1 Introduction

Californians are responsible for protecting and managing their natural environment. Watersheds, also known as catchment or drainage basins, provide a useful, natural unit for better understanding and achieving this responsibility (California Resources Agency & State Water Resources Control Board 2002). Assessing a watershed to understand its current condition, and how it got there, is usually the first step taken in developing a strategy toward improving and protecting the watershed's condition.

Chapter Outline

1.1 Audience and Purpose of the Manual

The California Watershed Assessment Manual (CWAM or Manual) provides guidance for conducting a watershed assessment in California. It is intended to support the planning and technical needs primarily of watershed groups but also local and state agencies, academic scientists, consultants, and individuals involved in developing and conducting a watershed assessment. In doing so, the Manual includes the recognition that not all assessments have the same level of complexity of questions or analysis. It is intended to reduce the reinventing of planning, data collection, and analysis approaches each time an assessment is done. This will result in less time spent by the assessor getting up to speed and provide a range of ways to approach a problem.

The Manual includes guidance on planning and operational principles and steps that are useful for assessment processes anywhere in the state. The topics addressed in the Manual cover the primary natural and human processes in rural watersheds of northern and central California. Many of the approaches for assessing urban and agricultural areas are still being developed for inclusion in a future update of the Manual. The optimal organizational and geographic scale for use of the Manual is for watershed groups conducting assessments in 10,000-acre to 1 million-acre watersheds.

The key reasons for developing this Manual are:

1. Citizen organizations and agencies requested a manual

The "12 Steps to Watershed Recovery in California," an action plan developed in May 2000 at the California Watershed Management Forums (Watershed Management Council 2000), included a recommendation for developing a state manual to help provide consistency and clear expectations to watershed groups, managers, and restoration specialists about recommended methods for: watershed assessments, water quality and habitat monitoring, data reporting, and watershed plans. Further, Assembly Bill 2117 Report to the Legislature (CRA & SWRCB 2002) identified the following need: "*Develop manuals that define the minimum level of science needed for acceptable watershed assessments, watershed plans, and monitoring activities. These manuals should provide technical assistance to newly formed watershed partnerships and to those choosing to upgrade their existing*

assessments and plans. The manuals should build on existing manuals and provide a menu-driven approach that can be tailored to the unique conditions of each watershed in California."

CWAM is a response to these requests.

2. State watershed grant programs want assessments

CWAM seeks to provide useful information to fulfill the requirement of many grant programs for watershed assessments (Table 1.1). Although the Manual includes assessment approaches and methods that are compatible with these state-agency funding programs, anyone conducting a state-funded watershed assessment should clarify proposed methodology with the appropriate state funding agencies.

3. Other manuals do not necessarily meet California's needs

This Manual is intended to complement and extend the information in other manuals. Whereas other states, such as Oregon and Washington, have prepared very useful manuals, no single existing manual meets the unique and current needs of local watershed practitioners in California, mainly because of the State's incredible hydrological, geological, and biological diversity. Further, most do not discuss methods for synthesizing data that links human activities to alterations in watershed processes. The Oregon Watershed Assessment Manual (WPN 1999) probably is the closest to meeting the needs of California practitioners. Its target audience is quite similar, the format is user-friendly, and the content is scientifically sound. However, it focuses only on salmon-producing watersheds, the local examples are all from Oregon, and the state technical and information sources are not applicable to California. Its low-tech, low-cost approach offers some advantages, but because of this approach, the manual does not include computer-modeling methods. In addition, it does not address a variety of important assessment issues related to scale, data analysis, complexity of analysis, and information integration.

Watershed conditions related to forest practices are the emphasis of several other state manuals: the Washington manual (Washington Department of Natural Resources, 1997), California's North Coast Watershed Assessment Program Manual (North Coast Watershed Assessment Program, 2002), and the watershed analysis manual for Jackson Demonstration State Forest in Mendocino County (Stillwater Sciences 1999). The assessment methods described in these three manuals require

Table 1.1 State watershed grant programs.

