2 Planning Your Watershed Assessment

This chapter address the typical process for beginning your watershed assessment: a) pulling together the assessment team and b) developing a statement of purpose and a plan for the assessment. Assessing watersheds involves "art" as well as "science". The first part of this chapter reviews the art of working with people and their decisions. The remainder of the chapter reviews the process for developing a statement of purpose and the factors you should consider when laying out the plan for your watershed assessment.

Chapter Outline

Introduction

This chapter addresses the question of how to plan a watershed assessment. To summarize the process: the first step involves organizing the assessment team. Once the group is assembled, you need to define the issues of concern and develop a plan for the assessment. Some of the key parts of this plan include defining the purpose and the audience, defining the watershed processes or parts of the system which will be the focus of the assessment, identifying the scope of the assessment, developing a conceptual model of the watershed, and developing a plan for the actual analysis of the issues. The plan should contain information on what data will be collected, how it will be analyzed, and finally, how information will be synthesized into a single analysis to inform decision-making.

2.1 Organize the Assessment Team: Assessment Planning as a Group and With the Community

If a group functions well and builds successful community relations, it is more likely to produce a successful watershed assessment. Conversely, a dysfunctional group with inadequate public participation has a poor likelihood of producing an assessment with broad acceptance, as shown by evaluations of watershed groups and collaborative processes (Wondolleck et al., 2000, Huntington & Sommarstrom 2000). This section of chapter 2 will provide some suggestions on how to successfully organize your assessment team.

It is beyond the scope of this Manual to describe ways to structure and manage your group's organizational abilities. There is no single method that will work in every watershed. Useful books, manuals, and other tools to help your group include: Kaner 1996; Moote 1997; Sierra Nevada Alliance 1999; For Sake of the Salmon Web site (http://www.4sos.org); River Network Web site (http://www.rivernetwork.org); and Know Your Watershed (KYW) Web site (http://ctic.purdue.edu/KYW/KYW.html).

One increasingly popular approach to improving community and agency relations is the use of collaborative, multi-stakeholder watershed groups, also referred to as watershed partnerships.

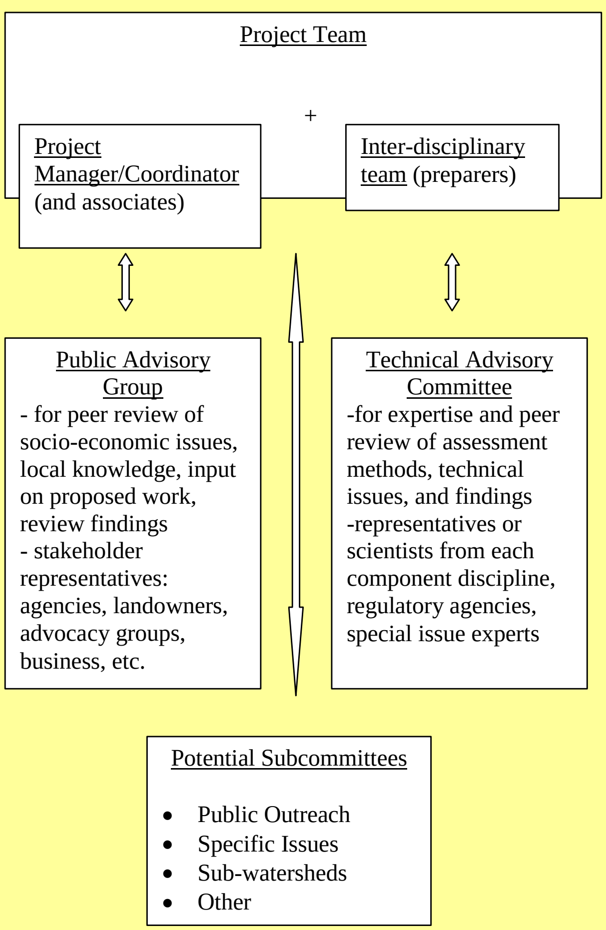
According to Know Your Watershed, common characteristics of a watershed partnership include:

- Broad range of stakeholders who make decisions
- Neutral coordinator respected by all with a stake

- Actions are voluntary; benefits are personal
- Strategies are specific to a watershed

This Manual does not assume that your watershed assessment group is such a partnership, but this approach may make your community involvement and ultimate acceptance of your product easier than alternative approaches (such as agency advisory committees, or a single stakeholder group) (Moote 1997; Huntington & Sommarstrom 2000; Wondolleck et al., 2000).

Sample Assessment Team and Committee Structure.
(adapted from: California Coastal Conservancy 2001; Coastal Watershed Council 2003)



2.1.1 Assemble the Team and Committees

No one has all the expertise required to do an assessment, not consultants, agencies, academics, or watershed groups. As a result, your assessment effort will need to draw on an assessment team.

Mixing Disciplines: Taking an interdisciplinary approach is a hallmark of the watershed assessment process. Accordingly, a good watershed assessment team should include members with a variety of disciplines or specialties. Because of the many physical, biological, and social connections that exist at a watershed scale, discussions, analyses, and interpretations across different specialties are often required to understand the cause and effect of a watershed problem. A specialist in fluvial geomorphology (the geologic study of the stream channel shape and evolution), for instance, may be able to perform a sediment budget, but collaboration with a fisheries biologist may be required in order to interpret the sediment's effect on fish habitat, with a civil engineer to interpret the effect on flooding, and with an long-time local resident to describe historical land uses that may have triggered increased sediment production.

Group Size: Keeping the assessment team and committees relatively small allows the group to make decisions in a timely fashion. Small for a group means from three to 12 members. The team can bring on additional support people for short-term efforts on an as-needed basis. In rural areas, finding sufficient qualified and interested people (agency, academic, or public) who are available to travel potentially long distances and attend many meetings will likely limit the number involved. In urban areas, the opposite may be true. In this case, having multiple, small committees may allow for increased participation by the higher number of interested and available people. The Santa Clara Basin Watershed Management Initiative (http://www.scbwmi.org) used this approach, for example.

Project Manager/Coordinator: This person provides administrative leadership and coordination for the process. Responsibilities may include:

- Assigning tasks;
- Contacting stakeholders;
- Coordinating the assessment components and team;
- Compiling and sharing existing data and information;
- Integrating results from individuals with different expertise;
- Setting the schedule and managing the team against it;
- Ensuring that the project stays within budget; and
- Achieving a satisfactory, completed product.

At a minimum, the Project Manager/Coordinator should possess good organizational and communication skills, project management experience, and training and experience in facilitation. A background in a natural resources-related field is very desirable. The Project Manager/Coordinator could be a staff person from the agency or organization conducting the assessment, or a consultant. In either case, before selecting the Project Manager/Coordinator, you should contact references provided by the potential hire/contractor, review the candidate's past work, and make expectations for the assessment job clear. If the Project Manager/Coordinator is an outside consultant, you must address several critical issues before developing a contract with that person (see 2.1.3).

Assessment Team: The Assessment Team includes the Project Manager/Coordinator, plus the people who will actually be developing the product. These may include your group's staff, private consultants, agency staff, community volunteers, scientists, college students, or a combination of such people. Each person's responsibilities may include one or more of the following:

- Helping focus the assessment on the important questions and issues;
- Deciding upon appropriate assessment methods;
- Compiling and evaluating existing data and information;
- Collecting and analyzing new data; using appropriate statistical design;
- Developing new maps, graphs, and other visual aids;
- Preparing a written draft section or sub-section of the assessment;
- Attending team meetings, working sessions, and public meetings;
- Reviewing and commenting on sections or sub-sections prepared by others; and
- Revising draft sections and completing the final product.

Assessment Team members should possess skills relevant to the technical requirements of their roles.

Technical Committee: Members of the Technical Committee may prepare and/or review the assessment, depending on how the committee is used. If committee members serve as peer reviewers of technical material prepared by the Assessment Team, then it may be appropriate to include experts from each relevant discipline, as well as representatives of regulatory or other agencies, funding sources, and special issue experts. Responsibilities for peer reviewers of technical issues may include:

- Attending committee meetings;
- Advising Assessment Team members,
- Advising on appropriate assessment approaches;
- Recommending and evaluating statistical methods; and
- Reviewing and commenting on specialty areas of the draft assessment.

Technical Team members should possess identifiable and respected expertise in the topics to be covered in the assessment.

Public Advisory Committee: One structural model has the Public Advisory Committee performing peer review of socio-economic issues only, while other models have it providing input on all matters (California Coastal Conservancy 2001; Coastal Watershed Council 2003). Members may be volunteer representatives of key local stakeholder groups (e.g., business, landowners, agencies, environmental groups, etc.) and/or at-large members of the public.

Responsibilities for Public Advisory Committee members may include:

- Sharing their knowledge of the watershed;
- Attending committee meetings;
- Learning about assessment methodologies;
- Reviewing and commenting on the assessment's draft findings;
- Helping with public outreach on the assessment; and
- Assisting with the next phase after the assessment is done.

Public Advisory Committee members should have local watershed knowledge and good communication abilities at the minimum. Being willing to serve as an unpaid volunteer and having the requisite time and patience for the process may be the most critical abilities to possess.

Special Subcommittees: In addition to the above committees, subcommittees may also be formed for special technical and public purposes. Subcommittees may address:

- Public outreach;

"Lessons Learned—Pilot Watershed Assessment Process" by the Santa Clara Basin Watershed Management Initiative

This very large, urban group in the San Jose area prepared a "Lessons Learned" report in February 2003 based on its experience with pilot watershed assessments, which began in September 2001. Comments came from its Watershed Assessment Subgroup (WAS), a stakeholder group composed of representatives from agencies, municipalities, and nonprofit groups, and from Watershed Captains, who are members of the WAS and who have specific expertise and knowledge of the pilot watersheds being assessed. WAS worked initially with its Watershed Assessment Consultant on data gathering and evaluation, then on reviewing the draft assessment.

Some of the procedural lessons may be unique to this group's experience, but the following lessons learned might also apply to other watershed assessment planning processes.

- Establish preliminary review points for working drafts of the assessment's chapters. Allow sufficient time to make changes in direction before it's too late.
- Once assessment steps begin, ensure that the same support staff and scientific experts are available for each meeting.
- Ensure that sufficient copies of all relevant materials are readily available to participants in all meetings.
- Make sure the experts, people with local knowledge, and the appropriate stakeholders are more involved in the review processes and meetings.
- Establish clear communication channels for inter-subgroup or team relations and coordination of work products.
- Have consultant offer feedback on issues brought up by commenters during the review process to make this phase move more efficiently and smoothly.
- Give more time for review and comment on completed draft documents.

For more information: HTUhttp://www.scbwmi.orgTUH

- Sub-watershed advisory;
- Specific issue or topic areas (e.g., water quality, fish habitat, flooding, groundwater, etc.);
- Monitoring and statistical analysis; and
- Report preparation.

Membership and skill level are linked to the subcommittee type, with skills ranging from the ability to translate technical reports to the public to the ability to generate these reports.

Interim Task Force: A short-term task force, either technical or public advisory in nature, may also be needed during the assessment process. It may contribute to a portion of the assessment and then disband before the assessment is completed. Members may come from existing committees or subcommittees, or they may be recruited only for this purpose. Examples of possible functions might be:

- Developing the assessment process (before the coordinator, teams, and committees begin);
- Collecting field data on selected parameters or certain locations;
- Working through a contentious topic;
- Developing new protocols, models, or methods as needed.
- Membership and skill level would be as appropriate for the task force's defined function.

2.1.2 Making Decisions

The above options for who coordinates, prepares, advises, and reviews the assessment lead to the inevitable question: Who makes the decisions? Is it all of the above, the Project Coordinator, the technical committee, the funder(s), an agency, or the entire watershed group? Make this determination very clearly at the beginning of the watershed assessment process. A group's by-laws or other rules may already state who has decision-making authority for its efforts, including an assessment. If the assessment is being done by an *ad hoc* or temporary group, the decision-making authority might not be as obvious. Sometimes public or stakeholder advisory committees have the impression (rightly or wrongly) that their recommendations are decisions rather than advice that can be taken or ignored. Without clarifying who makes what decisions and when during the assessment process, your watershed assessment may drag on unnecessarily, hit a dead-end, or not be accepted by important participants in the watershed community. How decisions can be made is discussed in section 2.4.2 below, which also addresses the various roles of possible decision-makers.

