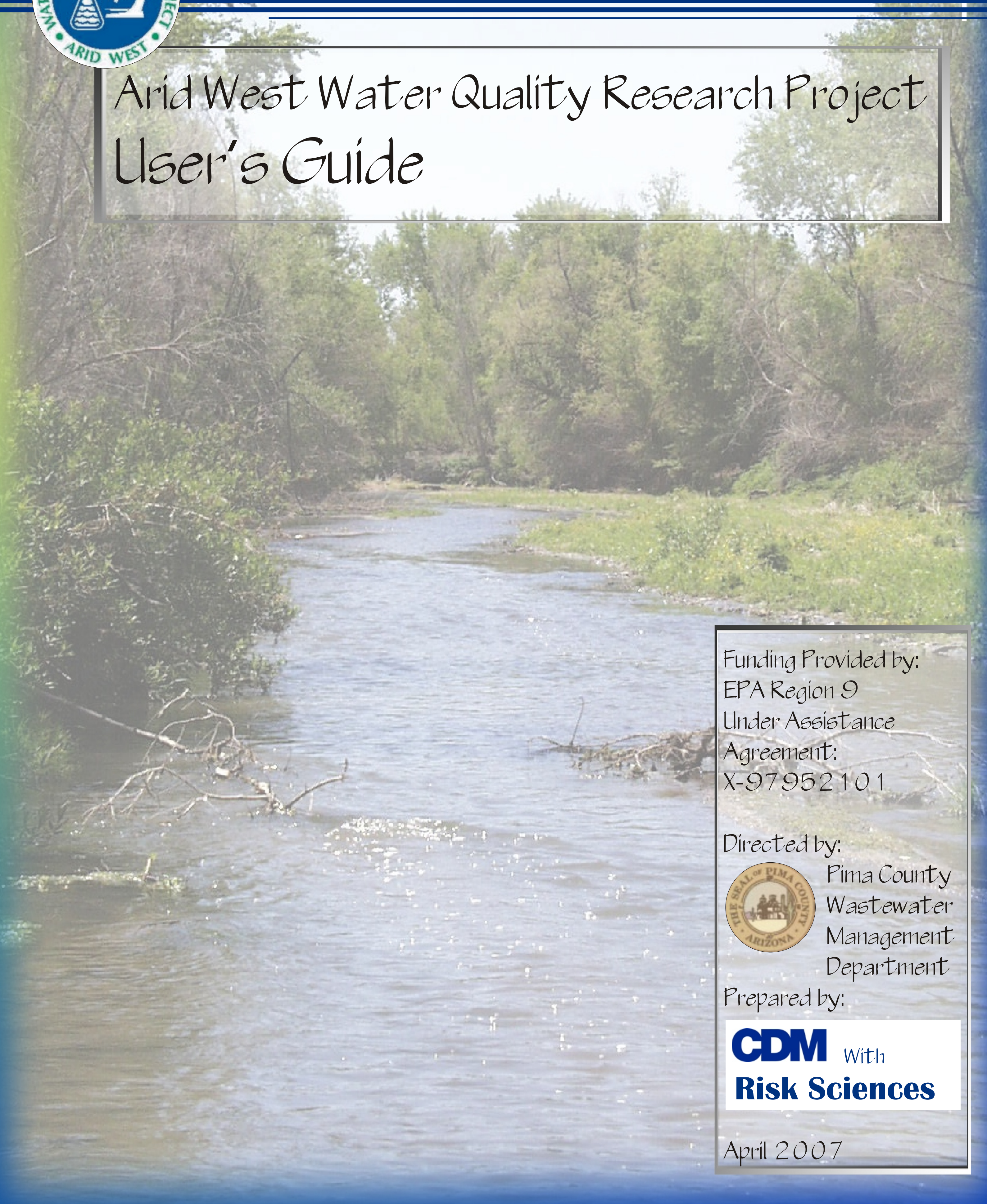
Arid West Water Quality Research Project

User's Guide



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Arid West Water Quality Research Project

Arid West Water Quality Research Project User's Guide

Prepared for

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Foreword

The Arid West Water Quality Research Project (AWWQRP or "Project") was established in 1995 as a result of a federal appropriation (Public Law 103-327) and the establishment of Assistance Agreements between the U.S. Environmental Protection Agency (EPA) and Pima County Wastewater Management (PCWMD), Tucson, Arizona (Phase I, #XP-99926701; Phase II, X-97952101). The establishment of these Agreements provided a significant opportunity for western water resource stakeholders to (1) work cooperatively to conduct scientific research to support development of appropriate water quality criteria, standards, and uses for effluent-dependent and ephemeral waters in the arid and semi-arid regions of the west ("arid west"); and (2) improve the scientific basis for regulating wastewater and stormwater discharges in the arid west.

With the establishment of the AWWQRP, a management infrastructure was created to support the development of peer-reviewed research products. From within the Environmental Planning Division of PCWMD, the AWWQRP Project Director, Program Manager, and support staff administers the Project. A Regulatory Working Group (RWG), comprised of 15 stakeholders representing both public and private interests, works to ensure that Project research has a firm regulatory basis and that research activities focus on important regulatory concerns. The Scientific Advisory Group (SAG), comprised of scientists with experience in water quality research, makes certain that project research has a good scientific basis and that studies are properly designed and technically sound.

This User's Guide was developed to provide a quick overview of the research findings from the many projects funded by the AWWQRP:

- *Pre-Research Survey of Municipal NPDES Dischargers in the Arid and Semi-Arid West*—compiled information regarding arid west effluent discharges and associated water quality concerns.
- *Habitat Characterization Study*—evaluated the physical, chemical, and biological characteristics of 10 effluent-dependent and effluent-dominated waterbodies in the arid west, and developed a conceptual ecosystem model.
- *Extant Criteria Evaluation (ECE)*—assessed the applicability of national ambient water quality criteria and the methods to modify those criteria in effluent-dependent, effluent-dominated, and ephemeral waters.
- *Evaluation of the Reliability of Biotic Ligand Model (BLM) Predictions for Copper Toxicity in Waters Characteristic of the Arid West*—appraised the relevance of the BLM for deriving site-specific copper criteria in effluent-dependent and effluent-dominated streams.
- *Hardness-Dependent Ammonia Toxicity and the Potential Use of the Water Effect Ratio (WER)*—performed an empirical study as a "proof of concept" to determine whether hardness exerts a significant enough effect on acute ammonia toxicity to be used as a basis for deriving site-specific ammonia standards in hard effluent-dependent waters.
- *Evaluation of EPA Recalculation Procedure in Arid West Effluent-Dependent Waters*— evaluated the use of EPA's Recalculation Procedure on selected water quality criteria with different modes of toxicity.
- *User's Guide for Development of Site-Specific Water Quality Standards in Arid West Effluent-Dependent Streams Using EPA's Recalculation Procedure*—prepared to provide a practical guide for water quality standards practitioners wanting to use the procedure to develop site-specific standards.
- *Aquatic Communities of Ephemeral Stream Ecosystems*—compiled a list of aquatic species observed in ephemeral streams following precipitation runoff events and documented changes in the aquatic communities over time following the runoff event.

Each of these research studies received a technical peer review from the SAG, a general review from EPA, and a regulatory review from the RWG. In addition to summarizing the research findings, preparation of the User's Guide provided the opportunity to place these findings within the context of the water quality standards program implemented under the federal Clean Water Act. The following table provides a guide to the most commonly requested information in this document.

Quick Guide to Key Topics in User's Guide Topic

Topic	Document Location
Overview of Water Quality Standards Regulations	Section 2 2.1—Federal Clean Water Act 2.2—Water Quality Standards Program
Description of Arid West Aquatic Environments	Section 2 2.3.1—Hydrology 2.3.2—Water Quality 2.3.3—Biological Communities Section 3 3.2.2—Habitat Characterization Study 3.2.7—Aquatic communities of Ephemeral Streams
Arid West – Aquatic Species Information	Section 3 3.2.2—Habitat Characterization Study 3.2.7—Aquatic Communities of Ephemeral Streams
Overview of Water Quality Criteria Development	Section 3 3.2.3—Extant Criteria Evaluation
Site-Specific Water Quality Standards Development	Section 3 3.2.4—Biotic Ligand Model 3.2.5—Recalculation Procedure and Guidance Manual Development Section 4 4.2.4—Compliance with Uses and Criteria
NPDES Permit Compliance Tools	Section 4 4.2.3—Permit Compliance
Net Environmental Benefit	Section 4 4.3.2—Net Environmental Benefit
Developing Stakeholder Consensus	Section 5 5.2—Critical Success Factors 5.3—Stakeholder Process and Management 5.5—Decision Framework
Regulatory Case Studies	Section 6
Finding the Best Regulatory Solution	Section 7

The AWWQRP has made a significant effort to share Project results and their implications in a variety of technical, regulatory, industry, and public interest forums, including publication in the primary scientific literature. As stated above, an important purpose for this document was to provide a vehicle for discussing research findings in a broader regulatory context. However, the concepts and ideas regarding the use of research within this context, and how those interested in using research to change regulations or affect regulatory outcomes, are based on the experiences and opinions of the authors. As noted frequently throughout this document, any effort to initiate and implement regulatory change should be done so only in close coordination with both state and federal regulators. In fact, the most successful regulatory processes have been a success largely because regulators were key participants.

The AWWQRP was designed to create a broader understanding of water quality issues unique to the arid west and provide scientific and regulatory data in support of a regional approach to the development of water quality criteria and designated uses. Heightened interest in arid west water quality issues continues to be fueled by the recognition that treated effluent is a valuable water resource. Accordingly, continued research is needed to find innovative ways to address increasingly complex, difficult regulatory questions.

The AWWQRP has been pleased to have fulfilled part of this need. It is recommended that the types of research conducted by the AWWQRP continue and be expanded upon so that basic questions regarding the basis for water quality criteria and use protection be addressed.

For additional Project information, please contact:

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Acknowledgments

Arid West Water Quality Research Project

Support of the AWWQRP by Pima County Government and staff has been an essential element for the Project accomplishments since its inception. The distinguished Director of the Wastewater Department at that time, the late George Brinsko, worked actively with the Congress and EPA to secure the funding to implement the Project. The County Administrator, Charles H. Huckelberry and Deputy County Administrator for Public Works, John M. Bernal, have consistently supported the Project purpose and activities. The assistance of the County Procurement Department, the Graphic Services Department, and Geographic Information Systems staff has been much appreciated. The Wastewater Department support for the Project has been exceptional, especially from the Director's Office, the Engineering/Planning Division, and the Finance/Administrative Services Division. The current Wastewater Director, Michael Gritzuk, has been involved with the Project since he became one of the initial members of the Regulatory Working Group in the mid 1990s and also assisted the Project in obtaining Phase II funding.

The AWWQRP is currently administered by the following individuals:

- Michael Gritzuk, P.E., Director, Pima County Wastewater Management Department
- Paul M. Bennett, P.E., Deputy Director, Pima County Wastewater Management Department
- Edward F. Curley, Project Director, Pima County Wastewater Management Department
- Karen Ramage, Program Manager, Pima County Wastewater Management Department
- Richard D. Meyerhoff, Ph.D., Research Manager, Camp Dresser & McKee Inc.
- Robyn Stuber, EPA Project Officer, EPA Region 9, San Francisco, California

Regulatory Working Group

The RWG was established by the AWWQRP to assist in the identification of regulatory issues needing to be addressed by scientific research. The RWG includes representatives from state and regulatory agencies, municipalities, Indian Tribes, industry, environmental organizations, consulting firms, and universities. The RWG also provided critical review of draft reports and project presentations. Currently, the RWG consists of the following individuals:

- Michael Gritzuk, P.E., Pima County Wastewater Management, Tucson, Arizona
- Edward C. Anton, California State Water Resources Control Board, Sacramento, California
- Rodney W. Cruze, Riverside Regional Water Quality Control, Riverside, California
- Paul D. Frohardt, Colorado Water Quality Control Commission, Denver, Colorado
- Robyn Stuber, EPA, Region 9, San Francisco, California
- Andy Laurenzi, The Nature Conservancy, Marana, Arizona
- Patrick J. Maley, Mining Industry Representative, Boise, Idaho
- Lynn Wellman, U.S. Fish & Wildlife Service, Albuquerque, New Mexico

- James F. Pendergast, EPA, Office Science and Technology, Washington, D.C.
- Sam Rector, Arizona Department of Environmental Quality, Phoenix, Arizona
- Eric Rich, EPA - Navajo Nation, Tuba City, Arizona
- Daniel Santantonio, Ph.D., City of Las Cruces, Utility/Water Division, Las Cruces, New Mexico
- Gary Ullinskey, City of Phoenix Water Services, Phoenix, Arizona

Others who have served this advisory group include: Catherine Kuhlman (EPA Region 9), Terry Oda (EPA Region 9), Susan MacMullin (U.S. Fish & Wildlife Service), Dan Beard (National Audubon Society), Barbara Tellman (University of Arizona), and Neil Stessman (Billings, Montana).

Scientific Advisory Group

The SAG was established to provide technical oversight and peer review of ongoing and planned research for the AWWQRP. The SAG provided critical review for all sections of this report. SAG members include:

- Paul Adamus, Ph.D., Corvallis, Oregon (Oregon State University)
- Gary Chapman, Ph.D., Paladin Water Quality Consulting, Corvallis, Oregon
- Karmen King, Envirotech, Cortez, Colorado
- Robert McFarlane, Ph.D., McFarlane & Associates Environmental Consultants, Houston, Texas
- Benjamin Parkhurst, Ph.D., HAF, Inc., Centennial, Wyoming
- Robert Gray, Ph.D., Richland, Washington
- Carlton Sims White, Ph.D. University of New Mexico, Albuquerque, New Mexico

Quality Assurance/Quality Control

All AWWQRP research products were also reviewed to ensure compliance with the project Quality Assurance/Quality Control (QA/QC) plan. This review was provided by:

- Frederick A. Amalfi, Ph.D., Aquatic Consulting and Testing, Tempe, Arizona

Research Teams

Contributors to AWWQRP-funded research included experts in a variety of technical disciplines. A complete list of contributors to each research project is included with each study's final report (see attached CD). We particularly appreciate the efforts of the following individuals for their efforts in producing quality research products:

- Linwood Smith, Ph.D. (Environmental Planning Group)
- Mark Murphy, Ph.D. (URS Corporation)
- Robert Gensemer, Ph.D. (Parametrix)
- Steve Canton (GEI Consultants)

Other Participants

We also acknowledge and appreciate the contributions by others who helped with the preparation of this User's Guide and provided materials:

- Susan Morea, CDM, Denver
- Nicole Rowan, CDM, Denver
- Connie Epson, CDM, Denver
- Bill DiRenzo, Wyoming Department of Environmental Quality
- Judy Guidotti, Pima County Wastewater Management Department, Tucson, Arizona

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Section 1 Introduction

1.1 Arid West Water Quality Research Project

The Arid West Water Quality Research Project (AWWQRP) was established as the result of concerns regarding the applicability of federal ambient water quality criteria to ephemeral, effluent-dependent, and effluent-dominated waters ("arid west waters"). Two key issues were originally identified: (1) federal ambient water quality criteria were based on aquatic species and flow regimes not necessarily representative of arid west waters; and (2) the methods provided by the U.S. Environmental Protection Agency (EPA) to modify federal water quality criteria for use in effluent-dependent and ephemeral streams were not readily applicable, primarily because of the lack of basic data on organisms of importance in these arid west waters. With these concerns in mind, regional stakeholders initiated efforts to demonstrate the need for a water quality standards research program dedicated to arid west issues.

These efforts bore fruit with the establishment of the AWWQRP in 1995 as the result of a $5,000,000 federal appropriation (Public Law 103-327) and the establishment of an Assistance Agreement between EPA and Pima County, Arizona. The establishment of the Agreement provided a significant opportunity for Pima County, EPA Region 9, and others throughout the arid west to work cooperatively to conduct the scientific research necessary to develop appropriate water quality criteria and standards for the region and improve the scientific basis for regulating wastewater and stormwater discharges in the arid and semi-arid west. An additional $500,000 was appropriated to the project in 2001.

Since the establishment of the research program, a number of research projects have been completed. These have ranged from a characterization of the physical, chemical, and biological characteristics of effluent-dependent and effluent-dominated waters to an assessment of the applicability of federal ambient water quality criteria to arid west waters and an evaluation of methods to modify criteria for these waters. This document includes a summary of the findings of this research, as well as other related research, and discusses these findings in the context of water quality standards program implementation as it is being carried out by the states and EPA.

1.2 Need for a User's Guide

This User's Guide was prepared with all water quality standards practitioners in mind; not just dischargers who must comply with the myriad of state and federal water quality standards regulations, but also state regulators who are often searching for practical and innovative ways to develop and implement water quality standards within the bounds of the Clean Water Act (CWA) and its implementing regulations. The focus of this document is on arid west waters and the protection of aquatic life and recreational uses.

To a large degree, the simple problems of water quality control have been addressed. Today, more than 30 years after establishment of the CWA, the remaining water quality issues are typically complex. To address these new challenges, water quality standards practitioners have had to identify new and innovative ways to develop and implement water quality standards. Often we find such innovation right next door in a neighbor state or in states that are not part of the arid west. Unfortunately, what has occurred in these other states is not always readily known.

In addition to the innovative regulatory concepts developed in various states, research continues to be conducted on arid west waters through the AWWQRP and other organizations. The information obtained from this research has practical application throughout the west and can be the impetus for additional regulatory innovation. To support the need to share this information, this User's Guide was developed to support water quality standards programs in the arid west.

Significant challenges exist regarding how water quality standards regulations should be applied to ecosystems modified by the discharge of effluent, especially for aquatic life uses. There are numerous opinions regarding the appropriateness of discharging effluent where the result is converting naturally ephemeral or intermittent streams into effluent-dependent or effluent-dominated waters, respectively. Completely opposite viewpoints exist. On the one hand, some view the act of discharging any treated effluent into ephemeral or intermittent waters as causing damage to the environment, while on the other hand others view the discharge of treated effluent as providing a valuable resource with multiple benefits. There are a number of permutations of these views that fall somewhere in between these two opposing views. Given the difference of opinion this document does not make any judgments regarding the appropriateness of such discharges. Instead the focus is on the recognition that such discharges are common, they are being studied, and present a challenge for how to best regulate them under the water quality standards regulation. In addition, this document recognizes that given the increased competition for water resources that will occur in the future—especially in the arid west—this challenge will not disappear any time soon.

1.3 User's Guide Roadmap

We have sought to prepare a document with sections that illustrate key points in a relatively brief, readable format. However, for those who wish to see the more substantive information behind what is presented, a CD has been included that contains extensive supporting documentation, including final reports of all AWWQRP research projects. Following is a summary of the sections contained in this guide.

Section 2 – Arid West Framework—This section presents a basic overview of the water quality standards program for the new water quality standards practitioner and provides an overview of arid west ecosystems and the challenges ahead in these waters.

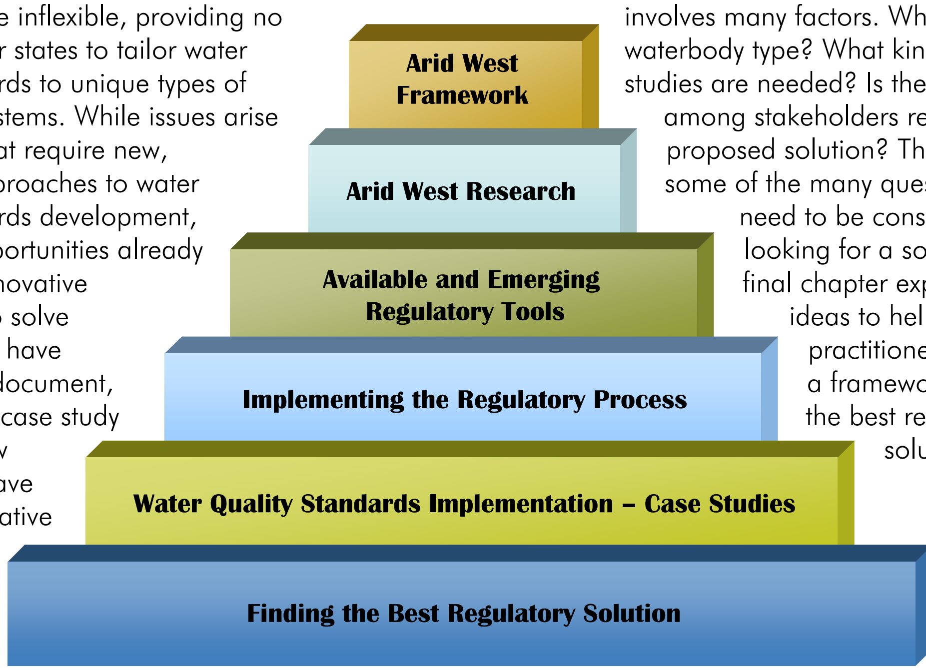
Section 3 – Arid West Research—This section provides an overview of the research conducted by the AWWQRP on arid west waters, as well as a brief overview of relevant research carried out by other organizations, especially the Water Environment Research Foundation (WERF).

Section 4 – Available and Emerging Regulatory Tools—Concerns regarding water quality standards applicability often arise through one of two paths: Issuance of a point source discharge permit or implementation of a Total Maximum Daily Load (TMDL). This section reviews a variety of tools currently in use to address water quality standards concerns and presents a number of emerging tools.

Section 5 – Implementing the Regulatory Process—The regulatory process that must be implemented to modify a use or criterion can be difficult. Why do some processes achieve success, while others result in either outright failure or, possibly worse, no action? This section will explore this issue and provide some recommendations for increasing the likelihood of achieving success when seeking to establish alternative water quality standards.

Section 6 – Water Quality Standards Implementation – Case Studies—Often it is heard that the CWA and its implementing regulations are inflexible, providing no opportunity for states to tailor water quality standards to unique types of aquatic ecosystems. While issues arise all the time that require new, innovative approaches to water quality standards development, numerous opportunities already exist to use innovative approaches to solve problems. We have attempted to document, in the form of case study examples, how some states have seized the initiative to develop innovative approaches.

Section 7 – Finding the Best Regulatory Solution—Identifying the best approach to address a water quality standards concern involves many factors. What is the waterbody type? What kind of scientific studies are needed? Is there consensus among stakeholders regarding the proposed solution? These are just some of the many questions that need to be considered when looking for a solution. This final chapter explores these ideas to help practitioners decide on a framework for finding the best regulatory solution.



User's Guide Roadmap

Section 2 Arid West Framework

Federal laws and regulations establish the framework for water quality regulation. At a minimum, states are required to implement the federal water quality regulations; however, they are afforded the opportunity to establish laws and regulations appropriate to their state, as long as they are consistent with federal statute. This section first describes the federal laws and regulations governing water quality that are applicable to all states, territories, and Indian nations. Second, a brief description of arid west ecosystems is provided to provide the reader with a general understanding of these systems. Finally, this section presents a look at the future, providing an overview of coming water resource and regulatory challenges facing arid west states.

2.1 Federal Clean Water Act

Quality of the nation's surface waters is regulated under what is commonly known as the Clean Water Act. Today's CWA is the result of an evolution of water quality legislation. The first comprehensive legislation for water pollution control was the Water Pollution Control Act of 1948. The concepts in this act were continued in the Federal Water Pollution Control Act (FWPCA) of 1956 and the Water Quality Act of 1965. Under the 1965 Act, states were directed to develop water quality standards for their waterbodies. Because of enforcement complexities and other problems, Congress passed the FWPCA Amendments of 1972, which established a discharge permit system and extended water quality standards to intrastate waters. The FWPCA along with major amendments in 1977, 1981, and 1987 comprise the current CWA. The requirements of the water quality standards program are contained in Section 303(c) of the CWA. The key elements of Section 303(c) include (EPA 1994a):

- Water quality standards are provisions of laws and regulations that include the designated uses of waters protected under the CWA and the water quality criteria needed to protect those uses
- The minimum designated uses that states are to consider when establishing water quality standards are public water supply, propagation of fish and wildlife, recreation, agricultural uses, industrial uses, and navigation
- A state's water quality standards must protect public health and welfare, enhance the quality of water, and serve the purposes of the CWA
- States must review their standards at least once during a 3-year period

Within the CWA, water quality standards implementation occurs in two primary areas: (1) issuance of a National Pollutant Discharge Elimination System (NPDES) permit, which provides two types of control: technology-based limits (based on the ability of dischargers in the same industrial category to treat wastewater) and water quality-based limits (if technology-based limits are not sufficient to provide protection of a waterbody); and (2) development of TMDLs, which are the key mechanism for bringing a waterbody into compliance with established water quality standards.

The following section provides a general overview of the basic elements of water quality standards. This information provides a foundation for subseqent sections of this guide.

2.2 Water Quality Standards Program

The CWA requires that state water quality standards include three elements—the designated use (or uses) of a waterbody, water quality criteria to protect these uses, and antidegradation provisions to prevent degradation of water quality (EPA 1994a). Together, these three elements constitute water quality that is safe because it presents an acceptably low level of risk. In simplistic terms, risk is considered using the type of exposure to a pollutant (implied in the designated use) and the amount of pollutant present (determined by the water quality criteria). The antidegradation provisions ensure that there is a low risk that the waterbody will be degraded over time.

Designated Uses—How the waterbody is expected to be used; e.g., recreation, water supply, aquatic life. There generally is more than one designated use for a waterbody.

Water Quality Criteria—Limits placed on the magnitude of pollutants so that the waterbody can be safely used as designated.

Antidegradation—A process to ensure water quality is not unacceptably degraded by human use if an activity is implemented.

2.2.1 Existing and Designated Uses

The CWA recognizes two different categories of water use—existing uses and designated uses (Figure 2-1). Existing use is defined by federal regulation as a use that has actually been attained on or after November 28, 1975, regardless of whether that use is included in a state's water quality standards (see 40 CFR 131.3). EPA has not provided detailed guidance on how to define existing uses and therefore states often determine existing uses on a case-by-case basis (Note: EPA is currently developing a designated uses question and answer document that may provide additional information regarding existing uses).

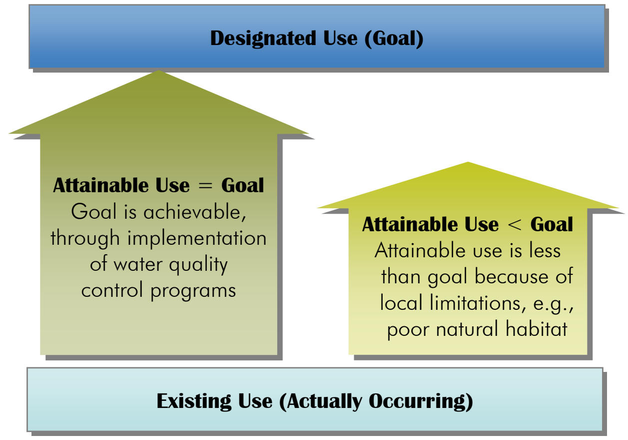


Figure 2-1
Understanding what is attainable is critical to establishment of appropriate designated uses.

Designated uses are those uses specified in the water quality standards for each waterbody or segment whether or not they are being attained. The federal water quality standards regulation, which implements Section 303 of the CWA, requires states to fulfill the following requirements when establishing designated uses for each waterbody:

- Each state must specify appropriate uses to be achieved and protected. The classification of the waters within the state must take into consideration the use and value of water for public water supplies; protection and propagation of fish, shellfish, and wildlife; recreation in and on the water; agricultural; industrial; and other purposes including navigation. In no case shall a state adopt waste transport or waste assimilation as a designated use for any waters of the United States (40 CFR 131.10(a)).
- In designating uses of a waterbody and the appropriate criteria for those uses, the state shall take into consideration the water quality standards of downstream waters and shall ensure that its water quality standards provide for the attainment and maintenance of the water quality standards of downstream waters (40 CFR 131.10(b)).

States may also designate other uses, subcategories of the uses, or even seasonal uses. For example, states commonly adopt use subcategories to address the "protection and propagation of fish and wildlife" separately in cold and warmwater waterbodies. A seasonal designated use may be established for seasonal primary contact recreation activities. For example, in cold climates, swimming may only occur during warm months.

States may designate a use regardless of whether the use is being attained in the waterbody. EPA requires states do this for the designated uses specified in the CWA, especially for the "fishable and swimmable" uses. If states do not designate a fishable or swimmable use for a given waterway, states must complete a Use Attainability Analysis (UAA). A UAA is a structured scientific assessment of the factors affecting the attainment of the use that may include physical, chemical, biological, and economic factors (examples of arid west UAAs are provided in case studies in Section 6). A UAA may result in the removal or subcategorization of a designated use, but cannot be used to remove or change an existing use.

The frequently heard phrase* "fishable/ swimmable" *goal of the CWA is a reference to the requirement that states establish designated uses for the "protection and propagation of fish, shellfish and wildlife, recreation in and on the water" (e.g., see 40 CFR 131.10(a)).

2.2.2 Water Quality Criteria

States are required to adopt water quality criteria that will protect the uses of a waterbody. These criteria must be based on a sound scientific rationale. EPA has provided guidance for the establishment of water quality criteria for various uses based on scientific information regarding concentrations of pollutants that protect aquatic life and human health (e.g., see EPA 1994a). States have the option of using the criteria recommended by EPA or developing their own criteria. However, if a state chooses to develop its own water quality criteria for a pollutant, it must demonstrate a sound scientific rationale for the alternative criteria and EPA must approve the alternative approach.

Water quality criteria are typically adopted as statewide or river basinwide criteria. Ideally, water quality criteria have three components:

- Magnitude is the maximum allowable concentration of a pollutant. For aquatic life criteria, the magnitude is generally expressed two ways—a short-term maximum concentration, also known as the Criterion Maximum Concentration (CMC) or acute concentration, and a long-term continuous concentration, also referred to as the Criterion Continuous Concentration (CCC) or chronic concentration.
- Duration is the amount of time aquatic life can be exposed to either the acute or the chronic criterion. Most federally-recommended criteria are based on an exposure duration of 1 hour for acute criteria and 4 days for chronic criteria. A notable exception is the federally recommended chronic criteria for ammonia, which are based on an exposure duration of 30 days.
- Frequency is how often the criteria can be exceeded and still be protective. EPA recommends that the allowable frequency of exceedance for aquatic life be no more than one exceedance every 3 years.

Water Quality Criteria

Water quality criteria are typically established for chemical pollutants, e.g., metals, toxics, and nutrients, and physical constituents such as dissolved oxygen, pH, and temperature. Water quality criteria may be expressed as:

- Numeric Criteria – these are the most common type of water quality criteria. Numeric criteria to protect aquatic life are developed to address both short-term (acute) and long-term (chronic) effects on aquatic life.
- Narrative Criteria – as a supplement to numeric criteria, states have adopted some form of narrative criteria. Narrative criteria typically describe toxicological, ecological, or aesthetic characteristics that should or should not be present in a waterbody.

Other Criteria Types

Many states are also beginning to establish other types of criteria, including:

- Biological Criteria – biological criteria are numerical values or narrative expressions that describe the expected reference biological integrity of an aquatic community in waters with a designated aquatic life use.
- Sediment Criteria – states typically have adopted narrative criteria for both clean sediment deposition in waterbodies and contaminated sediments. EPA is also working on developing recommended numeric sediment criteria.

States may also adopt site-specific water quality criteria for waterbodies so that water quality criteria reflect local environmental conditions. Often times, these site-specific criteria are less stringent than the existing water quality criteria of a waterway. Site-specific criteria are developed by taking into account the biological and water quality characteristics of a given site. Opportunities for the development of site-specific criteria will be discussed in Section 3.

2.2.3 Antidegradation

Antidegradation consists of a regulatory policy coupled with an implementation procedure designed to protect existing waterbody uses and prevent water quality from degrading. States are required to develop this policy and implementation plan as part of their water quality standards. States must adopt a policy that includes at least three levels of protection, called tiers (e.g., see Arizona Department of Environmental Quality [ADEQ] 2005), although states are free to include additional protection levels as appropriate. For example, West Virginia has established a Tier 2.5, Waters of Special Concern.

Recommended Additional Reading on Water Quality Standards

- Advanced Notice of Proposed Rulemaking for Water Quality Standards Regulation, 40 CFR 131, July 7, 1998, 63 Federal Register 36741-36806.
- EPA 1996. NPDES Permit Writers' Manual, EPA 833-B-96-003.
- EPA Water Quality Standards Handbook, EPA 823-B-94-005a, August 1994.
- EPA Technical Support Document for Water Quality-Based Toxics Control, EPA/505/2-90-001, March 1991.
- Federal Water Quality Standards Regulation, 40 CFR 131, November 8, 1983.
- EPA Office of Science & Technology http://epa.gov/waterscience/standards

The federal water quality standards regulation establishes the minimum requirements for establishment of an antidegradation policy (40 CFR 131.12).

- Tier 1 protection requires that existing instream water uses and the level of water quality necessary to protect the existing uses be maintained and protected. Where an existing use is established, it must be protected even if it is not listed in the water quality standards as a designated use. Tier 1 requirements are applicable to all surface waters protected under the CWA.
- Tier 2 applies to "high quality" waters where the quality of the water exceeds levels necessary to support propagation of fish, shellfish, and wildlife and recreation in and on the water. This level of water quality shall be maintained and protected unless the state finds after completion of an appropriate level of public input, that allowing lower water quality is necessary to accommodate important economic or social development in the area in which the waterbody is located. However, if lower water quality is allowed, the state must still protect the existing uses fully. Typically, unless a waterbody is designated as a Tier 3 water (see below), most state waters are presumed to be Tier 2 or "high quality" waters. State antidegradation procedures typically provide methods for how the state will determine whether a proposed activity will degrade water quality in a Tier 2 water.
- Tier 3 applies to waters designated as Outstanding National Resource Waters (ONRWs). Water quality must be maintained and protected in these waters. Except activities that might cause only a temporary change in water quality, no degradation is allowed. Decisions regarding which waterbodies qualify as ONRWs are made by states.

Antidegradation Tiers

- Tier 1 maintains and protects existing uses and water quality conditions necessary to support such uses. No degradation of existing uses is allowed.
- Tier 2 maintains and protects "high quality waters" – waters where existing conditions are better than necessary to support "fishable/swimmable" uses.
- Tier 3 maintains and protects water quality in designated Outstanding National Resource Waters.