State Agency	Watershed Grant Program
California Bay-Delta Authority (CALFED)	Watershed Program
Coastal Conservancy	Watershed Restoration Program, Resource Enhancement Program, Southern California Wetland Recovery Program
California Department of Conservation	Resource Conservation District Grants / Watershed Coordinator Grants
California Department of Fish & Game	Fisheries Restoration Grants Program (CCSRP, Prop. 40)
California Department of Water Resources	Urban Streams Restoration Program Grants
State Water Resources Control Board	Nonpoint Source Program (NPS), Prop. 13, Prop. 204, CWA 205(j), CWA 319(h), Prop. 40, Prop. 50

professional knowledge and extensive experience with physical and biological analyses. Other limitations pertain to the federal land managers' equivalents of watershed assessment manuals, such as the guides for "Ecosystem Analysis at the Watershed Scale" (U.S. Department of Agriculture 1995), "Hydrologic Condition Assessment" (U.S. Department of Interior & U.S. Department of Agriculture, 1998), or "Reconnaissance Level Assessment" (USDA Forest Service, 2000). In addition, the issues that these forest and wildland guides address are not always applicable to the rest of California, their focus on public lands means they may differ appreciably in purpose (e.g., urban and agricultural issues are not addressed at all), users, scale, data collection, management options etc. For these reasons, to name a few, there is a need for a California-specific manual. However, the manuals from other states and agencies can provide very useful information. Links to many other manuals are posted on the CWAM website (http://cwam.ucdavis.edu).

4. A manual will improve assessment quality and lower costs

Table 1.2 Attributes of successful and failed watershed analysis: live or dead? (from: Furniss 2001)

Live Watershed Analysis - As It Should Be -	Dead Watershed Analysis - As It Sometimes Is -
Science-based	Truth by assertion
Multiple scales, scale integrative	Single scale, not scale integrative
Interdisciplinary	Mono-disciplinary
Needed and effective inquiry	Doing what I like to do
Place-based	Actions-, proposals-, recommendations-based
Genuine learning	Shoring up one's position
Syn-ecological	Aut-ecological
Rates	States
Open, readily updated and revised	Onto the shelf. "Done"
Clean communication	Jargon-encrusted
Finds the holes, the critical uncertainties	Data bulking, nothing but knowns and givens
Seeking truth	Same old advocacy, spin, and worn-out, unexamined conclusions
Embracing complexity	Oversimplified
Active doubt	Dogma
Distilled meaning	Gobs of data
Multiple hypotheses	Single hypothesis, tightly held
Parallel, iterative	Strictly linear
Questions oriented	Methods oriented
Seeking results	Process obsessed
Teaching each other	Strutting our stuff
Adaptive, seeks to learn from failures	Static, ignores failures
Discerns patterns	Obsessed with details
Discovers that it's an elephant	"This is a fire hose, a brief case, a hat, a…"
Integrative	Reductionist
GIS is a tool	Obsessed with GIS
Welcomes and encourages critique	Critique is unwelcome and polarizes
Findings based on logic and backed by data	Data bulking with no logic trail between data and conclusions

Common shortcomings seen in many assessments include data cataloging with little attempt at analysis, little integration of different parts of the assessment, weak application of science, and few links to decision-making processes.

By clearly identifying a variety of accepted assessment methods, and presenting various data integration and analysis techniques, this Manual can be used as a tool to help improve the quality of watershed assessments being performed and increase the effectiveness of state-supported watershed projects. Assessment preparation costs can also be reduced. Groups often spend time and money (through consultants or staff time) to identify available assessment options, a process that can be redundant and inefficient. The Manual helps individuals and organizations narrow options at the outset. As a result, it saves time and money by reducing the spinning of wheels so common at the start of the process, and it gets the assessment process underway more quickly.

1.2 What are Watersheds and Watershed Assessments?

A common saying holds that "we all live in a watershed," yet watersheds and their needs for assessment can be quite diverse. A watershed assessment for San Jose's watershed (Santa Clara Basin), for example, will be different from one for Honeydew's (Mattole River watershed) or for Porterville's (Tule River watershed). There are still common features, however, for defining "watershed" and "watershed assessment" for the purposes of this Manual. Despite their diversity, watershed practitioners agree to common definitions. It is useful to know these definitions when conducting an assessment.

A "watershed" is defined as "the region draining into a river, river system, or other body of water above a particular point." Geologists commonly refer to watersheds as drainage basins. In Australia, New Zealand, and Great Britain, watersheds may also be called catchments. It is not uncommon for people to use the term 'watershed' to refer to a stream or riparian corridor. In fact, a stream is just one part of the watershed. Common zones within a watershed, often used for management purposes, are: 1) the upland area, the land above the zone inundated by floods or the transition between riparian and terrestrial vegetation, 2) the riparian zone, the vegetated area between the waterbody edge and the upland area, and 3) the waterbody itself, any stream, river, abandoned channel, pond, lake, wetlands, estuary, or ocean (U.S. Environmental Protection Agency, 2002). Ecologists also distinguish between headwaters, where water, sediment, and nutrients originate and hillslope is important (Meyer et al. 2003), and lowlands, where channel and floodplain interactions are important (Vannote et al., 1980).