2.1.3 Contracting Analysis and Coordination Work

It is possible that your assessment team will consist of people in your watershed group. However, for many assessments, a consultant will be hired through a contracting process to do part of the work. This person could fill a management and coordination role, or be a technical analyst, or bring the information you have collected together in an integrated assessment. Whatever the consultant does, there are some things to consider when developing the relationship.

The assessment decision-makers (e.g., technical advisory group or contract managers) should decide as many of the main topics and questions for the assessment as possible before contracted work starts. Other parts of this Manual describe formulation of questions, identification of problems, and other types of conceptual work that the assessment decision-makers and stakeholder committees can do before contracting with consultants. One Bay Area watershed group spent more than $200,000 on consultant time before it had formulated its primary assessment questions. After the fact, the group decided that this expenditure had been a waste and that group members could have done the work without the consultant.

The role of analyst is an important one on the assessment team. Funding is limited for most assessments, so often you must decide which analyst positions are most critical.

The types of analysis required and the amount of money needed to fund analysis are tightly tied to the primary questions of your assessment. For example, in two cases in Southern California, assessment developers decided that the largest expenditure (one-third of total funds) was to be on various kinds of hydrological modeling because their projects revolved around local groundwater storage and improved water quality and conservation.

In a sprawling urban area, for example, the impact of stormwater runoff on local stream water quality, channel integrity, and endangered aquatic wildlife might dominate the assessment. In this case, you would want an understanding of the hydrology or hydraulics of the system (hydrologist), an assessment of riparian and aquatic habitat condition (ecologist or geomorphologist), surveys of plant and wildlife communities (botanist and/or wildlife biologist), someone knowledgeable about contaminants in stormwater (toxicologist), and someone or a group process to integrate the information to inform decision-making.

Once you have identified the scientific expertise of the analysts needed for the assessment, you will face the most challenging aspect of team creation: deciding who is qualified to carry out the work. Nonprofit organizations, water districts, and local agencies have described their selection of consultant analysts as an *ad hoc* process based exclusively on reputation. This approach tends to favor larger, more well-known public and private organizations, without necessarily reflecting the abilities of these organizations to deliver the products expected or desired.

To evaluate possible analysts, check with references provided by the contractor or agency for similar projects. References can give you a sense of whether the information provided by the analyst was relevant to the project or decision-making process, whether the consultant can meet desired timeframes and communicate the work to diverse audiences, and whether cost matches the work expected.

Evaluate past analyses and reports in which the analyst did an identifiable part of the work. This will help you decide if a past project is similar to the needs of your assessment. Look at research or other articles written by the analyst. If the technical or scientific communities are peer-reviewing the analyst's work and approving it for publication, then other experts have already done part of the reference checking for you.

After choosing possibilities for the Project Manager/Coordinator and analyst part of the team, you must establish a contract, which can range from a contract with an individual to agreements with academic institutions or agencies. One of the first questions in the contracting process is usually about cost. Individual or company consultants usually charge higher hourly rates than universities or agencies, but these consultants also cover costs that may be part of the overhead costs of the latter organizations. Universities also charge an overhead rate, usually called "indirect costs", but total rates are still usually lower than those of private consultants. Universities and agencies often have access to resources not available to individual consultants (e.g., software licenses and interns). Ask for the actual hourly rate for agencies and academics so you can accurately compare these rates with those of private consultants.

The actual work expected should be detailed and agreed to in a Scope of Work (SOW) document. The more explicit the SOW, the more likely the finished product will reflect the needs of the assessment. Once contracts are underway, the SOW can be amended if needed to reflect changes in expectations or new information. The SOW should lay out a series of tasks with an explanation of the work to be performed as part of each task, the deliverables for each task, the timeframe for the deliverables, the time the task will take, and the budget devoted to each task. The SOW should reflect expectations of both the consultant and the funder, the role the funder will play in reviewing and approving deliverables, and what happens when something important changes (e.g., a delay in funder review of deliverables). The SOW informs the development of a budget, which might include additional costs for administration, supplies, equipment, and travel.

The SOW, the budget, and the contract language together form the usual contracting package. You should not expect work to commence before the contract between the funder and the consultant is signed. Similarly, work after the contract has expired will only occur if the consultant agrees to continue working. If changes to deliverables are desired after the contract has expired, an extension or amendment to the contract should be generated. The extension or amendment may or may not provide for additional funding, depending on the consultant. Keep in mind that most consultants will move on from your assessment fairly quickly—any changes in work or deliverables should be made as soon as possible within the contract period.

2.1.4 Keep Costs Under Control

The cost of doing a watershed assessment can vary greatly, depending on the scope, scale, time, and use of paid consultants. A few groups have kept their costs low by using experts (agency staff and academics) who have contributed their time for free, as well as by receiving volunteer time from their members and the community. The Mattole Restoration Council in Humboldt County is a good example of this approach. Geologists from Redwood National Park trained council staff to evaluate erosion problems and sediment sources so that staff members could do their own assessments and also train others. In Oregon, the State's manual anticipated that most watershed assessments would be done at a fairly low cost by watershed council members themselves, including staff, community members, and technical members from local, state, tribal, and federal agencies. As more funding became available, consultants became more involved.

Minimizing scale, scope, time, and consultant use can reduce costs. However, each assessment effort has certain minimum built-in costs no matter what the scale: project management, public participation, data and information collection, analysis, report writing, and draft and final report publication. While perhaps tempting, using a per-acre cost of estimating an assessment budget is probably not realistic.

Costs of completed watershed assessments vary considerably. The California Bay-Delta Authority's (CALFED) Watershed Program has awarded grants in recent years (2001 & 2002) ranging from $96,700 to $771,000 for projects described as watershed assessments. State grants are often for a watershed assessment combined with a watershed management plan and some monitoring, so the separate assessment costs are difficult to determine. In the central coast, combined watershed assessment and watershed enhancement plans that include field-work performed by consultants generally average about $200,000-250,000 for a 40 square-mile (26,000-acre) watershed. (Kate Goodnight, Coastal Conservancy, personal communication) Some grant programs have set a ceiling on the maximum the agency will spend on its share of an assessment and/or plan.

In Oregon, assessments based on the state manual have ranged from about $600 to almost $400,000 for fifth-field watershed-level assessments (at 60,000-acre scale), with 90% costing less than $100,000 and consultant-prepared assessments at the higher end (Ken Bierly, Oregon Watershed Enhancement Board, personal communication).

2.1.5 Develop a Schedule

It's important to be realistic about how much time it takes to perform a watershed assessment, but estimating time required can be challenging. Experience has shown that simpler assessments performed in-house with sufficient expertise and information may take four to eight months, while more complicated assessments or assessments where the process was not under tight scheduling controls can take as long as 36 months.

Whether you are doing the assessment yourselves or having a consultant do it, you should establish a schedule of the different steps or milestones from beginning to end. Assign a due date to each step.

<u>Sample Milestones (adapted from California Coastal Conservancy 2001)</u>

- Start-up
- Initial project team meeting (define approach)
- Public meeting #1 (review issues, concerns)
- Technical Advisory Committee (TAC) meeting #1 (review strategy)
- Begin assessment
- TAC meeting #2 (mid-progress review)
- Draft assessment complete
- Review results—TAC and Public Advisory Committee
- Release revised draft to public
- Revise and deliver final assessment

The Santa Clara Basin Watershed Management Initiative had a slightly different experience than the example above. They began outlining a detailed assessment process in 1998, when the assessment was only in its "gestational phase"; looking back five years later, the group concluded that it was "much smarter" about the detailed steps necessary to complete an assessment by the time it began one in 2001. Instead of spending so much time at the beginning detailing the assessment process, the group felt it should have spent that time producing a simple assessment work-plan with work-product-specific trigger dates. When those dates were reached, the group could have developed an expanded action plan for the specific work product, adding more details as the group learned more about what it wants and needs in the assessment.

A key scheduling lesson from this group's experience (and others) is to allow more time for review and comment on completed draft documents. Without sufficient time for this phase, unnecessary frustration in the process and lack of trust in the product could result due to unresolved issues.

Common Causes of Failure in Watershed Restoration Efforts

(from: Williams, Wood & Dombeck (1997). Watershed Restoration: Principles and Practices, pp. 10-11.)

This list of common causes of watershed restoration failures also highlights the reasons for doing a good watershed assessment, and the critical elements that need to be included in your approach.

1. Failure to understand the ecological history of area,
2. Failure to look at proper scale (i.e., watershed scale),
3. Failure to treat root causes of degradation, instead of symptoms,
4. Failure to work with local communities and to solicit their support for project goals,
5. Failure to integrate ecological principles,
6. Failure to develop proper goals,
7. Failure to institutionalize commitments within local communities and agencies, and
8. Failure to monitor and adapt management accordingly.

2.1.6 Involve the Community

Those who will be making decisions using information in the assessment should be included, consulted, or at least considered when designing an assessment. From start to finish, the assessment should make clear how and why various steps were taken. This approach has the benefit of getting all-important buy-in—stakeholders and decision-makers are more likely to trust the assessment's conclusions if they understand the reasons various approaches were taken or they were involved in gathering data and information for each step.

Some watershed groups, such as collaborative, community-based partnerships and most Coordinated Resource Management Planning (CRMP) groups, have community participation built into their membership and their processes. Others may not. The committee-subcommittee structures discussed can formally incorporate members of the community into your assessment process. Data gathering is another means of public involvement—citizen volunteer monitoring efforts are a popular example of a hands-on contribution to an assessment. However, such volunteer work demands quality training, supervision, and scheduling for it to make a meaningful contribution to the assessment.

Two-way communication—listening and informing—is a goal of community involvement in the assessment. Informal outreach—telling the public about the assessment—can occur in a variety of relatively traditional ways: newsletters, Web sites, press releases, flyers, photographs for newspaper articles, videotape for television spots, speaker presentations, etc. Getting input from members of the public not already involved in the process can require somewhat different approaches. The traditional method is formal public meetings publicly noticed in the newspapers; getting a human-interest story in the newspaper is a better method. Designing public participation processes is an art as well as a science, and guides are available to help you (e.g., Beierle & Crayford 2002; River Network's Web site: http://www.rivernetwork.org).

Public workshops, where watershed assessors explain the assessment process and progress and informally solicit comments, can serve functions of both outreach and input. Targeting public awareness campaigns to groups representing people with a stake in the watershed's condition—farming, ranching, fishing, recreation, conservation, industry, business, governing entities—through all the means mentioned above may help increase awareness and feedback. Public involvement can and will be different at different watershed scales. It's easier to contact a high percentage of a small or rural watershed's residents and users than of large basins or population centers. On the other hand, media can broadcast well throughout metropolitan watersheds like the Sacramento River basin, San Francisco Bay watersheds, and the Los Angeles-San Gabriel Rivers basin.

Using the media to explain what a watershed assessment is, why people should be interested, and how they can best be involved may require you to tap the expertise of public relations specialists.

2.1.7 Record the Assessment Process

Effectively tracking the progress of the assessment process for your group, for your funders, and for the public is very important. The larger the scope and scale of your effort, the more critical this tracking becomes. Key questions to address for your recording efforts are:

- Who should be responsible for tracking?
- How should progress be recorded?
- When or how often should recording be done?
- Where should the records be maintained and accessed?
- What form should the records take?

Funding entities may have their own requirements for recording the progress of the assessment. The Coastal Conservancy recommends that groups require their consultants to prepare quarterly reports. According to the Conservancy, "These reports come in handy to keep funding agencies informed of progress and are also useful to provide to all interested parties, including your committees and the community."

Web sites have become a common form of accessible communication. Regular postings can be put online under your home page's Watershed Assessment heading. Postings could include:

- Assessment's purpose/focus/issues
- Assessment's framework or outline; map of assessment area
- Scope of work for the consultant and the assessment's budget
- Organization chart and members of assessment's team, committees, subcommittees, task forces; application for membership
- Identification of decision-makers and decision-making process
- Agendas and minutes of meetings; schedule of future meetings
- Quarterly progress reports
- Data and information sources being used for assessment
- Explanation of how and why various steps were taken
- Public outreach efforts: past and proposed
- Draft chapters as completed, or the full draft document
- Final assessment

Actions 2.1

- *Assemble assessment team and committees*
- *If necessary, develop contracts*
- *Keep an eye on cost and schedule*
- *Involve the community*
- *Record the process*

2.2 Define the Purpose and Scope of the Assessment and Develop a Plan for Conducting the Assessment

The next step in planning a watershed assessment is to agree on why one should be done. This effort spawns many questions: What purpose will it serve? What is going to happen with the assessment when it is done? Who wants the assessment to be done and why?

