished anywhere in California. Monitoring by trained volunteers that supplements professional monitoring may be the only way to meet the local, regional and state monitoring needs. Volunteer monitoring has the added benefit of connecting watershed residents to their home watersheds through the development of scientific information that serves as the foundation for watershed management. Direct action by watershed residents is therefore ethical, as well as practical, and may be a meaningful management objective.

CONCLUSIONS AND RECOMMENDATIONS

This review indicated that, due to the complexities of watershed management issues, a systematic approach will help to coordinate watershed stewardship activities by agencies and community organizations. We introduce a simple model that could be used as a road map to fill the gaps between general societal and agency goals, local and regional information needs for developing very specific resource goals (how much of what kind do we want where?) and scientific measurements of progress that will guide continuous adjustments in policy decisions. With more than 200 monitoring activities undertaken by those agencies and volunteer organizations that responded to the survey (SFEI 1996), the potential users of the information need to adopt a common structure or framework for insuring that the information is synthesized and evaluated on a regular basis.

The Regional Monitoring Strategy should be used in a process of checking detailed protocols against stated objectives for establishing baseline conditions, developing or adjusting regular monitoring programs, data management and program maintenance.

We recommend a process by which identified information needs are incorporated into a scientifically supported regional volunteer inventory, assessment, and monitoring network that may augment agency efforts.

Some scientific redundancy is useful as quality control and assurance. But overlaps in data collection activities should be identified and reduced to free-up human and funding resources for filling gaps

A thorough review of existing environmental indicators and development of new ones is recommended as part of inventory and monitoring program development.

CHALLENGES

Because of the diffuse nature of watershed management, with no single entity guiding policy adjustments based on the collection of scientific information, implementation of the Adaptive Watershed Management Model represents a major challenge. No amount of data collection will bring about management adjustments unless data recipients and end users have been identified, contacted, and brought into the process. Each set of watershed stakeholders will have to develop its own unique way of acting upon monitoring information.

RESOURCE GUIDE AND RECOMMENDED READING

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APPENDIX A •

• From USEPA 1996.