Most of California's river systems eventually drain into the ocean. On the east side of the Sierra and in arid regions like the Mojave Desert, water may drain into a water body that has no outlet to the ocean. A watershed's physical features may include valleys, floodplains, ridges, plateaus, foothills, mountains, stream and river channels, riparian environments, estuaries, and wetlands.

The size of watersheds in California varies from very small such as the one-square-mile Codornices Creek watershed in Berkeley to very large such as the 26,000-square-mile Sacramento River Basin.

Because of the presence of water diversion and other water management infrastructure, the actual dimensions of the landscape contributing water to a point on a waterway may actually include parts of other watersheds. In other words, if some of the water in your watershed originates from another watershed, then you could consider

the source watershed as part of your assessment area.

The term "**watershed assessment**" has been described in a variety of ways:

1. The analysis of watershed information to draw conclusions concerning the conditions in the watershed. (Nehalem River Watershed Assessment, Washington)
2. A process for evaluating how well a watershed is working. (Oregon Watershed Assessment Manual, Watershed Professionals Network, 1999)
3. A process that characterizes current watershed conditions at a coarse scale using an interdisciplinary approach to collect and analyze information. (North Coast Watershed Assessment Program 2001)
4. The translation of scientific data into policy-relevant information that is suitable for supporting decision making and action at the watershed level. (Watershed Academy, U.S. Environmental Protection Agency).

Despite their differences, what is common to each definition is a process composed of actions—analysis, process, translation—that leads to the interpretation of information about the watershed's current condition. What is most critical is that the watershed assessment effort lead to a better understanding of watershed condition and why the watershed is in a certain condition. In this way, the assessment becomes a useful tool to help direct further actions.

A watershed assessment is usually composed of:

- A question or set of questions about watershed condition that sets boundaries on the assessment;
- A collection of relevant information about human and natural processes at the watershed scale;
- The identification of gaps in knowledge;
- The combination of information about various natural processes to reflect the integrated nature of watersheds;
- Analysis and synthesis of the information regarding the watershed's condition drawn from data collections, often at various geographic scales;
- A description of how the analysis can assist with decision making in the watershed;
- A design for the collection of future monitoring data; and
- A strategy to evaluate future data and communicate that information via a status and trends analysis.

An assessment moves beyond a simple description of what a watershed looks like, or what historical activities took place in the watershed. While these are some of the building blocks, an assessment should try to connect past and current human activities with current conditions and processes. To the degree that hypotheses can be developed about these relationships or actual cause and effect relationships can be identified, the watershed practitioners can propose solutions to problems and identify ways to achieve common goals. Without this understanding, proposed solutions may address only the symptoms. Frequently, watershed assessments stop short of making critical connections, yet are considered complete. A successful watershed assessment leads to the implementation of actions that benefit watershed processes and conditions—the ultimate "performance measure".

A watershed assessment is ideally part of an overall watershed management package consisting of:

- Problem or needs identification
- Assessment and analysis
- Planning
- Implementation
- Monitoring and evaluation
- Adaptive management

What an Assessment Is

- An objective problem-solving tool that identifies the potential causes of problems
- The scientific interpretation of watershed information and data, leading to conclusions about watershed condition
- A tool to help identify data and information gaps
- Analysis and findings that can be used to develop appropriate actions
- A component of a watershed management package that leads to planning, implementation, evaluation, and additional monitoring
- A product that is useful for its audience

What an Assessment Is Not

- Monitoring and data collection only
- A list of data only
- A consolidation or summary of existing information only
- Historical conditions or "baseline" only
- An identification of symptoms of problems only
- A plan
- An endpoint

1.3 Watershed Adaptive Management

Adaptive management is a systematic process of modeling, experimentation, and monitoring to compare the outcomes of alternative management actions. Management actions are treated like experiments". When actions are taken, it is recognized that there are hundreds of factors that influence a watershed. Management and restoration activities are designed with the best available knowledge at the time. However, much can be learned from these activities and future actions should be shaped by the knowledge gained from the original effort or "experiment". The sequence in Figure 1.1 describes this process, involving a cycle of monitoring data collection, analysis and evaluation, conceptualization of issues, planning, decisions, actions, and more monitoring. This is the adaptive management cycle, because it implies that management decisions will be adapted to fit and respond to new information about a system; new information that is gained from monitoring and assessment. Feedback loops that include assessing whether watershed's problems are improving – at the project or action level and at the watershed level – are important for gauging management effectiveness.