2.2.1 Identify the Questions and Issues of Concern

Watershed assessments may be motivated by one or more influences:

- to evaluate watershed conditions from a neutral perspective, i.e., with no prior assumptions;
- to address identified watershed issues or problems;
- to meet a particular purpose, e.g., identify conditions that need to be improved in order to increase drinking water quality;
- to meet a particular goal, such as educating the public about natural and human features of the entire ecosystem and assist in planning and decision-making.

For many assessments, one or more issue-based questions usually drive the process. A set of questions may be as generic and general as, "What is the condition of our watershed, and why is it that way?" More

"*Watershed councils have completed watershed assessments in most basins of the state, helping to assure that restoration dollars are invested wisely ... Watershed assessments completed by local citizens have significantly helped to identify key limiting factors present in individual watersheds and guide local restoration activities."*

"The Oregon Plan for Salmon and Watersheds: 2001-2003 Biennial Report", Oregon Watershed Enhancement Board, 2003, p. 42 & 54.

specific questions might be along the lines of, "Why did the salmon stop spawning in our stream? Why did the big flood come from such a small storm? Why can't we drink the stream water any more? Why does the stream now dry up in May when it used to flow until August?"

Questions based on observations and community concerns will direct the watershed assessment, which will in turn provide the basis for solving known problems. The term "problem" here means a potential or actual impact to the natural functioning of the watershed. If there are no fundamental questions guiding a watershed assessment, you may wish to reconsider the perceived need for the assessment. The questions should be stated clearly enough to capture the prevailing concerns that led to wanting or needing a watershed assessment. They should also open the door to the next step of defining watershed assessment approaches appropriate to the questions and specific protocols that can be used to assess particular conditions.

Watershed assessments are typically conducted when an opportunity for restoration or enhancement is recognized or in response to some commonly acknowledged problem relating to the local waterway or aquatic habitat. Such problems often relate to whether anything is perceived to be wrong or whether dramatic (and detrimental) changes have been measured with respect to streamflow, water quality, fish, or other aquatic organisms.

Often, the cause of a recognized problem is readily apparent: a new subdivision has resulted in loss of wetlands and change in local hydrology; a catastrophic wildfire removed 80% of the vegetation in the watershed and the stream's sediment load increased dramatically, a new reservoir was completed and most of the annual streamflow is diverted out of the watershed; etc. However, the causes of many other problems are not so obvious and may result from the cumulative effects of many localized disturbances. In cases where there is a dramatic water-related problem without an obvious cause, a watershed assessment may be useful in identifying the causative agents and may lead to possible solutions.
The problem(s) should drive the assessment. Again, any watershed assessment must have a reason for being conducted. This reason could be anything from meeting a narrow legal requirement (e.g., water quality standards in an agricultural area) to a very general "watershed condition" assessment.

Examples of five individual purpose statements for five different watershed assessments

"The purpose of the watershed assessment is to…"

A. Analyze conditions in the sub-watersheds of the basin and determine whether the waters of the basin are supportive of beneficial uses and community interests.
B. Integrate historical information with new assessment data to create a comprehensive steelhead restoration plan.
C. Educate the public about the human and natural features of the entire ecosystem, and assist planning and decision making.
D. Inform stakeholders about the human and natural features of the entire ecosystem and assist in identifying areas in which additional data are needed.
E. Gather and synthesize existing information on the historical and current environmental and land use conditions within the watershed.

As an exercise, decide how well each example answers the questions in 2.2.2. What could be changed to develop a "model" purpose statement?

2.2.2 Develop a Statement of Purpose

Watershed assessors should develop a clear purpose statement. A “fuzzy,” implied, or absent purpose statement that never gets clarified can lead to bigger and bigger problems (such as getting off target, or creating misunderstandings about different expectations of the product) as the assessment process continues. For this Manual, the term “purpose” is basically synonymous with “goal”. Questions (or parameters) to help focus your purpose statement are:

- What will occur during the assessment process? What will be assessed?
- What will the assessment product be used for?
- How does it lead toward managing (e.g., protecting, improving) the watershed? Will it make our effort in the watershed any better? If so, how?

People sometimes want to use a watershed assessment to measure “*watershed health*”. Watershed health is a subjective concept, however, and defining it precisely can be challenging. Most references talk about it without defining it. Here are two possible definitions that might help your effort:

- “An index or estimate of the degree to which the generation and transport of water and its constituents within a watershed function in a relatively natural manner [so as not to impair beneficial uses]”
- “An index or estimate of the natural functioning of the watershed relative to a reference or historic condition”

Balancing the needs of the community and governmental agencies.

It is important to clearly identify who really wants the watershed assessment, and why they want it. Otherwise, misunderstandings can occur. For example, the impetus may come from the local level—from a cooperative group (e.g., a watershed council), a local agency (e.g., a resource conservation or water district), or other private or public stakeholders—for a variety of reasons. On the other hand, the driving force often comes from the state or federal level as a requirement of a grant program or a regulation. For example, funding agencies may require that a watershed assessment be done as a condition of funding a watershed plan or restoration projects. Often, the agencies’ intent is to help target limited public funds to what is most likely to succeed in meeting agency goals and get the most bang for the buck. Members of a watershed group, however, might feel that their intimate knowledge of the watershed has allowed them to develop a good restoration project without any formal assessment work. They are concerned that an assessment will take years to complete, and they don’t want to wait that long, nor seek that much funding. Thus one of the challenges of whether and how to do an assessment then becomes how to balance the needs and perceptions of the agencies with those of the community. Fortunately, this balance can be met, but it will require successful meshing of various desires for the content and use of the assessment. The local group may do some research and find that watershed assessment doesn’t have to take a long time or be expensive. The more defined and widely supported the purpose of an assessment, the less time and money it will take to conduct. Successive assessments can be done, each focusing on another issue as other problems are identified, or as funding becomes available. An incremental approach is often the norm these days due to political and financial realities, and it can also be scientifically defensible. Funding agencies can find satisfaction in having a scientifically defensible basis for further watershed efforts. In the end, all parties can reach agreement and get what they need from the assessment.

2.2.2.1 Who Is the Intended Audience for the Assessment Product?

Identifying the target audience for the assessment is important both for refining the assessment's purpose and for developing and writing the assessment. Watershed assessors should agree to and clearly state the assessment's intended audience at the beginning of the process. In stating the audience, it may become apparent that the audience needs to be more diverse than originally envisioned. Initially, the audience might be perceived as only the advisory and decision-making bodies of a sponsoring agency or group. Then the general public might be added. However, those people who will be translating the assessment into action may need to also be a specific target audience. Otherwise, the product might not be very useful for implementation when completed. For example, state in the introduction that local restoration groups and landowners are intended audiences (and potential users) of a watershed assessment that is focused on identifying restoration opportunities. Then be sure that the assessment process involves your target and expanded audience and the product is useful to them.

2.2.2.2 How Might the Assessment Be Used?

Another factor to consider when developing a statement of purpose is to identify the potential uses for the assessment. Assessments generally serve to inform certain functions:

- General watershed planning with multiple purposes
- Regulatory concerns
- Restoration or enhancement planning
- Monitoring program development
- Management of risk areas and practices

You may want your assessment to serve all these functions, or just one or two of them. The more functions an assessment serves, the more complex it can become. The need to address many functions may reflect the complexity of the watershed, its problems, and possible solutions. As the assessor, you must show how the assessment can serve the functions you identify as important.

Assessments have been prepared for a variety of uses in California. For example, the North Coast Watershed Assessment Program (http://www.ncwap.ca.gov) provided a baseline assessment of conditions in certain watershed for use in restoration planning and implementation of existing regulations. This assessment was not intended to be used at the site or reach-specific scale, to result in new regulations, or to describe risk management.

An example of a focused landowner watershed assessment is that for the Upper Mokelumne River (Foster-Wheeler Environmental Corporation, 2002). In this case, the consultant analyzed certain existing conditions (e.g., road interactions with erodible soils) and ignored others (e.g., the relationship between riparian vegetation and temperature) to come up with a ranking for susceptibility of sub-watersheds to disturbance. This ranking was used to develop management recommendations for the development of timber harvest plans under the California Forest Practices Rules.

The Coastal Watershed Council (2003) developed the Aptos Creek Enhancement Plan, which contained a watershed assessment and was focused on salmonid restoration in the creek based on voluntary landowner participation (www.coastal-watershed.org).

Using the Assessment to Develop a Watershed Management Plan

Many local agencies and watershed groups choose to develop a watershed management plan (WMP) to guide a variety of different activities in a given watershed. WMPs are usually based on a previous watershed assessment, or one that is included in the watershed management plan itself. There are only general legal guidelines for the development and use of these plans, several of which are given below.

WMPs are different from watershed assessments. They represent the action corresponding to the evaluations in the watershed assessment. California Water Code Section 79078 provides one definition of a "local" watershed management plan:
"(c) '**Local watershed management plan**' means a document prepared by a local watershed group that sets forth a strategy to achieve an ecologically stable watershed, and that does all of the following:
(1) Defines the geographical boundaries of the watershed.
(2) Describes the natural resource conditions within the watershed.
(3) Describes measurable characteristics for water quality improvements.
(4) Describes methods for achieving and sustaining water quality improvements.
(5) Identifies any person, organization, or public agency that is responsible for implementing the methods described in paragraph (4).
(6) Provides milestones for implementing the methods described in paragraph (4).
(7) Describes a monitoring program designed to measure the effectiveness of the methods described in paragraph (4)."

The San Diego Regional Water Quality Control Board defines watershed management plan similarly:

"*Watershed management plan*—A planning document that presents solutions for addressing the water quality problems identified in the state of the watershed report for a single watershed management area or portion thereof. This document includes assessment results, specific management strategies and corresponding stakeholder roles for implementation to attain water quality goals."
The California Agency Watershed Management Strategic Plan (CalEPA and Resources Agency 2003) also defines "watershed management":

"Watershed Management"

- Effective watershed management results in successful projects that yield positive outcomes for the State's watersheds.
- Watershed management is a process for making decisions about activities that will affect the health of a watershed.
- The process is characterized by considerations of how actions in one location in a watershed will affect conditions in other parts of the watershed or other watersheds. This process uses open and transparent decision-making involving collaborations among interested parties by:
- Reliance on scientific description of conditions in the watershed and the application of scientific methods to develop decision support information and tools;
- And by a process of planning, implementation, assessment, and adaptive decision-making.
- The issues under consideration include ecological health (e.g., habitat, hydrologic function, and aquatic life), land use (e.g., commercial, industrial, agricultural, and residential uses), and resources use (e.g., recreation, water supply, water quality and flood control)."

Connecting Watershed Assessment With Watershed Management

Orange County has developed several watershed assessments embedded within watershed management planning processes. The plans focus on stormwater runoff, water quality, and restoration of channel and riparian function. The Aliso Creek Watershed Management Plan (http://www.ocwatersheds.com/watersheds/alisocreek_watershed_management_toc.asp) summarizes watershed conditions and lists specific actions that could be taken in certain reaches to improve functioning. The assessment findings and management actions are not always linked, but the plan's structure and layout make it easy for the reader to make the connections.

To encourage implementation of effective management actions, a watershed assessment that will inform watershed management planning should include the following components:

- o Obvious connections between individual assessment findings and potential WMP elements. Example: Analysis of erosion potential in connection with road construction and maintenance practices.
- o Specific findings for geographic sub-areas within the assessment area for individual impacts or cumulative effects of disturbances. Example: "The impervious surface area for Urban Creek is very high relative to standards for stormwater runoff management."
- o Assessment of processes at scales appropriate for the scales at which decisions are made. Example: Waterway effects of licensed water management occur on hourly to centuries-long timeframes, so multiple timeframes during hydroelectric project analysis are important for licenses with fixed time periods.