2.3 Arid West Characteristics

The arid west is defined as the arid and semi-arid portions of the western United States that extend from south-central Texas west to southeastern California and north along the east side of the Sierra Nevada and Cascade Ranges to the Canadian Border in eastern Washington. The eastern boundary of this region extends from central North Dakota south through central South Dakota, Nebraska, western Kansas, and Oklahoma to south-central Texas. The arid and semi-arid areas of this region, which incorporates portions of 17 western states, is characterized generally by annual precipitation of less than 10 and 20 inches, respectively (Figure 2-2).

While much of the region can be classified as arid or semi-arid based on annual precipitation, the northern portions are characterized by strong seasonality with warm summers and cold winters. By contrast, southeastern California, southern Arizona, New Mexico, and Texas are characterized by comparatively mild winters and warm to hot summers.

Within the arid west, there are eight ecoregions that have been defined based on elevation, topography, and vegetation (Omernick 1987). In general, vegetation is most frequently composed of plant communities of low stature, dominated by a variety of species of small trees, shrubs, grasses, and forbs. Forested landscapes are limited to higher elevation areas where precipitation is greater and summer temperatures are moderate. Riparian areas generally have the most complex vegetation communities in lower elevations (Pima County Wastewater Management Department [PCWMD] 2002).

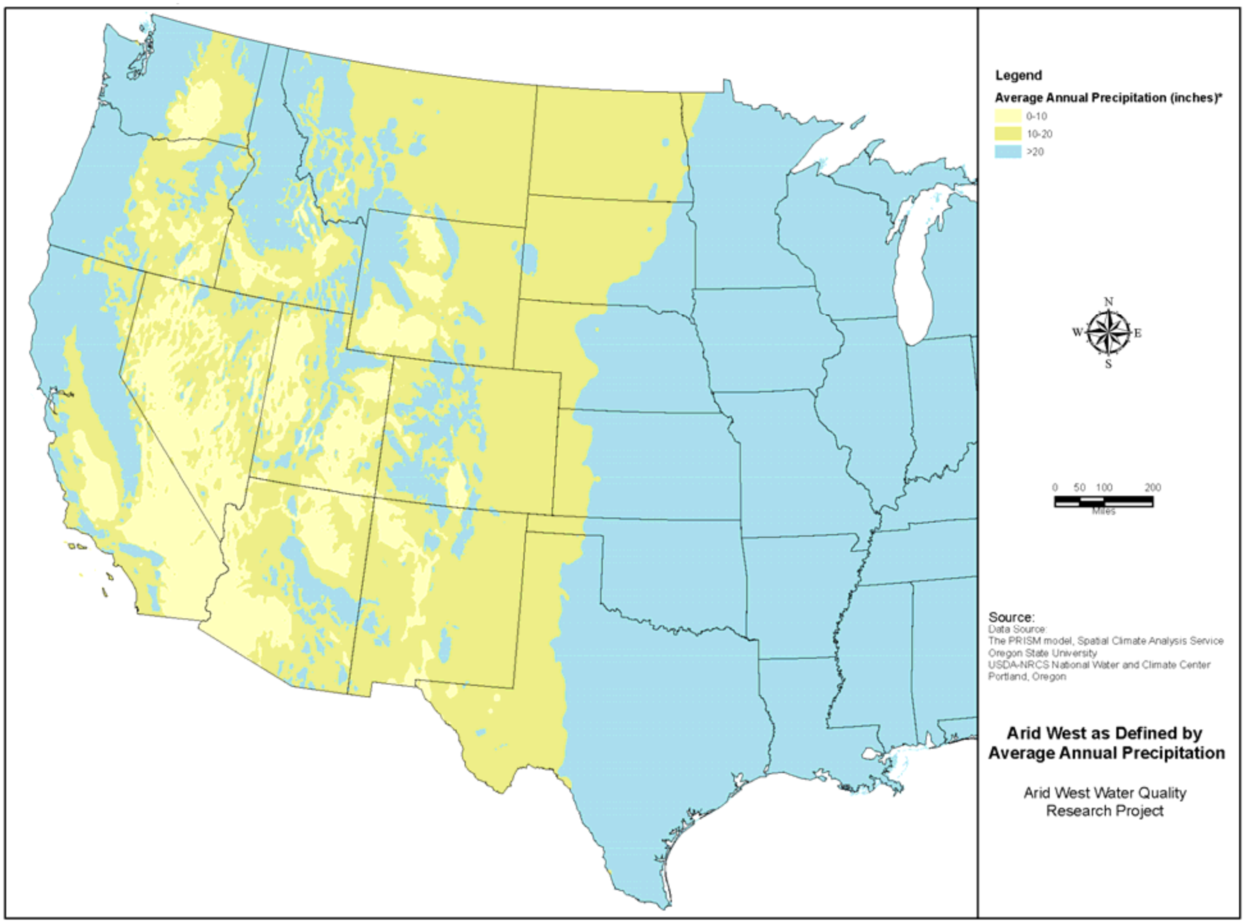


Figure 2-2
Average Annual Precipitation

2.3.1 Hydrology

Within the arid west there is a southerly trend of diminished perennial stream flow. In the southwestern United States there are relatively few perennial rivers, and where they exist, they are highly regulated systems providing water supplies for urban and agricultural uses and have been modified to provide flood control protection for urban areas. The majority of natural waterways in the region south of the 40 degree latitude are ephemeral (flowing only in response to precipitation) or intermittent (flowing only in short reaches or in certain seasons). For example, only 8 percent of total stream miles in New Mexico are classified as perennial and only 5 percent of Arizona's waterbodies flow perennially (New Mexico Water Quality Control Commission [NMWQCC] 2004; Arizona Comparative Environmental Risk Project [ACERP] 1995). The surface water hydrology of arid west regions is characterized by water courses where flow is controlled largely by precipitation events: water flows in response to spring snow melt and periodic storms, either as winter storm fronts or as summer monsoons.

Arid West Waters

Arid west waterbodies are often ephemeral or intermittent:

- **Ephemeral Stream**—surface water with a channel that is at all times above the water table and flows only in direct response to precipitation or snowmelt.
- **Intermittent Stream**—A stream whose channel bottom is alternately above and below the groundwater table for different portions of the year. An intermittent stream does not maintain a perennial surface flow, although permanent pools of standing water may be present at points along the stream.

Discharges of treated wastewater into ephemeral or intermittent stream channels create effluent-dependent and effluent-dominated waters:

- **Effluent-dependent Stream**—created when effluent is discharged to an ephemeral stream channel. Prior to the discharge, the waterbody may be naturally ephemeral or ephemeral because of anthropogenic impacts such as dams, diversions, and excessive groundwater pumping.
- **Effluent-dominated Stream**—where the effluent provides a significant portion of the flow. Waters that are effluent-dominated may have been naturally intermittent or historically perennial; however, anthropogenic activities have greatly reduced the amount of water that naturally flows in the river channel.

Discharges of treated wastewater into stream channels may create perennial waters that are either effluent-dependent or effluent-dominated. An effluent-dependent stream is a stream that would be an ephemeral stream without the presence of wastewater effluent, but which has continuous or periodic flows for all or a portion of its reach as the result of the permitted discharge of wastewater (Effluent-Dependent/ Dominated Waters [EDDW] 2006) (Figure 2-3). The waterbody may be naturally ephemeral or ephemeral either because of hydrologic modifications that dam or divert all of the flow, or activities that have resulted in lowered groundwater tables (PCWMD 2002).

Figure 2-3 illustrates how instream flows are changed by the addition of effluent to what would otherwise be an ephemeral stream. The site upstream of the wastewater plants (▲) is ephemeral and only flows in response to a precipitation runoff event. As a result, almost 90 percent of the time no flow occurs at this location. In contrast, the site downstream from the discharge of treated wastewater from two facilities (■) has flow all the time and has flows exceeding 50 cubic feet per second (cfs) more than 50 percent of the time. This regular flow occurs because of the relatively constant discharge of treated wastewater from the Ina Road and Roger Road wastewater facilities (see yellow and pink lines in Figure 2-3).

Effluent-dominated streams are stream systems where the effluent provides a significant portion of the flow (Figure 2-4). Waters that are effluent-dominated today may have been naturally intermittent or historically perennial, but dams or diversions and groundwater depletion have greatly reduced the amount of water that naturally flows in the river channel. Figure 2-4 illustrates how the discharge of treated wastewater can enhance or dominate the instream flow, but that even without the wastewater discharge flow would still occur in the waterbody. For example, upstream of the wastewater discharge (▲), the flow exceeds 100 cfs only about 50 percent of the time. However, downstream of the discharge (■), the flow exceeds 100 cfs almost all of the time. This difference is caused to a large degree by the constant input of treated wastewater into the waterbody (pink line in Figure 2-4).

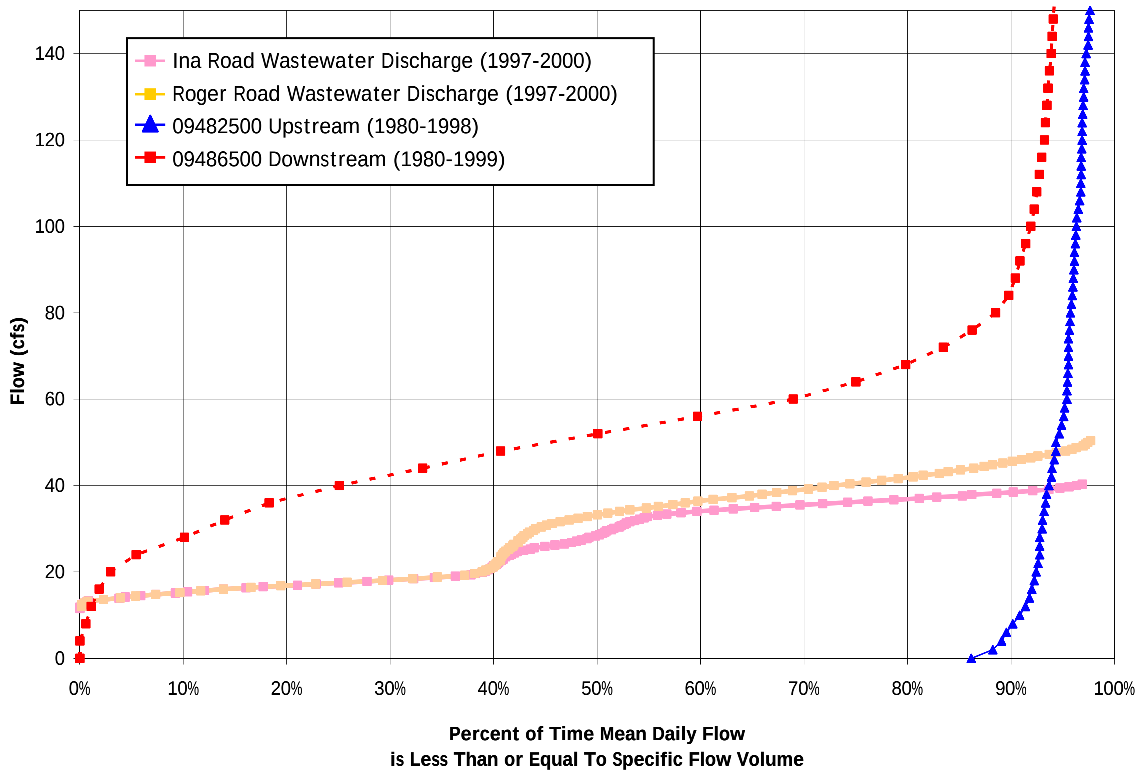


Figure 2-3
Mean daily flow in the effluent-dependent Santa Cruz River, Tucson, Arizona, upstream and downstream of the discharge of treated effluent (from PCWMD 2002; see Section 2.3.1 for discussion).

Creation of Effluent-Dependent Reaches in the Santa Cruz River Watershed, Arizona (compiled from Tellman et al. 1997)

The headwaters of the Santa Cruz River are located in the San Rafael Valley in southern Arizona. Initially, the river flows south into Mexico and eventually turns north, flowing back into Arizona. Ultimately, the Santa Cruz River, with a watershed area of 8,200 square miles, is tributary to the Gila River, reaching the Gila River on the Gila River Indian Community, southwest of the Phoenix metropolitan area.

Historically, the Santa Cruz River was perennial from its headwaters through Mexico and north to the town of Tubac, Arizona, approximately 40 miles north of the U.S./Mexico border. Except for two short reaches of perennial water near San Xavier, south of Tucson, and what is now central Tucson, the Santa Cruz River from Tubac northward to its confluence with the Gila River was ephemeral.

Today, primarily because of extensive groundwater pumping in the region, many of the formally perennial reaches downstream of the San Rafael Valley would be dry. However, two reaches of the river have relatively constant flow as a result of the discharge of effluent in the Nogales and Tucson, Arizona areas. The first effluent-dependent reach extends from Nogales 35 miles to north of Tubac, Arizona. The second reach begins in the western part of Tucson and continues downstream. In both reaches, extensive riparian ecosystems have developed in response to the constant discharge of effluent.

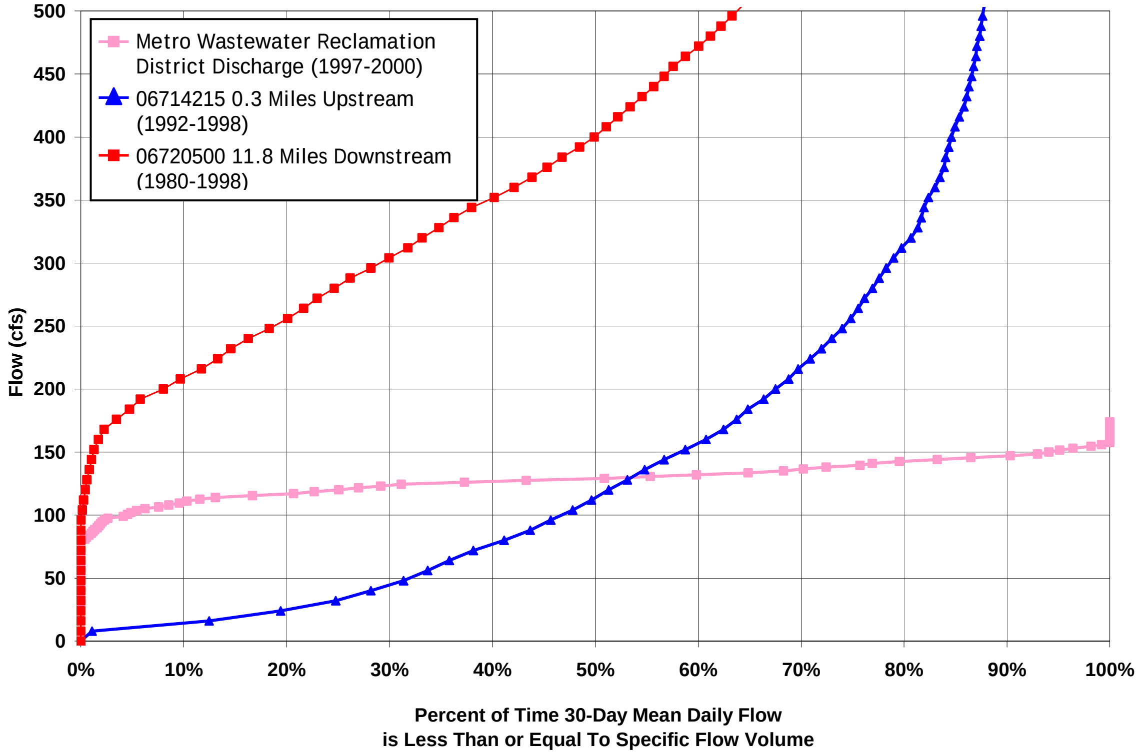


Figure 2-4
Mean daily flow in the effluent-dominated South Platte River, Denver, Colorado, upstream and downstream of the discharge of treated effluent (from PCWMD 2002; see Section 2.3.1 for discussion).

Creation of Effluent-Dominated Reach in the South Platte River Basin, Colorado (compiled from Harris et al. 1995 and CDM and CEC 2006)

Historically, the South Platte River was naturally intermittent with highly variable flows. Discharge was high in the spring during mountain snowmelt and very low during summer and fall.

Urbanization coupled with population growth has significantly changed the South Platte River drainage. Natural flow has been affected by trans-basin diversions, storage and flood control reservoirs, power developments, groundwater withdrawals, diversions for irrigation and municipal/industrial use, return flows from irrigation, and the discharge of treated effluent.

As a result of the changes to the river, the once irregular, but natural flow of the South Platte River has been replaced by a more controlled and steady flow. Today, Segment 15 of the South Platte River (Adams and Weld Counties in the north Denver metropolitan area) is effluent-dominated. For example, from 1999 to 2004 treated effluent from the Metro Wastewater Reclamation District comprised at least 85 percent of the flow more than 50 percent of the time.

As urban centers have grown, the need to dispose of treated wastewater has grown as well. Various options exist to dispose of wastewater, including discharge to river channels, and in this regard the west is no different than any other part of the United States. However, because so many surface waters in the west are ephemeral or intermittent, the discharge of treated wastewater to such waterbodies creates a modified aquatic ecosystem that either replaces predevelopment baseflow or creates a new perennial water where only ephemeral flows may have previously existed. In addition, the discharge of effluent has created opportunity for either the creation of a new riparian community or the reestablishment of a prior existing riparian community along the stream channel. It is in this regard that the arid west is fundamentally different from non-arid regions.

The hydrology in the arid west differs from that in stream systems in humid regions. Arid region streams are typically more "flashy" after precipitation events. The stream flow hydrographs generally have steeper limbs signifying the potential for more dynamic flooding. This also occurs from urbanization downstream from metropolitan areas due to increased impervious area.

The modification of the flow regime from effluent discharge has implications for the physical characteristics of the waterbody (PCWMD 2002). For example, in effluent-dependent streams, the imposition of constant flow in an otherwise dry channel creates a number of physical changes. Since wastewater is typically free of sediment, the flow often causes erosion and incision, although the erosive effects are attenuated downstream. In addition, constant flow creates a saturated zone below the channel that can extend laterally from the channel edge to the edge of or beyond the floodplain. The development of riparian vegetation along effluent-dependent streams is largely controlled by the extent, depth, timing, and duration of the saturated zone. Finally, the effluent-dependent channels will continue to accommodate flow from storm events, resulting in channel modifications. These physical changes also affect effluent-dominated streams, but often to a lesser extent.

The hydrology of arid west streams can affect the application of water quality standards. For example:

- Flashy nature of flow in ephemeral streams means that they are dry for significant lengths of time and then temporarily filled with water (Figure 2-5). Accordingly, the exposure duration assumptions inherent in federally recommended water quality criteria may not be appropriate, and as such could be modified.
- Effluent-dependent streams are artificially created habitats where the ecological community present is, by definition, adapted to the flow regime, i.e., the existing aquatic life use is dependent on the nature of the waterbody created (Figures 2-3 and 2-6). The extent to which aquatic life becomes established in an effluent-dependent stream

Figure 2-5
Ephemeral reach of Cienega Creek (upstream of Mescal Arroyo) in Arizona during both wet and dry conditions.

Figure 2-6
Effluent-dependent Santa Fe River, west of Santa Fe, New Mexico, upstream (left) and downstream (right) of point of discharge of treated effluent.

will be influenced by the duration and frequency of the effluent discharge. Some wastewater facilities are designed primarily to provide reclaimed water for reuse. However, occasionally these facilities may have to discharge to an ephemeral waterbody for a few days or weeks. The expectations for the aquatic community that develops downstream of these intermittently discharging facilities systems will be quite different from the community that develops in a waterbody that receives effluent all of the time.

Effluent-dominated streams support a different ecosystem than would be present without the additional flow added by the effluent; this modified ecosystem is maintained by the effluent flow regime.

2.3.2 Water Quality

Natural water quality in arid west perennial streams reflects the combined result of processes such as chemical weathering of bedrock and soils, biological activity in soils, groundwater discharge to streams, and runoff (Cordy et al. 2001). The underlying geology is a dominant factor in surface water quality. The igneous and metamorphic rocks characteristic of high elevations contribute fewer solutes to the streams than do sedimentary rocks in the lower elevations (Apodaca et al. 1996). In the large river basins (e.g., the Colorado, Rio Grande), the concentration of dissolved solids, nutrients, and suspended solids increases downstream because of both natural processes and anthropogenic influences (Moore and Anderholm 2002; Cordy et al. 2001). Reasons for these increases include the addition of suspended and dissolved constituents from stormwater runoff, decreasing water volume due to water diversion and use, evapotranspiration, and leakage to groundwater (Cordy et al. 2001; Apodaca et al. 1996; Moore and Anderholm 2002).

Water quality in effluent-dependent and effluent-dominant streams was studied as part of the Habitat Characterization Study (PCWMD 2002). The chemical nature of flows in effluent-dependent water reflects the characteristics of the effluent discharged to the stream channel. The chemical composition of effluent is directly related to the types of treatment processes and generally remains constant over a long period of time. It is possible to have variations in effluent quality reflecting diurnal or seasonal patterns associated with influent entering the treatment plant.

In effluent-dominant streams, the water quality is dependent on how much instream flow is available for mixing. The quality of effluent will be significantly different from the quality of the upstream flow. Mixing of effluent and upstream flow temporarily changes instream water quality; however, the extent of this temporary change is dependent on the relative volumes of upstream and effluent flow (Figure 2-7).

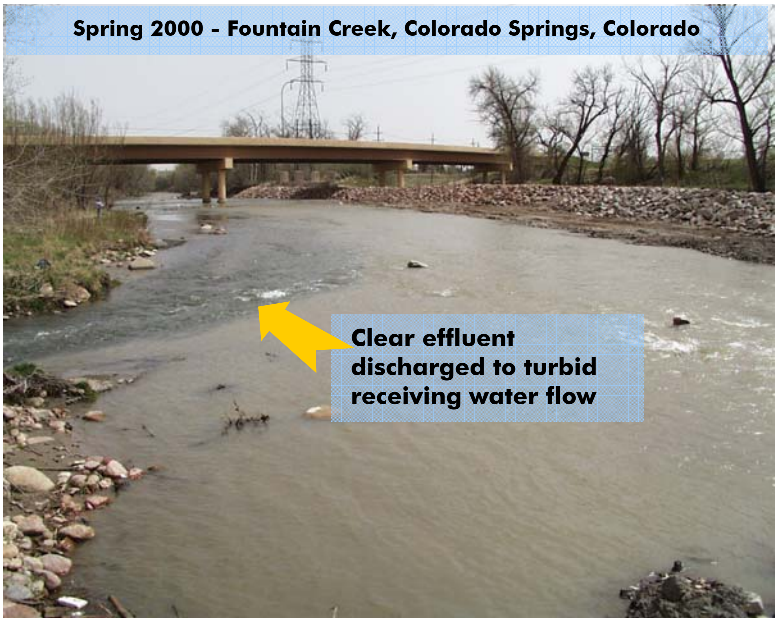


Figure 2-7
In effluent-dominated waters, the relative volume of instream and discharged flow varies by season; water quality is dependent on relative mix.

Although the chemical and physical composition of effluent is fairly constant at the point of discharge, these characteristics often change with distance downstream of the discharge as instream physical, chemical, and biological processes modify the chemistry. This is especially true for water quality parameters such as temperature, dissolved oxygen (DO), pH, and nutrients. For example, some degree of oxygen depletion can occur for some distance below the discharge point because of high biochemical oxygen demand (BOD) that can be associated with effluent where there is minimal removal of organic matter prior to discharge (PCWMD 2002; Cordy et al. 2001).

As part of the Habitat Characterization Study, the water chemistries from 10 case study sites were compared to the toxicity database water chemistries used in deriving aquatic life criteria and water chemistries of non-arid sites, using eastern Kansas and North Carolina waters as examples. The purpose of these analyses was two-fold: to assess whether arid west water quality differs from the waters used in laboratory waters used for criteria development, and to assess whether water quality in arid west streams is substantively different from water quality in streams in more humid regions. The results of these analyses showed (Table 2-1) (also see PCWMD 2002):

- Important differences exist between the ionic composition of waters used to develop water quality criteria for cadmium, copper, zinc, and ammonia and the ionic composition of waters from the arid west study areas.
- The arid west study areas have greater ionic strength than the North Carolina streams as measured by total dissolved solids, conductivity, hardness, and alkalinity; however, additional chemical data from non-arid streams over a broader geographical area would need to be reviewed to determine the geographical extent of observed differences.

Table 2-1 Comparison of Water Quality Characteristics between Waterbodies in Arid and Non-Arid Regions and Waters Used for Toxicity Studies to Support Ambient Water Quality Criteria Development

Source	Concentration			
	Hardness (milligrams/Liter)	Alkalinity (milligrams/Liter)	Conductivity (umhos/centimeter)	pH (Standard Units)
North Carolina Sites	≈ < 25	≈ < 25	0 – 400	6.0 – 9.0
Toxicity Studies[1]	50 – 200	25 – 175	0 – 500	6.0 – 9.0
Kansas River	100 - 400	100 – 250	300 – 1600	6.0 – 9.0
Case Study Sites[2]	100 - 500	50 – 300	500 – 1200	6.0 – 9.0
Las Vegas Wash[2]	600 - 900		2000 - 3000	

[1] Water quality characteristics of test waters used by EPA to develop national ambient water quality criteria for cadmium, copper, zinc, and ammonia (see Habitat Characterization Study).
[2] Habitat Characterization Study Sites; for specific parameters, Las Vegas Wash is separated from other case study sites.

2.3.3 Biological Communities

Effluent-dependent streams support valuable riparian communities with high biodiversity of terrestrial plants and animals (Cordy et al. 2001); however, the aquatic community is often limited at the point of discharge (PCWMD 2002). At or near the point of discharge, the species richness is generally low, but abundance can be high. With increasing distance downstream from the point of discharge, the stream flow regime equilibrates with its surroundings resulting in an improved physical environment to which the biological community often positively responds (see conceptual model in Figure 2-8 and the detailed discussion presented in the Habitat Characterization Study [PCWMD 2002] on the attached CD); moreover, the limitations that may be imposed by the quality of the effluent are reduced. Thus, with increased distance downstream of the discharge, biological indices such as species richness or diversity often increase, unless there are other factors such as engineered structures, other pollutant sources, e.g., stormwater, or limiting habitat characteristics, e.g., sandy substrates or bedrock (PCWMD 2002).

As noted above in Section 2.3.1, an important factor that will affect expectations for the aquatic community that develops below an effluent discharge is the duration and frequency of the discharge. If the wastewater facility only rarely discharges or discharges for only very short periods of time, then the expected aquatic community will likely be quite different from the community that develops in a waterbody that receives a regular effluent discharge.

Deciding what defines the appropriate level of protection for aquatic life in effluent-dependent ecosystems has been a significant unresolved issue for many years. A long-standing presumption exists that if you increase the level of wastewater treatment to improve effluent quality, then this improved treatment will be manifested in an improved aquatic community, e.g., as might be measured by increased richness and diversity. This presumption has been found to be highly dependent on site-specific conditions including flow frequency and duration (see discussion in PCWMD 2002).

If improved treatment levels do not achieve *a priori* expectations for the aquatic community, then it becomes increasingly important to determine what is an appropriate expectation for these waterbodies. In other words, what aquatic life use is attainable and how should attainability be measured?

When an aquatic life designated use is adopted for an effluent-dependent water, it is assumed, of course, that through water quality management programs the designated use or goal can be achieved. In practice, this approach will only work if an appropriate goal has been established. A key problem with the establishment of an appropriate use goal on effluent-dependent waters is the assumption that one knows the full potential for the aquatic ecosystem as a result of discharging effluent.

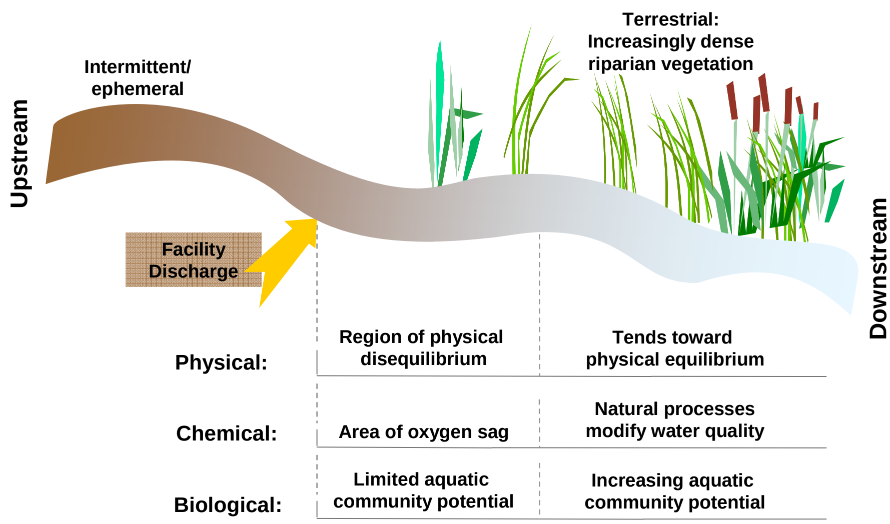


Figure 2-8
Conceptual model of an effluent-created aquatic ecosystem (adapted from Habitat Characterization Study).

One of the findings of the Habitat Characterization Study (PCWMD 2002) was the apparent wide gap between the actual potential versus the assumed potential of the aquatic community; moreover, the actual potential will likely be dictated by local site-specific factors. Furthermore, because the stream system is created and in a sense, evolving (Figure 2-9), it would be difficult, if not impossible, to extrapolate the ultimate potential of the system.

In arid west waters, the differences between terrestrial vegetation upstream and downstream of a discharge can be striking, especially where the water is effluent-dependent. Vegetative structural diversity is usually greater in the effluent-dependent or effluent-dominated riparian zones. Upstream areas that are dry or have limited water availability are more likely to have an open structure with gaps of varying sizes. In contrast, the reliable water source of the downstream riparian zone is more likely to support a multi-layered vegetation structure, with vigorous growth and high canopy coverage in the tree, shrub, and herbaceous layers (PCWMD 2002).

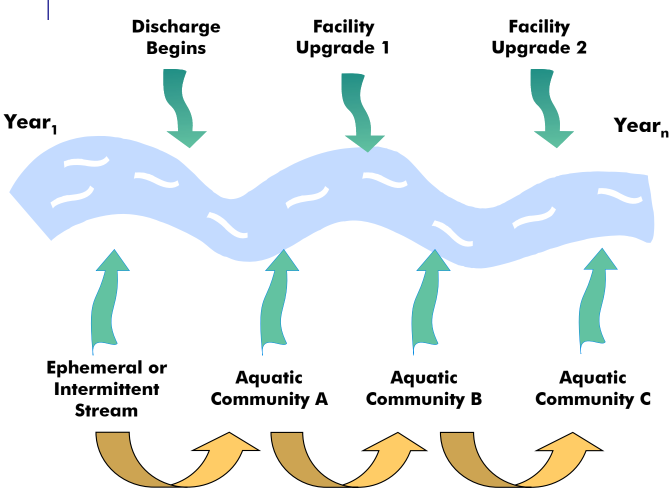


Figure 2-9
Characteristics of the aquatic community are expected to "evolve" as the primary source of flow, treated wastewater, changes. Expectations for the aquatic community are further influenced by watershed activities and local habitat limitations.

Dense riparian habitat created by discharge of treated effluent (2000 photograph of the effluent channel that receives treated wastewater from the City of Phoenix, Arizona, 91st Avenue Wastewater Treatment Facility).

The width of the riparian zone associated with the effluent stream will be related to the quantity of water available and to the geomorphologic characteristics of the stream channel. Generally, these zones are wider than the upstream riparian zones, and the downstream areas have more vigorous plant growth because of the greater availability of water. Differences in vegetation downstream from discharge points generally are related to increased channel width and/or braiding compared with discharge points, which are most often relatively narrow and confined (PCWMD 2002).

Like other riparian areas, the effluent-dependent riparian areas are particularly important for migratory bird species. The additional plant species diversity and vegetative structural diversity of these areas may provide temporary resting and foraging locations as well as possibly providing movement corridors for some species (PCWMD 2002).

2.3.4 Water Resource Limitations

Water scarcity (relative to demand) is reality in much of the west, but reservoir storage, transbasin diversions, groundwater development, water right transfers, conservation, and other measures have allowed growth to continue (Colorado Water Conservation Board [CWCB] 2004). However, in some areas for the first time, legal and physical limits are appearing on the planning horizon. In the future, we may not be able to sustain unlimited growth and still maintain our current quality of life. Difficult political choices will be necessary regarding future economic and environmental uses of water and the best way to encourage the orderly transition to a new equilibrium. Among other things, these new realities require an evaluation of the relationship between water policies and growth (Western Governor's Association 2006.)

Competition for water supplies will intensify as population increases in the arid west. For example, the U.S. Bureau of Reclamation (BOR) has identified areas where there will likely be water supply crises in the near future (BOR 2005).

The scarcity of water in the arid west has led to innovations in water management. One innovation is reuse of wastewater effluent for nonpotable uses, which is becoming the standard in most urban areas across the west. However, reusing water rather than discharging it can result in decreased stream flows, which has implications on the environment and recreation in these areas.

2.3.5 Trends Affecting Water in the Arid West

Population is increasing rapidly across the arid west where it has grown faster than in any other area in the nation. For example, the percent change in population from 1990 to 2000 for the United States shows that much of the growth in the west is centered in urban areas. This rapid growth, which is expected to continue unabated, is putting an increased demand on regional water resources.

It is obvious that changing demographics and values placed on various water uses is transforming the future of water management. Western states are experiencing large population percentage changes. According to the 2000 U.S. Census Bureau statistics, population growth varied significantly by region in the 1990s, with the highest rates in the west (19.7 percent). The west increased by 10.4 million to reach 63.2 million people. Because of differences in growth rates, the regional shares of the total population have shifted considerably in recent decades. Between 1950 and 2000, the percentage of the nation's population living in the west increased from 13.3 to 22.5 percent. More recently, from 2004 to 2005, five of the six fastest growing states are shown in Table 2-2. Notably, many of these states are also the driest states in the nation (Western Governor's Association 2006).

Table 2-2 Population Growth in Western States, 2004-2005

State	Percent Growth
Arizona	3.5%
Nevada	3.5%
Idaho	2.4%
Utah	2.0%
Texas	1.7%
Colorado	1.4%
Oregon	1.4%
New Mexico	1.3%
Washington	1.3%

Crop irrigation is the largest surface water use in the arid west, accounting for up to 90 percent of surface water withdrawals. Consumption of surface water for municipal and industrial (M&I) uses is a smaller but an increasing portion of water use. Many cities and towns presently rely on groundwater for M&I supplies, but as urban populations increase and aquifers become depleted, surface water will become an increasingly important source of M&I water. An important source of this water may be water currently used for agriculture as agricultural lands are retired and developed.