Decision-making is part of the adaptive management cycle that follows an assessment. Findings in the assessment, which are based on monitoring information, are used by the appropriate decision-makers to make the next step, which begins the planning process. What to do—such as identifying and recommending specific projects, policies, and priorities—is not necessarily obvious or easy. Political and economic choices come into play during the planning stage, which includes deciding the what, where, when, and how to be accomplished in the implementation phase (see chapter 8). As a result, it is best to clearly separate the "apolitical" assessment

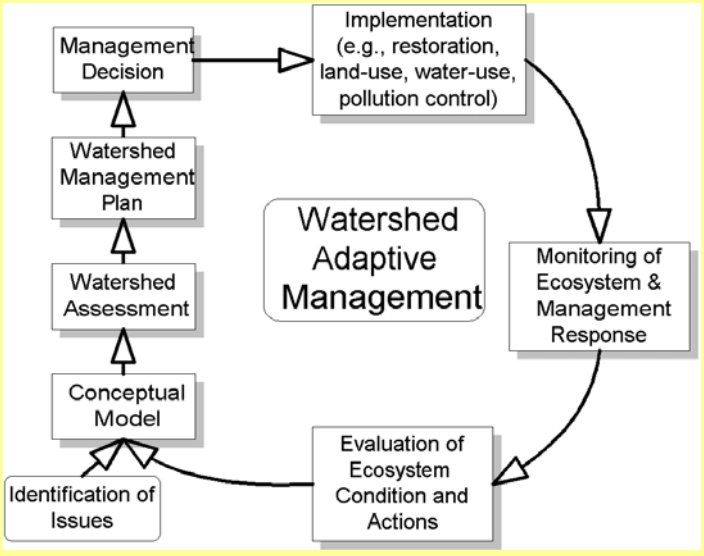

Figure 1.1 Watershed adaptive management

A watershed assessment is: "a process for analyzing a watershed's current condition and the likely causes of these conditions".

A watershed assessment report is: "a report documenting the findings of the watershed assessment process."

product from those decisions, which may have political, economic, or social implications.

In practice, watershed assessments and plans are sometimes combined into one document in order to fulfill a grant requirement or to show the transition from assessment to plan. In these cases, the assessment product should be distinct from the planning product so the reader can first understand the findings and then see what choices were made.

A federal watershed analysis usually suggests "management recommendations responsive to watershed processes identified in the analysis," but these suggestions are only for federal lands, which represent a different situation than a mixed-ownership watershed with various management expectations (Regional Interagency Executive Committee 1995).

In this Manual, it is assumed that the assessors and watershed managers will use an adaptive management approach to evaluate actions and make decisions about how to proceed. The watershed assessment is key to the success of this watershed adaptive management approach.

1.4 Approach Taken in This Manual

The Manual provides a toolbox of appropriate approaches and methods designed to help those developing and conducting watershed assessments. These approaches and methods address:

- Developing questions and strategies for conducting a watershed assessment;
- Determining the necessary complexity of an assessment (e.g., from reconnaissance to thorough)
- Collecting appropriate data;
- Analyzing data while taking appropriate account of time and space scale issues and uncertainty about data and results;
- Integrating the data to assess watershed condition; and
- Ensuring that the assessment can be integrated with future watershed monitoring, planning, implementation, and evaluation.

The approaches and methods described in the Manual are guidance for watershed assessment and are not the State's prescription of how watershed assessments must be done. While the Manual presents various existing tools and techniques, other valid tools and techniques are also possible. In keeping with comments received during the Manual's development, it is neither a "one-size-fits-all" guide nor a "cookbook". Given California's diverse landscapes and watersheds, there is a need for creative and flexible approaches to performing watershed assessments. At the same time, however, watershed assessments and other components of watershed management should be founded in credible, science-based approaches like those described in this Manual.