Using the Assessment to Support Regulatory Requirements

Some regulatory processes require or potentially require watershed assessments (see examples in Table 2.1). Under the federal Clean Water Act, for example, states must identify impaired water bodies and begin describing "total maximum daily loads" (TMDLs) (http://www.epa.gov/region09/water/tmdl/) for pollutants causing the impairment. Establishing TMDLs requires that Regional Boards in California analyze pollutant loads entering waterbodies on a watershed scale. The state must declare the maximum load allowed, and apportion the allowable load to polluters and dischargers within the watershed. A good TMDL will be based on a watershed-scale assessment of pollution sources and resemble a watershed assessment.

The State of Washington developed its watershed assessment manual (Washington Department of Natural Resources, 1997) explicitly to deal with the impacts of logging activities on anadromous fish. The manual describes how to assess watershed conditions in forested areas and how those conditions might influence salmon spawning and rearing habitat. The State of California has not yet adopted this approach. California's Forest Practice Rules (FPRs) require watershed assessment for long-term, large-scale management plans for logging operations on private lands. These assessments are usually focused on habitat concerns for endangered salmonids in waterways affected by the operations.

Typically, the analyses are restricted to those parts of watershed functioning where impacts are known to limit salmon spawning and rearing habitat (e.g., riparian retention and erosion risk). Examples of these types of assessments include the Pacific Lumber Company's watershed assessments for creeks on its property in the redwood forest of coastal Northern California, the upper Mokelumne River assessment for Sierra Pacific Industries lands (Foster-Wheeler Environmental corporation, 2000), and the Albion River watershed assessment for the Mendocino Redwood Company's holding in this basin (Mendocino Redwood Company 1999).

Sustained yield plans (SYPs) are a mechanism used by the state to regulate logging activities on private lands. The Forest Practice Rules state that SYPs are "a means for addressing long-term issues of sustained timber production, and cumulative effects analysis, which includes issues of fish and wildlife and watershed impacts on a large landscape basis" (Article 6.75, FPR; http://www.fire.ca.gov/ResourceManagement/doc/FPR200301.doc). The SYP must define a "watershed assessment area" and the

Table 2.1 Examples of potentially-regulated impacts of land and water uses

General Land/Water Use	Regulatory Issue or Stressor
Agriculture	
Row-crop	Ground and surface water quality impacts, ground and surface water diversion and use
Orchard/vineyard	Ground and surface water quality impacts, ground and surface water diversion and use, woodland habitat loss
Grazing	Surface water quality, riparian vegetation loss, woodland regeneration
Housing development	Ground and surface water diversion and use
Road system	Habitat fragmentation, stream channel alteration, erosion, stormwater runoff
Ownership	Fragmentation of responsibility/accountability and stewardship
Wastewater	Surface and ground water quality impacts
Logging	
Road system	Habitat fragmentation, stream channel alteration, erosion, stormwater runoff
Vegetation removal	Erosion, stormwater runoff, nutrient cycling impacts, habitat loss and fragmentation, stream channel alteration, herbicide applications
Mining	
Hard-rock	Changes to local sub-surface hydrology, mine pollutant drainage
Hydraulic	Excessive sediment contribution to streams, pollutant drainage (e.g., mercury), Changes to local surface and sub-surface hydrology
Gravel	Depletion of gravel from stream beds and floodplains, disturbance of benthic and riparian/floodplain habitat
Water Diversion & Storage	
Dams	Block migration of aquatic organisms, interrupt natural flow regimes
Reservoirs	Change water chemistry, trap sediment heading toward lower reaches, harbor lake-dwelling fish predatory on young of river fish
Pumps	Mortality for un-screened fish
Canals	Removal of riparian vegetation, flow regimes intended for irrigation needs not aquatic life

"assessment shall include an analysis of potentially significant adverse impacts, including cumulative impacts, of the planned operations and other projects, on water quality, fisheries, and aquatic wildlife." The Board of Forestry has included some detail on how the assessment under the SYP must be conducted. For example, one required data type is a "map of existing roads and approximate location and miles of proposed new, reconstructed, and abandoned roads." However, there are no prescribed analysis methods.

Using the Assessment for Restoration and Enhancement Planning

While not all watershed assessments are intended to inform restoration planning, it is a common goal of most watershed partnerships. Restoration is defined here as the renewal of a natural process (e.g., natural fire regimes) or feature (e.g., native fish species) through human actions. These actions could include changing permitted land or water uses (e.g., developing on steep slopes or diverting a majority of flow), restoring natural features (e.g., willow or gravel), or removing structures that are suspected or known to cause damage (e.g., roads or diversion dams).

The term "restoration" has been used to define numerous management strategies, from removing constraints, such as dams, and breaching levees to planting native riparian trees, but most river managers and scientists agree that fully restoring watersheds to their pre-disturbance conditions will be extremely difficult, if not impossible. For this reason, it is essential to define what is meant by restoration. Restoration science currently uses a definition such as "a return to sustainable processes," while terms such as "enhancement" are used for beneficial actions, such as replacing exotic vegetation with native species, planting vegetation to stabilize an eroding area, or placing spawning gravel in a river where gravel supply is limited by upstream dams. "Bioengineering" or "eco-engineering" describes actions that include erosion control or channel bank stabilization using hard structures that incorporate vegetation. Other terms often used to describe sustainable beneficial actions in watersheds include rehabilitation, naturalization, or recovery.

The ideal situation is for restoration planning to take place in the context of watershed assessment for the upslope and in-stream area surrounding the proposed restoration site. Taking a watershed approach to restoration planning is essential in order to determine how upstream or downstream processes and land uses may affect the restoration area. If the restoration is focused on an area of a hill-slope or a reach of a river, the essential unit for assessment and planning is the watershed. For this reason, watershed assessment can support subsequent decision making about where, when, and how to restore natural processes at specific sites or in larger areas (e.g., sub-watersheds) to benefit native wildlife. It can also inform decisions about how to monitor the effectiveness of the restoration action and how to maintain the action over time.

Some watershed assessments make explicit connections between the analysis of existing (or historical) conditions and specific actions that could be taken to restore natural functioning. Conducting the watershed assessment as if you are planning future restoration projects will help connect components of the watershed assessment and the restoration plan. For example, if your assessments suggests that road construction is resulting in multiple risks to natural functioning (e.g., weed invasion and increased erosion), then restoration actions could consist of modifying existing roads to accommodate natural processes, or changing how and where new roads are constructed. The Mattole Restoration Council, for example, identified excessive sediment from roads on private lands as a critical limiting factor for salmon reproduction. It established the "Good Roads, Clear Creeks" program, where sub-watershed and parcel assessments are used to prioritize road fixing or removal projects (http://www.mattole.org/program_services/grcc.html). The council does this in collaboration with landowners and reports a high level of success with owners of small to medium parcels (Chris Larson, personal communication).

Using the Assessment to Support Monitoring Programs

Watershed assessments are closely tied to past and current monitoring in watersheds. The assessor relies on data and conclusions drawn from monitoring programs to analyze watershed processes and conditions. In turn, the assessment can form the basis for developing or updating monitoring programs. This iterative process is part of an adaptive management and assessment approach that incorporates new information as it becomes available in order to make decisions. One important caveat is that monitoring information can lead in rare cases to regulatory action, which the assessor/monitoring team should explain to the stakeholders involved.

From the watershed assessment point of view, it's important to find areas in the watershed that might impact waterway condition (e.g., water quality). These areas will include both human-created and natural features that have the potential or are known to be releasing material into a waterway or otherwise influencing in-stream processes. At one end of the impact spectrum might be ridgeline roads that connect to streams through impacts to hillslope geomorphology or pollutant runoff. At the other end of the spectrum might be riparian developments (e.g., in urban settings) that have direct connections to channels and dominate the relationships between watershed hillslopes and waterways.

Watershed assessments or other inventories of disturbance could reveal that certain human activities are particularly concentrated in an assessment area's sub-watersheds. This could help focus monitoring efforts in these areas. Human activities that may impact water quality include housing developments, abandoned or current mining, agricultural operations, roads, and logging. Pollutant monitoring could take place downstream of the potentially impacted area within the sub-watershed (see Figure 2.1), and, for comparison, in nearby un-impacted sub-watersheds and upstream of the area of concern. In addition, monitoring sites could be placed on the main-stem river above and below the confluence with the waterway originating from the area of concern to measure the actual impact of the disturbance on the river. The data resulting from this combination of monitoring sites will provide information about the types and extent of impacts the site is causing on nearby waterways.

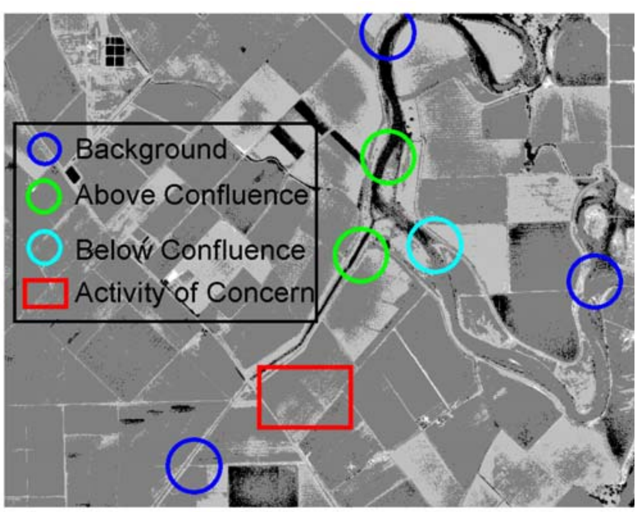


Figure 2.1 Possible locations of monitoring sites

Ultimately, the watershed assessment should serve in part to inform monitoring programs by revealing potential and actual impacts of human and natural processes in the watershed. Water quality monitoring is a form of continuing assessment of one watershed condition, and is one way to measure the effectiveness of protective actions taken on the landscape.

Other aspects of watershed monitoring may also tie into the assessment. These monitoring efforts include measuring and evaluating variables that can change over time, such as streamflow, aquatic organisms, channel conditions, riparian vegetation, water use, and upland vegetation. It is important to identify the type of monitoring (past, current, and proposed) because each type has a different purpose (baseline, trend, effectiveness, implementation, project, and compliance) (MacDonald 1991).

Using the Assessment as a Risk Management Tool

Risk assessment is a relatively new analytical field intended to support decision making in the absence of a complete understanding of a system. It usually employs analytical approaches in combination with "deliberative" approaches, which are linked to value judgments (National Research Council, 1996). The U.S. EPA has developed a framework under which large-scale "cumulative risk assessments" are done for multiple "stressors" (sources of stress to a system). Under this framework, cumulative risk assessment is defined as "an analysis, characterization, and possible quantification of the combined risks to health or the environment from multiple agents or stressors." (U.S. Environmental Protection Agency, 2003). This approach is similar in concept to watershed assessments, and the two approaches could act in concert (see later in this chapter and chapter 6 for more detail). The difference lies partly in the terminology, as many aspects of risk assessment can be found in watershed assessment. There is also a difference in substance – watershed assessment is often about actual impacts to condition, whereas risk assessment often stops at potential impacts. To the degree a watershed assessment estimates the potential for or actual harm caused by various human activities and the resultant stressors, it is quite similar to risk assessment.
A sub-category of cumulative risk assessment is ecological risk assessment, which is defined as a process that involves consideration of the aggregate ecological risk to a target entity (such as aquatic biota) caused by the accumulation of risk from multiple stressors (U.S. Environmental Protection Agency, 1998). One outcome of risk assessment is exposing uncertainty and data gaps that were found in the analysis phase and presenting recommendations for dealing with them. The final step in the risk assessment process is risk characterization, where "the information from all the steps is integrated and an overall conclusion about risk is developed that is complete, informative, and useful for decision-makers" (U.S. EPA 2003; CWAM chapter 6). An excellent tutorial on watershed risk assessment is available online at http://www.epa.gov/watertrain.

The connection between risk assessment and watershed assessment is that doing watershed assessment may involve analyzing risk to individual processes or features in the watershed as a result of human actions, or analyzing the cumulative risk of various actions on various watershed features or processes. A watershed assessment that includes risk analysis, and especially cumulative risk assessment, can then inform management activities intended to manage risk from human actions. It is not essential that risk assessment and management be part of watershed assessment. However, these concepts are often part of people's picture of watershed assessment because managing risk influences many areas of applied environmental science.