Industrial water use associated with increased oil and gas extraction activities may impact groundwater and cause possible return-flow water quality concerns. This is a particular concern in western states such as Colorado and Wyoming. In addition, mine site-related water quality concerns are a common problem throughout the arid west.

Competing with agricultural and M&I demands are recreational and environmental uses. Increasing population, leisure time, and disposable income have dramatically expanded the demand for more recreational opportunities. These demands are resulting in a desire for more and better quality water in urban rivers.

Virtually every western state has past and present water plans and many employ ongoing water planning efforts. These vary widely in detail, style, and size, but should form the basis for any future efforts to fashion a western or national water policy or plan, as some have suggested. An evaluation of common components may lead to the broader application of successful practices. State water plans may include management responses that (Western Governor's Association 2006):

- Improve demand management and conservation strategies
- Utilize integrated water resource management as an effective method for assessing adaptation options and their implications in the context of an evolving regulatory environment with its competing demands
- Develop new surface or groundwater storage capacity, including new reservoirs and expansion of existing reservoirs
- Enhance ways to manage all available water supplies, including groundwater, surface water, and effluent in a sustainable manner
- Increase ability to shift water within and between sectors (including agriculture to urban), while mitigating any associated impacts in the basin of origin
- Reuse municipal wastewater, improve management of urban stormwater runoff, and promote collection of rainwater for local use to enhance urban water supplies to the extent allowed by state water laws
- Increase efforts to restore and maintain watersheds to improve water cycle functioning (which would include invasive vegetation removal, forest management, etc.) as an integrated strategy for managing water quality and quantity
- Consider the energy-water nexus as a way for both increasing water use efficiency and minimizing emissions of greenhouse gases (from related energy use)
- Develop innovative water augmentation technologies such as weather modification, desalination, and chloride control

The management of water resources in the arid west must also take into account the potential use of water resources to provide support to created aquatic habitats or habitat restoration projects. Often the primary source of water for these existing or potential habitats is treated wastewater effluent. An example of an existing created habitat that supports a significant environmental resource is the Paiute Ponds near Lancaster, California. Originally created as an impoundment more than 40 years ago to mitigate flooding concerns on downstream Rosamond Dry Lake, which is used as a landing strip for Edwards Air Force Base, the primary source of water to the ponds is treated effluent. These ponds are located along an important bird migratory pathway and over time have become an important habitat resource for shorebirds, waterfowl, and raptors (California Audubon 2001; LAC 2000a, b).

Effluent is also often considered a key water source for habitat restoration projects developed or planned by the U.S. Army Corps of Engineers (USACE). For example, in Tucson, Arizona, the Ed Pastor Kino Environmental Restoration Project ("Kino"), which was developed cooperatively by Pima County and the USACE, is supported in

Inherent in arid regions is a limited supply of surface water and competition for its use – agriculture, power generation, municipal water supplies, recreation, and the environment.

part by treated wastewater effluent. Prior to the implementation of the project, Kino was a stormwater detention basin that, except for brief periods following stormwater runoff events, was often dry. In 2002, the original facility was expanded to 141 acres to incorporate a combination of riparian habitat, open water areas, mesquite bosque, and ephemeral grassland. The operational objective of the system to provide flood control capacity was maintained, but the habitat restoration elements of the project provided wildlife habitat and recreational amenities for local residents in an urban area (Megdal 2005). The USACE's Los Angeles District won the Chief of Engineers 2005 Environmental Award of Excellence for the design of the Kino project (USACE 2006a). Other habitat restoration projects, which rely on treated wastewater effluent as the primary water source, are being considered for development in the arid west, e.g., the Tres Rios del Norte Santa Cruz River project in the Tucson, Arizona area and the Tres Rios project near the Salt and Gila River confluence in the Phoenix, Arizona area (USACE 2006b).

2.4 Challenges Ahead

Regulators and the regulated community face challenges with implementing water quality standards in arid west ecosystems. These challenges include developing NPDES wastewater permit requirements in systems where dilution is limited, addressing stormwater quality issues, correctly identifying water quality impairments, and coordinated implementation with the requirements of the Endangered Species Act (ESA).

2.4.1 NPDES Permit Requirements in Effluent-Driven Ecosystems

The arid west has numerous streams that are dependent on or dominated by effluent discharged from wastewater treatment plants (WWTPs). In many cases the artificially created system would not persist without the addition of the effluent. Once established, the continued protection of these ecosystems presents challenges.

NPDES permit limits for effluent discharges to otherwise dry stream courses are calculated with critical low flows that are often zero or provide minimal dilution for derivation of permit limits. With no dilution, discharges to these effluent-driven systems often face compliance with water quality standards at the end of pipe, which leads to treatment of effluent to a very high quality. Premium treatment is expensive and results in such high quality water that the treated water may have more value outside of the waterbody, example for reuse, than in the waterbody. For example, along Colorado's South Platte system, all of the water that can be reused from a water rights perspective will be.

NPDES permit limits that are calculated based on dilution are challenged by the availability of water rights to ensure flow is maintained. This problem is exacerbated by the bifurcation of water quality and water resources issues in the west. Generally different state agencies have the responsibilities for quality versus quantity issues. In addition, the western water rights system only peripherally recognizes water quality in water rights transfer cases. Understanding water rights

Revitalization of Urban Centers, South Platte River Basin, Colorado

Coupled with the westward population migration is interest in revitalizing urban centers. Often, these urban revitalization efforts are focused on rivers. Revitalization places added emphasis in maintaining flows in rivers at the same time that other pressures are resulting in reduced flows.

For example, the City of Denver has restored the South Platte River near downtown Denver, an effort that includes developing urban riverside parks, high density housing, and a kayak course. Other examples include the City of Los Angeles, which is looking at restoring segments of the concrete-lined Los Angeles River at a potentially substantial cost, and the City of Phoenix's effort to see portions of the Salt River restored.

and the transfer process is an important aspect of water quality permitting in the west because so much revolves around how much water is available for dilution.

An important finding of the Habitat Characterization Study (PCWMD 2002) was that habitat can be a more limiting factor for aquatic life than water quality. NPDES permit effluent limitations, based on water quality standards, traditionally form the basis for the protection of aquatic life in all waters, regardless of the waterbody type (e.g., coldwater or effluent-dependent). It is assumed that meeting water quality standards should result in increased numbers and kinds of aquatic species, even in created habitats. Yet if the implementation of wastewater treatment improvements yields little to no enhancement in the aquatic community, it is likely that other limitations may exist (e.g., habitat). In these instances it can be very important to verify that the correct aquatic life use has been designated.

2.4.2 Stormwater Quality

As it is throughout the United States, stormwater in the arid west is regulated by the Phase I and II stormwater regulations. NDPES permits for stormwater are performance based, requiring best management practices (BMPs) as permit "limits" or conditions that must be met to achieve compliance with the permit. Similar to wastewater permitting in arid west regions, often times stormwater discharges provide the only source of water in arid west urban streams. However, stormwater quality can be a concern, especially for constituents such as for bacteria. Solutions intended to improve stormwater quality have the potential to remove water from arid west ecosystems.

An increasingly common area where BMP implementation designed to improve stormwater quality could ultimately result in less instream water is the need to control dry weather nuisance flows that often contain pollutants (e.g., bacteria). These flows commonly occur in urban environments where a combination of factors, e.g., leaking pipes and lawn watering, result in a steady continuous flow in small ditches and channels designed to move stormwater. These stormwater channels are often tributary to natural waterbodies. A common approach to minimizing pollutants carried in these channels is to divert the flows and prevent them from reaching the receiving waterbody.

Even if the diversion of water reduces instream flows in the receiving water, in many cases, it may be necessary to remove this water to achieve water quality standards. However, so that instream flows that provide habitat for aquatic life can be balanced with water quality requirements, it may be worthwhile to evaluate the appropriateness of the applicable uses and criteria in the receiving waterbody to be certain that the appropriate level of protection is being applied. In some instances, it may be found that a different aquatic life use with less stringent criteria that is still protective can be applied if the appropriate use attainability studies are conducted.

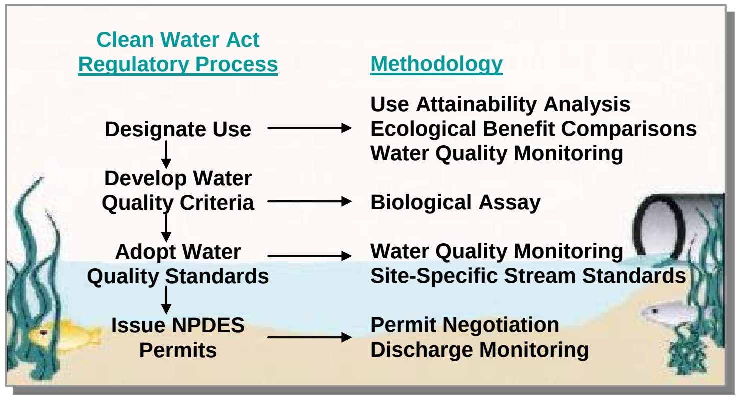
Dry Weather Diversions

While diversions of dry weather nuisance flows can achieve the end goal of improving downstream water quality, the result is also less water moving downstream. For example, as of 2003 in the Orange County area of southern California, dry weather diversions had been implemented at 38 locations to prevent dry weather flows containing elevated concentrations of bacteria from reaching coastal beaches (Santa Ana Watershed Project Authority [SAWPA] 2005). The dry weather flows are captured and piped to the Orange County Sanitation District for treatment. At that time, 38 additional diversions were proposed.

2.4.3 Addressing Impaired Waters

Section 303(d) of the CWA mandates the identification of waters that do not meet applicable water quality standards and existing required effluent limitations and other pollution control requirements are not sufficient to achieve the water quality standards. Waterbodies that meet these criteria are frequently called impaired waters. Once a waterbody is identified as impaired it is placed on the 303(d) list and is scheduled for development of a TMDL, the mechanism used to restore the water quality and achieve the water quality standards.

The TMDL itself is an estimate of the highest amount, or load, of pollutant that a waterbody can receive without violating the applicable water quality standard. This load is partitioned to provide a wasteload allocation for point sources, a load allocation for non-point sources (which includes natural background sources) and a margin of safety. The TMDL development process encompasses the steps needed to identify pollutant sources and allocate responsibility among those sources.



For effluent dischargers, the TMDL and the NDPES permitting process are closely intertwined. Wasteload allocations in TMDLs are incorporated into the calculation of NPDES effluent limits. For stormwater dischargers, the load allocation can be incorporated into NPDES stormwater permits.

While the identification of impaired waters and the development of TMDLs have become somewhat routine on a nationwide basis, significant challenges lie ahead for the development and implementation of TMDLs in arid west waters. The driver for a finding of impairment is the water quality standards and there is a common presumption that the existing state-adopted standards are not only correct but attainable. However, the National Research Council (NRC), in its 2001 critical review of the TMDL program, noted the importance of evaluating the attainability of the water quality standards in question at the outset of the TMDL development process (NRC 2001).

Unfortunately, too often the NRC recommendation to review uses and standards is bypassed, simply because of the time and cost involved in re-evaluating the water quality standard. States often have hundreds of TMDLs needed at any given time and many of these required TMDLs are under court-ordered deadlines. TMDLs may be done with simplistic assumptions or large margins of safety. This problem and challenge is particularly true in arid west waters that have designated uses that are not attainable. Exacerbating the problem is the expected increased demand on water resources that will reduce instream flows and leave less water instream for mixing.

2.4.4 Nexus with Endangered Species Act

The ESA sets forth the goal of protecting and recovering threatened and endangered species and the ecosystems upon which they depend (Federal Register 66:11208). The CWA sets forth a goal of restoring and maintaining the chemical, physical, and biological integrity of the nation's waters (e.g., see Section 101(a) of the CWA). Sections 303(c) (water quality standards) and 402 (NPDES permitting) of the CWA (as well as other provisions) are directed toward achieving this goal.

The implementing federal agencies for the ESA (U.S. Fish and Wildlife Service [USFWS] and the National Marine Fisheries Service within the National Oceanic and Atmospheric Administration [NOAA]) and the CWA (EPA) have agreed that the goals of the ESA and CWA acts are "compatible and complementary" (Federal Register, 66:11208). However, even with this agreement, actions taken under one Act may impact decisions made under the other Act. Examples of where the purposes of each Act can intersect include:

- State Adoption of Water Quality Standards—States may adopt water quality criteria that are consistent with EPA-issued federal guidance and approvable by EPA, but concerns regarding threatened and endangered species may still result in USFWS concerns. For example, in 1992 the State of Arizona adopted a water quality criterion for mercury that was consistent with EPA guidance. However, following review by the USFWS and a finding that the adopted water quality standard may not be protective of fish-eating wildlife, the EPA had to disapprove the Arizona standard. Ultimately, the disapproval was addressed through the establishment of an agreement between EPA and the USFWS.

- Federal Ambient Water Quality Criteria Guidance Documents—Federal guidance, which is often used by the states to set water quality criteria, may not be protective of threatened and endangered species. For example, in 1999 after extensive peer review, EPA published its revision of the ammonia criteria. Subsequently, the USFWS expressed concern that the revised criteria recommendations may not be protective of a particular freshwater mussel species. This concern has led to EPA conducting additional review of its ammonia criteria, which is still ongoing.

- Water Quantity/Quality—Maintenance of a threatened and endangered species may affect both water quantity and quality. In many arid aquatic ecosystems an important component of the flow may be treated effluent. Effluent discharge can create aquatic habitats where they did not previously exist, and these created environments can provide excellent habitat not only for aquatic species, but for wildlife species that use the associated riparian ecosystem. It is unclear whether a wastewater discharge facility could be compelled to continue an effluent discharge if it might impact a threatened and endangered species that is resident in an effluent-based ecosystem; however, the potential certainly exists for a discharge to have to maintain a minimum quality if it is deemed necessary to protect a species.

2.5 Flexibility

Section 2 has focused on providing an understanding of arid west waters in the context of the water quality standards regulations and challenges facing the arid west. Many of these challenges are driven by rapid growth of urban centers and water resource limitations. The presence of these drivers requires stakeholders to look for unique ways to address site-specific regulatory issues that are compatible with CWA regulations.

Comments are often heard that little flexibility exists in how the CWA and its implementing federal regulations may be applied to arid west waters. While flexibility may be limited in certain states due to state regulations, or in EPA regions because of different regional interpretations, the reality is that the CWA and implementing regulations contain a reasonable amount of flexibility. The key for any situation is to identify where that flexibility exists and how it may be accessed at the regional and state level.

The following sections were developed to provide direction and supporting information regarding where to find regulatory flexibility. Examples of where such flexibility exists fall into two categories: (1) development of NPDES permit effluent limits; and (2) development of alternative water quality standards through site-specific criteria development and/or refinement of designated uses. However, to use this flexibility, it is often necessary to have the research data to facilitate regulatory decisionmaking. Section 3 summarizes AWWQRP research activities that were implemented to support this need.

Section 3
Arid West Research

3.1 Overview

The focus of much of the scientific research that forms the foundation for the establishment of water quality standards is based on waterbodies in mesic or relatively wet environments. To what degree this research is applicable to arid west waters has been a subject of considerable debate for many years. An outcome of this debate has been increased interest in implementing research in a manner that takes into account aquatic habitat and water quality issues common to the west. This interest ultimately resulted in the creation of the AWWQRP as well as an increased focus on arid west type research activities by existing organizations already well known for conducting water quality research.

While the AWWQRP was established to specifically focus on arid west water quality-related research, other organizations, e.g., the WERF and the National Association of Clean Water Agencies (NACWA), and government agencies such as the BOR, have shown an increased interest in arid west matters. In the following sections, we highlight AWWQRP research results that have relevance to the establishment of water quality standards in the arid west. In addition, we also identify some of the other activities that are being carried by other organizations with interest in this area. The description of other activities are by no means meant to represent an exhaustive list of research; instead, it is intended to remind the reader that when initiating studies in arid west streams it may be useful to contact these organizations to determine if they have conducted research in the area.

3.2 Arid West Water Quality Project Funded Research

The AWWQRP was established to conduct scientific research and disseminate scientific information on western ephemeral and effluent-dependent waters to help resolve issues of significance to both the regulated community and regulators at state, tribal, and federal levels. To accomplish this purpose, research activities have focused on the following areas:

- Water quality criteria and standards for arid west habitats
- Water quality criteria for chemicals of concern
- Biological and ecological criteria and standards for arid west ecosystems
- Whole effluent toxicity (WET) testing guidance for arid west waters
- Arid west water quality policy and implementation issues

To facilitate this research, the project has been administered by an EPA Region 9 Project Officer and the AWWQRP office within PCWMD, Tucson, Arizona. A Regulatory Working Group (RWG), comprised of a 15 member stakeholder panel representing both public and private interests, guides the project to ensure that the research undertaken by the AWWQRP has a sound regulatory basis, and that, to the extent practicable, focuses on the regulatory needs of arid west states. In addition, a Scientific Advisory Group (SAG), comprised of established scientists (e.g., aquatic toxicologists, terrestrial ecologists, etc.) from throughout the west, was established to recommend research topics for study, to ensure that studies undertaken are designed appropriately, and to assist in the technical review of research products.

Research under the AWWQRP began through the implementation of three studies that provided a foundation for understanding the nature of arid west waters. Subsequent to these foundational studies has been the implementation of research projects focused on the development of alternative but protective criteria for these waters. Integral to this effort has been to publish research findings in peer-reviewed journals. Existing and planned publications are summarized in Table 3-1.

The following sections provide a summary of the research projects conducted under the auspices of the AWWQRP. The purpose of each project summary is to provide the reader with sufficient information to understand the project findings and their potential applicability to arid west water quality standards issues. Additional information regarding each project is provided in the reference material contained on the attached CD.

Table 3-1 Arid West Water Quality Research Project Publications

Habitat Characterization Study

- Meyerhoff, R.D., T. Moore, S. Morea, E. Curley, T. Foster, K Sierra, M. Murphy and L. Smith. 2002. *New Permit Approach Needed for Effluent-Dependent Waterbodies*. Watershed & Wet Weather Technical Bulletin 7: 7-12.
- Murphy, M., R. Meyerhoff, E. Curley and K. Ramage. 2008. Proposed title: *Characterizing the Habitat of Effluent-Dependent Waters* . In Prep.

Extant Criteria Evaluation

- Gensemer, R.W., R.B. Naddy, W.A. Stubblefield, J.R. Hockett, R. Santore and P. Paquin. 2002. *Evaluating the role of ion composition on the toxicity of copper to Ceriodaphnia dubia in very hard waters*. Pages 87-98, in: J.W. Gorsuch, C.R. Janssen, C.M. Lee and M.C. Reiley, editors. Special Issue: The Biotic Ligand Model for Metals—Current research, Future directions, Regulatory implications. Comparative Biochemistry and Physiology, Volume 133C, Numbers 1-2, September 2002.
- Naddy, R. B., G. R. Stern, and R. W. Gensemer. 2003. *Effect of culture water hardness on the sensitivity of Ceriodaphnia dubia to copper toxicity*. Environmental Toxicology and Chemistry 22:1269-1271.
- SETAC. 2007, In Press. *Relevance of Ambient Water Quality Criteria for Ephemeral and Effluent-Dependent Watercourses of the Arid Western United States* (with co-editors, Robert Gensemer, Parametrix; Ed Curley and Karen Ramage, Pima County Wastewater Management Department), Society for Environmental Toxicology and Chemistry (SETAC) Press, ISBN #978-1-880611-91-3.

Evaluation of the Reliability of Biotic Ligand Model Predictions for Copper Toxicity in Waters Characteristic of the Arid West

- Van Genderen, E., R. Gensemer, C. Smith, R. Santore, A. Ryan. 2007. *Evaluation of the Biotic Ligand Model relative to other site-specific criteria derivation methods for copper in surface waters with elevated hardness.* Aquatic Toxicology: Special issue in celebration of Rick Playle. Manuscript Accepted.

Evaluation of the EPA Recalculation Procedure In The Arid West

- Canton, S.P., L.G. Wall, R. Gensemer, and M. Murphy. 2007. *Evaluation of the U.S. EPA Recalculation Procedure in Arid West Effluent Dependent Waters: 1. Introduction to the Study*. In Prep.
- Lynch, J., S.P. Canton, G.D. DeJong, R. Gensemer, and M. Murphy. 2007. *Evaluation of the U.S. EPA Recalculation Procedure in Arid West Effluent Dependent Waters: 2. Development of the resident species lists.* In Prep.
- Carney, M, L.G. Wall, S. P. Canton, R. Gensemer, and M. Murphy. 2007b. *Evaluation of the U.S. EPA Recalculation Procedure in Arid West Effluent Dependent Waters: 3. Updates to the ambient water quality criteria for aluminum.* In Prep.
- Wolf, C., L.G. Wall, M. Carney, S. P. Canton, R. Gensemer, and M. Murphy. 2007. *Evaluation of the U.S. EPA Recalculation Procedure in Arid West Effluent Dependent Waters: 4. Updates to the ambient water quality criteria for ammonia*. In Prep.
- Wall, L.G. S. P. Canton, M. Carney, R. Gensemer, and M. Murphy. 2007a. *Evaluation of the U.S. EPA Recalculation Procedure in Arid West Effluent Dependent Waters: 5. Updates to the ambient water quality criteria for copper.* In Prep.
- Canton, S.P., L.G. Wall, M. Carney, R. Gensemer, and M. Murphy. 2007. *Evaluation of the U.S. EPA Recalculation Procedure in Arid West Effluent Dependent Waters: 6. Updates to the ambient water quality criteria for zinc.* In Prep.
- Wall, L.G. S. P. Canton, M. Carney, C. Wolf, R. Gensemer, and M. Murphy. 2007b. *Evaluation of the U.S. EPA Recalculation Procedure in Arid West Effluent Dependent Waters: 7. Modifications to the method for the arid West.* In Prep.
- Carney, M., S.P. Canton, L.G. Wall, R. Gensemer, and M. Murphy. 2007a. *Evaluation of the U.S. EPA Recalculation Procedure in Arid West Effluent Dependent Waters: 8. Case Studies*. In Prep.
- Canton, S.P., L.G. Wall, M. Carney, R. Gensemer, and M. Murphy. 2007. *Evaluation of the U.S. EPA Recalculation Procedure in Arid West Effluent Dependent Waters: 9. Recalculation Findings and Study Conclusions.* In Prep.

Table 3-1 Arid West Water Quality Research Project Publications (cont.)

Hardness-Dependent Ammonia Toxicity and the Potential Use of the Water-Effect Ratio

- Smith CA, Gensemer RW, Van Genderen EJ, Canton SP, Wolf CF, Wall L. 2007. *Hardness-dependent ammonia toxicity and the potential use of the water-effect ratio.* In Prep.

Aquatic Communities of Ephemeral Streams

- De Jong, G. D., S P. Canton, J. Lynch, and M. Murphy. 2007. *Aquatic Communities of Ephemeral Stream Ecosystems in the Southwestern United States: 1. Community Composition*. In Prep.
- De Jong, G. D., S. P. Canton, and M. Murphy. 2007. *Aquatic Communities of Ephemeral Stream Ecosystems in the Southwestern United States: 2. Biotic Succession.* In Prep.
- Canton, S. P., L. G. Wall, G. D. De Jong, and M. Murphy. 2007. *Aquatic Communities of Ephemeral Stream Ecosystems in the Southwestern United States: 3. Implications for the Recalculation Procedure for Site-Specific Water Quality Standards.* In Prep.

Other Publications

- American Fisheries Society. 2000. *Water Quality Matters.* American Fisheries Society, Water Quality Section Newsletter.
- Arizona Floodplain Management Association. 2002. *Arid West Water Quality Research Project: Ephemeral and Effluent-Dependent Streams Issues.* Floods Happen! Arizona Floodplain Management Association Newsletter.
- CDM. 2003. *Ensuring Sound Science in the Arid West*. CDM News, periodic publication of CDM.
- Curley E. and R. Meyerhoff. 2003. *Update: Arid West Water Quality Research Project.* Western Coalition of Arid States (WESTCAS) Newsletter, Volume 13, Spring 2003.
- Curley, E., K. Ramage, and R. Meyerhoff. 2007. *Focus on Arid West Water Quality Research Project.* WESTCAS Newsletter, February 2007.
- Ramage, K., E. Curley, and R. Meyerhoff. 2007. *Arid West Water Quality Research Project.* Arizona Water Pollution Control Association. January 2007.
- Southwest Hydrology. 2002. *WQRP Looking at Appropriateness of National Ambient Water Quality Criteria.* Southwest Hydrology, May/June 2002.
- Water Environment Research Foundation. 2000. *Arid West Water Quality Research Project.* Progress Newsletter, Summer 2000.

3.2.1 Discharger's Survey—Understanding the Issues

The initial research project conducted by the AWWQRP was based on a RWG recommendation to survey as many arid west dischargers as possible to obtain information to provide a preliminary characterization of arid west wastewater facility discharges and their associated water quality concerns. Effluent-dependent waters are a common phenomenon of the arid west. A 1998 survey of permitted wastewater discharges in the west identified 4,515 NPDES permits within the 17 western states that have arid and semi-arid lands. Of these permits, 1,001 were major municipal dischargers (discharge greater than 1 million gallons per day [mgd]), and of the 1,001 major dischargers, 251 were specifically located in areas considered arid or semi-arid. Within these 251 permitted discharges, there were 71 permit holders that resulted in 78 wastewater discharge sites, creating effluent-dependent waters in what would otherwise be ephemeral or intermittent watercourses (PCWMD 2000).

Additional information obtained since 1998 (e.g., establishment of new discharges, or updated survey information) suggests that currently the number of effluent-dependent waters is somewhat greater than 78 (AWWQRP, personal communication).

The Discharger's Survey also showed that the majority of wastewater treatment facilities in the arid west that discharge to ephemeral, intermittent, or effluent-dependent water courses are located in eastern California, Arizona, New Mexico, and west Texas (Table 3-2). These four states are collectively home to 65 percent of the discharge sites. The largest dischargers by volume are located in Arizona, Colorado, and Nevada.

A key finding of the Discharger's Survey was that there was a general lack of data that effectively described effluent-dependent and effluent-dominated aquatic habitats. This lack of data seriously impeded efforts to develop alternative regulatory approaches for developing or implementing water quality standards in effluent-based ecosystems.

Table 3-2 Distribution by State and Discharge Volume, the Number of Discharges Creating Effluent-Dependent Waters (from PCWMD 2000)

State	1-25 mgd	25-49 mgd	50-200 mgd	>200 mgd
Arizona	12	—	4	—
California	11	2	—	—
Colorado	2	—	1	—
Kansas	2	—	—	—
Montana	2	—	—	—
North Dakota	—	1	1	—
Nebraska	1	—	—	—
New Mexico	10	—	—	—
Nevada	1	—	2	1
South Dakota	2	—	—	—
Texas	12	—	—	—
Utah	5	1	—	—
Washington	1	—	—	—
Wyoming	4	—	—	—

3.2.2 Habitat Characterization Study

The Habitat Characterization Study was commissioned to document the physical, chemical, and biological characteristics of 10 effluent-based waters in the arid west. Six of the 10 sites may be characterized as effluent-dependent, while four sites are better characterized as effluent-dominated (although in all cases the effluent contributed most of the flow during the year or almost all of the flow at least part of the year, e.g., wastewater effluent contributes more than 98 percent of the flow in Segment 15 of the South Platte River at certain times of the year). These 10 sites represent case studies, and as such, the study was not conducted to scientifically verify any particular hypothesis, but to collect data to objectively describe and characterize effluent-based ecosystems. The need for this activity was generated by the frequently asked question: When we implement water quality programs in effluent-based waters, what are we trying to protect?

Habitat Characterization Study Objectives

- Review existing physical, chemical, and biological data
- Conduct a site reconnaissance level survey to characterize habitats using established protocols adapted for arid west conditions
- Identify similarities and differences among sites
- Discuss potential approaches to protect these habitats in the context of existing regulatory programs
- Recommend areas for additional study

Project Approach

Historical and site reconnaissance data were collected at all 10 study sites. Historical physical data included electronic records of streamflow upstream and downstream of WWTP outfalls and climate and stage-discharge relationship data. If available, results from site-specific hydrology and geomorphology studies were incorporated, and a reconnaissance level field geomorphology assessment was conducted at each site.

Historical water quality data included EPA, U.S. Geological Survey (USGS), and discharger records collected upstream and downstream of each WWTP outfall. If available, results from site-specific water quality studies were also incorporated.

Where available, site-specific historical aquatic and terrestrial species data from fish and wildlife agencies, state environmental departments, and other historical studies were evaluated. In addition, a site reconnaissance level field assessment of aquatic habitat, aquatic species, terrestrial habitat, and terrestrial species was conducted at each site. An important product from this effort was the establishment of the most comprehensive list to date of aquatic organisms present in these aquatic environments (see species list in attached CD (HCS Appendix M).

The project team utilized the available historical and site reconnaissance data to characterize the aquatic and terrestrial habitats of the 10 case study sites. Commonalities as well as differences among sites were identified and these findings were used to develop an effluent-created stream ecosystem model based on accepted riverine ecological models (see Section 2).

Effluent-Dominated Sites

- Fountain Creek below Colorado Springs, Colorado
- South Platte River at Denver, Colorado
- Crow Creek below Cheyenne, Wyoming
- Carrizo Creek below Carrizo Springs, Texas

Effluent-Dependent Sites

- Santa Cruz River below Nogales, Arizona
- Santa Cruz River below Tucson, Arizona
- Salt and Gila Rivers below Phoenix, Arizona
- Santa Ana River below San Bernardino, California
- Las Vegas Wash below Las Vegas, Nevada
- Santa Fe River below Santa Fe, New Mexico

Project Findings

The Habitat Characterization Study final report was the first known significant compilation of physical, chemical, and biological characteristics of effluent-based ecosystems. This report, which was developed with the oversight of regulatory and scientific advisors and interested stakeholders, supports the concept that effluent-based ecosystems, especially effluent-dependent waters, represent a distinct waterbody class, which has significant implications for the implementation of water quality programs in these created ecosystems (see Federal Register 57:60878 regarding EPA's statement that ephemeral streams and effluent-dominated waters are distinct classes of waters). The final report presents results and findings, not only from a technical perspective, but also from a regulatory and economic perspective. The following subsections highlight some of the key findings based on the 10 study sites (see the attached CD for the complete report).

Ephemeral Waters vs. Effluent-Dependent Waters – Is Wetter Better?

Without question, the addition of effluent into what would be a naturally ephemeral channel is a change to the natural state of the system. With the addition of an artificial perennial flow, biologically speaking, the system clearly will be different from how it was historically. Biological attributes such as aquatic community richness and diversity likely will be greater. The increased biological productivity of the aquatic community will provide additional food resources for terrestrial organisms. In addition to these changes in the aquatic community, the terrestrial community will be substantially different, especially in terms of the types of organisms supported. Are these biological changes good? Is having a wetter channel better biologically? These questions have no simple or single answer. In fact, the answer will depend on public values and local needs. One can easily argue that the number of ephemeral channels, especially in arid regions, far exceeds the number of naturally perennial channels, and thus the creation of a perennial stream in a previously ephemeral stream is a positive benefit. However, in some areas, especially in rapidly developing urban environments, the number of lost ephemeral channels can be significant and the loss of habitats as a result of effluent discharge can be an important issue for the public to consider.

While the public needs to evaluate the benefits of changes that will be invoked by the addition of effluent, important consideration also must be given to where an effluent-dependent channel should be created in the first place. As discussed elsewhere above, one of the important findings from the evaluation of the study areas is the need to consider physical and hydrological principles when selecting a location for an effluent discharge. Therefore, the question of whether wetter is better must be evaluated within many contexts and should be part of the public evaluation process.

Key Findings from Habitat Characterization Study

- Effluent-dependent waters are sufficiently different from other waterbody types to represent a distinct waterbody class
- Physical habitat of an effluent-dependent water results from a combination of several factors, most significant of which are the physical dynamics associated with the discharge itself and channel modifications associated with development of urban areas
- Differences exist between the chemical composition of waters at the study sites and laboratory water used for WET testing and pollutant-specific laboratory toxicity studies
- Aquatic and terrestrial biological communities are a reflection of the physical and chemical template resulting from instream flow characteristics (natural and effluent-driven)
- Increased levels of wastewater treatment may not be the most cost-effective approach for improving the aquatic communities of waters receiving discharges of treated effluent

While the Habitat Characterization Study acknowledged that wetter may not necessarily be better, the primary purpose of the report was to characterize effluent-based ecosystems.

Hydrologic Template Key to the Physical and Biological Response

Natural Flow Regimes—Because water use by a landscape is controlled by its shape, geology, and the climate (Dunne and Leopold 1978), the environment must work within these limitations to create habitat. These limitations might include the dynamics of all natural and created watercourses, amount and timing of runoff and stream hydraulics, movement of sediment by runoff and stream flow, movement and storage of water in both the deep and shallow subsurface, and ability of the soil to hold moisture for plants. Each of these factors is important to the creation of both aquatic and riparian ecosystems and each is itself a function of arid climatic conditions.

Change of both the aquatic and riparian environments can occur quickly in the form of disturbance (flood, fire, human intervention, and other factors) to this physical template. Disturbances that involve rapid swings in physical conditions are called "harsh" and the ecological communities that use these environments are different than the residents of more "benign" systems. Studies of harsh environments report that these environments have lower species richness and simple food chains. Plant and animal life must be resilient, relative to more benign systems. Many taxa will have increased drought or flooding resilience, depending upon the individual ecosystem.

Streams of the arid west are generally within this harsh group of aquatic environments. In particularly arid areas, because the location of precipitation is more influenced by steep mountain ranges and the total rainfall is low, stream flows might be infrequent for many years. When rain finally comes, streams begin flowing suddenly and at abruptly rising velocities and discharges. Channels may become abandoned from one storm to the next and new channels are rapidly cut into the existing floodplain. Many of the fauna found in arid west streams have adapted to extreme disturbance with changes in behavior or physiology. For example, macroinvertebrate species in flashy streams progress to adulthood more rapidly and have longer reproductive periods than similar species in more benign environments. As a result, the recovery period following disturbance is typically relatively short, from as little as 1 week to no more than 2 months (see discussion in Habitat Characterization Study [PCWMD 2002] on attached CD).