1.5 How Complex Should Your Assessment Be?

Watershed assessments can be conducted at a wide range of levels of detail and complexity – from simple reconnaissance-level overviews to very thorough studies involving an array of mathematical models. The team contributing to this Manual discussed various approaches to levels of

analysis over several months. Eventually, the team decided that there wasn't much value to dividing the continuum of detail into several discrete groups. The spectrum of progressive detail and analysis does not naturally break into clean categories. Different parts of an assessment will inevitably receive different degrees of attention and analysis depending on the personal interests of the people developing the assessment, the expertise and availability of those people, the principal issues and driving questions of the watershed assessment, data availability, financial resources, and time constraints. In most cases, the level of effort will simply depend on how thorough an assessment you desire balanced against your constraints of time, money, and data. Another way to evaluate the appropriate level of detail for a particular part of your watershed assessment is to consider the following question: How much confidence in your conclusions can you afford? Alternatively, how much uncertainty can you live with?

In practice, most watershed assessments that lie in between a simple reconnaissance and a multi-decade, thoroughly interdisciplinary watershed research project vary in their level of detail in different aspects of the assessment. Some rely only on existing data, but use that data in some complex mathematical models to arrive at some carefully considered conclusions. Others compile a mass of existing data and just tabulate it without any real analysis. Still other assessments acquire a lot of new data that present a thorough snapshot of current conditions, but largely ignore historical information and are thus unable to say anything about how the current condition developed. Some assessments are strong on hydrology and geomorphology, but pay little attention to biology. Conversely, some assessments are all about biology and give scant attention to the physical environment. Very few assessments adequately consider the social aspects of the watershed or of the assessment process itself. Because most assessments are a mix of complexity in various parts, ranking one as "more advanced" than another usually requires focusing on just a single aspect of the assessments.

Some of the factors that contribute to the complexity of an assessment are:

- Data Quantity
- Data Quality
- Data Analysis
- Data Synthesis & Integration
- Professional Understanding and Acceptance
- Social Understanding and Acceptance

Estimating where along the continuum of LOW ◄——► HIGH various aspects of the assessment fall provides an indication of the complexity of the analysis. For example, one assessment might reflect very high data quality but low data analysis. Watershed assessments that have most marks near the higher end of the scale will be more complex and have a lower degree of uncertainty associated with the conclusions than those that fall toward the lower end of the scale. Valuable assessments can and have been performed at all points along the continuum. Perhaps the important thing to remember is that you can approach your assessment in many different ways at many different levels of detail and still end up with a useful product IF your approach fits your issues and problems. The only real way to know whether your approach has potential is to leap in and do a reconnaissance-level assessment, get a lot of feedback from a broad audience, refine your approach, and focus on the important lessons learned from the first iteration. The availability of time, expertise, interest, and money will limit what you can do at any stage. At almost every possible level of detail, there is something to be learned from an assessment—something that will contribute to dealing with the issues and questions you have identified.

In an effort to give you a better understanding of the diversity of types of watershed assessments and the various

levels of complexity associated with them, the following assessments and URLs are provided for your review.

1. Basic watershed assessments

- Aliso Creek (USACE/OC) http://www.ocwatersheds.com/watersheds/Aliso_reports_studies.asp.
- Tomales Bay Watershed Stewardship Plan www.tomalesbaywatershed.org/stewardship.html
- Cottonwood Creek Watershed Assessment/Analysis http://wim.shastacollege.edu/watersheds.aspx?ws=5

2. Intermediate level of complexity

- Arroyo Seco Watershed Restoration Feasibility Study www.arroyoseco.org/WatershedSlides.htm
- Upper Clear Creek Watershed Analysis www.shastalink.k12.ca.us/clearcreek/WA%20Final.htm
- Aptos and Gazos Creeks www.coastal-watershed.org

3. More complex watershed assessments

- Lake Tahoe Watershed Assessment www.fs.fed.us/sw/publications/documents/gtr-175/.
- North Coast Watershed Assessment Program (Gualala and Mattole Rivers) www.ncwatershed.ca.gov/all_watersheds.html.
- Newport Bay/San Diego Creek Baseline Condition Report (USACE/OC) www.ocwatersheds.com/watersheds/pdfs/NewportBay_Baseline_Conditions_Report(F3).pdf.
- Napa River Basin Limiting Factors Analysis http://www.coastalconservancy.ca.gov/Programs/EXECUTIVE%20SUMMARY.pdf

4. Research watersheds (sites where long-term, continuous, in-depth studies of watershed processes and experimental alterations are occurring)

In California

- Caspar Creek Experimental Watershed www.fs.fed.us/psw/rsl/projects/water/caspar.html.
- Castle Lake http://outreach.ucdavis.edu/programs/castel2.htm.
- Kings River and Teakettle Creek Experimental Watersheds http://zimmer.csufresno.edu/~sblumens?KREW_INFO/KREW%20USFS1c.pdf.