Actions 2.2
- *Describe the purpose of the assessment*
- *Identify the issues and questions*
- *Describe the intended audience*
- *Describe the eventual use of the assessment (e.g., restoration, regulation)*

2.3 Basic Watershed Assessment Process

The following sections address the question of: "How do I design the assessment?". To summarize the process, the first step is to get a basic picture of the watershed, what we call an *initial scoping*. This includes clarifying the assessment's purposes, identifying the focus of the assessment, and developing a conceptual model or diagram that reflects the relationships of key factors and processes in the watershed. Next comes the task of collecting and *analyzing existing and new information* and data. The final step is the *information integration* phase in which all the information is assembled in some systematic fashion to see what it means.

2.3.1 Phase 1: Initial Scoping - Defining the Biological, Spatial, and Temporal Scope of the Watershed Assessment

We suggest that you begin with an initial assessment or scoping of your watershed. Defining the scope of the assessment involves identifying the breadth of your efforts. What temporal and spatial scale will you select? This involves identifying the boundaries of your watershed and determining time period over which data will be collected; both existing data and future collection efforts. Like most parts of the assessment, you will likely revise your initial estimate based on the availability of data and other factors. Nonetheless, it is valuable to identify the scope of the assessment before beginning so you have some sense how much time and effort might be involved. This initial assessment will help organize your team and your approach, show what might be gained from a more detailed assessment, and provide some clues about which parts of a more thorough assessment will be relatively easy to perform and which parts will be more difficult. Taking an iterative approach to assessing a watershed is usually an efficient use of personnel, consultants, and finances.

Guidelines for Choosing a Starting Place

Getting started with a watershed assessment assumes there is something already going on in the watershed. Sometimes an appropriate sponsoring group for the assessment does not already exist or may not be apparent. An example from the Bay Area offers a way to look at the spectrum from “good” to “best” in opportunities for choosing the appropriate group as a “starting place” for a watershed assessment.

The starting place should help reduce the cost of getting started. The following conditions suggest the suitability of a starting place. The upper two sets of conditions, dealing with local, non-governmental interest groups and volunteers, are probably the most important for reducing costs.

Good	**Better**	**Better**	**Best**
There is a local interest group	that includes all pertinent local agencies	and non-governmental organizations	and wants science support.
There is a local volunteer monitoring organization	that focuses on watershed health care	and has strong links to public education	and pertinent local agencies.
There is a local legacy of environmental studies	that includes a written natural history	and the history of fire and flooding	and the history of land use.

“Bay Area Watersheds Science Approach”*, San Francisco Estuary Institute (1998)*

In most cases, it is not obvious at the outset how deeply your assessment must delve into a particular problem. You must first learn some basics about the problem before deciding how and how hard to tackle that problem. For some problems, a well-considered experimental design, a prolonged period of data collection, and rigorous hypothesis testing may be necessary. In other cases, existing data and earlier analyses may offer a perfectly adequate answer for your purposes. The appropriate level of detail for different parts of your assessment will depend on the tradeoffs between the level of confidence you want and the effort required to obtain that level.

An initial scoping serves as the foundation on which all further work is built. In some cases, especially for watersheds where little information is available, the watershed assessment might consist only of this phase. This initial assessment or problem definition phase involves identifying your purpose, developing a basic picture of the watershed, identifying the valued watershed resources and processes about which you are most concerned, and building a conceptual diagram or "a descriptive picture" of the relationships between key factors within the watershed.

2.3.1.1 Defining the Boundaries of the Watershed

Establishing the boundaries of your watershed assessment area is a critical early step. The only watersheds defined by nature are those with a low point at the ocean or a closed-basin lake. All others (including those contained within a "naturally-defined" watershed) are defined by a human choice of the lowest point (e.g., the map of the Yuba River basin in Figure 2.2). Not all watershed boundaries are obvious, and decisions about boundaries and other related issues will have to be made early in your assessment process. Choosing the size or "scale" of the watershed will determine where to pick the lowest point that defines the entire watershed and vice-versa. Some watershed studies start at a point in the middle of the river, such as at a dam or a stream-gaging station, and evaluate the watershed above this site. Agreeing on the assessment area at the outset so that everyone knows exactly what piece of ground is under discussion can head off many problems and arguments.

In determining your assessment area, consider only watershed boundaries—the perimeter of the area in which water drains to some arbitrarily defined point. Do not confuse your watershed boundary with county lines, property boundaries, rivers, highways, fences, vegetation-type edges, federal reserves, or any other non-watershed boundary.

The availability of information used in an assessment may vary across property-ownership or political lines, but you should still think about all parts of your topographically defined watershed. Although information may be hard to obtain (or simply doesn't exist) for some areas of your watershed, these areas may still play important roles in influencing the downstream water bodies.

2.3.1.2 What Is the Watershed Boundary?

Choosing a point along a stream or river that then defines the lowest point or downstream end of your watershed is the sole decision that defines a watershed. Once you choose that point, everything upstream of it becomes your watershed. Your watershed includes all land that drains downhill (or could contribute water via gravity) to the point of your choosing. Imagine there is a line extending uphill away from your point along the stream on either side of which water flowing downslope will reach the stream above or below your point. This line may be hard to visualize or accurately map (and the exact location isn't important for your assessment because errors of a few feet are insignificant with respect to your entire watershed), but there is a physical micro-topographic divide (or underground geologic structure, sometimes termed the phreatic divide) that separates water to one direction or the other

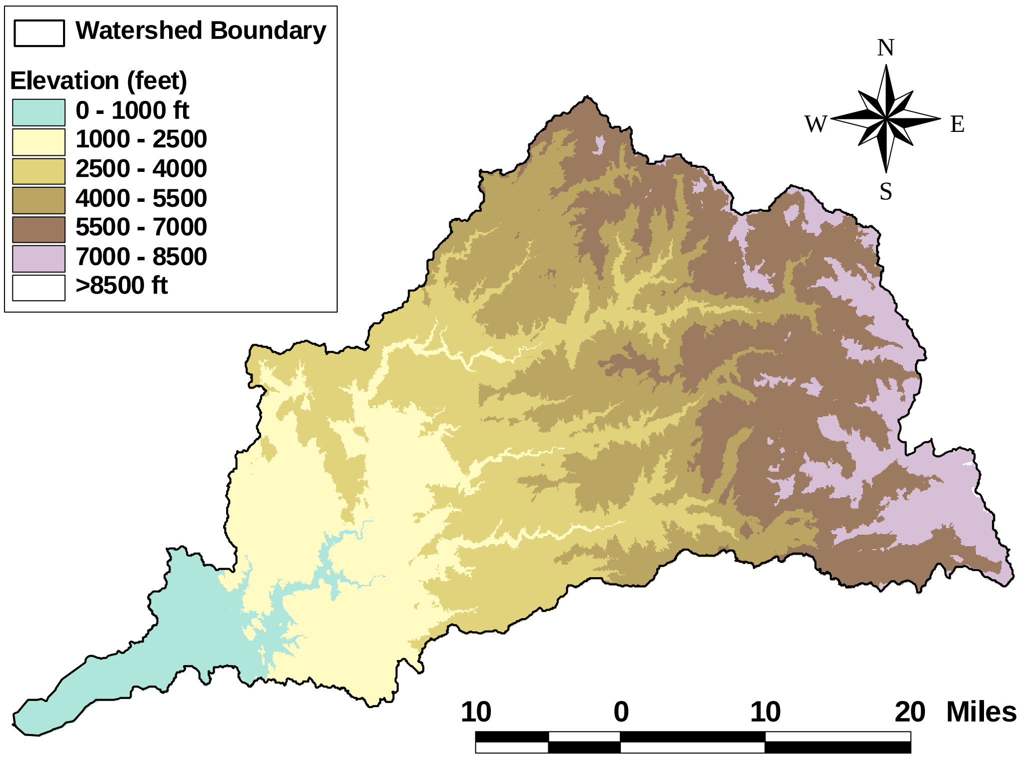


Figure 2.2 Map of the Yuba River watershed from the confluence with the Feather River

with respect to your point on the stream. This line will eventually reach a ridgetop, where it becomes obvious that water will flow either into or away from your watershed—imagine the Continental Divide where water on the west side flows toward the Pacific Ocean and water on the east side flows toward the Atlantic Ocean. The same concept of a divide scales down to the smallest watershed you care to define with your chosen point.

For mapping purposes, locate your point on a topographic map and draw a line away from your point separating the area inside your watershed from that outside. Following along the obvious ridgetop is generally easy, while connecting the ridgetop to your point along the stream may not be so easy if the topography has little relief. See *Water: A Primer* (Leopold 1974) or *Watershed Hydrology* (Black 1996) for more details on drawing watershed boundaries. Alternatively, almost all common GIS packages have a simple function for drawing watershed boundaries given the defining point on the stream.

Obviously, delineating watershed boundaries is much easier in steep terrain with lots of relief than in low-lying, nearly level areas. Prominent ridges make the process very obvious and straightforward. Conversely, defining a watershed boundary in flat areas with all the topographic relief of the Sacramento-San Joaquin River Delta is nearly impossible. In flat areas such as the Delta, having an uncertain boundary is probably adequate for most purposes (imagine using a very broad crayon to mark the divide on your map).

Another complication is the presence of engineered water imports and exports. Aqueducts, canals, penstocks, storm drains, and pipelines can interfere with the otherwise-clean delineation of a watershed. In such cases, start with the natural, topographically defined boundaries. Then consider the effects of the water diversions and append those considerations to the natural watershed. For example, if 100% of a neighboring watershed's flow is captured and diverted into your watershed, then you may wish to add the entire area of that other watershed to yours. If only a small fraction of the flow is imported into your watershed, then you probably don't want to adjust watershed area, but will instead deal with the imported water just as quantity of water (and its constituents) added from outside. In the case of water exports out of your watershed, you should usually maintain the natural watershed area and consider the impacts of the diversion on aquatic resources.

So, how do you choose this all-important point to define the watershed boundary? That depends largely on the objectives of your assessment and the general area in which you are interested. Common points to pick are the mouth of a stream at an ocean or lake, the confluence of a stream of interest with another stream or a much larger river, a point immediately upstream of a major water diversion, a stream-gaging station where flows have been measured for several years or decades, or a location where water quality samples have been consistently obtained. Sometimes, another entity (e.g., a funding agency) will pick the point for you. Also consider using the state's CalWater system of delineated watersheds if your watershed approximates one of the CalWater watersheds. Be aware that topographic and hydrologic errors exist in some of the watersheds in CalWater 2.2 and that there may be seemingly odd distinctions between "upper" and "lower" watersheds. Another source of information for defining watershed boundaries is the US Geological Survey. Each hydrologic unit in the U.S. is identified by a unique hydrological unit code (HUC) consisting of two to eight digits based on the four levels of classification in the hydrologic unit system. You can get additional information about this system at http://water.usgs.gov/GIS/huc.html. Selecting the watershed boundaries is also influenced by the objectives of the assessment. You may wish to define watershed boundaries broadly or narrowly. For example, if you wish to study the effect of local land-use changes, you may wish to assess several small watersheds where these changes will have a more noticeable impact on the local stream (simply because they occupy a greater proportion of the watershed area). If you are primarily interested in broad regional issues, you may wish to assess a single large watershed or river basin where impacts from small disturbances tend to be diluted.

Your watershed will be part of one or more ecoregions—a term defined as "major ecosystems largely determined by climatic conditions that affect the distribution of plant and animal species" (Bailey 1995). Ecoregion classification systems, such as those of Bailey (1995) and Omernik (1995), distinguish areas based on terrain, climate, and major vegetation cover. Although ecoregions rarely correspond to watersheds, the finer-scale ecoregion characterizations provide much information about vegetation and other influential factors, as well as attributes of aquatic habitats that should be useful in your watershed assessment (Omernik & Bailey 1997). Keep watershed boundaries in mind as you seek ecological information from larger-scale ecoregions.

2.3.1.3 Identify the Watershed Processes and Valued Ecological Components to Focus on

Once you have defined the purpose(s) of the assessment and geographically defined the area of assessment, you can apply this information to identify the processes and components of the watershed that reflect the purpose and goals of the assessment. This involves identifying the watershed processes or components are most important to the stakeholders. Watershed processes refers to the natural physical, chemical, or biological

Table 2.1 Examples of ecosystem endpoints

Watershed Assessment Purposes	**Ecosystem Endpoints**
Determine sustainability of native fish population in the stream	Reproducing steelhead population
Determine ecological requirements of riparian vegetation to aid in long-term management.	Viable population and condition of cottonwood trees
Determine availability of recreational lands	Amount of and accessibility to urban parks
Determine impacts to creek in the face of rapid urbanization	Species composition, diversity, and organization of fish and benthic macroinvertebrate communities

processes that interact to form the terrestrial and aquatic ecosystems, such as the water cycle. “Valued ecosystem components” refers to the things within the watershed that stakeholders value, such as fish, trees, or open space. Some watershed scientists have used the term ‘*ecological endpoints*’ to refer to any ecological components or processes that are the focus of the assessment. We will use that generic term or the related term “ecosystem endpoint” in this Manual.