Modified Flow Regimes—In many of the 10 study areas of the Habitat Characterization Study (e.g., Santa Cruz River and Santa Ana River), the channel used by the effluent discharge has been fixed in place, relative to the upstream reaches. By discharging a steady flow of sediment-free effluent, most of the effluent flows have eroded down into the floodplain and formed entrenched channels. For example, the Santa Fe River directly below the effluent discharge point is clear and immediately begins to cut a new channel into the river bed. Within a mile downstream, the water becomes cloudy as sediment eroded from the channel becomes suspended in the stream. Eventually, the downcutting ends as the new stream adjusts to the existing, larger channel.

Any natural stream channel with a mobile bed represents a balance between the energy used for erosion and movement of the bed and the gravitational settling of the transported material. For a perennial stream, the shape of the channel will represent the most frequent flood event that maintains this balance over time, the so-called "channel-maintaining" or bankfull flow (see PCWMD 2002). In perennial waters, the flow that occurs about every 1.5 years is usually about equal to bankfull flow. Many intermittent to ephemeral streams in the arid west show a rough correlation in width between the 1.5-year discharge and the stream channel morphology (Moody 2000). The reasons for this relationship are not clear since the shape of an ephemeral channel usually changes with each event. It may be that the 1.5-year return interval is just a statistically significant lower bound for channel forming events in the southwestern United States.

For an effluent discharge channel that is protected from floods, which is common in urban environments, the channel-maintaining flow may simply be the average effluent discharge released by the WWTP. But how does the effluent discharge compare to the flows that form the size and shape of the existing channel? To test this, the 1.5-year interval flood flows were calculated for nine of the study areas. These calculated flows were compared to the wastewater effluent discharges that comprise the typical flow at each site (Table 3-3).

Table 3-3 Comparison of 1.5-Year Return Interval Flow to Introduced Effluent Flow (PCWMD 2002)

Waterbody	1.5-Year Flow (cfs)	Effluent Flow (cfs)	Effluent Flow vs. 1.5-Year Flow
Salt River, Arizona	9,373	92.6	<
Santa Cruz River, Nogales, Arizona	1,781.9	10.9	<
Santa Cruz River, Tucson, Arizona	1,677.3	47.0	<
Santa Ana River, California	380.6	62.7	<
Fountain Creek, Colorado	2,846.4	38.5	<
South Platte River, Colorado	3,069.3	149.0	<
Las Vegas Wash, Nevada	105.91	134.1	>
Santa Fe River, New Mexico	681.1	5.5	<
Crow Creek, Wyoming	40.0	10.0	<

In most cases, the effluent discharge is much lower than the 1.5-year flood flow. This could suggest that the effluent stream is too small to change the form of the river channel and that the habitat will hydrologically remain similar to an ephemeral stream. Where the effluent discharge volume is much greater than the 1.5-year flood flow, there may be more geomorphologic resemblance to a perennial stream. However, where the two 1.5-year flow and the effluent discharge are about equal, it may be difficult to predict what sort of channel will evolve, e.g., it may be stable one year, but migrate across the floodplain the next. It is not clear how this variability might affect the habitat that is established and such a system might be under constant disturbance.

Wastewater Treatment and the Aquatic Community

The Habitat Characterization Study data suggest that improvements in wastewater treatment may yield only limited improvements in the aquatic community, especially with regard to taxonomic richness. NPDES permits for discharges to arid west streams are often established with the presumption that the critical low-flow value is zero (i.e., no provision is available for instream dilution). As a consequence, the effluent limitations incorporated into NPDES permits are typically equivalent to the water quality standard. In most instances, the most stringent water quality criteria established for the protection of arid west streams are those established to protect aquatic life. If these standards are set at a level to protect 95 percent of all aquatic species regardless of their presence or absence (as is the presumption if nationally recommended criteria are used), then one should expect that wastewater treatment improvements should result in improvements to the aquatic community such that the aquatic community below an effluent discharge is not substantively different from the aquatic community that would be found in a similar waterbody not influenced by effluent—unless other factors, e.g., habitat quality, limit the aquatic community.

A comparison of treatment levels and taxonomic richness found no consistent pattern associated with improved treatment levels (Table 3-4). At the lowest levels of treatment, with chlorination but no dechlorination, there was a sharp decline in taxonomic richness between the sites above and below the effluent discharge. However, at higher levels of treatment, both increases and decreases in taxonomic richness occurred. In some cases it appeared that changes in richness could be more related to changes in habitat quality than chemical quality. Taxonomic composition varied somewhat with increased levels of treatment, especially at the highest level of treatment (i.e., chlorination with dechlorination, nitrification and denitrification, and filtration). Sites with this high level of treatment had increased abundance of "cleanwater taxa," so-called EPT organisms (the acronym EPT represents *Ephemeroptera, Plecoptera*, *Trichoptera*, which are the taxonomic names for the aquatic mayflies, stoneflies, and caddisflies, respectively).

Table 3-4 Wastewater Treatment vs. Macroinvertebrate Communities at Habitat Characterization Study Sites where Flow Occurred Upstream and Downstream of Effluent Discharge (adapted from PCWMD 2002)

Treatment Level		Taxonomic Richness - Upstream vs. Downstream of Discharge	Percent Cleanwater Taxa Downstream of Discharge
Higher Quality Effluent ↓	Chlorination with no dechlorination	Substantial decline downstream of discharge	None present
	Chlorination with dechlorination; nitrification with denitrification	Variable; increase or decrease downstream of discharge	From none present to less than 10 percent of aquatic community
	Chlorination with dechlorination; nitrification with denitrification; filtration	Decrease below discharge	Present, percentages range from 17 to 99 percent. Cleanwater taxa limited to or heavily dominated by baetid mayflies.

However, it should be noted that these "cleanwater" taxa were often limited to or dominated by baetid mayflies. Other EPT taxa were generally absent (Table 3-4).

An evaluation of long-term changes in aquatic communities relative to upgrades in wastewater treatment can be evaluated only at sites where aquatic species data are available over a sufficient period of time during which upgrades in wastewater treatment were implemented (Table 3-5). A site-specific comparison of long-term changes in aquatic communities and concomitant changes in water quality treatment levels show that improved treatment capabilities resulting in improved water quality are not always manifested in an improved aquatic community; moreover, in one instance, the fish community improved following treatment upgrades while the macroinvertebrate community declined (Table 3-5). These mixed results from these four study areas suggest that factors (e.g., habitat limitations) other than wastewater treatment improvements have influenced aquatic community characteristics.

Table 3-5 Summary of Changes in Aquatic Community Structure Following Wastewater Treatment Upgrades (adapted from PCWMD 2002)

Case Study Site	Data Record	Wastewater Treatment Upgrade History	Aquatic Community Characteristics
Santa Ana River, California	Macroinvertebrates and fish sampled in 1991 and 1998	Two discharges combined into single discharge. Tertiary treatment implemented; nitrogen removal.	Macroinvertebrates: Cleanwater taxa abundance increases both upstream and downstream of effluent discharge; prior to treatment upgrades, highest numbers of cleanwater taxa found downstream of effluent discharges. Fish: Species richness increased both upstream and downstream of effluent discharge.
South Platte River, Colorado	Macroinvertebrates sampled 1988 to 2004; fish sampled 1986 to 2005	Dechlorination added in 1988. Nitrification and denitrification treatment processes added to North Complex by 1991. Significant facility rehabilitation from 1991 to 2002.	Macroinvertebrates: Taxonomic richness has remained essentially the same over time. Fish: Species richness has generally ranged between 8 and 12 species per site per sample over 20 years.
Fountain Creek, Colorado	Macroinvertebrates sampled in 1980, 1989, 1998, and 1999. Fish sampled in 1980 and 1989.	Dechlorination added to treatment facility in mid-1980s; nitrification and denitrification added in 1996.	Macroinvertebrates: Taxonomic richness was markedly lower in 1989 than in 1980; richness rebounds to 1980 levels by 1998 and 1999 - upstream and downstream of the discharge similar. Cleanwater taxa abundance greater upstream of discharge in 1998/1999; but cleanwater taxa richness similar at sites immediately upstream and downstream of discharge. Fish: Species richness increased 1980 - 1989.
Santa Fe River, New Mexico	Macroinvertebrates and fish sampled in 1994 and 2000	Between 1994 and 2000, City of Santa Fe upgraded wastewater facility to include filtration and replace chlorination with ultraviolet disinfection.	Macroinvertebrates: Taxonomic richness increased Fish: Abundance increased

Importance of Understanding Factor(s) Limiting Aquatic Communities

The biological community observed in a given stream or river is to a large degree dependent on the physical and chemical template of the environment in which it lives. Therefore, explaining why the biological community of a given stream has the qualities it does requires an understanding of what factor or factors limit the community.

Understanding limiting factors has critical importance in how dischargers and regulators go about the business of implementing water quality programs. This fact is applicable to all stream types, but especially effluent-dependent waters where the "river" is, for the most part, treated effluent. If the goal is an improved aquatic community and the emphasis of the water quality program is only on improving chemical water quality, but it is determined that physical habitat is the limiting factor, then efforts to improve the aquatic community by only focusing on water quality may produce only limited results (Figure 3-1).

Unfortunately, there are a multitude of variables that can be measured on any stream. If the question is how the physical or chemical characteristics of a stream affect fish species richness or invertebrate abundance, determining which variables to measure to answer this question can be a daunting task. Moreover, even if the multitude of available variables are measured, it is still unclear how to evaluate the data in a manner that provides insight into determining what the limiting factor is affecting the biological variable of interest.

Providing an answer to the problem of identifying the limiting factor has been the subject of recently completed research commissioned by the WERF: *Ability to Discriminate Chemical vs. Habitat Limitations, Project No. 98-WSM-1* (see Section 3.3.1 for more information on this tool). The WERF research showed that the limiting factor in many of the study areas is not effluent quality, but physical habitat. This supposition has been documented by WERF research on two of the Habitat Characterization Study sites:

- In the Santa Ana River, the biological response variable, fish abundance, was most affected by the degree of channel alteration. Other independent variables, including water quality related factors (e.g., bank vegetation, metals, and ammonia), were found to be important within various ranges of channel alteration scores, but ultimately a habitat characteristic was the primary limiting factor.
- In Fountain Creek, Colorado, the biological response variable, macroinvertebrate taxa richness, was most affected by average embeddedness of stream substrates. The WERF study found that this variable separated into seven nodes or ranges. At the sixth highest range (87 to 97 percent embeddedness), BOD_5 was found to be a secondarily important variable and at 100 percent embeddedness, the presence of silt, clay, marl, muck, and organic detritus was shown to be important.

The above results for the Santa Ana River and Fountain Creek illustrate how the aquatic community can be structured by a complex set of varying physical and chemical variables. Determining which of these variables is the most important in influencing the aquatic community can and should greatly influence how one addresses water quality concerns in a given water body. For example as was illustrated in the Ambient Based Dissolved Oxygen Water Quality Criteria Case Study (Section 6), establishing that habitat was the factor limiting the aquatic community was critical to the acceptance of an alternative DO standard.

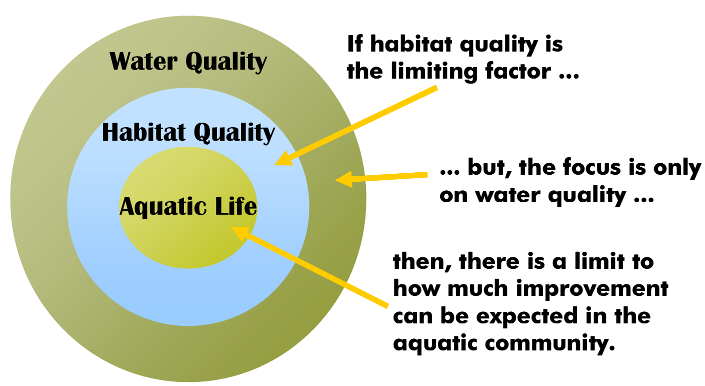


Figure 3-1
Importance of understanding the relationship between limiting factors and aquatic life.

Potential Ecological Benefits of Effluent Discharge

The addition of effluent, which augments or creates instream flows, has the potential to influence aquatic and terrestrial species richness and diversity in stream ecosystems in the arid west. This influence may be positive or negative depending on many factors including both habitat and water quality. Regardless of the effects on aquatic species, the potential for a positive response from or benefit to the terrestrial ecosystem associated with the stream ecosystem is great. These benefits include support of aquatic organisms that provide food for higher trophic levels (e.g., piscivorous birds and mammals) and riparian vegetation that provides food, cover, and nesting opportunities for terrestrial fauna including threatened and endangered species.

As was described above, evidence exists that improvements in wastewater treatment may only yield modest improvements in the aquatic community, especially with regards to taxonomic richness (for example, see Tables 3-4 and 3-5). However, regardless of the taxonomic richness observed, a viable aquatic community is typically present in effluent-created ecosystems. A viable aquatic community provides benefits in an ecosystem that, except for the input of effluent, would be ephemeral or at best intermittent. While these benefits could be compartmentalized into ecosystem subcomponents, these benefits generally can be collapsed into a single overall benefit—the aquatic community provides food resources to higher trophic levels, especially fish and terrestrial communities. The link between aquatic and terrestrial communities is not well studied, but as noted above, an important study conducted on a southwest arid non-effluent-dependent water found that 96 percent of the biomass of emerging insects was transferred to the terrestrial ecosystem as food to terrestrial insectivores (e.g., birds and bats) (Jackson and Fisher 1986). The importance of this link cannot be minimized and illustrates well the potential benefit to the terrestrial ecosystem of a viable aquatic community.

Riparian ecosystems develop in the arid western United States in direct response to the presence of water beyond that which occurs as a result of normal precipitation events. The presence of riparian habitat along streams, whether containing treated effluent or normal runoff, is of immense importance to all classes of wildlife. The finding that the discharge of treated wastewater influences the presence and structure of riparian systems in otherwise dry streambeds is unequivocal. Of the 10 Habitat Characterization Study areas, those sites that were effluent-dependent showed marked differences in vegetation characteristics upstream from the effluent outfall compared with downstream (Figure 3-2). In contrast, those sites that would be better classified as effluent-dominated, i.e., at least some intermittent flow occurs without the effluent discharge, showed less of a contrast in riparian community characteristics upstream and downstream of the discharge. In addition, the Habitat Characterization Study demonstrated that a significant difference exists between riparian areas in arid areas and non-arid areas with regards to the richness of birds, reptiles, and amphibians.

Figure 3-2
Riparian community associated with effluent-dependent Santa Cruz River, Arizona.

Overall, with the exception of mammals, the results from the terrestrial species analysis confirm expectations that there is a fundamental difference between the terrestrial component of riparian ecosystems in the arid west and non-arid areas. This finding reinforces the importance of supporting riparian habitats in the arid west, including those created as a result of the discharge of effluent. In addition, the aquatic community supported by the effluent flow can serve as an important food resource for animals using this riparian habitat, especially birds.

Habitat Characterization Study Summary

The Habitat Characterization Study demonstrated that an effluent-based ecosystem, especially an effluent-dependent system, must be viewed as a created system in search of a stable relationship with its surrounding environment. Similarly, such a waterway cannot be viewed as a natural, perennial water in sync with its surroundings. Given enough time and assuming no additional stressors, the created system will establish a new equilibrium, but until that occurs, expectations for a biological community that is similar to a natural stream in the same region cannot be achieved simply based on physical and hydrological considerations. In addition to physical and hydrological restrictions, limitations imposed on the biological community by the chemical characteristics of effluent also must be considered. Arguably, increased levels of treatment, resulting in improved effluent quality, will result in at least some improvement in the biological community over the long term. However, the degree to which improved treatment will result in this improved biological community is first and foremost limited by the physical template upon which the biological community must colonize. Moreover, the importance in understanding what is limiting the biological community of effluent-created waters cannot be emphasized enough.

Understanding the potential for biological communities in effluent-created waters is important not only from a technical or scientific standpoint, but also from a regulatory perspective.

With these considerations in mind, establishing a goal to achieve an aquatic community in an effluent-created water with characteristics similar to an aquatic community in a natural stream may be inappropriate. The physical effects of effluent discharged into a streambed that is dry during most of the year may work against the benefits to the aquatic community that might be achieved from improved water quality. Superimposed on this template are activities that work against achieving a positive physical environment for aquatic organisms, activities such as channel modifications for flood control, hydrologic modifications, water diversions, grade control structures, additional effluent discharges, and bridges. Each of these activities further disrupts the natural tendency for these streams to establish equilibrium.

Although habitat, water quality, or both may limit the aquatic system, the terrestrial community is only limited by factors associated with habitat (often temporary) and non-native species. As indicated above, the contrast between waters above and below the effluent discharge can be significant and the support of greater vegetative diversity provides increased benefits for many terrestrial wildlife species.

Understanding the potential for biological communities in effluent-created waters is important not only from a technical or scientific standpoint, but also from a regulatory perspective. After all, determining what is attainable in a waterbody forms the foundation for the establishment of water quality goals under the CWA. Development of the aquatic and terrestrial community in and along effluent-based waters is dependent on a variety of physical and chemical factors. How these factors may limit the development of these communities is critical to an evaluation of what uses are truly attainable in these waters. Section 4 discusses some of the regulatory implications of use attainability in the context of these waters.

3.2.3 Extant Criteria Evaluation

EPA's National Ambient Water Quality Criteria (AWQC) are used as the basis for establishing state water quality standards and implementing these standards through NPDES permits. These criteria set maximum threshold concentrations of contaminants for both freshwater and marine environments. Numeric AWQC are derived using a well-defined process that relies on the collection of mostly laboratory-derived toxicity data that are then used to calculate both an acute and a chronic criterion.

One major difficulty in applying AWQC to surface waters in the arid west is that they are derived chiefly from standardized toxicity tests using aquatic species that may not be representative of aquatic biota in this region. Furthermore, the physical and chemical characteristics of surface waters in the arid west differ substantially from those in more mesic or wetter regions. AWQC thus may not provide an appropriate or consistent level of protection for aquatic ecosystems in arid regions that are subject to these unique environmental conditions. Based on these concerns, the AWWQRP commissioned a study, the Extant Criteria Evaluation (ECE), to evaluate the applicability of national AWQC to arid west waters.

Project Approach

The goal of the ECE was to evaluate the relevance of selected EPA AWQC to ephemeral and effluent-dependent watercourses in the arid west. Four objectives were established to guide the project (see text box). In addition, rather than attempt to evaluate all possible AWQC, four selected AWQC were evaluated as "models" for important contaminant classes of interest to dischargers in the arid west:

- Copper represents metals for which accumulation at the biotic ligand best predicts toxicity. Other important metals in this category include silver, zinc, nickel, and cadmium.
- Selenium is an example of an inorganic element for which bioaccumulation or dietary intake is important to toxicity. Another example in this category is mercury.
- Diazinon, an organic insecticide, represents contaminants that are primarily toxic to invertebrates, rather than fishes.
- Ammonia is an example of a constituent for which criteria are derived on the basis of pH and water temperature.

Extent Criteria Evaluation Project Objectives

- Examine the appropriateness of AWQC for arid western ecosystems
- Identify potential weaknesses in the AWQC (or their derivation methods) for these systems
- Evaluation of hardness-based relationships for metals using copper as a test case
- Recommend future research to address any identified potential weaknesses

Throughout the evaluation of these "model" criteria, special emphasis was placed on considering modifications to AWQC duration and frequency periods to better reflect the biotic and hydrologic conditions encountered in these systems. In addition to the specific evaluations of these "models," a special study was conducted to shed some light on metals toxicity in particularly hard waters.

Project Findings

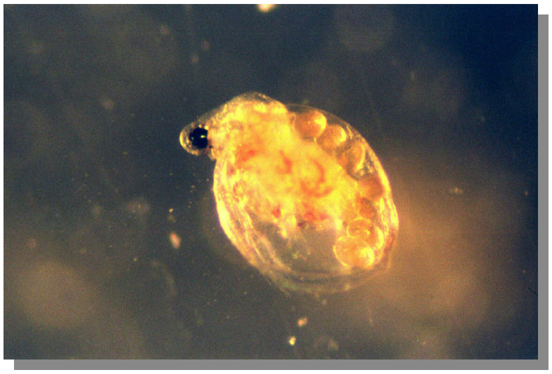
An Executive Summary of the ECE project findings may be found in the attached CD. A full report will be published by the Society of Environmental Toxicology and Chemistry (SETAC) in 2007 (SETAC 2007, in press).

AWQC Magnitudes

Changes in default national AWQC magnitudes are probably warranted to maximize the accuracy by which they represent concentrations that are protective of aquatic life in these systems. For the most part, existing site-specific criteria modification methods (i.e., recalculation procedure, water-effect ratio procedure, and resident species procedure) may adequately address these changes, and so a "regional" approach may not be necessary in many cases. The extent to which methods for site-specific magnitude modification may be applied on a regional scale depends mostly upon the ability to generalize the composition of biotic assemblages for use with a Recalculation Procedure. In particular, the presence vs. absence of planktonic cladocerans needs better confirmation owing to the importance of these taxa to criteria derivation for many criteria chemicals.

AWQC Duration and Frequency

Criteria implementation also depends upon the duration (i.e., averaging period) and frequency (i.e., period between criteria excursions that still allows for recovery of aquatic communities) components of an AWQC. Because default duration values are based entirely on laboratory toxicology and toxicokinetics data, it is not possible to suggest modifications on the basis of conditions unique to the arid west. However, recent laboratory evidence suggests that these default duration values may be overly conservative (i.e., too short) in some cases. Increasing duration values would significantly increase design flows for NPDES permit calculations, and so is an important avenue of future study.



***Ceriodaphnia dubia*, a commonly used test organism for conducting toxicity tests.**

The relevance of the default 3-year recovery period to arid west biotic assemblages was evaluated not only as a function of community recovery from disturbance, but also as a function of hydrologic disturbance frequency. The analysis suggests that the frequency and duration of hydrologic events in ephemeral streams of the arid west have the potential to be of similar importance to biotic communities as is exposure to toxics. The frequency of hydrologic disturbance to ephemeral and effluent-dependent streams certainly is high enough to suggest that these ecosystems could be disturbed more frequently than once every 3 years. In contrast, the biotic assemblages of ephemeral and effluent-dependent streams may still require longer time periods (e.g., 3 years) to recover from disturbance even if a substantial number of endemic species still remain. This suggests that it may be environmentally conservative to retain the default 3-year frequency of allowed excursions except, perhaps, for relatively unmodified ephemeral streams. Frequency values also can have a significant impact on derivation of NPDES permit design flows, and so a closer examination of the 3-year default frequency—at least in the case of ephemeral streams—deserves closer attention.

Copper Hardness-Toxicity Study

The mitigating effect of increasing hardness on metal toxicity is reflected in EPA water quality criteria, but are limited to a hardness range of 25 to 400 milligrams per liter (mg/L) (as $CaCO_3$). However, waters in the arid west frequently exceed 400 mg/L hardness, and the applicability of hardness-toxicity relationships in these waters is unknown. Thus in a companion study to the copper AWQC evaluation, acute toxicity tests with *Ceriodaphnia dubia* were conducted at hardness levels ranging from ca. 300 to 1,000 mg/L using reconstituted waters that mimic two kinds of natural waters with elevated hardness (Las Vegas Wash, Nevada, and a $CaSO_4$-treated mining effluent in Colorado). The moderately-alkaline EPA synthetic hard water was also included for comparison. Although copper toxicity still decreased with increasing hardness at levels greater than 400 mg/L, the hardness-toxicity relationships differed with ion composition. In particular, increasing alkalinity, magnesium, or sodium concentrations explained decreases in copper toxicity better than did either hardness or calcium concentrations. Therefore, further study is needed to determine whether simple hardness-based metals criteria are appropriate for use in the arid west, or whether more complex approaches are warranted.

3.2.4 Biotic Ligand Model Evaluation

As part of the ECE, copper was evaluated to represent a metal for which aquatic impacts depend strongly on site-specific water quality characteristics such as hardness, alkalinity, and pH. Metal toxicity often varies as a function of hardness, and so AWQC for metals—including copper—are typically derived as a mathematical function of hardness. In contrast, hardness may not be the best predictor of copper toxicity in arid west streams. As a result, simple hardness equations typically used to adjust copper AWQC may not accurately represent the more realistic and complex factors that may control metal toxicity in very hard waters.

To further evaluate these more complex factors controlling copper toxicity, the ECE evaluated the relevance of the Biotic Ligand Model (BLM) for use in site-specific AWQC modification in arid west watercourses. The BLM is a mechanistic model of metal bioavailability that simulates metal interactions with specific receptors (the "biotic ligand") in aquatic organisms associated with metal toxicity. Even though this model was developed using data from relatively soft to moderately hard waters, ECE studies suggested that model predictions are still accurate in very hard waters characteristic of the arid west. This predictive power is important because the BLM has been incorporated by EPA as an alternative to Water Effect Ratio (WER) studies in the draft copper AWQC released at the end of 2003 for public comment. In addition, studies are underway to develop BLMs for other metals including zinc and nickel.

Project Approach

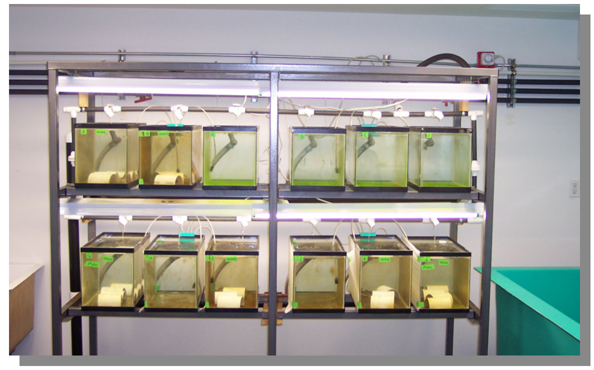
Evaluating the Reliability of the BLM to Predict Copper Toxicity in Arid West Waters

Even though the results of the initial BLM tests in the ECE were promising, they were based on the outcome of a single study of copper toxicity using the cladoceran *Ceriodaphnia dubia*. Evaluating the generality of this conclusion for copper required testing with additional species (e.g., fathead minnows or *Daphnia magna*), and using waters characteristic of a wider range of natural waters in the arid west. Therefore, this project entailed a series of studies designed to further evaluate the reliability of the BLM to predict copper toxicity in arid west waters.

Biotic Ligand Model Evaluation Objectives

- Conduct acute copper toxicity tests under range of arid west water quality conditions under both high and low-flow conditions
- Conduct statistical evaluation of predictive capabilities of BLM in these waters
- Evaluate role of Ca:Mg ratio in controlling toxicity

Acute copper toxicity tests were conducted using three different aquatic test species under a range of water quality conditions (e.g., cations, anions, and dissolved organic carbon) representative of waters in the arid west. This range of water quality conditions was generated collecting waters under both high- and low-flow conditions from sites already studied in other AWWQRP studies. Researchers conducted a series of WER-style studies to compare copper toxicity in a particular "site" water to that of a laboratory reconstituted water designed to mimic the major ion composition of the site water. Based on the water quality data obtained from these studies, a statistical analysis was conducted to evaluate the predictive capabilities of the BLM for the study waters.



Toxicity tests being conducted with fathead minnows, *Pimephales promelas*.

Role of Calcium/Magnesium in Controlling Copper Toxicity in Aquatic Life

The project team conducted a series of tests to further evaluate the different roles of calcium vs. magnesium in controlling copper toxicity to invertebrates and fishes. While water hardness alone may not be the only modifier of metal toxicity to aquatic organisms, the major ions that contribute to water hardness (calcium [Ca] and magnesium [Mg]) may influence copper toxicity differently. For example, water hardness consisting primarily of Ca ions (i.e., Ca to Mg molar ratios of greater than 2:1) may be more protective of copper toxicity to freshwater fish, while water hardness consisting of similar proportions of Ca and Mg (i.e., molar ratios of 1:1) may be more protective of some aquatic invertebrates.

The BLM for copper does not explicitly contain a biotic ligand-Mg interaction for fish or invertebrates. However, BLM predictions conducted in the ECE for *Ceriodaphnia dubia* in very hard waters were improved by incorporating a biotic ligand-Mg interaction into the model (Gensemer et al. 2002). Accordingly, there was a need to further characterize the influence of Mg as a modifying parameter of copper toxicity in very hard waters for proper validation of predictive models for criteria derivation. Studies included conducting acute copper toxicity tests with two different aquatic test species (*Ceriodaphnia dubia* and *Pimephales promelas*) under a range of Ca and Mg concentrations that are representative of waters in the arid west. These species were chosen to provide a comparison between an invertebrate to a fish, and because the relative effects of Ca and Mg on copper toxicity in *P. promelas* are relatively well understood.

Based on the water quality data obtained from the acute copper toxicity studies, a statistical evaluation of the predictive capabilities of the BLM for these toxicity tests was conducted to evaluate the accuracy and precision of the BLM with and without inclusion of the biotic ligand-Mg interaction.

Project Findings

The complete BLM Evaluation report may be found on the attached CD. Following is a summary of the key findings.

Overview

Findings from this study suggest that the BLM generates more appropriate and protective copper standards for waters with elevated hardness when compared to the hardness-based equation or WER approaches. Although the historical site-specific methods (hardness equation and WER) are useful for surface waters with low to moderate levels of hardness, the unique chemical conditions of arid west streams require site-specific methods that account for the influences of all water quality variables (i.e., pH, dissolved organic carbon, alkalinity, and major ions). Therefore, the BLM offers an improved alternative to the hardness-based and WER approach for modifying copper criteria, particularly for situations where the current methods would be under-protective of sensitive aquatic life.

Water Effect Ratios

WER values ranged from less than one to greater than 13 for the natural waters tested in this BLM evaluation study, meaning that copper toxicity was up to 13-fold lower in site waters when compared to hardness-matched synthetic laboratory waters. WER values among species varied by up to 15-fold at individual sites and greater than 10-fold among sites for individual species. Generally speaking, *C. dubia* produced the largest WER values and fathead minnows had the smallest (most conservative). However, results for one site in Arizona—Pinal Creek—suggested that the invertebrates were equally sensitive to site and laboratory water (i.e., WER values approximating one) while the fathead minnows had a calculated WER of greater than 10.

For most study sites, WER values changed substantially during different flow conditions and were generally highest at base flow and decreased with elevated flows. However, WER values were relatively similar among flow levels for the Santa Ana River in southern California, most likely owing to significantly elevated flows being observed there throughout the study.

Several design strategies and implementation concerns should be considered prior to initiating a definitive WER study for waters of elevated hardness. First, because hardness was not correlated with alkalinity in site waters used in the present study, both parameters should be matched in concurrent reconstituted waters to account for confounding variables. Second, the current study clearly demonstrated the importance of matching ion ratios (primarily calcium and magnesium) of the concurrent reconstituted water to site conditions. Finally, calculating site-specific criteria from observed WER values coupled with use of the existing hardness equation is likely to be under-protective and, thus, not appropriate in waters with hardness greater than 200 mg/L as $CaCO_3$.

Calcium vs. Magnesium Hardness

While both calcium and magnesium contribute to water hardness, they may not exert similar influences on copper toxicity to all freshwater organisms. In this study, increasing total hardness from 200 to 1,000 mg/L as $CaCO_3$ using either calcium or magnesium had considerably different effects on acute copper toxicity to *C. dubia* and fathead minnows. A 10-fold addition of calcium doubled the LC_{50} for each species. However, while a similar protective effect from magnesium addition occurred for *C. dubia*, acute toxicity to fathead minnows remained constant.

These study results justified incorporation of a magnesium-gill interaction into the BLM to account for competition between magnesium and copper on the biotic ligand of invertebrates. Additionally, an increase in copper toxicity to fathead minnows at the highest magnesium concentrations was observed, which was also incorporated into the model to improve performance in high hardness waters.

Biotic Ligand Model Performance

The unmodified version of the BLM only predicted 61 percent of the copper toxicity values in the present study with reasonable accuracy (i.e., within two-fold of empirical toxicity values). While the majority of the unacceptable predictions were for the fathead minnow, the model performed remarkably well for the two invertebrates whose sensitivity to copper were closest to the acute criterion concentration. Further investigations revealed that carbonate precipitation was likely occurring in site and laboratory waters due to elevated concentrations of calcium and magnesium. Consideration of carbonate precipitation and interactions between magnesium and the biotic ligand of fish and invertebrates improved model predictions by 40 percent. Therefore, the BLM evaluation study demonstrated the utility of considering the influence of all water quality variables when deriving site-specific criteria for waters with elevated hardness.

Regulatory Implications

Neither of the formal recommendations from EPA for calculating a site-specific copper criterion in waters with hardness greater than 400 mg/L as $CaCO_3$ (i.e., capped hardness equation or the product of a measured WER and hardness equation) were protective of all sites used in this study. For example, the first approach (capped hardness equation) would likely be under-protective of sensitive biota in the Albany Drainage Swale study site (Oregon) and Pinal Creek (Arizona) because the hardness equation produced a criterion equal to or greater than the acute lethal concentration of copper to C. *dubia*. The consequence of regulating copper at an acutely lethal level could be decreased populations of sensitive biota. Similarly, the second approach (WER) would be under-protective of sensitive biota in six of the seven sites tested in this study (Albany Drainage Swale, South Platte River, Pinal Creek, Las Vegas Wash, Salt River, and Santa Ana River).

In contrast, the BLM-derived acute criterion for copper was protective of sensitive biota for all seven of the sites used in this study. This demonstrates the utility of considering the influence of all water quality variables, particularly when deriving site-specific criteria for waters with elevated hardness. Study results suggest that the BLM offers an improved alternative to both of the current site-specific methods for modifying copper criteria, particularly for situations where the hardness equation and WER approach would under-protect sensitive aquatic life.

3.2.5 Recalculation Procedure Evaluation with Guidance Manual Development

Although AWQC are intended to protect many aquatic species nationwide, they may not always represent the contaminant sensitivity of species resident to a particular site. At present, EPA has provided guidance for the development of site-specific criteria using three primary methods (EPA 1994a):

- Recalculation Procedure
- Water-Effect Ratios
- Resident Species Procedure

Recalculation Procedure Evaluation Objectives

- Evaluate potential use and/or modification of the recalculation procedure with five chosen AWQCs based on resident species data from five streams
- Update the toxicity databases for the five AWQCs: copper, zinc, ammonia, diazinon, and aluminum
- Evaluate alternative approaches to the use of the Recalculation Procedure in arid west waters
- Develop a User's Guide for the Recalculation Procedure to assist dischargers and permit holders in how to apply the procedure given the unique biological conditions of effluent-dependent waters.