Outside California

- H.J. Andrews Experimental Forest (OR) www.fsl.orst.edu/lter.
- Fraser Experimental Forest (CO) www.fs.fed.us/rm/fraser.
- Walnut Gulch Experimental Watershed (AZ) www.tucson.ars.ag.gov/unit/Watersheds/WGEW.htm.

Finally, some useful insight can be gained from the experiences of British Columbia and Washington. Earlier watershed assessment approaches (e.g., British Columbia Ministry of Environment 1995 http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/iwap/iwap-toc.htm and Ministry of Forests, 1999 http://www.for.gov.bc.ca/tasb/legsregs/fpc/FPCGUIDE/wap/WAPGdbk-Web.pdf; Washington State Department of Natural Resources, 1997) recognized the need to conduct watershed assessments at different levels of detail. Each increasing level represents progressively greater data amounts and precision, intensity of analysis, time, and (usually) cost. Each tier is designed to increase understanding and reduce uncertainty. However, the less complex levels of analysis can still produce very valuable information and should contribute to the more complex levels, and the more detailed approaches should build

on the fundamentals of the broad overviews. To get an idea of how people in other states and provinces have approached the issue of complexity in watershed assessments, information from British Columbia and the State of Washington is provided below.

British Columbia's Coastal / Interior Watershed Assessment Procedure Guidebooks (1995 & 1999) for forested watersheds divides its assessment protocols into three levels:

- BC Level 1: A reconnaissance-level analysis intended as a coarse filter to identify watersheds that may have impacts from the cumulative effects of past logging or planned future logging.
- BC Level 2: An overview stream channel assessment performed by someone with basic experience in hydrology and/or geomorphology
- BC Level 3: A very detailed analysis performed by a watershed specialist, involving mostly field work. The work is guided by the results of the level 1 and level 2 analyses.

The State of Washington distinguishes detail into two levels:

- WA Level 1: A reconnaissance assessment, relying predominantly on maps and remotely sensed information with some field checking. The assessment is designed to take one to two weeks of effort by the team, but could take longer depending on the time needed for data acquisition.

- WA Level 2: This level may be similar to Level 1, but results in a more detailed assessment of the overall watershed, or it may be focused on specific resource issues identified in Level 1. More experience and education are required for Level 2 specialists, and more time may be needed.

1.6 Manual Development

The concept for this Manual came from the California Watershed Management Forum (see section 1.5.1). The California Department of Forestry and Fire Protection (CDF) and CALFED provided funding to the University of California, Davis, to develop the Manual, with the project coordinator selected from within the Department of Environmental Science and Policy. The Manual was developed by an interdisciplinary team of watershed scientists affiliated with U.C. Davis and the Office of Environmental Health Hazard Assessment (California EPA) with assistance from staff at CDF. A technical steering committee was established to advise the team in development of the Manual. The committee was composed of practitioners, agency representatives, and researchers involved in watershed assessment in California.

A critical part of the process involved collecting ideas and advice from diverse interests and experts from the larger watershed community. Various announcements about the project were distributed and team members made presentations at regional and statewide conferences and to local, regional, and state groups, (e.g., the Bay-Delta Public Advisory Committee Watershed SubCommittee). The team solicited comments about the types of problems encountered in conducting watershed assessments and suggested tools for conducting assessments.
The team assembled various watershed assessment approaches from a wide range of sources. The team determined which tools best address the variety of watersheds and watershed factors that need to be assessed and the social and environmental issues facing California watershed groups and analysts. This document represents the first version of the Manual. A revised Manual will be released in December, 2004 with edits based on public comment on the first draft.

The Manual is available in three formats: hard-copy, CD-ROM and online http://cwam.ucdavis.edu. The Web-site also provides relevant technical and spatial information.

In the Manual, there is an emphasis on narrative explanations for why particular approaches are important, short explanations for how to do various tasks, and references and links to outside resources for specific protocols. Look for the text boxes inserted throughout the text and the action steps following certain sections.

1.7 Next Steps in Manual's Evolution

The Manual focuses on watersheds of northern and central California. It also focuses primarily on the processes of planning and conducting assessments and secondarily on the specific tools associated with investigating particular watershed processes. Future Manual volumes will include protocols for assessing specific watershed conditions (e.g., land-use analysis) and functions (e.g., ground-water supply). The process may eventually include testing in real-world situations and further revision of the Manual. A training program may be developed to assist Manual users.

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