There are numerous valued components and processes in a watershed. You could spend forever studying them. By identifying a few that are especially important, you can focus your efforts and simplify the assessment. A few criteria are useful for selecting the ecosystem processes that will be the focus of the assessment.
These should be:

- Important to the health and sustainability of the watershed;
- Related to the assessment’s purposes;
- Have societal value; in other words, are important to the community

These ecosystem endpoints might include, for example, benthic macroinvertebrate communities, drinkable water, a species of fish or a plant that is important to the stakeholders, or, more generally, the overall riparian corridor or upland habitats. Table 2.1 presents some possible purposes for conducting a watershed assessment and related ecosystem endpoints.

Often it is difficult to measure these endpoints directly. For example, quantifying steelhead reproduction is a challenging task. So a series of measurements or monitoring data can be substituted that reflect the condition or status of the endpoints that are the focus of the assessment.

In one of the examples in Table 2.1, stakeholders believed the population of native fish was declining, which prompted their watershed assessment. Because steelhead was among the most visible native fish in the stream and is a listed species, it was selected as the ecological endpoint. However, due to the difficulty of accurately measuring the steelhead population itself, the stakeholders selected a number of other measurements that were relatively easy to collect that would serve as indicators or surrogate measurements of the steelhead population (Table 2.2). Without the appropriate habitat and water quality conditions, it is unlikely a viable population of fish could persist. Measurements of stream morphology or water quality, for example, serve as useful indicators because they reflect the conditions in the stream that are needed to support a viable population of steelhead AND are relatively easy to measure.

2.3.1.4 Develop a Conceptual Model

One of the last preliminary yet very important steps in the scoping process is the development of a conceptual model. A conceptual model is a graphical

Table 2.2 Examples of relevant metrics for different ecological endpoints

Purpose	Ecosystem Endpoint(s)	Measurement or Data to be Collected
Determine sustainability of native fish population in the stream	Reproducing steelhead population	Water temperature Habitat suitability Contaminant concentration, etc.
Determine impacts to warm-water habitat in creek in the face of rapid urbanization	Species composition, diversity, and organization of fish and benthic macroinvertebrate communities	-Index of Biotic Integrity (composed of 12 attributes) - Invertebrate community index (based on 10 measurements)

representation of important relationships within the watershed. Once you have identified the ecological values you are most interested in, you will need to think about how they are impacted by changes in watershed processes and the stress that may result from human activities. The relationships among human activities, watershed processes, sources of stress ("stressors"), and the ecological endpoints are depicted in the conceptual model. The term stressor refers to anything, natural or human-induced, that could cause harm to components and processes within the watershed. Watershed assessments typically focus on those stressors that are human-induced, since they are the ones we have some ability to control. The specific interactions will be unique to your watershed, though experts and technical and scientific literature can provide you with many of the clues you need to understand the interactions. At this point, you should not draw conclusions as to what the relationships are; you should think about what they could be.

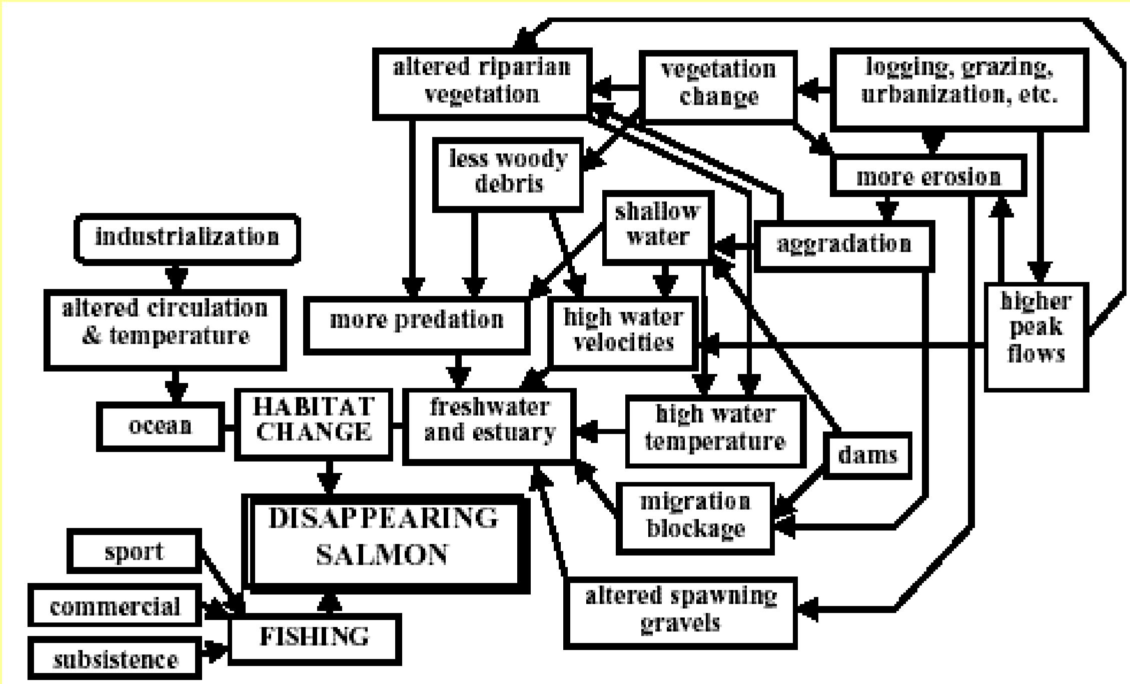
The conceptual model can be a valuable learning tool. When initially drawing the model, represent the relationship you think exist based on the initial scoping you have done. It is not necessary to wait until you collect additional data and information. At this point, it is simply useful to hypothesize the relationship between the human activities/land uses, altered conditions or processes, and the potential effects of these alterations on the ecological endpoints.

Over time, as the team gains additional information, you can modify the conceptual model to better reflect the reality in the watershed. But in the beginning, it primarily serves as an aid to your understanding and a guide to the type of data and information you might want to collect for the assessment.

Conceptual models can be developed in a variety of ways. You should develop one as part of the scoping process. In the first example, the model below was developed to represent hypothesized relationships in a small watershed where salmon populations were declining (Figure 2.3; Ziemer, 2004). The diagram shows the possible influences of landscape and in-stream processes on salmon populations. In this case, municipal water use, oceanic processes, roads, and logging are the primary influences on success of salmonid reproduction and population health.

It quickly becomes clear that in order to prepare these diagrams, you will need to understand the watershed processes or mechanisms that link human activity to changed conditions. For example, increases in impervious surfaces (e.g., urban areas and roads) can cause alterations in stream morphology as a consequence of changes in peak flow rate and total surface.

Using another example from the same conceptual diagram, the relationship identified between increased fine sediment from excessive erosion and mortality of salmon eggs and yolk-sac fry is based on an



"The process of developing the diagram is more important that the final diagram itself. In building the diagram, individuals with different backgrounds and focus can identify where their knowledge contributes to the solution of a single issue. In [this figure], there are three major components potentially affecting salmon: land use, human predation, and ocean condition." (Ziemer, 2004)

Figure 2.3 Conceptual model illustrating relationships among human activities, altered conditions, and ecosystem processes and the effects on salmon population

understanding that conditions of depleted oxygen occur as fine sediment are deposited in spawning gravels. The knowledge required to draw accurate conceptual models can be significant. That is why having a team of people with varied backgrounds is very helpful.

Another example of a conceptual model is shown in figure 2.4. It focuses on the influences on domestic water quality in the Mad River watershed (Reid & Zeimer, unpublished).

Shaded boxes and thickened arrows indicate the impact mechanisms that are expected to be most important. Lines without arrowheads indicate subsets within a category (e.g., coarse and fine sediment). In this case, channel dynamics, sediment composition, and the presence of pathogens have the most impact on the quality of the municipal water supply.

The key point is that the diagrams should identify hypothesized relationships between human activity, changed conditions in the watershed, and the potential effects of these changed conditions on the selected ecological values.

When preparing a conceptual model, a few points should be kept in mind. First, the development of the conceptual model is not data dependent. You are trying to reflect relationships that you think exist, even if there is little available data to support it. Based on the model, you can identify key areas for

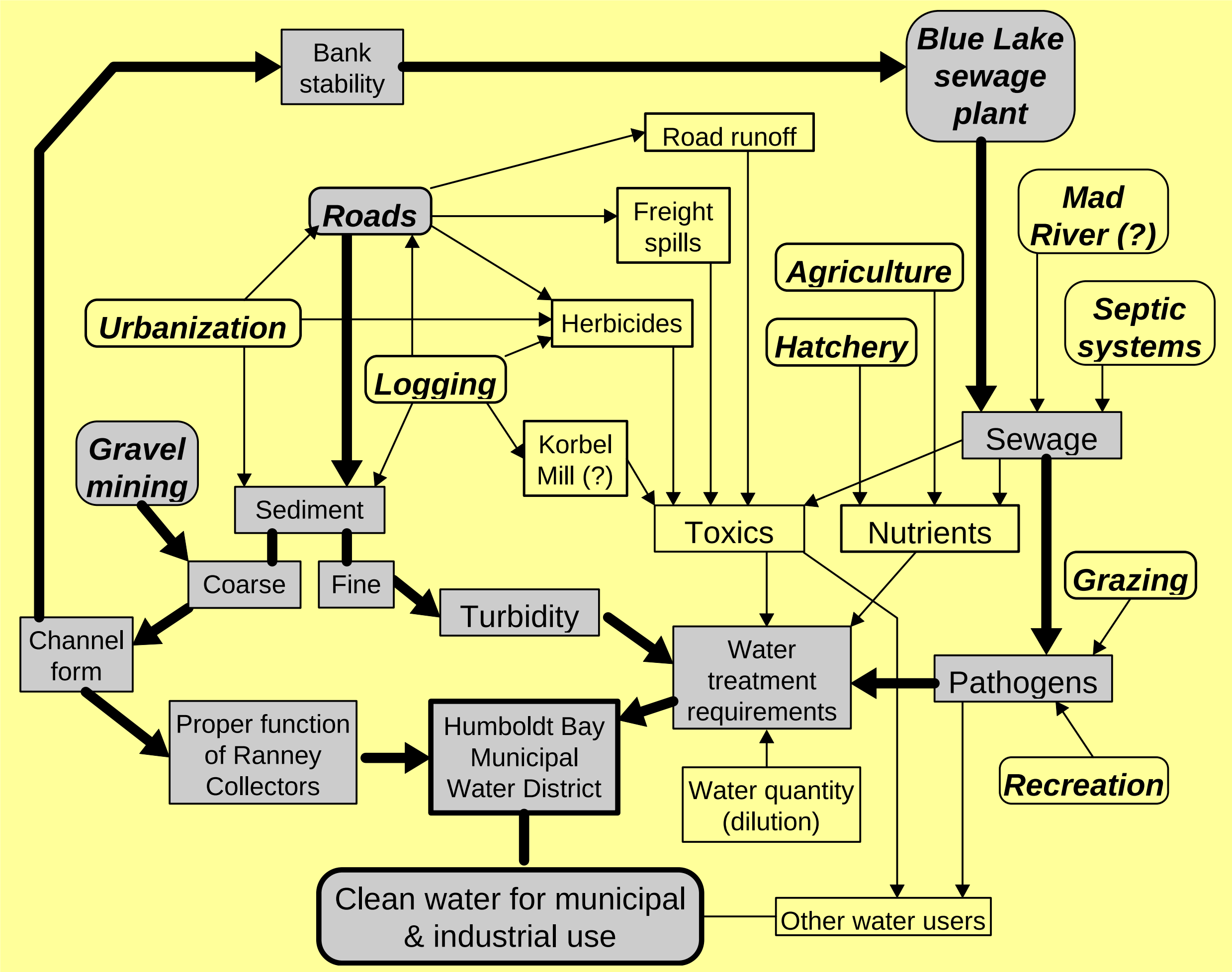


Figure 2.4 Conceptual model of factors affecting water quality in Mad River

which you need data. If such data exists, you can assemble it. If it is not available, you might decide to collect it on your own. Second, the conceptual model is a 'work in progress'; it will change as your understanding of the watershed expands. Most conceptual models undergo numerous revisions as the work proceeds and new relationships are revealed.