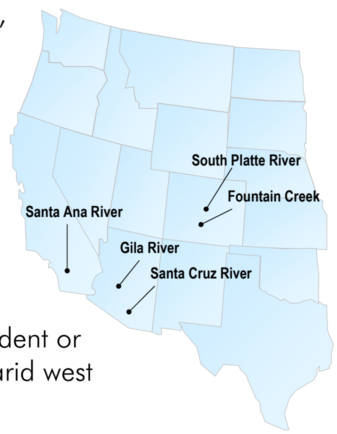
EPA established the Recalculation Procedure (EPA 1994a,b) to provide a mechanism to modify a national AWQC to reflect toxicological differences between the aquatic species used to derive the national criterion and the aquatic species present at a specific site. The ECE concluded that (1) changes in default national AWQC magnitudes are probably warranted to maximize the accuracy by which water quality standards protect aquatic life in arid west effluent dependent waters, and (2) existing site-specific criteria modification methods, e.g., EPA's Recalculation Procedure, may adequately address such proposed changes. The

AWWQRP conducted this study to further evaluate this procedure for use in arid west waters. This research study also applied further developed tools for modifying AWQC on a site-specific basis for arid west effluent-dependent waters.

Project Approach

The goals for this project were two-fold: (1) Evaluate the use of the EPA Recalculation Procedure to modify criteria in each arid west stream given the available data, and (2) develop a User's Guide for water quality standards practitioners to provide guidance on how to apply the Recalculation Procedure to arid west waters in general. To accomplish these goals, the evaluation focused on AWQC that represent different modes of toxicity, robustness of toxicological databases, and other recalculation issues (Table 3-6).

In this study, AWQC were recalculated to better reflect the resident species observed in a number of effluent-dependent or dominant streams in the arid west (See map).



All stream segments were located downstream of WWTPs that discharge treated effluent into streams that would otherwise have low or no flow during most of the year. All or some of these waters were also included in other AWWQRP studies, e.g., habitat evaluations or for WER testing for copper and ammonia (e.g., PCWMD 2002, 2006a,b).

Resident species lists were developed for each of the five waterbodies for comparison to the toxicity databases as a required step in the recalculation procedure. Fish and invertebrate taxa lists were compiled from a literature review to determine what taxa currently occur or could potentially occur at the sites.

Prior to recalculation, the researchers also updated each of the selected criteria (ammonia, copper, zinc, diazinon, and aluminum) through:

- Review of the criteria documents for technical accuracy
- Literature review to update the criteria toxicity databases
- Development of revised, updated national criteria

These updated AWQC were subsequently used as the basis for evaluating the recalculation procedure (EPA 1994a,b) at each of the case study sites listed above.

Table 3-6 Selected Criteria for Recalculation Procedure Evaluation (adapted from PCWMD 2006c)

Criteria	Basis for Selection
Aluminum	Aluminum (EPA 1988) is an example of a criterion based on a very limited toxicity database, one that just barely meets the "eight-family rule" (described below). As such, it presents unique problems for the recalculation procedure. In addition, aluminum can be a metal of concern in streams throughout the arid West, given its ubiquitous presence in the clay soils common to this region. Many Western streams are listed as impaired due to aluminum, despite bioassessment evidence to the contrary.
Ammonia	Evaluation of the ammonia criteria would allow an analysis of how recalculation procedures work for irregularly derived criteria since EPA's final derivation of acute and chronic ammonia criteria was not directly based on standard EPA criteria calculations of final acute and final chronic values (Stephan et al. 1985). In addition, ammonia's mode of toxicity is different than that for metals, it was previously identified by the ECE study as a potential candidate for recalculation, and it has recently come under scrutiny by EPA as a result of newly published toxicity data, specifically on unionid claims.
Copper	The validity of BLM predictions in very hard waters common to the arid West was evaluated as part of a separate AWWQRP project (PCWMD 2006a); the use of the BLM is also incorporated into EPA's revised copper criteria guidance (EPA 2007). The evaluation of copper facilitated analysis of the recalculation procedure for a BLM-adjusted toxicity database.
Diazinon	Diazinon provides an example of a contaminant with a modest sized database that presents toxicity values for many aquatic organisms with a wide range of sensitivities. In addition, diazinon has been steadily gaining environmental significance in arid Western states due to its increasing presence in urban wastewater, where it has been suspect in numerous WET testing failures.
Zinc	Zinc is a common metal found throughout the West owing to the presence of mineralized soils in many locations. This metal also has a rather extensive toxicity database, so zinc represents the evaluation of the recalculation procedure for a criterion with a robust database.

Project Findings—Recalculation Procedure Evaluation

The complete study report is available on the attached CD. The following discussion provides a brief summary of the findings for each criterion, with comments on the mechanics of updating the national criteria, creating site-specific databases, and deriving final site-specific criteria.

Aluminum

Al Compared to the updated national aluminum criteria, site-specific aluminum criteria were more restrictive or equal to the national criteria, except for the Santa Cruz near Nogales site. These counter-intuitive findings resulted from two basic factors:

- All site-specific databases contained greater variability in the four lowest Species Mean Acute Values (SMAVs), resulting in less statistically confident Final Acute Value (FAV) calculations and, hence, more restrictive criteria.
- The site-specific databases resulted in fewer taxa than the updated national databases. Reduction in number of species (N) within the site-specific toxicity databases decreased the degrees of freedom afforded to the four lowest ranked SMAVs.

In other words, the lower aluminum criteria resulting from site-specific recalculations reflected a reduction in the size of an already limited toxicity database and are not related to the species richness of the study sites. Accordingly, it was recommended that one use the national criterion based on the updated aluminum AWQC presented in the study report and continue further investigation into site-specific recalculations when a more robust species database becomes available.

Ammonia

NH_3 With regard to ammonia, there was little variability in site-specific criteria between any of the sites or regions. However, regional criteria were less restrictive than all but one site-specific criterion. This finding was directly associated with using the larger regional toxicity databases when compared to using just the site-specific databases. The similarity in results for all sites and regions with the updated national criterion suggest that site-specific recalculations for ammonia might not be necessary, as the breakdown of warm and cold water habitats proposed in the national updated ammonia criteria may already account for site-specific differences in arid west streams, making further species-based recalculation efforts unnecessary.

Copper

Cu The recalculation procedure for copper provided substantial site-specific differences in criteria concentrations in arid west study streams compared to national criteria. Unlike ammonia, it was found that a substantial increase occurred in all site-specific criteria (i.e., were less restrictive) compared to national or updated national AWQC. This finding was primarily a result of the deletion of non-resident cladocerans.

Diazinon

DRecalculated site-specific diazinon criteria were substantially greater (i.e., less restrictive) than the updated national criteria. The site-specific databases are half as variable as the national update, which increases confidence in respective estimates and results in greater values. Furthermore, site-specific criteria for diazinon were more variable between sites than other criteria evaluated as part of this project. Although the most sensitive organisms were similar among most sites, the variability in database size between sites was substantially different. The significant increase of the recalculated criterion and the variability of criterion among sites provide some evidence that moderately-sized databases are uniquely sensitive to the arid west recalculation procedure.

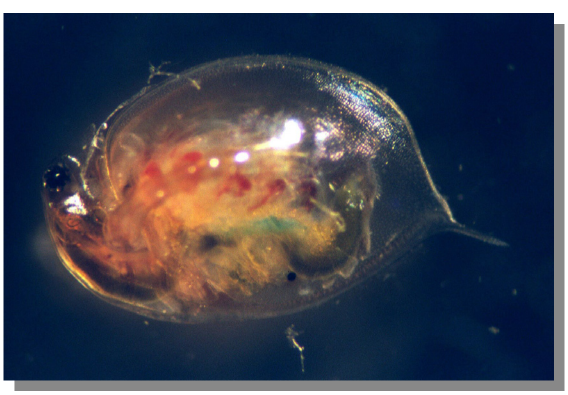
Zinc

Zn In general, the arid west recalculation procedure applied to the updated national zinc database successfully generated site-specific criteria that reflected the relative sensitivity of organisms at the site, rather than criteria that are driven by database size. The species composition of the site-specific databases and ranking were variable among sites, which greatly influenced the numeric outcome of the recalculated criteria. Initiating the deletion process with the robust updated database made it more likely that the site-specific databases would reflect the unique species composition for each arid west site.

Factors Affecting Recalculation Procedure

Based on the analyses conducted as part of this study, the recalculation procedure can be a useful tool, particularly when modified and applied to arid west streams. The results of recalculated site-specific criteria resulted in significant changes for some, but not all AWQC reviewed in this analysis.

Significant changes in site-specific criteria as a result of the recalculation procedure included copper, diazinon, and zinc. Implementation of the recalculation procedure for these toxicants produced universally less restrictive criteria than updated national criteria, while ensuring the same levels of protection for resident fauna for all study streams. It was clear that starting the deletion process for criteria with a more robust toxicity database increased the chance that the taxa retained for each site would vary, which then influences the final criteria concentrations. Since ammonia criteria were already partitioned into cold and warm water equations, and many of the most sensitive species in the updated warm water database are resident to the arid west, the resulting site-specific criteria would be expected to be similar. This expectation was confirmed. The issues with recalculation of the aluminum criteria (as described above) surfaced due to the relatively limited number of species in the updated national toxicity database. Until more aluminum toxicity data are available for more aquatic organisms common to the arid west, it may be more appropriate to adopt the updated national criterion developed as part of this study.



***Daphnia magna*, a commonly used test organism for conducting toxicity tests.**

Although results from the recalculation procedure could be used to derive scientifically defensible site-specific criteria, the tasks involved require considerable effort. However, the updated toxicity databases developed for this study can be used as a starting point for future updates to these five criteria. Furthermore, relevant invertebrate and fish population data are required for the development of resident species lists. Invertebrate and fish population monitoring plans should be initiated and maintained in the reach of interest. Lastly, there needs to be continued support for more toxicity testing for all AWQC, especially with species resident to arid west streams.

Project Findings—Recalculation Procedure User's Guide

Overview

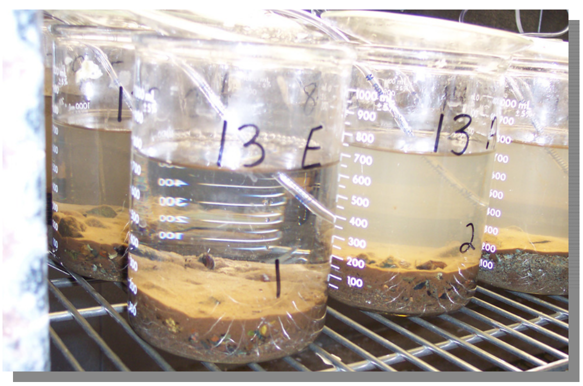
The User's Guide was developed to provide a handbook for water quality standards practitioners for using various EPA methods for developing site-specific criteria, especially the EPA's Recalculation Procedure. The complete User's Guide is available on the attached CD; following is a summary of the content of the guide.

The Recalculation Procedure may be particularly important for use in arid west waters because aquatic assemblages are often unique and contain substantially fewer species compared to perennial waters in other regions (PCWMD 2002). In such cases, concerns have been raised that the surrogate laboratory species used to develop the national AWQC do not adequately represent those encountered in arid west waters. Furthermore, it is possible that standard methods for conducting a Recalculation Procedure are less statistically robust when the total numbers and types of aquatic species are low, as is often the case in these waters.

The purpose of the User's Guide is to provide assistance for how to apply EPA's Recalculation Procedure given the unique biological conditions often present in arid west waters. This Guide was not developed to just be a "how-to" manual for use of the Recalculation Procedure, but rather to provide a description of how to apply the procedure given what was learned from the companion report (see above) and other

AWWQRP funded studies (PCWMD 2003, PCWMD 2006a,b).

The User's Guide begins by placing the Recalculation Procedure in the context of the full suite of possibilities for deriving site-specific water quality criteria in arid west waters. The primary goal of this element was to help permit holders decide whether the Recalculation Procedure is appropriate for their specific needs and, if it is deemed appropriate, how to proceed with an analysis that would achieve both scientific and regulatory acceptance. A secondary goal was to summarize alternative scientific methods for conducting the Recalculation Procedure as recommended in the companion report to this User's Guide (see above), and assist readers as to the appropriate selection of these vs. other accepted EPA methods for derivation of site-specific AWQC.



Cultures for laboratory toxicity tests.

While the User's Guide is focused on the Recalculation Procedure, it is important to put its content in the context of other site-specific AWQC procedures because no one procedure may be best suited for all sites. That is, depending on biological or chemical conditions at any given site, the Recalculation Procedure may not always be the best or only choice for maximizing the accuracy of aquatic life protection afforded by water quality criteria. Prior to conducting any site-specific AWQC study, therefore, all possible options for criteria development should be evaluated to increase the likelihood that the approach selected will be both scientifically defensible and acceptable to regulators. To assist with this evaluation, the User's Guide provides a comparison of changes in AWQC that could result from the application of procedures other than the Recalculation Procedure (e.g., WER, simplified recalculation, etc.). Case studies from other AWWQRP projects (PCWMD 2002, 2003, 2006a,b) provide the basis of this comparison.

Proposed Modifications of Recalculation Procedure for Arid West Waters

The User's Guide also describes proposed modifications to the standard EPA Recalculation Procedure that would derive site-specific AWQC that should more accurately represent and protect the unique biological conditions typically encountered in arid west effluent-dependent waters. These recommended modifications, which were based on results from case studies conducted using actual species assemblages in six arid west waters and AWQC for aluminum, ammonia, copper, diazinon, and zinc, include:

- Revise the Non-Resident Species Deletion Process—Two primary changes to EPA's deletion process were proposed. First, it was recommended that the phrase *occur at the site* be redefined by delineating the organisms that occur at the site as resident and transient species. When using the Recalculation Procedure in arid west effluent-dependent waters, *transient* taxa would not be considered to occur at the site, and would be deleted from the toxicity database. Second, it was recommended that several changes be made to the detailed stepwise process used by EPA with the goal of generating a site-specific toxicity dataset more representative of the species that occur at the site than what would normally be derived using the standard process.
- Revise the "Eight-Family Rule"—EPA guidance specifies that, at least for acute criteria development, a minimum dataset must be available for at least eight different families of aquatic organisms, which is more commonly called the "Eight-Family Rule." These families must represent various types of taxa, e.g., fish, crustaceans, or insects. In many arid west waters, the lack of resident fish in the *Salmonidae* family or planktonic crustaceans, e.g., cladoceran zooplankton, can make it difficult to satisfy this rule. A possible solution is to create a revised "eight-family rule" that utilizes the EPA methodology but incorporates more typical arid west stream aquatic communities (Table 3-7).

Table 3-7 Taxonomic Requirements for Derivation of Freshwater Final Acute Value and Recommended Arid West Revisions (adapted from PCWMD 2006c)

Existing "Eight-Family Rule"	Recommended Arid West Revision
♦ Salmonidae family in Phylum Chordata, Class Osteichthyes	♦ Fish in the Centrarchidae family in Phylum Chordata, Class Osteichthyes
♦ Second family in Phylum Chordata, Class Osteichthyes	♦ Fish in the Cyprinidae family, Phylum Chordata, Class Osteichthyes
♦ Third family in Phylum Chordata	♦ Third family in the Phylum Chordata (fish or amphibian)
♦ Planktonic crustacean family	♦ Benthic crustacean family
♦ Benthic crustacean family	♦ Aquatic insect family
♦ Aquatic insect family	♦ Second aquatic insect family in a different order
♦ Family in phylum other than Chordata	♦ Family in phylum other than Chordata or Arthropoda
♦ Family in any order of insect, or any phylum not already represented	♦ Family in any order of insect or any phylum not already represented

- **Use SMAVs Rather than Genus Mean Acute Values (GMAVs) for FAV Calculation**—Because arid west waters often have small and species-poor aquatic communities, it was recommended for a number of reasons that criteria be calculated from SMAVs rather than GMAVs for a number of reasons. First, the deletion process itself is conducted on a species level rather than a genus level, making it more acceptable to utilize the SMAVs for the FAV calculation. Second, while within-genus toxicity values are relatively consistent (at least more so than higher taxonomic levels), the toxicity of a contaminant to different species within the same genus is not always equivalent. Calculating criteria from the number of species in the database rather than the number of genera can increase the database sample size and help resolve potential sample size effects without affecting the protectiveness of the resulting criteria through inclusion of SMAVs for sensitive species (PCWMD 2006c).

It is important to note that the proposed modifications to the Recalculation Procedure, as described above, have not been formally approved by EPA although they have received some review. Accordingly, the recommendations contained in the User's Guide should only be considered technical proposals based on the findings of the companion Recalculation Procedure study (PCWMD 2006c). If there is interest in applying the proposed modifications to the Recalculation Procedure to calculate site-specific criteria in an arid west water, it is strongly recommended that the user consult closely with both the state and EPA.

3.2.6 Ammonia Water Effect Ratio Study

EPA established the WER methodology to provide a mechanism to modify a national aquatic life criterion that takes into account the relative differences between the toxicity of a chemical in laboratory dilution water and the toxicity of the chemical in the water at a particular site. Based on findings from the scientific literature, the ECE report identified the potential existence of a WER for ammonia based on water hardness. The AWWQRP commissioned a study to evaluate this potential.

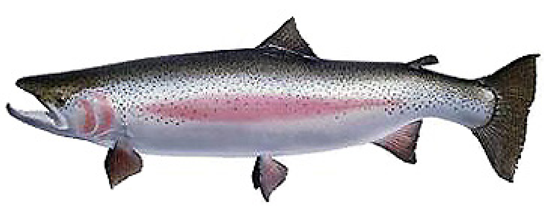
Ammonia Water Effect Ratio Study Objectives

- Conduct literature review to update data contained in the 1999 Ammonia AWQC guidance document.
- Perform a series of acute toxicity tests with independently varied hardness and pH to evaluate the significance of hardness-ammonia toxicity relationships for both freshwater fish and invertebrates.
- Conduct confirmatory WER studies in effluent dependent waters of varying hardness to determine whether WERs >1 can be derived in very hard waters.

Project Approach

The emphasis of this study was to conduct a simple empirical study as a "proof of concept" to determine whether hardness exerts a significant enough effect on acute ammonia toxicity to be used as a basis for deriving site-specific ammonia standards in hard, effluent-based ecosystems. The study included the following key elements:

- A literature review was conducted to identify any relevant studies carried out since the publication of EPA's 1999 ammonia AWQC guidance document that support or refute the possibility of the existence of a hardness-toxicity relationship (EPA 1999).
- A series of acute toxicity tests that independently vary hardness and pH was carried out to further evaluate the significance of hardness-ammonia toxicity relationships for both freshwater fish and invertebrates. Test species included: fathead minnow (*Pimephales promelas*) as a surrogate of warmwater fishes; rainbow trout (*Oncorhynchus mykiss*) as a surrogate of coldwater fishes; and two invertebrates, an amphipod (*Hyallela azteca*) and the cladoceran, *Ceriodaphnia dubia*. For each species, six toxicity tests were conducted at three nominal hardness levels (100, 300, and 600 mg/L as $CaCO_3$) and two nominal pH levels (7, 8). Tests were conducted in synthetic freshwaters in which alkalinity was held constant to control for the potential confounding effects of sodium.



Rainbow Trout

- Acute ammonia toxicity tests using paired site-water and reconstituted laboratory water as dilution water were also conducted. Four arid west waters (Las Vegas Wash, Nevada; Salt River, Arizona; Santa Ana River, California; and the South Platte River, Colorado) were chosen due to the wide range of water hardness present at these sites. Acute toxicity tests were conducted with *C. dubia, P. promelas*, and *Chironomus tentans*. Differences in ammonia toxicity between sites and laboratory water were evaluated by calculating WERs for each of the acute tests.

Project Findings

Literature Review

The literature review revealed few studies that have specifically examined the role of hardness on ammonia toxicity to aquatic organisms; most of these studies were conducted with invertebrates. In general, these studies indicated that changes in the ion composition of freshwaters can indeed decrease ammonia toxicity for some (but not all) species, but this is not likely to be a consistent function of hardness per se. Varying responses to elevated hardness may instead be more of a function of changes in sodium ion concentrations rather than calcium or magnesium ions.

Acute Toxicity Tests

For both fish species examined, ammonia toxicity was relatively constant with increasing pH when expressed on an un-ionized basis, while ammonia toxicity significantly increased with pH when expressed on the basis of total ammonia-N. These results were consistent with those from previous studies that suggest the effect of pH on ammonia toxicity in fish is best explained by the pH-dependent speciation of un-ionized ammonia. In contrast, for both invertebrate species tested, ammonia toxicity, expressed on an un-ionized basis, decreased with increasing pH. As suggested by previous researchers, these results indicate that the toxicity of ammonia to invertebrates may be best explained by a joint toxicity model wherein both the ionized and un-ionized fractions play an important role in ammonia toxicity. This is important because EPA uses a form of this joint toxicity model in the derivation of the acute ammonia AWQC.

No significant relationships were observed between hardness and the toxicity of ammonia to either of the fish species examined. These findings contradict the conclusions of several physiological studies that suggested an ammonia/hardness relationship might exist owing to an increase in ammonia excretion with increasing hardness. However, these physiological studies were conducted at ambient ammonia concentrations much lower than those tested in the acute toxicity tests, and in natural waters where the ionic composition was likely very different from that of the acute toxicity test waters, wherein calcium and magnesium were the only ionic constituents manipulated. Furthermore, even though a physiological relationship between hardness and ammonia excretion may exist under ambient conditions in natural waters, this condition may not necessarily elicit a toxicological response.

Culture room for laboratory toxicity testing.

For the invertebrate species tested, the only significant hardness/ammonia toxicity relationships observed were at pH 8, where ammonia toxicity increased with increasing hardness for *H. azteca* and decreased with increasing hardness for *C. dubia* when expressed on the basis of total ammonia-N. These results were not in agreement with previous studies that found the toxicity of total ammonia to *H. azteca* decreased with increasing hardness and the toxicity of total ammonia to *C. dubia* increased with hardness. However, the previous *H. azteca* studies were confounded by the fact that alkalinity (and likely, sodium) co-varied with hardness, while alkalinity was held constant in the acute toxicity tests conducted in the present study.

To determine whether or not this discrepancy in experimental design could explain the inconsistency in study results, a series of additional acute *H. azteca* studies were conducted wherein sodium was independently manipulated in conjunction with hardness and alkalinity. The results of these studies confirmed that allowing alkalinity to fluctuate with hardness likely had a significant effect on the results previously observed, and that elevated sodium levels offer considerable protection to *H. azteca* against ammonia toxicity, especially when coupled with elevated hardness. Differences in test water ionic composition related to hardness (e.g., sodium) may also help explain why this study's results with *C. dubia* did not agree with previous studies.

WER Studies

WERs, expressed as total ammonia, were fairly consistent among species. In particular, fathead minnow WERs generally ranged from 0.5 to 2 among all sites, WERs were consistently highest for *C. tentans* among all sites (0.5 to 3), and WERs for *C. dubia* were less than or equal to 1 for all sites. WERs, expressed as total ammonia, were also fairly consistent among sites. The highest WERs were generally found in the South Platte River, the lowest WERs were generally found in the Santa Ana River, and the Salt River and Las Vegas Wash WERs were intermediate. This was somewhat unexpected given that the South Platte River had the lowest hardness (198 to 214 mg/L $CaCO_3$), that the Santa Ana River had the second lowest hardness (258 mg/L $CaCO_3$), and that the Salt River and Las Vegas Wash had the two highest hardness values measured at any of the sites (374 and 480 mg/L $CaCO_3$, respectively). However, as previously discussed, other water quality parameters (i.e., alkalinity and sodium) may affect the toxicity of ammonia in natural waters; thus, the lack of a clear relationship between hardness and the WERs measured at these sites may be due to the fact that other factor(s) was contributing more heavily to the toxicity of ammonia to the species tested.

This study supported the findings of the limited available toxicity literature, which suggests that hardness (and/or related cations) may influence acute ammonia toxicity. However, these effects have been shown to be species-specific, (i.e., no one ion composition will exert the same influence) and only valid for invertebrates, not fish. To further elucidate the mechanisms governing these effects, however, major ion composition other than hardness (sodium is of particular interest) needs additional independent experimental manipulation. This study has also demonstrated that WERs greater than one can be observed in arid west waters for both fish and invertebrates. The WERs found to be greater than one may have been the result of a difference in ionic composition between the site and laboratory waters, but it is clear that the protective effect associated with these significant WERs was not due to hardness cations alone. Although the development of WERs may be a viable approach for deriving acute site-specific standards for ammonia in arid west waters, until these potential ion effects and/or mechanisms are better understood, it is difficult to predict whether a positive WER could be achieved for a given site without first conducting empirical tests.

3.2.7 Aquatic Communities of Ephemeral Streams

Most states apply the same national ambient, acute, and chronic aquatic life water quality criteria to perennial and ephemeral waters (as defined above) without taking into account differences in aquatic communities or potential differences in the default exposure assumptions associated with these criteria. For example, national water quality criteria are derived using both fish and invertebrate toxicity data. However, ephemeral stream fish communities are highly limited and, in most cases, nonexistent. To aid states with the development of appropriate criteria, it is necessary to have an acceptable aquatic species list. Accordingly, an important focus of this project was the preparation of an aquatic species list for ephemeral stream communities.

Aquatic Communities of Ephemeral Streams Study Objectives

- Collect aquatic community samples from ephemeral streams following precipitation events to develop a list of aquatic species for this waterbody type.
- Monitor over a period of days the aquatic habitats created by precipitation events to evaluate the persistence of the ephemeral habitats and identify changes in the aquatic community over time.
- Evaluate findings in the context of the application of chronic water quality criteria to short-term treated wastewater discharges that create temporary aquatic habitats.

A second area of focus for this project was an evaluation of the applicability of chronic aquatic life criteria to ephemeral streams or the applicability of chronic toxicity tests to temporary discharges to ephemeral streams. The duration of chronic toxicity tests for deriving federally recommended chronic aquatic life criteria ranges from about 7 days to more than 28 days. However, at the outset of this study it was believed that the *in situ* exposure duration in an ephemeral stream is likely to be much shorter, often on the order of only a few days. Under this project, field studies were conducted to evaluate exposure duration (e.g., time that water is present) in the context of the basis for the derivation of chronic aquatic life criteria.

Ephemeral Mescal Arroyo upstream of Cienega Creek.

Project Approach

In addition to the preparation of a literature review on the state of knowledge of ephemeral stream communities, the project focused on the collection of field data from selected ephemeral stream sites in the arid west.

Sample Locations and Methodology

In this project, the researchers were concerned with the fauna in ephemeral streams (or ephemeral reaches of intermittent streams) that colonize in response to flows from monsoonal thunderstorms. Fifteen study sites were identified, visited, and sampled over the course of up to 10 days. These sites were located within three broad geographic regions based on factors such as rainfall, temperature, stream flow, and dependent ecology:

- High Plains, e.g., central Colorado slopes east of the Front Range
- Cool desert Great Basin, e.g., Colorado Plateau (e.g., near Grand Junction, Colorado); the Rio Grande Rift (e.g., near Albuquerque, New Mexico); or high desert of Nevada/Utah/Oregon
- Hot desert setting, e.g., Chihuahuan, Sonoran, and Mojave Deserts of Arizona and California

Seasonal weather patterns were analyzed to anticipate the formation of monsoonal thunderstorms. When it was deemed that potential runoff-producing conditions had occurred and that flows were expected to continue for several days, a team of biologists traveled to each study area to initiate sampling of the potential aquatic biota.

Ephemeral pool following stormwater runoff event in Arizona.

Water column samples were collected to account for the potential for transient microinvertebrates (i.e., zooplankton). Benthic samples were collected to account for the presence of macroinvertebrates (e.g., aquatic insects, amphipods, and isopods). Vertebrate samples were collected to account for the presence of fishes and amphibians. In addition to identifying the aquatic biota observed at each study site, the research team also attempted to evaluate the "succession" of these fauna within the streams as related to the duration of the flow events. Sites were generally visited and sampled daily after peak flows began to subside until no surface water remained.

Benthic macroinvertebrate samples were collected using methods consistent with EPA Rapid Bioassessment Protocols. Microinvertebrate samples were gathered by filtering a known volume of stream water through a 68 μm mesh zooplankton. Vertebrate sampling was conducted by targeting appropriate habitats (e.g., pools, snags, or other instream cover).

In the arid west, flow events in ephemeral streams are generally characterized by a sharp increase, followed by a gradual decrease in flow, making aquatic biological collections difficult. Enough time needed to pass to allow the recently wetted stream channel the potential to be colonized, yet sampling was not delayed too long, since flow could cease and the channel become quickly dry. Sampling was not conducted on the rising limb of the hydrograph, when the system is "flushing" and restricting movement of potential colonizers (therefore posing safety hazards to field personnel). Rather, sampling began on the declining limb when flows lessen to levels at which biota movement is not restricted. In addition, significant habitat is created well after the peak has passed in most desert streams, as ephemeral ponds and other short-lived aquatic environments persist.

Data Analysis

The applicability of national AWQC was evaluated in a two-step process. First, results from the biological sampling were compared to representative national toxicity databases to determine whether ephemeral stream communities are represented in the existing criteria. Second, EPA chronic toxicity requirements for inclusion in the national toxicity database were evaluated. Many requirements, such as the inclusion of a certain life stage over another and strict interpretations of necessary test durations, may not be appropriate for ephemeral streams given the limited exposure potential. Additional and more relevant sub-chronic toxicity data may be available from short-term chronic tests (e.g., 7-day chronic tests), data presently not used in criteria derivation.

In addition to the toxicity database evaluation, the temporal ecological and flow data from each sampled storm event were used to evaluate the application of chronic criteria and community assessment to temporary discharges of treated wastewater.

Project Findings

Much of the limited previous research on ephemeral streams has been conducted on perennial reaches of interrupted streams and vernal pools. However, because the former has a water table above the channel for at least some portions (and, therefore, perennial water available) and because the latter has no connection to flowing water, these systems are not appropriate surrogates for ephemeral streams.

Key findings from this study included:

- A total of 21 distinct taxa of microinvertebrates were collected; however, it was concluded that most of the taxa and most of the individuals within this group were from terrestrial sources or were the immature stages of aquatic macroinvertebrates. The few truly aquatic microinvertebrates (i.e., zooplankton) included microcrustaceans, rotifers, and gastrotrichs. Most microinvertebrates were collected in very small densities, except for the cyclopoid copepods, which were abundant at only one site.
- A total of 86 distinct taxa of aquatic macroinvertebrates were collected, including *Insecta, Hydracarina, Crustacea, Oligochaeta, Hirudinea*, and *Gastropoda*. Most of the taxa had aerially dispersing life stages and were present either in that form or as immature larvae recently hatched from eggs deposited by the aerial life stage. The remaining taxa likely came from upstream perennial water sources, terrestrial sources, and or cryptobiotic life stages. Succession patterns of the aquatic macroinvertebrates, at sites with and without known or likely upstream sources of potential colonizers, were typical of succession patterns on ephemeral habitats. Although many taxa were collected repeatedly throughout succession, some taxa were collected only once or a few times, suggesting that they were using the ephemeral habitat resource only as a "stop-over" between other aquatic habitats. Generally, taxa richness was highest in the first few days after flows began to recede, and decreased as available habitat diminished.
- Four species of fish were collected, although, of these four species, two were nonnative species collected only as desiccated specimens from the middle of a dry streambed. The native species were collected in small numbers at only a few sites, apparently arriving within 1 day (longfin dace) to 3 to 5 days (fathead minnows) after high

Ephemeral Pantano Wash near Tucson, Arizona before and after a storm event.

flows begin to recede. It is unknown how long the fathead minnows would have persisted, as flows still had not fully disappeared when sampling ceased at the site where the fathead minnows were observed.

- Six species of amphibians were collected, including one *Salientia* and five species of *Anura*. Both adult and tadpole life stages of the anurans were collected, with many individuals in the process of metamorphosis from tadpole to adult. Amphibians were collected throughout succession and apparently can remain in the streams until they reach adulthood, if surface water persists.
- Very little similarity was observed between the communities collected in the three study areas. Data analysis indicated that the sites appeared to group within and between study areas. Overall similarity between watersheds was about 5 percent. Based on the aquatic macroinvertebrate data, the closest similarity between any two individual sites was only 25 percent. Such a low similarity value is likely the result of biogeographic patterns and differences in latitude, substrate, riparian vegetation, and the apparently random pattern of colonization.
- Areal extent of aquatic habitat tended to decrease with time after high flows began to recede. Similarly, the number of taxa tended to decrease as available aquatic habitat diminished, a natural result of less habitat being available.
- Representative resident taxa lists from the arid west region, as compiled from previous AWWQRP projects, were supplemented by an additional 50 taxa collected in this study, and only 35 taxa overlapped between the two lists. It is expected that the lack of resident fish (particularly centrarchids) and elimination of key water quality indicator organisms such as cladocerans and isopods from the resident species lists will have a considerable effect on the development of water quality criteria as applied to ephemeral streams.
- When evaluating water quality standards for effluent-dependent/dominated streams, a different level of protection may be warranted, if the expected condition is set to resident communities of ephemeral streams more representative of upstream conditions. Differences in aquatic communities sampled from the ephemeral stream sites in this study as well as resident species lists derived for effluent-dependent/dominated streams would result in standards for some toxicants that are substantially different from national, state, and site-specific standards for sites with perennial flow, while still being protective of those communities.

Recommendations for further study in ephemeral stream ecosystems include the following types of research projects:

- Further studies on ephemeral stream ecosystems, either expanding the geographic area or investigating each of the study areas more intensively. This could involve more streams and more stream sites, more storm events, and snowmelt runoff, where applicable, with the result of better characterization of these ecosystems.
- Better characterization of watershed hydrology through sites located at or near gages on gaged streams. This can result in attempts to relate watershed morphology, size, and geology to biological diversity, succession patterns, and duration of aquatic habitat.
- Life-history studies on various aquatic macroinvertebrate taxa collected to determine longevity of the aquatic stages (i.e., can they actually complete the life stages from egg to adult—or maybe a semi-terrestrial pupa—in the time frame that the water is present?). Results could help address applicability of chronic criteria to sites with flows lasting <7 days and "resident" status of these organisms.
- Studies to determine fate of organisms suspected of having cryptobiotic life stages (i.e., did they really enter a cryptobiotic life stage or did they just die?). Results could help address the "resident" status of these organisms.
- Studies to determine the fate of native fishes (i.e., did the longfin dace and fathead minnows actually make it downstream to another perennial stream reach or did they just die?). Results could help address

applicability of chronic criteria to sites with flows lasting <7 days and "resident" status of these organisms.