2.3.2 Phase 2: Plan Data Collection and Analysis

The previous section described conducting an initial assessment. From this point on we will be discussing ways you can approach the main part of your assessment.

The next step in planning your watershed assessment is actually writing a plan for analysis. Having laid the foundation for the assessment by focusing the assessment on key issues of concern, defining the scope, and developing your conceptual model, the final step before actually commencing the assessment is to lay out a plan to do the work. This section reviews the factors you should consider in developing your analysis plan. Each of the topics is discussed in detail in subsequent chapters, which are identified in the appropriate section. One point to keep in mind, as with everything in a watershed assessment, is that this is an iterative process. To the best of your ability and based on your present knowledge, lay out a plan for analysis. But keep in mind that it is likely you will need to revise it as you go along and learn about factors you had not considered in the beginning.

The data collection and analysis effort constitutes the heart of the watershed assessment. The conceptual model or diagram constructed as part of the initial scoping can serve as a guide. Accordingly, as you plan for the analysis phase of your assessment, you should identify the data and information that must be gathered and outline the process for organizing and analyzing this material (discussed in more detail in chapters 4 and 5). There are two primary forms of data and information you will collect based on your conceptual model or similar plan. One is existing data and the other is new data. Existing data already exist for the watershed, though they may not have been collected to support an assessment. New data are collected to fill gaps in information and knowledge about how the watershed functions.

The watershed assessment focuses in part on the potential harmful effects of human activities on watershed properties and function. These effects occur when human activities cause changes in the physical, chemical, or biological characteristics of the watershed.

Physical changes include water temperature and flow rate, sediment characteristics, stream channel shape and connectivity with

Table 2.3 Examples of questions to help focus data collection efforts

Issue	Some Relevant Questions to Ask
Topography	What are the elevation profiles and slope angles?
Hydrology and water use	How much water is in the watershed and where does it go? What is the seasonal pattern of stream flow? Are there dams, diversions, and/or culverts that might affect flow and act as barriers to fish passage? What about floods and the floodplain?
Sediment Sources and Transport	Has turbidity in the stream changed over time? Have the characteristics of the streambed changed? Is there evidence of erosion upland or in the stream banks? Have fine sediments filled what were once pools or gravel beds?
Riparian Vegetation	What proportion of the watershed is covered by native vs. non-native species? What is the extent of the riparian corridor?
Instream habitat, including water quality	Does it appear that the stream channel has been altered? Does the water appear clear and of good quality? Is there a history of fish kills? Are there human activities close by that might degrade the water quality?
Fish and wildlife	Has there been a decrease in the diversity or abundance of fish in the stream? Have the number and kinds of birds and mammals in the watershed changed? Have the number of frogs and toads decreased? What changes have occurred in streamside vegetation? Are there invasive animals present?
Historical and present land uses	What was the land in the watershed used for historically? What is the legacy of these land uses? What are the present land uses? Could any pose a risk to aquatic life either directly or indirectly (i.e., releasing contaminants or increase sedimentation)?

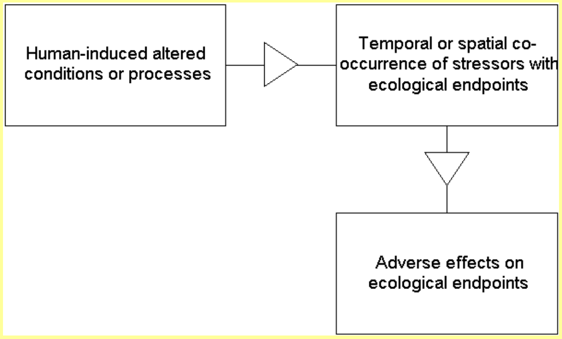


Figure 2.5 Important relationships to evaluate during data analysis

the floodplain, erosion and incision of the streambank, and any other physical characteristic that makes up the habitat on which the watershed processes being evaluated depend.

Chemical changes include the introduction of pesticides, excess nutrients, oil/grease, and effluent from industry, or other contaminant to the targeted habitat. Biological alterations that might be associated with harm could include invasive species, pathogens, habitat fragmentation, and changes in ecological processes. *A key function of the analysis plan is to focus attention on the relevant changes in processes and conditions and outline how these changes might affect the ecological endpoints, the valued ecosystem components and processes that you identified as the focus of your work*

2.3.2.1 Identify the Data to Collect

In determining what data you want to collect, one criterion you might want to consider is its relevance to the focus of the assessment, the ecological endpoints (Table 2.3). It might serve as a useful exercise to ask yourself – To what degree are these issues and their related questions relevant to the focus of my watershed assessment? Table 2.3 is not inclusive; there might be other issues of importance in your watershed.

This list is not comprehensive. However, the list highlights key topics that are likely to be important in most watersheds.

2.3.2.2 Decide How You Will Evaluate and Analyze the Data

The following section describes one approach to collection and analysis of data. It has been proposed in the U.S. EPA's watershed risk assessment guidelines (posted at: www.epa.gov/watertrain). It is limited to human effects on water quality and the impacts of water quality on waterway biology ("ecological endpoints"). This simplified diagram illustrates EPA's recommendations. Figure 2.5 reflects the relationship between altered conditions and processes associated with human activity, the potential for exposure, either temporally or spatially, of the ecological endpoints to these stressors, and the potential adverse effects that might result from this exposure.

The following questions might serve as a useful guide to determine the degree to which each of these issues is important in your particular situation.

1. Is there temporal and spatial co-occurrence of the stressors or altered conditions and the ecological endpoints?

You should assess the pattern of stressors occurring in space and time and the pathway by which this pattern might lead to harmful effects on watershed processes. To do this, ask yourself two questions.

- Is it likely that the putative stressors are present prior to the observed changes or endpoints?

An example can best be used to explain what we're getting at with this question. Assume changes in the riparian canopy have occurred as a result of changes in the hydrological patterns in the watershed. The hydrological changes have caused streambank erosion and loss of some riparian cover.

Consequently, the summer temperature of the water has increased. If one of the ecological endpoints is anadromous fish, then it is necessary to determine if this species was present in the stream in the summer, during the period that the temperature was high. Although the water temperature might exceed tolerance limits for this fish, if the fish isn't present, there is no *temporal coincidence*, and there is no opportunity for harm to occur.

- Is there spatial overlap between the geographical distribution of the ecological endpoints and the altered conditions/stressors or processes?

For example, warm-water fish, such as bass, often prey on young salmon. Typically, the bass live at lower elevations, where the water is warmer than that inhabited by juvenile salmon, which need cooler waters. Although non-native bass and salmon share the same stream, if there is no/little spatial overlap, it is unlikely that invasive bass will act as a biological stressor on the salmon, except for the relatively brief period when the young salmon migrate downstream and pass through the bass habitat.

You might also want to consider the effect of secondary stressors or alterations in evaluating possible harm. For example, acid mine drainage in Northern California has been a significant problem in certain areas. During the rainy season, sulfuric acid spills into the rivers and creeks, depressing the water's pH and causing significant toxicity to aquatic life. Not only does the acid spill cause direct toxicity, but it also increases the solubility of copper, zinc, and other potentially harmful metals. These metals are secondary stressors and can independently cause toxicity to fish and invertebrates.

2. Is it likely or is there evidence to suggest that the altered conditions might have an adverse effect on the ecological endpoints?

To make this analysis, you need to determine whether conditions in the watershed have been altered enough to reduce the viability of the watershed processes that are the focus of the assessment. You will want to understand the conditions in your watershed relative to those known to be protective of aquatic resources. One way to do this is to characterize the stressor-response profile.

In summary, when planning your data collection effort, consider the value and appropriateness of collecting data on the human activities (i.e., land uses) within the watershed that might alter watershed processes or conditions, thereby causing stress on the ecological endpoints of interest. Second, consider the temporal and spatial co-occurrence of these stressors on the ecological endpoints. If there is no temporal or spatial overlap, it is unlikely the stressor will/does present a problem for the ecological processes that are the focus of your

Examples of typical types of data collected in a watershed assessment and the optimal scales for these data

Type of Data	Temporal/Spatial Scales
Contaminants in water	Throughout the year and immediately after rain events; above and below sites of concern (storm drains, road effluent, wastewater treatment plants). Ideally, regular monitoring over many years.
Sedimentation	In streambed, on hillslopes, below roads, primarily following storm events, in smaller streams and periodically in smaller and larger waterways.
Dissolved oxygen, temperature	Weekly or monthly in all sub-watersheds of the stream.
Road maps	1:24,000, updated every five years.

assessment. If there is co-occurrence, then it is important to evaluate if theses stressors have an adverse effect on the ecological endpoints. These are important issues to review when planning data collection and analysis.

2.3.2.3 Scale: An Important Issue in Planning Your Analysis

One important consideration in developing an analysis plan is the question of scale. The term scale has a variety of uses depending on the context and need of the user. In ecology, the scale of measurement refers to the classes or types of values that describe a feature or process. For example, soil classes are an example of a “nominal” (naming) scale of measurement, whereas temperature is an example of an “interval” scale because values range across a numeric scale (Jongman et al. 1995). There is also “spatial scale”, which refers here to the scale at which a place is measured or viewed. Temporal scale is the timeframe over which analyses or measurements are taken for a process. This Manual deals primarily with the latter two uses of the term and qualifies the word where needed.

The spatial and temporal scales used in a watershed assessment must be appropriate for the type of information being collected and the questions or problems being addressed.

Different analytical approaches depend on different scales of input data. Varying results and conclusions are possible depending on how fine or coarse the resolution of data collection is. The scale at which data and knowledge (what we know from the data) have been developed determine the kinds of management, regulatory, or restoration decisions that can be supported by a watershed assessment For example, if it is likely to take six months before logging activity potentially causes environmental changes, then data should be collected before logging begins, again six months later, and at least one more time per season (for wildlife) or week and storm event (for water quality) within several years of the activity. By collecting data over this period of time, there is a good chance that changes that might have resulted from the logging will be detected.

- *The link between the assessment questions and scale*

This Manual is designed for watershed assessments that support questions, decisions, and implementing actions. The types of questions you ask in your assessment, the decisions you expect to make, and the actions that might result will determine the scale of data you need. If you are assessing the condition of a 10,000-acre watershed in order to prioritize sites for restoration, you may need to go beyond most readily available spatial data sets and use custom digital spatial data or field data to differentiate among areas within the watershed. For large watersheds (e.g., 1 million acres), the condition assessment may allow you to differentiate among sub-watersheds for potential action and likely condition, but there probably won’t be data for the whole watershed with fine enough resolution to answer site-specific questions. These types of issue highlight the relationship between the assessment questions and the spatial scale of your data.

- *Data scales*

You may be relying on existing data for your assessment. In this case, you will not have an opportunity to make a decision about scale. This situation exists for topics like plant and animal distribution across the landscape, as well as for topics like changes in water quality over time. Academic definitions of studies, including watershed assessments, often differentiate between those where the investigator can control some aspects of the system (an experiment) and those studies where the investigator has no control of the system and relies on already-collected data (a “survey”; Jongman et al. 1995). This difference is important because cause and effect are harder to determine in surveys than experiments.

Watershed assessments will generally involve only survey data that has already been collected. Data collected at scales that you cannot control constrains the use of that data in new analyses. However, much of the information that an assessment relies upon as "data" may actually be products of computer models (e.g., for wildlife habitat, fire hazard, and landslide risk), which potentially increases the range of uses of data, but not necessarily the reliability.

2.3.3 Phase 3: Data Synthesis and Integration

Another part of the plan you develop should contain your best estimate of the methods you plan to use to integrate the data and identify relationships among watershed processes and problems. Integrating data refers to the process of incorporating the analysis of the physical, biological, and chemical conditions in the watershed into a single useful estimate of the potential for adverse effects on the watershed processes and features of interest. This topic is discussed in more detail in chapter 6.

The integrated assessment evaluates the likelihood that a potentially harmful event has occurred or will occur. Comparing data of disparate types can be challenging. The difficulty of data integration is that the data exist in a variety of forms that do not lend themselves to comparison. Data on water quality might be reflected in units of parts per billion. Data on riparian vegetation could be expressed in terms of percent canopy cover or area covered by invasive species. Data related to stream morphology might be expressed as particle sizes (mm), percent fines, or percent change in pool volume. Information on land use might be expressed as acres of land use "x". All of these watershed characteristics are important to the overall assessment, yet the basis for quantitatively comparing them is difficult because you are, in effect, comparing apples and oranges. An unfortunate consequence is that many watershed assessments do not include an information integration step.

The data synthesis phase of the watershed assessment allows you to evaluate the nature of the relationships you hypothesized in the conceptual model. For example, you might have speculated that high turbidity was responsible for a decline in the population of a valued aquatic organism. However, in synthesizing all the data, you might learn that in fact, depleted food supply associated with changes in riparian cover is a more important factor. Your initial speculation might have been inaccurate. But you have identified those factor(s) that appear to be most important for protecting or restoring the valued processes and resources in your watershed. This prioritization is the real power of the data synthesis/integration step - it can serve as a guide for action.

At present, there is not one single method of information integration that is widely used or accepted. A variety of methods have been used; each has its strengths and weakness. Different methods are appropriate for different situations. Chapter 6 focuses on these methods. The following list summarizes a few of the methods used for information integration and analysis

2.3.3.1 Models for Data Integration

- Team Mental Integration: Weighing the Evidence

Team Mental Integration is really nothing more than using best professional judgment to analyzing and synthesizing the data. Pulling from the knowledge and experience of the assessment team and appropriate experts, a systematic weighing of the data and information collected can help link the impacts on the watershed to potential causes.

- The Relative Risk Model

The Relative Risk Model (RRM) methodology assigns numbers or ranks to stressors identified in the conceptual model so that the potential effects of a variety of chemical, physical, and biological factors can be compared to each other. This method can be applied to assessments with only limited amounts of data, as well as those with significant amounts of data.

- Knowledge-Base Models

The Ecosystem Management Decision Support model (EMDS) is one knowledge-based model that can be used to integrate and analyze data. The model evaluates the "truth" of an assertion about a place, such as "changed land uses impact aquatic ecosystems." A knowledge base provided by the user guides the evaluation. The knowledge base shows relationships among the parts of the system under study. A variety of environmental conditions can be evaluated with this model; all are integrated into a single analysis. Maps are then generated that reflect ranking of areas by watershed or process conditions.

- The SCREAM Model (Southern California Wetlands Recovery Project)

The Southern California Riparian Ecosystem Assessment Method (SCREAM) is a GIS-based tool to assess the ecological condition and stressors affecting riparian habitat at a landscape scale. In the SCREAM model, existing or new GIS data layers are compiled and organized, and the information contained in those layers are used to calculate hydrologic, biogeochemical, and habitat condition scores. The developers of the model, the Southern California Coastal Water Research Project or SCCWRP, envision that the SCREAM tool will be used as part of a comprehensive assessment program to evaluate the condition of and stressors affecting wetlands and riparian ecosystems in southern California.

Although you can probably say for sure which approach you will eventually use, it is wise in the planning stage to review the various options and tentatively identify which one is most suitable to your level of expertise and the amount of data you plan to collect.

In conclusion, the analysis or assessment plan should outline the key steps in the assessment and how they will be carried out. As you proceed with the assessment, you will likely modify the plan as you gain new knowledge about the watershed or recognize things you might have initially overlooked. An analysis plan is similar to a business plan or a work plan for a project in that it facilitates carrying out the assessment in a more systematic fashion.

Actions 2.3

- *Conduct initial scoping for focus of assessment*
- *Develop a conceptual model*
- *Plan collection and analysis of data*
- *Describe the spatial and temporal scales of the data*
- *Plan synthesis and integration of data to describe watershed condition*

2.4 Important Issues in Conducting a Watershed Assessment

This section tells you about issues such as uncertainty and data gaps that are important to cover in your assessment. Just as important as what is known about a watershed is what is not known.

2.4.1 Uncertainty

The term "uncertainty" has a variety of uses in everyday language, in social and natural sciences, and in statistics. The dictionary defines "uncertainty" as literally a lack of certainty about something. There is also a statistical meaning to the term that refers to the probability of an outcome occurring, for which the variation in possible values might be known and specific statistical tools can be used to measure the uncertainty. One statistics text considers "uncertainty to be synonymous with diversity" (Zar 1984). This example presents one way to think about uncertainty: Let's say that there is a high probability of occurrence of salmon spawning in gravels between one and three inches in diameter that are deeper than 6 inches below the water's surface and a low occurrence of spawning anywhere else. The diversity of places that salmon spawned would be low and the uncertainty about where salmon spawn would also be low.

There is often a great deal of uncertainty associated with the measurement and analysis of natural conditions. Some of this uncertainty is associated with the measurement and analytical approaches themselves, because we don't know how to perfectly sample or represent complex systems. Some uncertainty comes from incomplete measurements of the systems due to inadequate resource investment, for example, or inaccessibility of a place. Generally, most science and knowledge development aims to reduce uncertainty (Dawes, 1988) and increase our ability to predict things around us, for which there is a known or unknown probability.

2.4.2 Data Gaps

A critical part of any assessment is recording gaps in data or knowledge that become obvious when gathering and analyzing watershed information. These gaps may be large enough to make the assessment insufficient for certain kinds of decision making. They may also form the foundation of future monitoring and data collection activities that will allow for more comprehensive condition assessments. One approach to this issue, suggested by Bingham (1998), is to inventory and collect existing data and, based on these data and on watershed management goals, develop critical questions before continuing the planning process (as described in Section 2.2 on "Formulating Questions"). These questions will determine the amount and type of data that is needed to continue.

2.4.2.1 Data vs. Knowledge

Data refers to "facts or pieces of information" (Spellman & Drinan 2001), while knowledge is the use of that information to form a mental picture of a process or phenomenon. Usually monitoring programs collect data, which then must be analyzed and assembled in some way to provide knowledge about a place or process.

2.4.2.2 What is a Complete Data Set?

A "complete data set" may be defined as "sufficient data to answer the assessment questions". However, most investigators may not have sufficient data to adequately address assessment questions. They may also not have investigated the question of sufficiency (how much data is needed) appropriately to actually answer the assessment questions. This is particularly true for water quality data. Although quality assurance is required for data collected by state-funded projects, there is no requirement to calculate the sampling intensity (number of samples and frequency of sampling) needed to determine 1) the actual value of a measured constituent, 2) differences between or among mean values, and 3) trends in values over time. The approaches to calculating how much data is needed for an analysis are available in statistical texts (e.g., Zar 1984) and summarized in this Manual and should be understandable to most assessors with professional scientific degrees.
For parts of the watershed assessment not dependent on comparison of measures of watershed condition, there are few standards for determining data completeness. The approach to determining adequacy of the

"*Where is the wisdom*
We have lost in knowledge?
Where is the knowledge
We have lost in information?"
~T.S. Eliot

"*Where is the information*
We have lost in data??"
~Anonymous

available data should consist of first identifying the questions, then determining the data that are needed to answer the questions, and finally comparing the available data to the list of data needed. Deciding whether or not there is a complete data set then becomes a job for professional judgment.

2.4.2.3 When do You Know Enough?

Watershed assessment is a continuous process, reflecting the changing nature of the subject. The minimum information needed to answer the assessment questions may turn out to be a fuzzy concept, based on the people involved and the complexity of the questions. For example, resolving a question about the immediate and cumulative impacts of new urban development in a sub-watershed might revolve around the timeframe for the question, the particular natural processes affected, and the likelihood that general plan and specific plan amendments that could modify the actual extent and layout of the development will occur in the timeframe of the question. An example of a data gap in this case could be the actual developed area that will result and a knowledge gap could be the linkage between the modification of the sub-watershed and the response of a particular natural process (e.g., seasonal drying-out of the streambed). Whether or not you know enough may be a research question. Detailing the steps between developing critical assessment questions, collecting relevant data, and making linkages between the questions and the data is the job of the assessment planning team.

2.4.2.4 Prepare a List of Data and Knowledge Gaps

A primary product in your assessment that should result from this section of the Manual is a list of data and knowledge gaps. This list should include the nature of the gap, how and why it was identified as a gap, what would be required to fill the gap, and who should fill it. This product tells you and future assessment users how complete the data set and knowledge base were for the analyses performed and judgments made. It also lays out what is needed in order for future assessment to be more thorough. If this task is carried out thoroughly, it should lead directly to funding proposals and program development for monitoring and research into watershed condition and processes.

Examples of data gaps:

a) Flow data available for 50% of major tributaries
b) Water quality data available for1970 to 1990; no recent data is available
c) Plant community map does not show actual condition or land use
d) Cross-section survey data utilized in hydraulic model from 1940 instead of in 2004

Examples of how a data gap is identified:

a) To run a hydrologic or hydraulic model, flow data are needed for all major tributaries for water years representing a range of flows for a minimum of 10 years.
b) Watershed development has occurred primarily since 1990. Long-time watershed observers and experts consider the current condition relatively deteriorated.
c) Vegetation maps show the plant community type, but not the growth stage, canopy closure, human extraction activities, or fragmentation.
e) Hydraulic models rely on a definition of channel shape characterized by cross-section or topographic data, and the channel may have changed significantly in the past 60 years since the survey data were collected.

Examples of how a data gap should be filled:

a) Establish flow gauging stations at the mouth of the major tributaries in cooperation with regional expert (university, USGS, DWR, water district).
b) Develop and implement a water-quality monitoring program using a combination of professional and volunteer monitors.

c) Take the vegetation map and add attributes for land condition/use based on local knowledge, recent aerial photos, and recorded extraction activity (e.g., timber harvest plan) relying on GIS staff.
d) Conduct field-work to resurvey channel cross-section or topographic data.

2.4.2.5 Using Data Gap Information to Inform Future Monitoring

An explicit link should be made between the watershed assessment process and the development or maintenance of a monitoring program. This can be done by describing data and knowledge gaps and proposing resolution for the gaps. Thus new data collection fills data gaps and develops knowledge about processes. For example, a monitoring program may intensify its existing sampling and increase the number of sample sites in order to meet data needs identified in the knowledge gaps part of the assessment. Or additional processes may be investigated to aid in developing an understanding of how activities in a watershed affect natural processes and other beneficial uses.

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SUMMARY

DEVELOP your watershed assessment to:

- Answer fundamental questions—let the problem drive the assessment
- Address the cause and not the just the symptoms of your watershed's problems
- Understand **why** the current watershed condition seems to be the way it is
- Interpret the physical, biological, and social interconnections within the watershed
- Be useful for later decisions and actions

CLARIFY the:

- Purpose of the assessment—Who wants it and why? Who will use it?
- Structure of who will be involved and what their roles will be
- Decision making—Who are the decision-makers? How are decisions made?
- Recording of the process—Who, how, when, where?
- Best options that will meet your needs
- Reasonable expectations of the assessment product
- Scope of the assessment

FOCUS on:

- Your most critical or key issues, so the product is useful and not too general
- Effects and processes occurring within your watershed boundaries
- Using consensus effectively in your partnership group
- Keeping costs under control and meeting timelines
- Working with the public through two-way communications
- Satisfying and helping the ultimate users of the assessment

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Assessment Planning Check List

Organize the Assessment Team and Community Input	
1) Assemble assessment team and committees	
2) Develop contracts, if necessary, with outside consultants	
3) Track itemized costs and schedule	
4) Involve the community	
5) Record the planning and implementation process	
Define Purpose and Scope and Plan the assessment	
6) Formulate questions about your watershed	
7) Describe the purpose of the assessment	
8) Identify the audience and users of the assessment	
9) Describe the uses of the assessment	
Basic Watershed Assessment Process	
10) Conduct initial scoping for focus of assessment	
11) Develop a conceptual model	
12) Plan collection and analysis of data	
13) Describe the spatial and temporal scales of the data	
14) Plan synthesis and integration of data to describe watershed condition	
Important Issues in Conducting a Watershed Assessment	
15) Identify sources of uncertainty	
16) Provide estimate of uncertainty and ways to reduce uncertainty	
17) Develop list of data and knowledge gaps	