- Development of WET test protocols for taxa typical of ephemeral stream ecosystems (e.g., aquatic insects, copepods, toads).
- Subsequent WET tests on some of the more important taxa (i.e., taxa collected at four or more sites), such as *Callibaetis sp., Sigara sp., Lipogomphus sp., Berosus sp., Postelichus sp., Ochthebius sp., Chironomus sp., Tabanus sp., Erpobdella punctata punctata*, red-spotted toads, and Couch's spadefoot toad.

3.2.8 Additional AWWQRP Studies

The AWWQRP funded two small studies that supplemented the findings of two previously completed research projects. The first study explored the scientific potential for the combined use of EPA's Recalculation Procedure and the BLM-based acute copper criteria methodology to derive site-specific copper criteria (see EPA 2007). The second study conducted additional ammonia toxicity studies to further elucidate the role of sodium in controlling acute ammonia toxicity in very hard or ion-rich waters. The findings from both of these studies are presented in a single report: *AWWQRP Special Studies Report: Use of the EPA Recalculation Procedure with the Copper Biotic Ligand Model, and the Relative Role of Sodium and Alkalinity vs. Hardness in Controlling Acute Ammonia Toxicity* (see attached CD).

3.3 Arid West Related Research Activities

Research particularly relevant to effluent-based ecosystems is periodically conducted by organizations with an interest in arid west waters. In addition, studies are occasionally conducted by state and federal agencies on specific watersheds or waterbodies. This section highlights some of these activities; however, no attempt was made to create an exhaustive summary.

3.3.1 Water Environment Research Foundation

WERF promotes research and development in water quality science and technology. With funding provided by subscribers (e.g., utilities, municipalities, industry, government agencies) and the federal government, WERF implements research activities on a wide-range of areas related to water quality. While many of the organization's studies have at least some application to arid west water resource issues, a few of these studies have particular relevance. Following is a brief summary of these studies; if more information is needed, the reader should contact WERF (www.werf.org).

Joint WERF/AWWQRP Research Project

Evaluation of Whole Effluent Toxicity Testing as an Indicator of Aquatic Health in Effluent-Dominated Streams: A Pilot Study (Project 03-ECO-2)

This project, which was a pilot study for a future nationwide study, was directed by WERF, but was a collaborative research effort between the AWWQRP and WERF. Both organizations have a common interest in developing a better understanding of the usefulness of chronic WET test results to evaluate the health of aquatic communities—in perennial and effluent-based aquatic habitats. WERF managed and directed the research project; the AWWQRP, as a collaborative partner, contributed research funds and technical oversight through participation on the Project Subcommittee (established by WERF to provide technical peer review of research activities).

Toxicity testing laboratory.

This project evaluated the quality of data needed to determine relationships between chronic WET test results in treated effluent and the condition of the biological community in the receiving water. Six facilities (four eastern and two western United States) participated in this study. All had receiving waters that were effluent-dominated with design effluent concentrations comprising greater than 60 percent of the stream flow. Final project results were published in 2007; the reader is referred to WERF to obtain final project results and information on plans for follow-up studies.

WERF Research Projects

Distinguishing the Relative Influence of Habitat and Water Quality on Aquatic Biota (Project 98-WSM-1, 2001)

This project developed a multivariate statistical approach using principal components analysis, all regressions analysis, and Chi-Square Automatic Interaction Detection (CHAID) to evaluate data and identify the variables (e.g., habitat characteristics or water quality) that exert the greatest influence on biological response variables (e.g., fish or macroinvertebrate abundance). This tool uses data mining techniques to identify patterns in the data and allow the researcher to develop reasonable explanations for the relationships identified by the analysis. As was noted in the case study in Section 6, this data analysis tool can provide significant incite into the factor(s) limiting aquatic communities. More importantly, the case study in Section 6 provides an example of where this tool was successfully used to demonstrate that habitat was the primary limiting factor in several small intermittent streams, and this demonstration provided critical support for the establishment of site-specific DO criteria.

Physical Effects on Wet Weather Flows on Aquatic Habitats: Present Knowledge and Research Needs (Project 00-WSM-4, 2003)

This evaluation was conducted to lay the groundwork for future research on the development of guidance that municipalities may use to design new stormwater control systems or improve existing systems to not only provide appropriate flood control, but maximize protection of aquatic communities that receive wet weather flows from urban areas. Although this project does not focus on effluent-based ecosystems specifically, because many effluent-based waters are in urban areas, understanding how wet weather flows may impact aquatic communities separately from the impacts from the effluent discharge itself is critical to gaining an understanding regarding what kind of aquatic community is attainable given a certain degree of urbanization.

Protocols for Studying Wet Weather Impacts and Urbanization Patterns (Project 03-WSM-3)

This study, which is still ongoing, builds upon the recommendations of Project 00-WSM-3 (see above) and is focused on the development of tools and measures to help standardize data generation for identifying linkages between urban land use, stormwater runoff characteristics, geomorphic parameters, and effects on aquatic ecosystems. The developed protocol is being piloted using eight small watersheds in North Carolina. Similar to Project 00-WSM-3, this project will provide critical insight on how to improve aquatic communities in urban areas through establishment of effective wet weather controls, e.g., selection of appropriate BMPs.

Using WERF's Aquatic Ecological Risk Assessment Tool to Improve the Effectiveness of Water Quality Management (Project 97-HHE-2)

WERF conducted this project to demonstrate the application of a particular aquatic ecological risk assessment method developed previously (Aquatic Ecological Risk Assessment: A Multi-Tiered Approach, Project 91-AER-1, 1996) to practical water quality issues. The project results demonstrated that the tool developed in 1991 may be used to help derive and evaluate risk-based water quality standards and NPDES effluent limits.

Technical Approaches for Setting Site-Specific Nutrient Criteria Project (Project 99-WSM-3)

WERF commissioned this research to develop a methodology for establishing site-specific nutrient criteria for surface waters. "The methodology was developed to extend EPA's regional nutrient criteria for localized conditions characterized by particular desired water quality requirements of designated uses. The proposed…methodology provides local stakeholders with a recipe for estimating nutrient criteria consistent with site-specific water quality management goals and objectives." The methodology may be of use to those who have a need to develop nutrient criteria in effluent-based ecosystems."

Workshop on Partitioning Multiple Stressors: Approaches, Information Gaps and Tools (Project 03-ECO-1)

WERF has previously conducted studies on the role of multiple stressors on aquatic communities and the ability to link cause, e.g., pollutants or habitat factors, with effects, e.g., aquatic community characteristics (Effects of Multiple Stressors on Aquatic Ecosystems, Project 96-IRM-2, 1996). WERF convened a workshop in 2005 to (1) assess progress made toward developing tools that could be used to determine if the participant's facilities were contributing to aquatic life impairment; (2) identify currently available tools for partitioning effects from multiple factors; and (3) summarize the applicability of these tools and to provide recommendations for research areas that would improve the use and acceptance of available tools. This issue is of particular importance to understanding what type of aquatic community to expect in effluent-created ecosystems.

Factors for Success in Developing Use Attainability Analyses (Project 04-WEM-1)

WERF is conducting research to enhance and supplement the UAA Handbook recently published jointly by NACWA and WERF (NACWA and WERF 2005). This new guidance will document actual experiences with UAA efforts by collecting and comprehensively evaluating case studies. The product will benefit stakeholders that are considering developing a UAA or stakeholders who are potentially impacted by a UAA. The information will be presented in the form of a User's Guide and provide critical factors for success in the UAA process.

3.3.2 Other Sources of Arid West Research Data and Guidance

State and federal agencies, as well as professional, industry, and non-governmental organizations, are potential sources for research studies and guidance that can support efforts to address specific arid west water quality standards issues. The list below provides a summary of examples of sources of such information as well as examples of studies or guidance that may be available. This list is by no means exhaustive and it is strongly recommended that the reader consult local organizations to identify other regional studies and guidance that may be available for their area. In addition, it is common for agencies and organizations to update documents; accordingly, any document referenced in the list below should be checked to determine its status, e.g., to determine if an updated document is available.

- An Exploration of Nutrient and Community Variables in Effluent Dependent Streams in Arizona (Walker et al. 2005)
- Guidance on Developing Nutrient Standards for Protecting Designated Uses of Water Bodies (Federal Water Quality Coalition 2005)
- Collaborative Water Quality Solutions: Exploring Use Attainability Analyses (NACWA and WERF 2005)
- Creating Successful Maximum Daily Loads (NACWA 2004)

Section 4
Available and Emerging Regulatory Tools

4.1 Introduction

States often establish water quality standards using a statewide approach. That is, designated uses and their associated criteria are applied universally or regionally without regard to the type of waterbody. This approach is the norm simply because of the resources required to develop waterbody-specific uses and criteria. However, periodically local issues arise where the possibility exists that the uses and/or criteria are not particularly applicable and it becomes necessary to resolve the conflict.

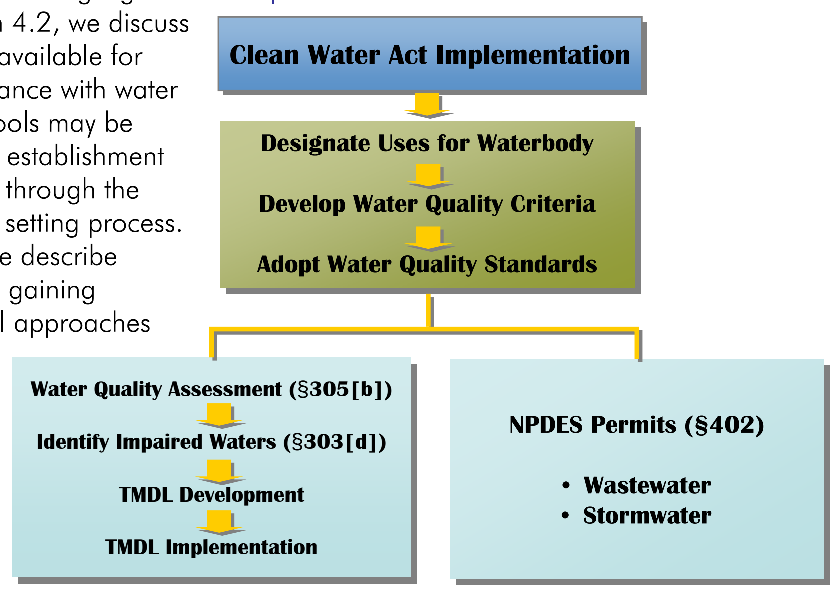
Questions regarding the applicability of uses or criteria most often arise when a permit is under development or during the development of a TMDL for a waterbody identified as impaired. Resolving these questions is often achieved by making use of the considerable flexibility that exists in the CWA and its implementing regulations. In the following sections we highlight this flexibility. In Section 4.2, we discuss tools that are currently available for addressing non-compliance with water quality criteria. These tools may be used either through the establishment of discharge permits or through the water quality standards setting process. Then, in Section 4.3, we describe emerging tools that are gaining acceptance as potential approaches for establishing or implementing water quality standards that are more appropriate for, but still protective of, arid west ecosystems.

4.2 Water Quality Standards Application

Water quality standards are used to implement CWA requirements in several key ways: (1) they provide the basis for assessing water quality to determine if the designated uses established for a given waterbody are being protected; (2) they provide the basis for developing wasteload and load allocations in TMDLs; and (3) they are used for deriving water quality-based effluent limits in NPDES permits.

4.2.1 Water Quality Assessments

Section 305(b) of the CWA requires states to assess the quality of waters under CWA jurisdiction at least once every 2 years. The information obtained from this periodic evaluation is used to assess whether waters are meeting water quality standards and, if not, if the degree of non-compliance is sufficient to make a finding that the waterbody is impaired.



As noted in Section 2.4.3, Section 303(d) of the CWA mandates the identification of waters that do not meet applicable water quality standards and existing required effluent limitations and other pollution control requirements are insufficient to achieve the water quality standards. Waterbodies that meet these criteria are considered impaired. Once a waterbody is identified as impaired it is placed on the 303(d) list and is scheduled for development of a TMDL.

4.2.2 Permits

Under the CWA, point sources are regulated through the issuance of federal NPDES permits. The CWA allows EPA to delegate the NPDES permit program to the states and accordingly most states have been authorized to issue these permits. However, even with this delegated authority, EPA retains an oversight role to ensure that state-issued permits are compliant with CWA requirements. The types of permits and methods of issuance vary from state to state; accordingly, the reader should consult directly with the state environmental agency regarding how the NPDES permit program is managed in their particular state.

Point sources include both wastewater and stormwater discharges. Wastewater point sources include a variety of facility types including sanitary treatment, industrial, and concentrated animal feeding operations facilities. Every NPDES permit issued to a wastewater treatment facility contains technology-based effluent limits, which are based on minimum technologically-based treatment requirements. Many wastewater NPDES permits also contain water quality-based effluent limits that are designed to protect the designated uses of the waterbody receiving the discharge.

Stormwater point sources are the storm drains that discharge collected stormwater from impervious areas such as paved streets, parking lots, and building rooftops during rainfall and snow events. Stormwater NPDES permits typically rely solely on the use of BMPs to control pollutants carried by stormwater runoff. The use of BMPs in this manner is equivalent to the application of technologically-based treatment requirements on wastewater treatment facilities. Water quality-based effluent limits are rarely applied to stormwater NPDES permits, but that may change in the future (e.g., see California State Water Resources Control Board [SWRCB] 2006).

The following sections briefly explore options or tools that exist for addressing use and criteria questions. Many of these tools are explained more fully in guidance documents, which will be recommended where appropriate for further reading. Some of the tools are facility-specific (or permit-specific), providing a means to address a site-specific issue. Other tools are waterbody or waterbody type-specific, which if applied, affect larger areas. As would be expected, the resource needs associated with using any of these tools is directly related to the size of the area to which they will apply, which is from a single point (or single facility) to a watershed, basin, or even the entire state.

4.2.3 Permit Compliance

Concerns regarding water quality criteria often become evident during the process of developing water quality-based effluent limitations for an NPDES permit. These concerns may be dealt with either through the use of permit-related methods or through the modification of the designated uses applicable to the receiving water (which often results in a change in the applicable water quality criteria). When addressing a concern that is associated with a single facility it is often recommended that a facility-specific (rather than

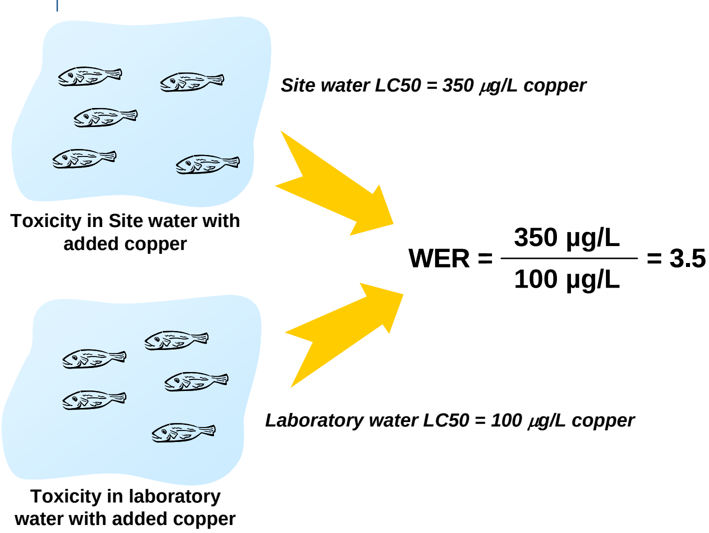
Best management practices—schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of "waters of the United States." BMPs also include treatment requirements, operating procedures, and practices to control plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage (40 CFR 122.2).

Point source—any discernible, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, vessel, or other floating craft from which pollutants are or may be discharged. This term does not include return flows from irrigated agriculture or agricultural stormwater runoff (40 CFR 122.2).

a receiving water) solution be developed. This approach is preferred simply because the solution only affects the individual permit. If the solution affects the water quality standards applicable to the receiving water, then multiple permits may be affected and the degree of complexity in implementing the solution increases substantially. Examples of tools to achieve compliance through the permit itself include:

Water Effect Ratio

This procedure is intended to take into account how water quality characteristics affect the toxicity of a pollutant in laboratory dilution water relative to that in a receiving water (Figure 4-1). The procedure is most often applied to metals. Unless otherwise specified, the WER is assumed to be equal to one. However, typically a WER study will show that the WER is greater than one, meaning that water quality characteristics of the receiving water mitigate the toxicity that was observed in laboratory dilution water. Additional information regarding WERs is provided at EPA's website, http://www.epa.gov/seahome/wer.html and various guidance documents, including EPA (1994b), EPA (2001), and PCWMD (2003, 2006a,b,c). In some states, e.g., California, a WER may be used directly in the development of effluent limitations for a NPDES permit. Where this is not allowed by a state's regulations, then a WER is developed as a site-specific water quality standard (see below).



Source: PCWMD 2006d

Figure 4-1
Calculation of a WER by comparing toxicity in site water versus laboratory water.

Translators

Translators are used to convert water quality criteria expressed in one form to permit limits in another form. The use of translators is rapidly gaining acceptance as an effective and efficient way to adjust permit requirements to reflect relevant local conditions.

Water Quality Criteria

Water quality criteria for heavy metals are often expressed in the dissolved form because it most accurately represents the toxic bioavailable fraction. However, regulations require that permit limits for heavy metals be expressed in the total recoverable form. Translating dissolved criteria into total recoverable limits provides an opportunity to make site-specific adjustments. In most instances, such adjustments will make the permit limit less restrictive. In a few cases (acid mine drainage) the permit limit may need to be more restrictive.

Once foreign and controversial, metals translators are now very common and well understood. Translators are now viewed as providing "functionally-equivalent" water quality protection rather than undermining strict standards. Consequently, the concept of using translators for other pollutants is also gaining greater acceptance.

For example, ammonia criteria are now routinely translated into permit limits for un-ionized ammonia (the toxic fraction of ammonia) based on the ambient temperature and pH of the receiving water. And, EPA recently released new software ("Biotic Ligand Model") that translates metals criteria into permit limits that account for organic binding that renders the pollutant significantly less toxic (See Section 3.2.4 for additional discussion on the BLM).

Frequency, Duration, and Magnitude

Of growing importance is the use of "Frequency, Duration, and Magnitude" translators. All water quality criteria are published with a default set of exposure assumptions. For most toxic substances, EPA recommends two different magnitudes (concentrations) depending on the length of exposure: one for acute (short-term exposure) and one for chronic (long-term) exposure. In both instances, EPA recommends that the maximum allowed concentration not be exceeded more often than once every 3 years. This is the "frequency" component of the standard.

The selection of exposure regime (chronic or acute) and return interval (frequency) drives the permit limit calculation. Several factors common to the arid west may be used to translate the default water quality criteria into less restrictive permit limits. For example, an intermittent stream may go completely dry at some time each year. The absence of flow acts to "reset" the biological system on an annual basis. Therefore, it is inappropriate to apply a once-in-3-year return interval for other stressors. The 1:3 frequency assumes the existence of perennial flow. Likewise, chronic criteria may not be applicable to ephemeral streams because the flow does not persist long enough to establish a long-term exposure condition (see Section 6 for case study example of the adoption of acute only criteria in ephemeral waters).

Recently, frequency, duration, and magnitude translators have been used to adjust pathogen criteria to reflect differing levels of recreational use and body contact. The level of exposure and risk of bacterial infection is considerably less in low-flow wading streams than it is at a designated swimming beach where full body immersion is possible. In this instance the concentration (magnitude) of pathogens may be adjusted up because the exposure variables (frequency, duration) are so much lower. The net result is a "functionally-equivalent" level of protection. However, the less stringent permit limits may save many millions, perhaps billions, of dollars in unnecessary infrastructure improvements.

Averaging Periods

Another common permit translator is the use of "averaging periods." As noted above, "duration of exposure" is a significant variable in calculating both water quality criteria and effluent limits. However, the time units used to express the water quality criteria may not be relevant to the actual discharge situation. This is particularly important where the pollutant-of-concern is known to be log-normally distributed. In such cases, the effluent quality may comply "on average." But, individual measurements may be quite high. As long as the high values persist for only a very short time, it may be possible to demonstrate compliance by using longer averaging periods. Some chemicals, such as chlorine, are known to be fast-acting toxicants. Longer averaging periods would not be appropriate for these pollutants. Other chemicals, such as un-ionized ammonia, are slow-acting toxicants and longer averaging periods can be used to calculate permit limits without compromising environmental protection. The difference between an instantaneous maximum, daily average, 4-day average, weekly average, or monthly average can be enormous when calculating reasonable potential, permit limits, or assessing compliance with those limits.

Example of Narrative Criteria from State of Arizona (Arizona Administrative Code, Title 18, Chapter 11, Article 1, March 31, 2003)

A. A surface water shall be free from pollutants in amounts or combinations that:
    1. Settle to form bottom deposits that inhibit or prohibit the habitation, growth, or propagation of aquatic life
    2. Cause objectionable odor in the area in which the surface water is located
    3. Cause off-taste or odor in drinking water
    4. Cause off-flavor in aquatic organisms
    5. Are toxic to humans, animals, plants, or other organisms
    6. Cause the growth of algae or aquatic plants that inhibit or prohibit the habitation, growth, or propagation of other aquatic life or that impair recreational uses
    7. Cause or contribute to a violation of an aquifer water quality standard prescribed in R18-11-405 or R18-11-406
    8. Change the color of the surface water from natural background levels of color
B. A surface water shall be free from oil, grease, and other pollutants that float as debris, foam, or scum; or that cause a film or iridescent appearance on the surface of the water; or that cause a deposit on a shoreline, bank, or aquatic vegetation. The discharge of lubricating oil or gasoline associated with the normal operation of a recreational watercraft is not a violation of this narrative standard.

Narrative Criteria

There is at least one situation where translators must be used. That is when permit limits are written to implement a narrative water quality criterion. A narrative criterion is often expressed in "free-form" language rather than as specific numeric chemical thresholds. For example, nearly every state prohibits the discharge of any material in concentrations that may be harmful to humans, plants, animals, or aquatic organisms. Likewise, most states prohibit the discharge of any substance that may stimulate excess algae growth. These receiving water limitations are intentionally vague because the variety of pollutants is too large to manage by naming each chemical individually.

EPA requires states to identify the "implementation procedures" that will be used to assess compliance with narrative water quality criteria. Many states have since developed such procedures for parameters like WET. And, many others are working on implementation procedures for nutrients like phosphorous and nitrogen.

Therefore, it is essential for dischargers to actively participate in the process of developing narrative translators for the resulting procedures will, undoubtedly, appear as some sort of numeric permit limit. On the other hand, narrative translators also provide an excellent opportunity to develop "multi-metric" indicators of use attainment rather than relying on measurements of a single chemical to evaluate impairment. For example, a combination of factors (such as Secchi depth, turbidity, total suspended solids, chlorophyll-a concentrations, percent macrophyte coverage, percent dominance by invasive plant species, etc.) can be used along with phosphorous and nitrogen concentrations to determine whether the narrative nutrient criteria have been exceeded or not. This is a practical way to implement the "weight-of-evidence" approach and is similar to the Biocriteria Strategy developed by Ohio and North Carolina.

Narrative translators are particularly important for WET limits in the arid west. The natural ionic composition of water supplies in the west is significantly different from that used to culture the standard organisms used in WET testing (e.g., see Section 2.3.2 and PCWMD 2002). Consequently, the time required to assimilate to higher salinity, conductivity, hardness, or alkalinity concentrations may temporarily inhibit growth or reproduction and cause interference with proper conduct and interpretation of the test. EPA guidance allows adjustments to be made to account for such interference (EPA 1994a). However, it is necessary to include these adjustments in the NPDES permit as the narrative toxicity criteria are being translated into specific monitoring and reporting requirements. Failure to properly "translate" the narrative toxicity criteria will reduce the accuracy and reliability of WET test results as an indicator of actual instream conditions.

Variances

EPA guidance and regulations recognize that there are instances where water quality standards may not be attainable at present (EPA 1994a). However, there remains the possibility that the uses and associated water quality criteria may be achieved at some future date if circumstances change. In these situations, EPA recommends that the state issue a "variance" from water quality standards.

A variance is a temporary exemption from meeting water quality standards. Variances are most often granted where it is technically or economically infeasible to meet current water quality standards. Because economic conditions may improve or technical innovations may provide new treatment alternatives, a variance allows the state to defer the compliance issue to some later date rather than downgrading or deleting the use altogether.

Variances

Variances are typically approved when:

- The variance is included as part of the water quality standard
- The variance is subjected to the same public review as other changes in water quality standards
- The variance is granted based on a demonstration that meeting the standard is not feasible due to the presence of any of the same factors used to justify the removal or downgrade of a use (see 40 CFR 131.10(g) of the water quality standards regulation)
- The discharger either meets the standard by the expiration of the variation or makes a new demonstration of need and that reasonable progress is being made towards achieving the standard
- Existing uses will be fully protected

Federal regulations require that variances be temporary and subject to review every 3 years. However, a variance may be extended upon expiration.

The advantage of a variance is that it provides relief from unreasonable regulatory requirements without foreclosing the opportunity to reconsider at some point in the future. In fact, federal law requires that variances be reviewed every 3 years. At that time, the state may renew, revise, or rescind the variance.

The disadvantage to variances is that they assume a designated use is ultimately attainable. And, dischargers who operate under a variance must demonstrate that they are making reasonable progress toward achieving eventual compliance. The most common application of variances is in an area that is developing but lacks the rate-payer base or tax base to build necessary infrastructure in advance. Variances allow the community time to achieve a critical mass of financial wherewithal to support the treatment upgrades needed.

Several years ago, most EPA regions were strongly encouraging the application of variances in response to a large number of UAAs that were recommending that certain designated uses be downgraded or deleted. Many of these variances were renewed two or three times. However, variances were intended to provide temporary exemptions from water quality standards. Repeated renewals, without any real indication of progress in meeting water quality standards, violates the letter and spirit of the variance process. Therefore, variances are a poor substitute for proper use classification and subcategorization. But, they work well where compliance is expected to occur in the long-term.

Related to the variance concept is the use of temporary water quality standards modifications. These modifications require a rulemaking and EPA approval, but may be used for periods longer than envisioned for a variance. Section 6 provides a case study example from the State of Colorado where temporary modifications are allowable.

Actual Dilution

Most permit limits are written so as to ensure that the water quality criterion is attained even under critical low-flow conditions. Therefore, the maximum allowed dilution is routinely limited to that which occurs under such low-flow conditions regardless of how much upstream flow is actually present in the receiving water. In most states, available dilution is calculated based on the 7Q10 (lowest 7 days of flow in any given 10-year period) or some similar variation (e.g., 1Q30, the lowest single day in any given 30-day period).

Some states allow monthly or seasonal dilution factors to be calculated where there is a wide variation in background flows during the course of a year. Even effluent-dependent streams may have some dilution flow during a few months of the year. And, that dilution flow often occurs during the winter months when treatment plant efficiency is lowest for ammonia-nitrogen removal. Therefore, if the discharger is willing to install and maintain state-of-the-art flow monitoring gauges, it is often possible to apply more realistic dilution factors in the permit. Such factors must necessarily remain conservative but they need not be falsely assumed to be zero.

Nowhere is this more important than in stormwater permitting. Ironically, the chemical limits in most arid west stormwater permits are set equal to the water quality criteria with no allowance for available dilution. This occurs because the 7Q10 for the "receiving water" (often a dry ditch or stormwater channel) contains no background flow unless it is raining. However, during rain events, there can be considerable dilution available. Therefore, it is illogical to assume that the stream is at "critical low-flow conditions" when it only flows under precisely the opposite set of circumstances. To avail themselves of the flexibility that comes with dilution, dischargers must first invest considerable resources in quantifying and characterizing the true nature and composition of stormwater runoff in the watershed.

4.2.4 Compliance with Uses and Criteria

As noted above, states are required to routinely assess the quality of surface waters. The assessment process compares water quality data with the standards applicable to the waterbody from which the data were collected. This evaluation is pollutant or constituent specific. Finding an exceedance of a water quality standard is by itself not unusual or necessarily a concern. What is of concern is when exceedances are of sufficient magnitude, duration, or frequency that a finding must be made that the waterbody is impaired.

EPA has provided guidance to the states on how to evaluate data from multiple sources (e.g., chemical and biological) and use the data to determine whether or not a waterbody should be considered impaired (EPA 2002). However, it is up to each state to evaluate its data and make the initial determination of where impairment exists. In some states, e.g., Arizona, this determination is made according to a methodology established by promulgated state regulations. EPA does review each state's data and findings and occasionally may make a finding that additional waters should be listed as impaired.

Since federal regulations require that a TMDL be established for waters listed as impaired, the listing of a waterbody as impaired often leads to a discussion of whether or not a water quality standard has been appropriately set. In fact, it is strongly recommended that the water quality standard be evaluated as the first step in the TMDL process—before resources are expended on TMDL development and ultimately TMDL implementation (e.g., see NRC 2001, Figure 4-2).

The evaluation of the basis for the impairment finding and the applicability of the water quality standards may focus on the assessment method, water quality criterion, the designated use(s), or some combination of the three. This evaluation may include one or more activities, which could lead to a no impairment finding (that is, remove the waterbody from the 303(d) list based on new information) or a modified water quality standard, which may also result in the removal of the waterbody from the 303(d) list.

Potential approaches from the simplest to the most complex are discussed below.

Evaluate Basis of Impairment

The assessment process is becoming more rigorous by necessity. Many states recognize that having data from multiple sources, both biological and chemical, provides multiple lines of evidence for making impairment decisions.

The importance of having adequate data was strongly emphasized by the NRC (2001) evaluation of the TMDL program. This body recognized that the available data from a waterbody can be insufficient or conflicting. In these situations, rather than list the waterbody as impaired, it is better to place the waterbody on a preliminary list. Such a list identifies the waters with the highest priority for additional monitoring and assessment.

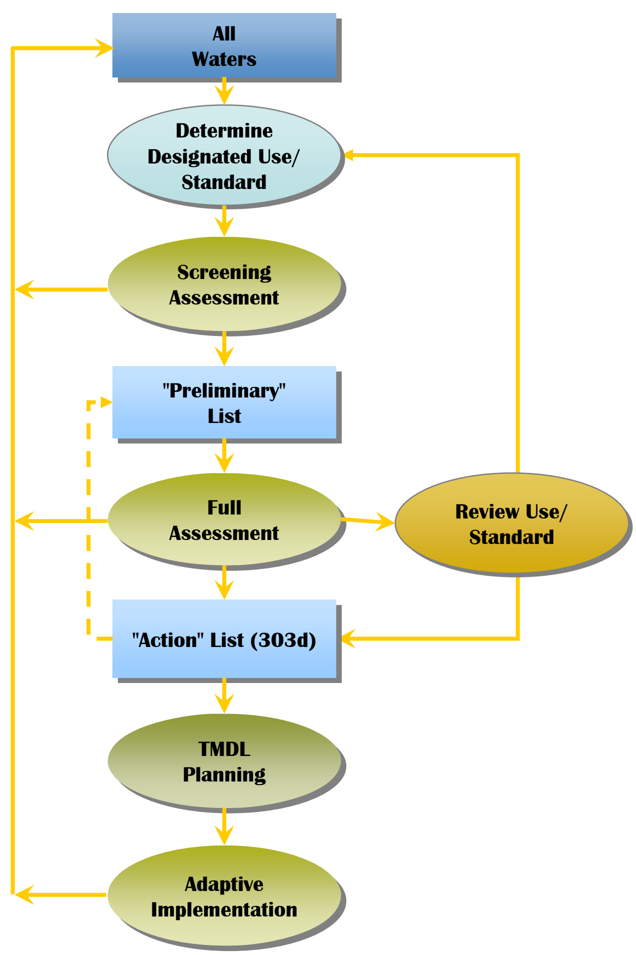


Figure 4-2
Framework for water quality management (adopted from NRC 2001).

Monitoring and assessment activities should focus on evaluating the three components associated with numeric water quality standards: magnitude, duration, and frequency.

Water Quality Standards Components

- Magnitude—represents the maximum allowable concentration. For aquatic life criteria, the magnitude is generally expressed two ways: (1) a short-term maximum concentration (acute); and (2) a long-term continuous concentration (chronic).
- Duration—establishes the period of time over which the instream concentration is averaged. For aquatic life criteria the exposure duration is typically 1 hour for acute criteria and 4 days for chronic criteria. A notable exception is the federally recommended chronic criteria for ammonia, which are based on a 30-day averaging period. For pathogen criteria the averaging period is often 30 days.
- Frequency—defines how often a criterion may be exceeded and still be protective. EPA recommends that the allowable frequency of exceedance for aquatic life criteria be no more than one exceedance every 3 years.

Many states have incorporated these elements into their state water quality standards, but often a disconnect occurs when water quality data are assessed for compliance with water quality standards. This disconnect is most significant for the "duration" component simply because multiple ambient water quality samples are not typically collected over a 1-hour or 4-day period so that the average concentration may be determined. Moreover, water quality sampling programs often rely on single point grab samples rather than a sampling protocol that gathers data from multiple points under different habitat/flow conditions.

In some cases, when more comprehensive monitoring is conducted, the waterbody will be found to be in compliance with water quality standards. In these instances, spending resources on data collection ultimately results in avoiding a costly TMDL. However, even if the additional studies confirm the impairment and the need for a TMDL, the increased certainty of the impairment decision is beneficial since resources can now be focused on real problems; not presumed problems.

Develop Site-Specific Water Quality Criteria

Since all water quality criteria are derived using specific assumptions, in theory a site-specific water quality criterion could be developed for any constituent, regardless of the applicable designated use. However, in practicality, site-specific criteria development will be more difficult to develop for certain constituents and uses.

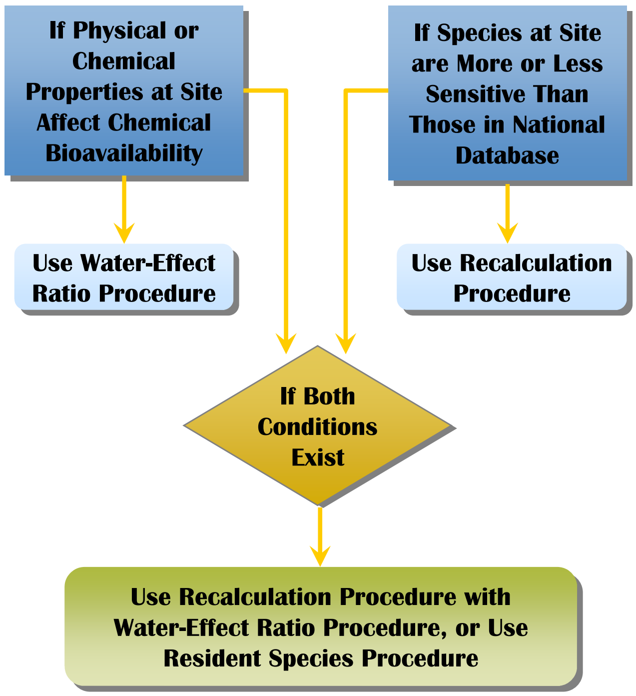
For example, EPA has long recognized that the national water quality criteria that it recommends for the protection of aquatic life may be under- or over-protective if (1) the aquatic species resident in a waterbody are more or less sensitive than the species included in the national dataset used to calculate the water quality criteria; or (2) physical and/or chemical characteristics at the site alter the biological availability and/or toxicity of the chemical (EPA 1994a).

Other criteria, such as those to protect human consumption of fish or swimming, are based on exposure assumptions such as number of fish meals or volume of water consumed per day, respectively. To develop site-specific criteria for these types of criteria it would be necessary to have data that demonstrate that different exposure assumptions should apply.

EPA has established methods for developing site-specific aquatic life criteria (Figure 4-3):

- Water Effect Ratio—As noted above, this method may be used within the permit development process, but it may also be used to establish a site-specific criterion applicable to a waterbody (see above for additional method description and sources for additional information).
- Recalculation Procedure—This method takes into account the relevant differences between the sensitivities of the aquatic organisms used to establish national water quality criteria and the sensitivities of organisms that are actually resident at a given site. EPA has published a methodology and a number of policy documents on its use (EPA 1994a,b); this methodology was recently evaluated for the arid west and recommendations were made to improve its applicability (see PCWMD 2006c).

- **Resident Species Approach**—This procedure is designed to take into account the differences in site water characteristics and sensitivities of resident species at the same time. Essentially it combines the methodologies described above for the WER and Recalculation Procedures.



Source: PCWMD 2006d

Figure 4-3
EPA-established methods for developing site-specific aquatic life criteria.

Modifying or Refining the Designated Use

Subcategorization

Subcategorization is not a new concept in water quality standards setting. Distinctions between freshwater and marine ecosystems and coldwater vs. warmwater habitats have been recognized since the first wave of waterbody classifications took place back in the mid-1970s. EPA guidance strongly encourages the use of more detailed use designations because it provides greater opportunity for regulatory flexibility while continuing to ensure existing uses will remain fully protected.

To some, this seems a bit counterintuitive. Wouldn't greater flexibility result from vague general use classifications? No. When a waterbody is designated to protect "Aquatic Life" without any additional detail, then water quality criteria must be adopted that would ensure protection of all aquatic life regardless of whether it is, or ever could be, present. For example, if a state does not specifically identify a given waterbody as "warmwater habitat," then water quality criteria must be set to protect both warm and coldwater species. This may result in water quality criteria that are unnecessarily restrictive if the more sensitive cold-water species cannot actually inhabit the waterbody in question.

Recognizing a distinction between warmwater habitat and coldwater fisheries allows a state to adjust water quality criteria to provide the optimum level of protection. Likewise, some of the water quality criteria for marine organisms are more restrictive than needed to protect freshwater species. Therefore, subcategorization provides the legal basis for greater regulatory flexibility.

Subcategorization is now recognized as a powerful tool for resolving other controversial issues related to water quality standards. For example, most states have only a broad general classification for recreational uses. Often, that designation is intended to cover a wide diversity of activities, including fishing, swimming, boating, wading, etc. As noted earlier, unless additional detail is given, all of the recreational activities are assumed to occur wherever the general recreational use classification is assigned. And, there is usually only one set of water quality criteria adopted to protect all of these uses. By law, those criteria must protect the most sensitive activity included within the designated use regardless of whether or not it is actually occurring. However, where a state differentiates between different types of recreation, with different levels of body contact, the state is better able to tailor its water quality standards to reflect the variations in risk exposure. Many states now draw a distinction between waterbodies that allow full body contact and those where shallow depths limit the recreational opportunity to wading. That distinction is usually accompanied by different bacterial standards.

In the arid west, natural habitat conditions (higher water temperatures, shifting sand substrates, lack of bank vegetation, higher dissolved solids concentrations, etc.) may severely restrict the richness and abundance of aquatic organisms. If the stream classification system recognizes such factors, then site-specific water quality criteria can also be applied. However, in the absence of such detailed use designations, federal law assumes that a warmwater stream in southern Nevada is capable of supporting all of the same sort of species that one would expect to find in a warmwater creek in southern Mississippi.

As is illustrated in Section 4.3.3, the State of Ohio has taken the concept of aquatic life subcategorization to a new level by carefully defining different types of aquatic habitats and establishing appropriate biological expectations for each of these habitat types. This level of detail represents well what EPA envisioned when it discussed subcategorization of uses in the 1983 water quality standards regulation and subsequent guidance (see additional discussion in Section 4.3.3 and 48 Federal Register pp. 51409-51410, November 8, 1983, Appendix to Water Quality Standards Regulation, Final Rule).

Just as with the effluent-dependent streams classification, the easy part is recognizing that there is an essential difference, some fundamentally different factor. The hard part is figuring out how to develop site-specific water quality criteria to go with that new subcategory. Once again, the tendency is to establish water quality criteria based on ambient concentrations in the stream. EPA can approve such standards provided that the state can demonstrate that the aquatic ecosystem is not "impaired." Impairment is usually assessed by comparing the receiving stream to some other reference creek or by comparing the richness and abundance of organisms downstream of the discharge with that found upstream of the outfall.

Subcategorization of a designated use requires the preparation of a UAA (EPA 1994a). However, any attempt to subcategorize or refine a designated use is likely to be a lengthy, complex process. As described in the case studies in Section 6, one of the keys to success in subcategorizing a designated use and adopting revised water quality criteria is a strong stakeholder, science-based process. In addition to the information and examples provided in this document, an excellent source of information regarding the UAA process and is a recent joint publication by the WERF and the NACWA (2005).

4.3 Water Quality Standards—Emerging Tools

4.3.1 Introduction

This section highlights emerging regulatory tools that are gaining acceptance as valid approaches for establishing and/or implementing water quality standards that are more appropriate for, but still protective of, arid west ecosystems. Two of these emerging tools—net environmental benefit and establishment of a habitat-limited designated use for aquatic life—are discussed in detail as methods for subcategorizing uses and modifying water quality criteria. The other tools discussed, e.g., adaptive management and points of compliance, are particularly important as implementation strategies for permits or TMDLs.

4.3.2 Net Environmental Benefit

Net environmental benefits represent the gains in ecological function or other ecological properties attained by actions, minus the environmental impacts caused by those actions. When the "actions" in question are effluent discharges creating effluent-dependent systems, then the concept of "net environmental benefit" is one of balancing the value of a created habitat against the impact of removing it. Applying net environmental benefit involves quantifying the needs and costs of potential wastewater treatment modifications necessary to meet water quality standards with a realistic appraisal of the ecological benefits of continued discharge in a waterbody that would otherwise be dry [Note: For the purposes of this discussion it has been assumed that the addition of water to an otherwise dry riverbed is a "benefit." It is acknowledged that preservation of naturally ephemeral channels can likewise be beneficial (e.g., see Section 3.2.2). However, in an urban environment such preservation may not always be practical, given requirements for flood control in urban areas].

Establishment of the Concept

The recognition that effluent-dependent waters may require a different approach to managing water quality has been recognized since 1992 when EPA Region 9 published its *Interim Final Guidance for Modifying Water Quality Standards and Protecting Effluent Dependent Ecosystems* (EPA 1992, see CD). This document first established the term "net ecological benefit," a concept that recognized the potential value of having wastewater discharged to an otherwise dry riverbed. The term "net ecological benefit" has been replaced by "net environmental benefit," but for purposes of this discussion the terms are considered equivalent.

To demonstrate that an environmental benefit existed, EPA (1992) recommended preparation of a UAA, which included an "ecological benefits comparison." In order to approve the UAA, the EPA required six positive demonstrations (EPA 1992):

1. The waterbody is in a primarily arid area where aquatic resources are limited and ecologically valuable. The waterbody supports an ecologically desirable aquatic, wetland, or riparian ecosystem and supports native plant and wildlife species. For a new discharge, the waterbody must have the potential to support such an ecosystem.
2. Effluent discharges may not produce or contribute to concentrations of pollutants in tissues of aquatic organisms or wildlife that are likely to be harmful to humans or wildlife through food chain concentration.
3. The discharger documents that a feasible plan to remove the discharge is under consideration.
4. The analysis demonstrates that a continued discharge to the waterbody has not created and is not likely to cause or contribute to violations of downstream water quality standards or groundwater basins.
5. All practicable pollution prevention programs, such as pretreatment and source reduction, are in operation. The discharger verifies that it has responded appropriately to previous and ongoing compliance actions.
6. In order to preserve the net ecological benefit associated with the discharge, it is recommended that the discharger commit to providing effluent to the stream that is sufficient to protect and maintain the ecological benefit as determined by EPA, and state and federal wildlife agencies.

EPA (1993), *Supplementary Guidance on Conducting Use Attainability Analyses on Effluent Dependent Ecosystems*, provided draft guidance on how to develop an ecological benefits comparison by defining six key steps (see attached CD) (Figure 4-4).

Recent Developments

Although interest in the idea of using the net environmental benefit concept was high following its initial publication by EPA Region 9, implementation of the concept has been slow. The apparent reluctance to implement this concept appears to have been driven primarily by the recognition that conducting the UAA to demonstrate net environmental benefit only achieved a modified aquatic life use, e.g., subcategorized use, and did not resolve the issue of site-specific criteria. In other words, once the use was modified, then how was a state to go about modifying the aquatic life criteria in a manner that demonstrated that the existing and attainable uses were protected?

The lack of understanding with regard to how to use the net ecological benefit concept in a regulatory context to address use and criteria modifications left the concept unused and untested for many years. However, in the past few years net environmental benefit has been revived as a viable approach to addressing unique water quality standards issues associated with effluent-dependent waters. This interest has been revived primarily because of two particular efforts:

- The Habitat Characterization Study, which for the first time documented the physical, chemical, and biological characteristics of effluent-dependent waters (PCWMD 2002, see Section 6), dusted off the concept and recommended it as a viable tool for use in effluent-dependent waters. This recommendation included the suggestion that establishment of a net environmental benefit

Steps	Considerations
Step One: Define ecological benefits and detriments	Develop clear definitions of the ecological benefits or detriments that are related to continuing or removing the effluent discharge. The identification of concerns should consider the resource in a broad, watershed context and consider all three of the key elements of the ecosystem, i.e., physical, chemical, and biological elements. Where appropriate, identification of ecological benefits should consider site-specific elements important or even unique to the area in question.
Step Two: Construct a succinct description of the waterbody	Determine how the discharge affects valued water body resources and identify the factor of factors governing how the discharge affects valued water body resources.
Step Three: Develop specific net ecological benefit comparison objectives and define expected performance	Select a reasonable set of ecological benefits and detriments and establish how they will be assessed. To the extent possible, it is recommended that benefits and detriments be quantifiable.
Step Four: Establish testable hypotheses	The null hypotheses states that there is no difference with or without the discharge, while the alternate hypothesis indicates that there is a measurable difference.
Step Five: Collect data and conduct specified analyses	Identify potential sources of existing data; where data gaps exist, collect necessary information.
Step Six: Evaluate net ecological benefit and determine subsequent actions	Evaluation considers all testable hypotheses established in previous steps. Where mitigation of potential detriments is possible, these actions are identified. If mitigation is not possible or detriments are significant, then a finding of no net environmental benefit may be warranted.

Source: EPA 1993

Figure 4-4
Six Key Demonstrations to Support Net Environmental Benefit Finding

could lead to the establishment of a performance-based approach to implement water quality criteria in waters with an approved UAA demonstrating that a net environmental benefit exists from the continued discharge.

- The Western States Water Council (WSWC) Water Quality Committee has discussed/ debated the net environmental benefit concept through a series of workshops with its member states and EPA. Part of the driver for this discussion was the need to resolve critical water quality standards regulatory issues in some western states, especially Wyoming.

The result of this effort has been the development of a Question & Answer document, *Final Discussion Paper: Questions and Answers Regarding Appropriate Water Quality Standards for Effluent-Dependent Waters in the Arid West* (Effluent-Dependent Waters Drafting Group, 2006). This discussion paper reviews the net environmental benefit concept in a question and answer format that provides guidance regarding how and where it may be applied. Questions addressed by the document include:

- What is a "net environmental benefit"? What benefits (and/or potential losses) can be considered when using this approach?
- Do the federal regulations allow for a "net environmental benefit" evaluation approach to adopting or revising water quality standards for effluent-dependent waters? If so, which of the six UAA factors (40 CFR 131.10(g)) are conducive to making a "net environmental benefit" demonstration?
- What, if any, constraints do federal statute and regulations impose on when and how a "net environmental benefit" evaluation approach can be applied?

- Can the concept of net environmental benefit be applied in the case of a new discharge to an ephemeral channel or dewatered stream?

EPA is currently reviewing the work product produced by the EDDW Drafting Group to determine how to best move forward with the developed regulatory concepts.

From Concept to Practical Use

Arizona was the first state to adopt regulations recognizing net environmental benefits as a methodology to develop alternative water quality standards for effluent-dependent waters (Arizona Administrative Code, Title 18, Chapter 11, Article 1, Section 106; see attached CD). Although, the state has adopted a water quality standard that allows for the use of a net environmental benefit approach to modify a water quality standard, the regulation has not been used.

The State of Washington's Department of Ecology (WDOE) recently developed a draft UAA guidance document that provides explicit instructions for conducting a UAA based on a net environmental benefit (WDOE 2005). The state received numerous comments on the draft, both positive and negative. The state plans to wait at least a couple of years before finalizing the document. This delay is considered necessary to allow time to gain additional knowledge and insight into how to manage the UAA process.

Wyoming is the first state to move the net environmental benefit approach from concept to practical use. The Wyoming Department of Environmental Quality (WDEQ) is developing regulations and guidance that not only provide the basis and methodology for establishing an aquatic life subcategory for effluent-dependent streams by using a net environmental benefit demonstration, but also provide the means for establishing site-specific criteria (see Section 6 Case Studies).

Throughout the development process, WDEQ has worked closely with EPA Region 8 to develop an approach that is approvable. A case study presented in Section 6 provides an overview of WDEQ's application of net environmental benefit as a means to address a water quality standards compliance issue. Significant to this effort is the recognition that the discharge that creates the effluent-dependent water dictates to a very large degree the water quality in the receiving water. Therefore, what is attainable, from a water quality standpoint, is defined by the discharge.

> **Examples of Benefits and Detriments and Testable Hypotheses**
>
> - **Example Benefit:** The effluent discharge supports perennial aquatic habitat that is used by state or federal aquatic and terrestrial species of concern.
>   - **Null Hypothesis:** The area influenced by the discharge supports no more state or federal aquatic and terrestrial species of concern than would be present if the created habitat were not present.
> - **Example Detriment:** The effluent discharge results in the bioaccumulation of pollutants detrimental to aquatic and terrestrial species.
>   - **Null Hypothesis:** Concentrations of bioaccumulative pollutants in the water column, sediments, and/or biological tissues have reached levels of concern.

Recommendations for Using the Net Environmental Benefit Concept

Net environmental benefit as a regulatory concept is gaining acceptance. With this increased acceptance comes significant responsibility to demonstrate through a UAA that the current designated use is not attainable. This is not necessarily a simple exercise nor will the requirements to make such a demonstration be the same in each effluent-dependent water. For example, the requirements for a discharge resulting from well production water (e.g., Wyoming) will likely be quite different from the requirements where the discharge is from a wastewater treatment facility. To increase the likelihood of success when developing a UAA to demonstrate a net environmental benefit exists, the following should be considered:

- The waterbody should be truly effluent-dependent; effluent-dominated waters may include such a broad range or mix of natural and created flow regimes that significant questions will be raised regarding what is attainable in the receiving water (see Section 7 for additional discussion regarding the role of the waterbody type in the regulatory process).

- Avoid a strategy that seeks to entirely remove an aquatic life use; instead, establish an aquatic life subcategory that is limited to the waters to which the net environmental benefit concept applies, e.g., an effluent-dependent water subcategory (see *Use Designation and Ambient-Based Criteria Procedures for Effluent-Dependent Waters* Case Study example in Section 6).
- Provide clear, concise definitions for what defines an effluent-dependent water.
- Establish UAA procedures that are specific to effluent-dependent waters and the information that is required to demonstrate a net environmental benefit. The WDEQ has developed a good example of such procedures.
- Establish separate procedures for developing alternative water quality criteria in waters where a net environmental benefit is demonstrated. That is, separate decisions regarding the use from decisions regarding appropriate water quality criteria.

4.3.3 Establishment of a Habitat Limited Use

Many arid west waters are impacted as a result of factors such as urbanization, flood control activities, and water diversions. Some of these waters may be effluent-dependent or effluent-dominated; others may still have only natural flows. At least to some degree urbanization type activities are irreversible—at least in the short-term. As a result, the recreational opportunities and aquatic life communities may be somewhat limited and what is attainable is something less than what would be attainable in a free-flowing non-urban waterbody.

From a hydrologic standpoint, there is general agreement that three basic stream types exist: perennial, intermittent, and ephemeral. This distinction is recognized at 40 CFR 131.10(g)(2), in federal water quality standards guidance, and often acknowledged in state water quality standards. However, it should be noted that although these stream types are routinely acknowledged by definition in federal guidance or state regulations, rarely is guidance provided or criteria established that take into account the differences among these different stream ecosystems. This lack of definition is getting increased attention (see Section 7).

Commonly superimposed on these stream types are the limitations imposed by urbanization that result in modified stream channels. In the arid west, naturally perennial waters are relatively uncommon, and where perennial waters may have existed historically, hydrologic modifications have left these waterbodies intermittent or ephemeral. These waterbodies are often further modified by the discharge of effluent that converts the intermittent or ephemeral water into an effluent-dominated or effluent-dependent water. The result of all these changes has resulted in streams that are "modified" in ways that affect expectations for what uses are attainable (PCWMD 2002):

- The discharge of effluent may result in erosion and channel incision, creating an aquatic habitat with decreasing potential nearer the point of discharge
- The flow is primarily or completely effluent and the instream water quality can be expected to be similar to the quality of the effluent
- Urban expectations for flood and erosion control may nullify the expected gains from improved treatment levels, expectations for returning the watercourse to a natural condition are low or nonexistent
- Other sources of discharge to the stream, e.g., stormwater outfalls and agricultural return flows, influence the stream in their own ways

While any one of the above ways in which a stream is modified is sufficient to impact the aquatic community, in actuality these modifications often occur in various combinations. The reality that a combination of factors simultaneously influences expectations for what is attainable in these watercourses raises important questions with regards to how water quality standards are established and implemented. The following sections will explore how habitat-based subcategorizations may be used to establish appropriate water quality standards.

Regulatory Basis for Establishing a Modified Habitat Use

The foundation for water quality standards is the establishment of appropriate designated uses for surface waters under the jurisdiction of the CWA (see Section 2 for more discussion in this area). EPA has recognized the importance of correctly establishing designated uses and has specifically encouraged the establishment of uses that best define what can actually be attained in a given type of waterbody. This recognition includes the understanding that use attainability is not necessarily linked to original habitat conditions, i.e., returning all jurisdictional waters back to a pre-settlement condition:

> "It has never been the intention of the water quality standards program to bring all waters to a pristine condition or necessarily to set standards based on original habitat conditions. In the first instance, some waters are naturally of "poor" quality, and in the second, man has changed the environment and there are instances where an attempt to correct or control some sources of pollution either simply cannot be effected or would cause more environmental damage to correct than to leave in place" (48 Federal Register pp. 51409-51410, November 8, 1983, Appendix to Water Quality Standards Regulation, Final Rule).

Moreover, EPA has recognized also that when establishing appropriate beneficial uses for the protection of aquatic life it can be appropriate to consider functional aspects of the aquatic system:

> "Subcategories of aquatic life uses may be established on the basis of attainable habitat (e.g., coldwater versus warmwater habitat); innate differences in community structure and function (e.g., *high* versus low species richness or productivity); or fundamental differences in important community components (e.g., warmwater fish communities dominated by bass versus catfish). Special uses may also be designated to protect particularly unique, sensitive, or valuable aquatic species, communities, or habitats… (EPA 1994a).

As noted above, the water quality standards regulations already explicitly acknowledge the existence of three types of waterbodies based on flow characteristics: perennial, intermittent, and ephemeral. Furthermore, the regulations recognize that flow characteristics can limit use attainability. This recognition is explicitly stated in three of the six use attainability provisions at 40 CFR 131.10(g):

- 40 CFR 131.10(g)(2)—Natural, ephemeral, intermittent, or low-flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for by the discharge of sufficient volume of effluent discharges without violating state water conservation requirements to enable uses to be met.
- 40 CFR 131.10(g)(4)—Dams, diversions, or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the waterbody to its original condition or to operate such modification in a way that would result in the attainment of the use.
- 40 CFR 131.10(g)(5)—Physical conditions related to the natural features of the waterbody, such as the lack of a proper substrate, cover, flow, depth, pools, riffles, and the like, unrelated to water quality, preclude attainment of aquatic life protection uses.

A fourth criterion, while not restricted to flow considerations, can be related to flow:

- 40 CFR 131.10(g)(3)—Human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place.

The emphasis on flow/habitat related factors in the use designation/use attainability provisions indicate the importance with which this factor can define expectations for aquatic life use on a given waterbody. However, it appears that while the lack of flow has been recognized as a limitation, it has been assumed that compensating for the lack of flow, even through effluent discharge, can supplement or replace the lack of water (see provision at 40 CFR

131.10(g)(2)). The language in this regulation assumes that the addition of flow from an effluent source can be equated with the presence of natural flow, i.e., it assumes that the presence of flow regardless of its source and input mechanism will result in the same outcome with regards to use attainability. The findings of the Habitat Characterization Study (PCWMD 2002) showed that this presumption is likely false and needs to be taken into account when establishing appropriate aquatic life uses in places where habitat is modified.

Use Designations Based on Habitat

A number of states have established aquatic life use subcategories that recognize the impact of habitat modifications on use attainment. Generally these uses recognize the existence of irretrievable human-induced conditions such as stream channel modification, abandoned mine land runoff, or permanent impoundment of free-flowing waterbodies.

The establishment of recreational uses that specifically recognize habitat limitations, other than flow, are not very common. However, in states such as California and Idaho, recreational uses have been modified because of habitat conditions, e.g., limited habitat (vertical, concrete-lined flood control channels) or irrigation channels that are unsafe to recreate in.

The establishment of a designated use subcategory that recognizes habitat limitations as limiting use attainment is a critical first step in recognizing that physical characteristics can limit the recreational and aquatic life uses of a waterbody. However, although some states have established habitat-based uses in many instances the water quality criteria have not been adjusted to reflect different expectations for aquatic communities or exposure assumptions for recreational contact. Instead, the same criteria are applied regardless of the subcategorization of the designated use.

The need for alternative water quality criteria, especially for many metals and organics where the sources are anthropogenic, is limited, and thus using the same criteria for all subcategories of a use may be warranted. However, the concentration of other constituents, especially constituents such as DO, pH, temperature, or nutrients, may be affected by the nature of the habitat.

The following sections provide examples of subcategorizations where habitat limitations provide the basis for the subcategorized use designations. The best example of this type of subcategorization is from the State of Ohio, far removed from the arid west. However, it is provided here because the principles adopted in Ohio can be applied anywhere.

Habitat-based Aquatic Life Use Subcategorization

The Ohio Environmental Protection Agency ("Ohio EPA") currently has seven aquatic life use subcategories. Two of these uses have been established to address waters that have been modified in some manner [Ohio Administrative Code (OAC) 3745-1-07, see Ohio Regulations on attached CD]:

Ohio's Habitat-Based Aquatic Life Uses

- Modified Warmwater Habitat—waters that have been the subject of a UAA and have been found to be incapable of supporting and maintaining a balanced, integrated, adaptive community of warmwater organisms due to irretrievable modifications of the physical habitat.
- Limited Resource Water—waters that have been the subject of a UAA and have been found to lack the potential for any resemblance of any other aquatic life habitat as determined by the biological critiera.

- Modified Warmwater Habitat (MWH)—"waters that have been the subject of a [UAA] and have been found to be incapable of supporting and maintaining a balanced, integrated, adaptive community of warmwater organisms due to irretrievable modifications of the physical habitat. Such modifications are of a long-lasting duration (i.e., 20 years or longer) and may include the following examples: extensive [permitted] stream channel modification activities extensive sedimentation resulting from abandoned mine land runoff, and extensive permanent impoundment of free-flowing waterbodies…The modified warmwater habitat designation can be applied only to those waters that do not attain the warmwater habitat biological criteria…because of irretrievable modifications of the physical habitat. All waterbody segments designated modified warmwater habitat will be reviewed on a triennial basis (or sooner) to determine whether the use designation should be changed. A temporary variance to the criteria associated with this use designation may be granted as (per regulatory requirements)."

- Limited Resource Water (LRW)—"waters that have been the subject of a [UAA] and have been found to lack the potential for any resemblance of any other aquatic life habitat as determined by the biological criteria…of this rule. The [UAA] must demonstrate that the extant fauna is substantially degraded and that the potential for recovery of the fauna to the level characteristic of any other aquatic life habitat is realistically precluded due to natural background conditions or irretrievable human-induced conditions. For waterbodies in the Lake Erie drainage basin, the designation of waterbodies as limited resource waters shall include demonstrations that the "Outside Mixing Zone Average" water quality criteria and values and chronic [WET] levels are not necessary to protect the designated uses and aquatic life…All waterbody segments designated [LRW] will be reviewed on a triennial basis (or sooner) to determine whether the use designation should be changed…A temporary variance to the criteria associated with this use designation may be granted as described in…the Administrative Code…Waters designated [LRW] will be assigned one or more of the following causative factors…:
  - *Acid mine drainage*—…surface waters with sustained pH values below 5.1 SU or with intermittently acidic conditions combined with severe streambed siltation, and have a demonstrated biological performance below that of the modified warmwater habitat biological criteria.
  - *Small drainageway maintenance*—…highly modified surface water drainageways (usually less than 3 square miles in drainage area) that do not possess the stream morphology and habitat characteristics necessary to support any other aquatic life habitat use. The potential for habitat improvements must be precluded due to regular stream channel maintenance required for drainage purposes.
  - Other specified conditions."

For the MWH and LWR uses, the aquatic life criteria for ammonia and DO are less stringent than for other warmwater habitat uses. Other criteria may be less stringent as well. For example, chronic WET test procedures are not applicable to waters designated as LRW. The biological expectations for MWH are "tolerant assemblages of fish and macroinvertebrates, but otherwise similar to warmwater; irretrievable condition precludes complete recovery to reference condition"; for LRW the biological expectations are "fish and macroinvertebrates severely limited by physical habitat or other irretrievable condition" [see, Summary of Ohio's Beneficial Use Designations, April 2004, on attached CD].

The Ohio EPA has invested substantial resources to understand biological expectations in state waters and established aquatic life use subcategory-specific biological criteria. With a firm understanding of biological expectations, Ohio EPA has established an approach for evaluating use attainment for certain aquatic life subcategories, which differs from the typical approach used in other states. Specifically, for waters designated as warmwater habitat, exceptional warmwater habitat and MWH, biological criteria, not chemical criteria, are used as the primary measure of attainment of the use (OAC 3745-1-07, see attached CD):

> "Demonstrated attainment of the applicable biological criteria in a waterbody will take precedence over the application of selected chemical-specific aquatic life or whole-effluent criteria associated with these uses when the director, upon considering appropriately detailed chemical, physical, and biological data, finds that one or more chemical-specific or whole-effluent criteria are inappropriate."

If this finding is made, the state regulations identify procedures for the establishment of site-specific criteria or effluent limitations. In contrast, if the biological criteria are not attained, but other criteria are met, then a separate set of procedures may be implemented to identify the cause of non-attainment and either modify the use or address the cause of non-attainment when determined.

Habitat-based Recreational Use Subcategorization

Until recently, a number of waterbodies in Idaho, which are irrigation ditches, have been protected with a primary contact (swimming) recreational use. The state completed UAAs on selected waterbodies demonstrating that habitat-related conditions (high-flows coupled with steep, entrenched channels with heavily vegetated banks) make these waters unsafe for swimming (there have also been several documented drownings) (see EPA letter to Idaho Department of Environmental Quality, November 29, 2004 and supporting EPA technical analysis on attached CD).

Similarly, a portion of Ballona Creek in the Los Angeles, California area was recently reclassified from a water contact use (swimming) to a limited contact use. The re-designation was based on habitat-related characteristics that limited recreational contact or swimming activity (e.g., vertical, concrete-lined channel). This example is discussed in more detail as a case study in Section 6 (*Refinement of Recreational Uses*).

Concrete-lined reach of Ballona Creek in Los Angeles, California area.

Recommendations for Establishing and Implementing Habitat-based Water Quality Standards

Stream modifications that alter physical habitat are commonly observed, especially in urban areas. The above examples illustrate how habitat-based uses may be established to address both aquatic life and recreational uses. Additional examples for aquatic life uses may be found in Texas, Idaho, Colorado, and Oklahoma, although none of these examples is as developed as the example described above for Ohio.

Three key steps are involved in establishing and implementing a habitat-based use aquatic life or recreational use. Depending on the resources available, it may be best to separate these steps into separate rulemaking activities:

- Establish the use subcategories with appropriate definitions, i.e., clearly define the type of waterbody and characteristic habitat. It is critical that clear boundaries are established so that all stakeholders understand what types of waters belong in a particular subcategory.
- Establish a methodology and process for decisionmakers to classify waters in the subcategory.
- Because a UAA will be required to demonstrate that the waterbody belongs in a subcategory, establish procedures for conducting the UAA.
- Establish appropriate, attainable water quality criteria that protect the subcategorized use. This step may require the development of a scientifically defensible methodology. For recreational uses, this may mean developing data that demonstrates the extent of recreational activity, e.g., through use surveys. For aquatic life, examples of approaches used by various states include:
  - *Recalculate criteria based on resident species.* The EPA recalculation procedure can be used as a starting point for implementing this approach (EPA 1994a; also see Arizona Case Study, *Subcategorization of Aquatic Life Uses,* in Section 6 and PCWMD 2006c).

- *Apply acute aquatic life criteria only.* This approach protects aquatic life in habitats where water is present only sporadically (see Arizona Case Study, *Applicability of Chronic Water Quality Criteria to Ephemeral Waters,* in Section 6).
- *Establish ambient-based criteria.* This approach recognizes that the ambient water quality supports the existing aquatic life community, is consistent with the existing use provisions of the water quality standards regulation, and prevents deterioration in water quality that would result in more limited aquatic life (see Wyoming Case Study, *Use Designation and Ambient-Based Criteria Procedures for Effluent-Dependent Waters,* in Section 6).

4.3.4 Points-of-Compliance

Many wastewater facilities in the arid west discharge to small (often unnamed) dry washes that may not have any formal use designations or water quality criteria. Nevertheless, most states operate under a "Tributary Rule" where downstream uses and criteria are assumed to apply to undesignated upstream tributaries until such time as site-specific stream classifications and criteria are imposed.

Blanket application of the Tributary Rule can have some odd and inappropriate impacts on permit limits. For example, dry washes are rarely relied on or designated for municipal water supply use. However, they may be tributary to larger downstream waterbodies that are classified for municipal drinking water supply. Consequently, under the Tributary Rule, downstream water quality criteria are applied at the upstream discharge location. However, the absence of dilution at that location makes some of these criteria (especially low-level organics) nearly impossible to meet. There is no real threat to drinking water because, by the time the effluent reaches the downstream location, it has been significantly diluted or transformed. Unfortunately, downstream dilution is not usually recognized or included when calculating permit limits.

One solution is to identify multiple "Points of Compliance" for some pollutant parameters within the permit. By noting that the designated use in question actually occurs far downstream from the present discharge location, adjustments (e.g., dilution factors or other translators) can be used to calculate a more appropriate effluent limit while continuing to protect downstream water quality.

Similar strategies are now being employed for stormwater channels that are themselves not suitable for recreational activities but may be tributary to downstream waterbodies (lakes, reservoirs, ocean beaches) where water contact recreation does occur. In such cases, a point-of-compliance further downstream can be identified and the effluent limits recalculated based on the results of a formal fate and transport study (provided that the study shows significant reduction in pollutant concentrations at the downstream location).

This approach is merely the flip-side of the normal load allocation process used when implementing TMDLs. If a lake or reservoir is impaired by nutrients, it is common for nutrient loads to be limited throughout the tributary system in order to ensure the downstream waterbody meets water quality standards. Conversely, if there is assimilative capacity in the downstream waterbody, where the use is actually occurring, then effluent limits in distant upstream tributaries should reflect that availability provided the relevant use is not occurring between the two locations.

It is increasingly common to see wastewater facilities construct artificial wetlands to "polish" the effluent prior to discharge. These natural treatment systems produce a very high quality wastewater product and are particularly effective at reducing the concentration of ammonia, nitrogen, metals, and organics. However, it is essential that the point-of-compliance be designated at the outfall from the artificial wetlands, otherwise the effluent may be required to meet water quality standards prior to discharge into the wetlands. On the other hand, natural treatment systems are also known to increase pathogen concentrations (due primarily to birds and other wildlife). Therefore, it is not unusual to see a different point-of-compliance, above the wetlands, for bacteria limits in the permit so that the discharger is not penalized for naturally-occurring pollutants that are beyond their control.

4.3.5 Adaptive Management

Adaptive Management is most often recommended as a regulatory implementation strategy in lieu of downgrading or deleting a use, similar to variances (see Section 4.2.3). Interest in Adaptive Management arises where there is significant disagreement over the true potential for uses within a waterbody and especially where there is considerable uncertainty over what level of water quality would be necessary to achieve that potential.

Rather than remaining locked in polarized positions, those in disagreement with one another agree to implement incremental improvements and assess the influence of each change on instream conditions. It is regulation by prospective experimentation rather than by retrospective investigation.

In order to be successful, Adaptive Management strategies must adhere to certain principles:

- All must agree on exactly what constitutes "full attainment" and what constitutes "impairment" of beneficial uses. These must be measured at the true endpoint (e.g., richness, abundance, etc.) rather than at some intermediate indicator (water chemistry).
- Adaptive Management requires proponents to make specific predictions about how a change in water quality will result in some measurable difference in a relevant metric of beneficial use. All must agree on exactly how those differences will be measured and analyzed.
- Adaptive Management requires proponents to specify Go or No-Go decision rules, in advance, that describe under what conditions the next incremental improvement will be initiated or no further incremental improvements will be required. In a sense, Adaptive Management is somewhat analogous to mandatory arbitration.

  Everyone agrees on the rules ahead of time and then lives with the outcome.

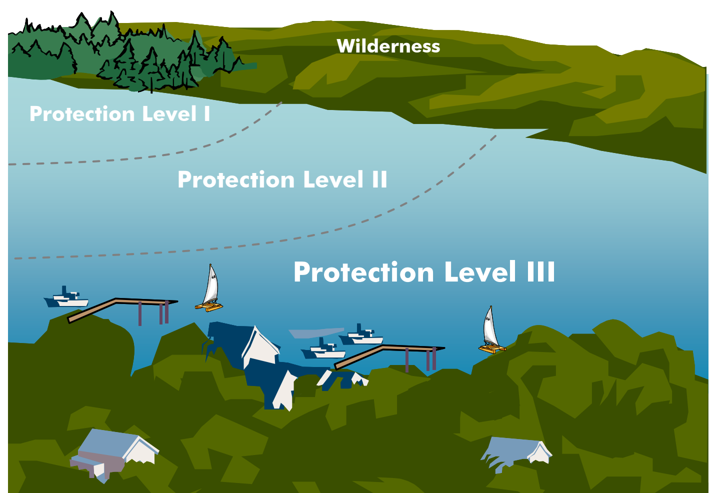
The use of Adaptive Management as an implementation tool is really still in its infancy. EPA, in coordination with many stakeholders, is developing a policy document on the use of Adaptive Management as a regulatory tool.

4.3.6 Beneficial Use Mapping

When a waterbody is classified, the designated use applies to the entire waterbody. Therefore, the relevant water quality criteria apply everywhere within that waterbody. Usually, that approach is appropriate because the uses are also spread out throughout the waterbody. However, on occasion, uses can come into conflict.

For example, a lake may be designated to protect recreation and aquatic life. But, the existence of boating activities may stir up sediment that impairs benthic organisms or fish spawning and the growth of aquatic plants may, in turn, impair recreational boating. Sometimes, it is impossible to protect all uses, in all places, at all times, simultaneously. In such instances, it is useful to develop Beneficial Use Maps.

Beneficial Use Maps are created as part of the watershed management planning process (see Figure 4-5, for example). The purpose of these



Protection Level I - Protect sensitive species

Protection Level II - Mixed use

Protection Level III - High recreation use, boat navigation, launch ramps, facilities

Figure 4-5
Conceptual beneficial use map for a lake or reservoir.

maps is to show how designated uses will be prioritized when they come into conflict with one another. In the aforementioned lake example, boating may be identified as the "priority use" in and around launch ramps and marina areas. It would be appropriate to reduce aquatic vegetation and other hazards to navigation in such areas even if it meant a localized loss of habitat. Similarly, the Beneficial Use Maps would identify other areas where powerboats may not be allowed in order to provide refuge for sensitive aquatic plants or other organisms.

The concept of Beneficial Use Maps is borrowed from the U.S. Forest Service (USFS). The USFS has considerable experience developing Forest Management Plans intended to accommodate multiple uses. Their strategy of "zoning" the forest to favor some uses over others is an elegant approach to resolving potential conflicts and works equally well when applied to designated uses within a waterbody.

Beneficial Use Mapping has been instrumental in resolving management conflicts between flood control and recreation. Some states have temporarily suspended the designated recreational use in engineered stormwater channels after it rains more than ½ inch. The suspension is terminated 24 hours after the rain ends (see *Suspension of Recreational Uses During High-Flow Events* Case Study in Section 6). In this situation, waterbodies or portions of waterbodies have been identified where channel conditions and high stormwater flows combine to create hazards that temporarily preclude recreational uses. By recognizing that recreation does not and should not occur under certain circumstances, bacterial criteria may be suspended during the same period of time. This provides considerable flexibility when implementing water quality standards for stormwater permits.

Beneficial Use Mapping may also be useful where marginal or incidental uses may arise, on a limited or temporary basis, in artificial waterways such as agricultural drains or water conveyance canals. In these cases, strict application of default water quality criteria in order to improve the potential among the secondary uses may interfere with attainment of the existing primary uses. Beneficial Use Maps could codify such priorities more explicitly.

Section 5
Implementing the Regulatory Process

5.1 Introduction

The 34th anniversary of the 1972 CWA recently passed. Over this period, significant improvements have been made in water quality. This improvement has been achieved by dealing with the obvious and relatively easily solved problems from both a technology and regulatory perspective. Yet even with all of this effort, many waterbodies are still finding their way on to the 303(d) list of impaired waterbodies. Now comes the difficult part—solving the less obvious or subtle problems that may not be caused by something that requires a technological fix (e.g., treatment upgrade or alternative discharge solution), but instead may be caused by inappropriate expectations, i.e., a water quality criterion or beneficial use is not attainable.

In working in the water quality regulatory arena, there are some lessons learned that can be shared from the efforts that have been put forth in the arid west and throughout the country. The following sections focus on the *process* used to make changes to water quality regulations. The emphasis is on issues that should be considered before undertaking such a process. In addition to the information presented here, it is strongly recommended that the reader consult NACWA and WERF (2005) for additional thoughts regarding implementation of a regulatory process.

5.2 Critical Success Factors

We have identified several critical factors that, when implemented, can increase the likelihood of a successful conclusion to a regulatory process:

- Define Clean Water Act Boundaries and Legal Ramifications. Oftentimes there is a perception that to seek regulatory change is in violation of the CWA. Therefore, the legal issues in the CWA as well as EPA policies and guidance need to be understood. By working closely with the regulators, and understanding that they are often struggling with the same issue, the potential to achieve a positive outcome is increased. Ultimately, the regulators have to find an approach that can be approved.

- Be Flexible. Both sides (the regulators and regulated community) must remain flexible. Regulators typically do want to resolve the problem, but at the least cost and time and using a pathway that will meet the least resistance institutionally, legally, and politically. Substantial flexibility exists in the CWA and its implementing regulations. The fact that this flexibility exists is demonstrated by the Section 6 Case Studies.

- Change the Nature of the Debate. Previous consensus-building efforts may have not been successful because they failed to address the perception that any effort to change a water quality standard is a downgrade and there is then a risk imposed on the environment and public health. A successful communications program must address that perception with each interest group, addressing their unique concerns while advancing the broader issues for cooperation and consensus. By arriving at a common understanding, it is possible to then move toward consensus.

- Simplify the Message. Successful public information campaigns are built on a set of simple, cogent messages. There is a need to inform the public with key messages and ample information, and not overwhelm them with excessive technical detail.

- Listen Carefully. If you ask the public and stakeholders for comments, you have to show you have heard them and then demonstrate how their input has helped to define or modify the process and the outcomes. It is imperative that a continuous feedback loop exists to show that the team is listening to stakeholders—this is what has been observed to lead to active participation, common understanding, compromise, and consensus.

- Be Prepared. Before we even begin any public information and involvement efforts, it is important to do a comprehensive inventory of all the issues, stakeholders, and dynamics. This includes evaluating the existing and emerging regulatory tools (see Section 4). Only through this thorough assessment—and knowing ahead of time where the likely problems will be—is it possible to begin to build an effective consensus process.

- Create a Win/Win Outcome. The best way to build consensus on a proposed approach is to have stakeholders invested early in the project. How? By bringing stakeholders in early to define goals, objectives, and a vision for success. Taking time to implement this step allows all stakeholders to become invested in the overall outcome.

- Develop a Common Understanding of the Problem. An important part of developing consensus on complicated and controversial issues is to get all the key stakeholders to first agree that there is a problem and to agree on the nature and scope of the problem. By reaching agreement, the discussion can then shift to how the problem can be solved.

- Be Open, Be Honest, Be Complete. The biggest asset that can be earned is the trust gained from the public and stakeholders. Accordingly, all communications must be open, honest, and complete.

5.3 Stakeholder Process and Management

5.3.1 Overview

Changes in water quality criteria or designated uses will not be successful without input from stakeholders. Accordingly, a stakeholder process must be incorporated into any project where the outcome will be a proposal to modify state water quality criteria, beneficial uses, or a discharge permit.

The type or nature of the stakeholder process greatly depends on the type of action anticipated. For example, as long as the outcome is very site-specific, e.g., a site-specific water quality criterion, then stakeholder involvement may be fairly limited. However, if the outcome has the potential to affect multiple waters, then the stakeholder process can be significant. It is critical to understand that the phrase "potential to affect" can be interpreted differently by different interests. For example, a common concern by a public interest is that a proposed change sets a precedent that could be applied far beyond the particular waterbody of interest. As a result, no matter how site-specific an issue is, if the proposed resolution could have far reaching implications, then the stakeholder base will be much larger than anticipated.

DO

- Develop critical position paper regarding the situation; document the problem.
- Educate yourself on the regulatory options that are acceptable for resolving the problem – from easy to difficult.
- Understand the costs and benefits of various approaches.
- Understand how your approach to resolving the issue affects your stakeholders.
- Schedule appropriate meetings to discuss options.
- Establish a process flow chart with key decision points that dictate next steps.

DON'T

- Presume that decisionmakers understand the problem.
- Select your tool(s) without input from the stakeholders.
- Presume that the costs are insurmountable and thus require a regulatory solution (depends on stakeholders).
- Presume to know what any stakeholder wants or will accept.
- Implement a single action until you have a process flow chart.

Adjusting a water quality criterion or use is not a purely scientific process—it is also a legal and political process. When attempting to change a water quality standard, states are hesitant to invest significant financial resources to develop the data to justify a new standard. Success in this effort is more likely if all participants including EPA are involved early in the process.

5.3.2 Identifying Stakeholders

The arid west is as regulatory diverse as it is geographically diverse. Consider the number of governmental agencies, many of them with a regulatory function, encompassed by this region:

- All or portions of five EPA regional offices (Regions 6, 7, 8, 9, and 10)
- Seventeen state governments often with more than one agency with regulatory jurisdiction over the state, including jurisdiction over water quality, water quantity, and state fishery and wildlife issues
- Numerous tribal governments (28 tribal governments in Arizona alone)
- Other federal agencies with interests in western water resource management, including the USFWS, USACE, BOR, USFS, and BLM
- United States-Mexico border agencies that implement cooperative agreements to address cross-border environmental concerns

Given the diversity of the entities with potential interest in environmental issues in the arid west, especially water quality issues, it is not surprising that there can be many different and possibly conflicting viewpoints over how water resources should be regulated or managed.

Once appropriate stakeholders have been identified, these groups can be organized according to each stakeholder's anticipated approach to the regulatory process. Stakeholder groups can be divided into groups such as regulated community, regulators, special interest groups, and the public (Figure 5-1).

It is important to understand the particular goals, values, and drivers of each stakeholder group. In addition, each group's issues and concerns should be understood and their expectation for how they plan to be involved in the process should be discussed.

5.3.3 Communication Among Stakeholders

There are many electronic tools available nowadays to facilitate communication among stakeholders: e.g., e-rooms, websites, ftp-sites, and the ability to conduct meetings via the Internet. However, there is a cost in terms of funds and time for setting-up, and more importantly, managing these electronic tools. Consequently, when establishing a budget for implementing a regulatory process, the cost of providing an adequate mechanism for sharing information should be considered. In some cases, the stakeholders may be able to pool resources to share the burden, e.g., by having one stakeholder manage the information on their own server and providing access to the information through an e-room. But if trust is a critical concern where the issues are contentious, funding an independent organization to manage the information flow may be a wise use of funds.

Regulated Community	Regulators	Special Interests	Public
♦ Municipal Dischargers	♦ State Water Quality Agency	♦ Business and Industry Groups	♦ Schools/Civic Groups
♦ Industrial Dischargers	♦ State Wildlife Agency	♦ Watershed Basin Councils	♦ General Public
♦ Water Purveyors	♦ USEPA	♦ Stream Users	♦ Homeowners Associations
♦ Stormwater Dischargers	♦ USFWS	♦ Environmental Groups	♦ Private Non-Government Organizations (NGO)
♦ Agricultural Uses	♦ USBOR	♦ Recreational Interests	
	♦ USFS	♦ Homebuilders/ Construction	
	♦ USACE		
	♦ USBLM		

Figure 5-1
Key stakeholder groups.

5.3.4 Common Problems that Arise in Stakeholder Process

There are a number of common problems that can arise in any stakeholder-driven process. Having a facilitator and a written record of meetings and a decisionmaking process can help address some of these problems. The decision framework that uses these tools is outlined in Section 5.5. It is important that decisionmakers for each agency or interest group be at the table to avoid issues that can arise later in the execution of the project. Also getting all interest groups to the table will be important. Note that in the environmental arena oftentimes a single environmental group does not speak for all other environmental interests. Figure 5-2 illustrates an example of how a decisionmaking team interacts with the state agency.

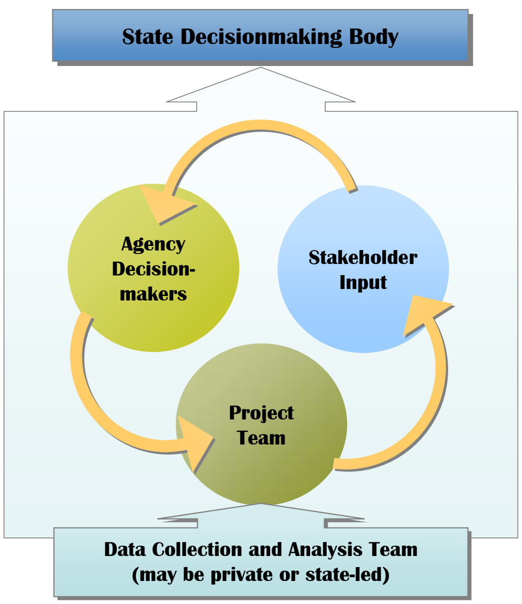


Figure 5-2
Integrated decisionmaking team.

Be aware that rarely will you achieve 100 percent consensus. Expect the unexpected. Decisionmakers want comfort that local, state, and federal regulators are on board, which will be the case if the stakeholder process is open.

5.4 Regulatory Approval

The goal of any regulatory process is a change in a regulation, whether it is a use designation or water quality criterion change, or how a water quality standard is implemented. One of the factors that should be understood before implementing a process to change a regulation is what the requirements are and who the key players are in the regulatory approval process. This information will help define who the key stakeholders are and make clear process deadlines, if time is an important factor driving the regulatory process.

5.4.1 State Approval

While similarities certainly exist in how a state goes about reviewing and approving proposed regulations, there can be important differences and subtle nuances to each state's process. Accordingly, it is critical that the state's regulatory process be fully understood.

Typically, a final regulatory decision is not up to the state water quality agency staff, but the responsibility of political appointees to a board or commission. While the position of the state staff regarding the proposed regulatory change carries significant weight with the decision body, the fact that the final regulatory decision is the responsibility of an appointed body, changes to or rejection of the regulatory proposal can still occur.

For regulatory proposals that are complex or may affect a large area, a state may rely on established multi-interest stakeholder groups to lead the development of the proposal. For example, in Colorado it is not unusual for regulatory proposals for basin scale or statewide changes to the water quality standards to be developed through Workgroups that are managed under the umbrella of the Colorado Water Quality Forum ("Forum") (www.cwqf.org). The Forum's membership is open to all stakeholders and includes water suppliers; municipal and industrial dischargers; environmental groups; and local, state, and federal regulatory agencies. Funded by the voluntary donations of its members, the Forum is facilitated by the University of Colorado at Denver Center for Public-Private Sector Cooperation. As a functioning body since 1992, the Forum has provided an important venue for developing regulations in a cooperative manner.

5.4.2 EPA Approval

Any change to a state's water quality standards or approval of a TMDL requires the approval of the federal EPA. Given this critical role, it is strongly recommended that EPA automatically be included as a stakeholder in the regulatory process. The extent of their participation may vary during the development of a regulatory proposal and will vary depending on the complexity of the issue.

Typically, EPA is unable to provide a formal response to a draft proposal, i.e., their function is to approve or disapprove formally submitted changes to a regulation—not a *proposed* change. However, their participation in the development of the proposal is valuable since EPA staff can be a good sounding board for understanding whether the approach being considered for making regulatory change is supported by EPA guidance and falls within the realm of an approvable approach.

5.4.3 USFWS Section 7 Consultation Process

The USFWS has a critical role in the regulatory approval process. Any water quality standards change is subject to an ESA Section 7 consultation. Once a formal proposal is submitted to EPA for approval, EPA is required to consult with USFWS to determine if any element of the proposed regulatory change could impact a threatened or endangered species. The evaluation of potential impact goes beyond the direct protection of aquatic species. USFWS is also concerned with the bioaccumulation of chemicals in the environment that may impact terrestrial species.

The consultation process typically involves the USFWS office within the state that developed the regulatory proposal. USFWS allows each state office to have considerable autonomy in how it conducts its review and decision process. Accordingly, it is important to include the USFWS as a stakeholder early in the regulatory process—particularly if the regulatory change involves an aquatic life use or a water quality criterion established to protect aquatic life.

5.5 Decision Framework

5.5.1 Overview

In order to facilitate decisionmaking as part of the stakeholder process, a decision framework is useful. Depending on the complexity and/or significance of the proposed project, it is strongly recommended that some type of decision framework be established at the beginning of the process. This framework becomes the "roadmap" for the project and provides an "if this, then that" structure. For example, "if the resident species are less sensitive to the pollutant, then a site-specific criterion would be acceptable," or, "if habitat is the limiting factor, then a subcategory of aquatic life use can be established."

5.5.2 Simple Decision Framework

The decision framework used in a particular project can be simple. However, at a minimum, even a simple decision framework should include a clearly stated objective (or objectives), possibly some sub-objectives, and clearly stated measures for how it will be determined if the objectives have been met. The results of the measures dictate the next steps in the project. For example, if it is shown that habitat limits the aquatic life potential of a waterbody, then a decision is made to go forward with the placement of the waterbody in an aquatic life subcategory, or if no such subcategory exists, then the decision is made to develop the subcategory.

5.5.3 Complex Decision Framework

General Approach

A complex decision framework may be necessary where the diversity of stakeholder interest is high and the potential for disagreement on the outcome is great. Complex decision frameworks are often used for water resource planning studies to develop appropriate alternatives to guide future development. These concepts can easily be transferred to the water quality standards regulatory process. The terminology associated with this type of approach is provided in Table 5-1.

Table 5-1 Terminology

Objective	The overarching interest(s) in the water quality standards - they define major goals of the waterbody in clear, understandable terms
Preferences	Stakeholder values, specifically the weights that they assign to each objective, relative to the other objectives
Performance Measures	Indicators of how well the objectives are being achieved
Options	The individual regulatory strategies that could be implemented to meet the objectives
Family of Options	A grouping of similar types of options
Alternatives	Combinations of options that appear to best meet the water quality standards objectives

The approach to developing a water quality strategy could be based on the use of options—individual solutions—as "building blocks" for waterbody alternatives. Alternatives can be developed using options that have the likelihood of being preferred by the stakeholders in a watershed, as described more specifically below. This approach consists of the following steps:

- Develop regulatory options based on stakeholder discussions
- Group options into families of options
- Evaluate families of options against objectives and sub-objectives using performance measures and stakeholder preferences
- Identify preferred families of options and use them (with specific options from those families as available/appropriate to the watershed) to construct alternatives that resolve the water quality standards concern

The options are evaluated against a set of performance measures developed by the project stakeholders. Stakeholder preferences (weights of importance assigned to each objective) are factored into the evaluation, as will be described in more detail below.

The unique aspect of this approach is that the preferences (or objective weights) for each stakeholder is maintained. This approach helps allow for the discovery of common ground through facilitated discussion, rather than a strictly numeric or "voting" approach (Keeney 1992), which can lead to discord because one or more stakeholder's views can be out-voted by the majority.

Quantitative scoring provides guidance to decisionmakers, but it is not intended to "make" the decision. Depending on the weights placed on the objectives, the quantitative comparison will differ from person to person and illuminate the tradeoffs associated with each option.

Figure 5-3 illustrates the overall evaluation framework described above. By deliberately first analyzing the objectives (the goal of the water quality standards project) separately from the options (specific solutions intended to meet the goal), participants are better able to draw out interests over positions, illustrate tradeoffs, and identify creative solutions that might otherwise not come forward.

The "why" portion outlines which aspects of water quality management are important to someone, as illustrated through the objectives. The "how" portion describes how one addresses a water quality management need—specific projects or ways in which the objectives could be accomplished.

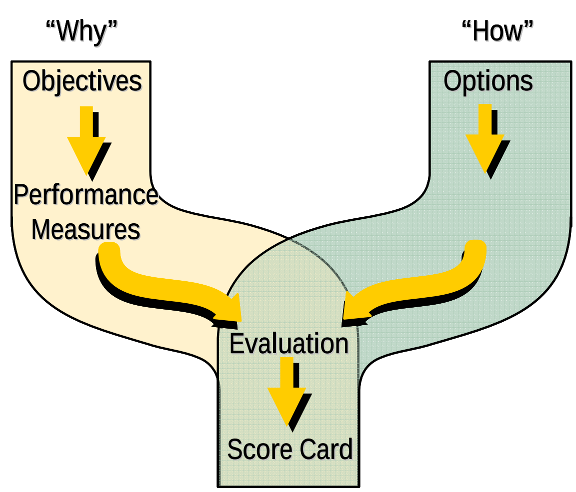


Figure 5-3
Evaluation "road map."

Defining Objectives and Performance Measures

The first step in developing the evaluation framework is to define the water quality standards objectives for stakeholders and the associated performance measures. These form the evaluation criteria that options and alternatives can be compared against. The initial list of objectives may be developed by a project team, but ultimately these objectives need to be subjected to stakeholder input.

Figure 5-4 illustrates a possible outcome for a water quality standards project involving a UAA. Each of the objectives has one or more sub-objectives that help further define the goal. Once the objectives are defined, performance measures are developed to indicate how well the objective and its sub-objectives are being achieved. These performance measures are used to score and rank the options before regulatory alternatives are built.

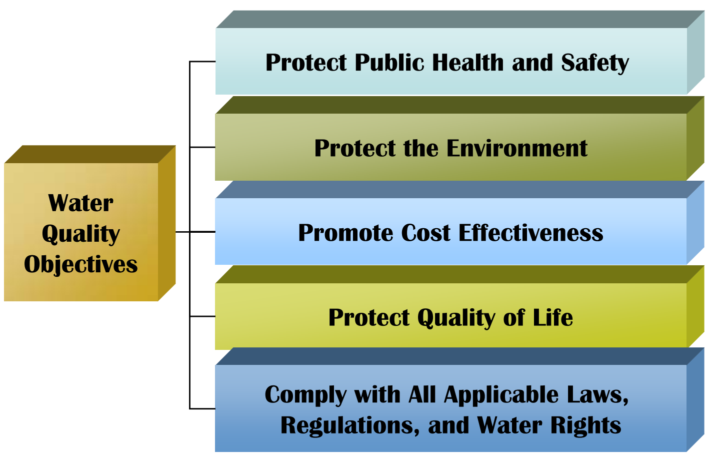


Figure 5-4
Water quality management objectives.

Objectives represent the reasons "why" the project is necessary. For example, the most common reason why a UAA is implemented is to bring the waterbody into attainment with water quality standards, i.e., to establish uses that are actually attainable. An objective associated with that could be to protect the environment for aquatic life uses. A site-specific criterion may be desired for a number of reasons all of which are typically related in some manner to bringing the waterbody into attainment with the water quality standards.

Often more than one objective can be identified as to why a project is needed. Moreover, the project objectives may not always be as simple as bringing the waterbody into attainment. This may be the regulatory objective, but the community that is involved in the decisionmaking process may have other objectives in mind. For example, in the case of a waterbody that cannot attain its water quality standards because of legacy mining, the immediate objective is to address the non-attainment of water quality standards. But stakeholders may have a more over-arching objective—cleaning up the legacy mining to support economic revitalization. It is by bringing in some of these community values that one can ensure success.

Situations may exist where the objectives conflict. Consider the situation where a site-specific criterion is desired by a wastewater facility so that its discharge does not cause a violation of an instream water quality standard. The community's stated objective may be quite different. It wants the wastewater facility to comply with the existing water quality, regardless of the cost. However, the cost to comply is ultimately borne by the community and these costs may be disagreeable. In these types of situations, which are very common, it may be helpful to establish objectives at a higher level. For example, in the above scenario, an over-arching objective may be to simply comply with a water quality standard at a reasonable cost to the community. The sub-objectives that would be established to support the objective would be to look for a balanced approach that may result in a combination of some treatment upgrade and some modification in the water quality standard.

For each project, once the objective, or "why," has been established, it is helpful to establish sub-objectives. These are tailored to the specific project. For example, the sub-objectives associated with a UAA may range from identifying the existing uses to identifying what uses are attainable. Sub-objectives may also include analyses of impacts if the discharge is reduced or eliminated.

Once the sub-objectives are developed for each project, performance measures should be developed. The performance measures will indicate when a particular sub-objective is being achieved. Performance measures may be qualitative or quantitative, but what is critical is that agreement is reached on what the outcome will be when the performance measure is achieved.

Individual Preferences

Stakeholder preferences are solicited to determine the range of values and interests associated with the project. To solicit preferences, each of the stakeholders is asked to complete a weighting exercise for the water quality standards objectives. An approach called Pair-Wise Comparison may be used for this effort.

In Pair-Wise Comparison, a person must indicate their preference between two objectives, compared to each other. For example, which objective is more important: (1) enhance recreational opportunities; or (2) protect cultural values? Stakeholders should be told that although both objectives might be important to them, they must choose which is more important. Each possible pair of objectives is put before each stakeholder. Individual results are maintained, but are kept anonymous to the other stakeholders. Clearly, for this process to work, it may be necessary to have an independent facilitator who is viewed as unbiased.

The Pair-Wise Comparison is not a voting process. Rather, it was used to identify and illustrate the values and preferences different stakeholders place on project goals and objectives. By exploring these different preferences, discovery of common ground or consensus is more likely. This helps move the process from "position-based" debates to "interest-based" dialogue, a key step if a complex regulatory issue is being addressed.

A position-based debate is one where stakeholders lay down positions, such as "the aquatic life use must be changed" or "a site-specific criterion is the only way to solve our compliance problem." Both of these positions can be intractable—often leading to stalemate. Any alternative that results in a change in an aquatic life use will often be viewed as downgrading water quality protection and seen as adversarial to some stakeholders.

An interest-based dialogue, in contrast to position-based debate, is where stakeholders identify their preferences (or interests) for well understood and accepted objectives. For example, the stakeholder whose position was "a site-specific criterion is the only way to solve our compliance problem" may have an interest to protect the environment (which is likely shared by many other stakeholders, but in varying degrees), it's just that some stakeholders may have different views of how to achieve the same interest.

Moving from positions to interests, and understanding how stakeholders value these interests, allows solutions to be identified that can achieve multiple interests. This is how consensus and common ground can be discovered.

Section 6
Water Quality Standards Implementation—Case Studies

Case Study Examples

This section provides case study examples of water quality standards program implementation. Some of the examples provided are not yet complete; however, the progress achieved in the effort to date warrants their inclusion as an example of how to proceed when addressing a water quality standards implementation issue.

Probably the most common element among case studies that have successfully achieved their purpose is the close cooperation and coordination that occurred among stakeholders. Regardless of whether the process to address the concern is initiated by a discharger or a regulatory agency, cooperation is essential because use and criteria modifications affect all users of the waterbody and must go through substantial public review and state and federal approval.

Rio de Flag Copper Site-Specific Criterion

Existing Situation

The City of Flagstaff is located in Coconino County in north central Arizona. High concentrations of copper in the influent to the WWTP occur from naturally elevated copper levels in groundwater that is the primary source for the city's drinking water. The city discharges treated effluent from two WWTPs (Wildcat Hill and Rio de Flag) into the Rio de Flag, an effluent-dependent stream.

Water Quality Standards Driver

The Wildcat Hill WWTP was issued a new permit in August of 1994 that incorporated water quality-based effluent limits for copper discharges based on the state's water quality standards. Historical monitoring data from both WWTPs indicated a potential for noncompliance with the NPDES permit. Flagstaff's goal was to find a solution that resulted in consistent compliance with the copper effluent limit without additional treatment or removal of effluent from the stream.

Approach to Resolve Problem

The city followed a step-wise approach to identify the best way to achieve the goal of consistent compliance. The various approaches that were considered, but ultimately rejected included: net environmental benefit methods, recalculation and resident species procedures, economic feasibility analyses, and even development of a TMDL to allocate loads between the facilities since differences in influent quality entering each facility differed. None of these potential approaches met the city's goal.

Rio de Flag

The approach that was ultimately successful was the development of a WER coupled with supporting data to provide a weight of evidence that demonstrated that elevated copper would not impact the designated uses of the receiving waters. Supporting data included a receiving water human health and ecological risk assessment and a TMDL based on a site-specific standard based on the findings of WER studies. The City of Flagstaff worked closely with EPA and ADEQ to develop the data necessary to resolve the issue. Key findings from laboratory and field studies included:

- WER Studies—Two WER studies were conducted to compare copper toxicity in the laboratory with toxicity in the receiving water. WERs observed in these studies ranged from 6.9 to 27, which indicated that the existing copper water quality criterion was over-protective.
- Receiving Water Assessment—Water quality, benthic macroinvertebrate, fish, and sediment samples were collected from the Rio de Flag. Macroinvertebrate diversity was equal to or better than what was observed in other Arizona effluent-dependent waters. Copper concentrations for fish and invertebrate tissue were similar to expectations for uncontaminated waters, indicating no bioaccumulation concerns. A correlation between sediment copper concentrations and water quality characteristics was observed, suggesting that copper is adsorbed by dissolved organic carbon and precipitated to the sediments.

- Human Health and Ecological Risk Assessment—A human health and ecological risk assessment was performed to evaluate the risks associated with a copper concentration of 36 μg/L, the proposed site-specific copper standard based on a conservative WER of 2, and associated calculated effluent limits for the two WWTPs of 46.7 μg/L and 20 μg/L.

Human health effects were considered negligible given that fish are not generally consumed from the stream and copper concentrations in fish were at background levels. Copper concentrations in the stream were below levels considered harmful to people who drink, swim, or wade in the stream. Finally, the ecological risk assessment analysis concluded that there is very little risk of copper toxicity to aquatic life.

Outcome

WER study results indicated that the water quality standard for the Rio de Flag could be increased 6.9 times without compromising the protection of sensitive aquatic species. However, the study showed that a change in the standard by a factor of 2 from 18 μg/L to 36 μg/L would be adequate to meet the goal of consistent permit compliance and still provide adequate protection to the receiving water. Ultimately, ADEQ adopted and EPA approved a site-specific copper standard of 36 μg/L for the Rio de Flag, from the Rio de Flag WWTP discharge to its downstream confluence with San Francisco Wash.

Case Study Recommendations

- Establish a clear goal or outcome that defines success.
- Coordinate with EPA and state when identifying an approach to achieve permit compliance.
- Consider using a variety of tools that develop a weight of evidence.
- Recognize that a simple WER may need to be supported by additional data to demonstrate that the risk of a revised standard is low.

Ambient-Based DO Water Quality Criteria

Existing Situation

Denver International Airport (DIA), located 23 miles northeast of downtown Denver, was built in 1995. DIA discharges stormwater to three intermittent waters (Second Creek, Third Creek, and Box Elder Creek) and two ephemeral waters (Barr Lake Tributary and Hayesmount Tributary). The aquatic life use established for all of these waterbodies is Warm Water Aquatic Life 2. This aquatic life use is applicable to surface waters that are not capable of sustaining a wide variety of warm water biota, including sensitive species, due to physical habitat, water flows or levels, or uncorrectable water quality conditions that result in substantial impairment of the abundance and diversity of species (Colorado Code of Regulation (CCR) 31.13(1)(c)(iii)) (see attached CD).

The applicable DO criterion to protect the aquatic life use in Warm Water Aquatic Life 2 waters is 5.0 mg/L (daily minimum). In addition, all of the receiving waters at this location are classified with an agriculture use, which in Colorado is protected by a minimum 3.0 mg/L DO criterion.

Water Quality Standards Driver

DIA seasonally uses chemicals for aircraft deicing to enhance air travel safety. DIA has a state-of-the-art aircraft deicing fluid (ADF) collection system and, according to the Colorado Water Quality Control Division (WQCD), has implemented all best practical, available, and economically achievable technology for the control of ADF. However, even with these systems in place, the open air application of deicing chemicals to aircraft creates a potential for migration of fugitive ADF to the storm sewer and thus to the local receiving waters. The propylene glycol-based ADF can exert an oxygen demand on receiving waters as it biodegrades.

Second Creek, near DIA

DIA developed stormwater management controls and implemented BMPs to reduce the potential for ADF to reach receiving waters. DIA expended more than $106 million on structural controls, and annual operation and maintenance activities cost an additional $2 million per year. Both EPA and the WQCD noted that DIA's stormwater management program resulted in a substantial reduction of fugitive ADF discharges. Complete recovery of the ADF used at DIA was found to be both economically impractical and technologically infeasible. Moreover, even with implementation of all practical BMPs, DO levels in local receiving waters did not meet state water quality standards.

Approach to Resolve Problem

Resolving the DO problem at DIA was undertaken in two steps: (1) understand the existing and attainable conditions in the receiving waters; and (2) based on the findings of (1) develop site-specific ambient-based DO standards.

Understanding Existing and Attainable Conditions

Working closely with EPA, WQCD, and the Colorado Division of Wildlife (CDOW), DIA implemented a Receiving Water Study to assess potential impacts of fugitive ADF on airport receiving waters, including potential effects on DO levels. Results of the physical, chemical, and biological sampling showed that DO concentrations regularly fall below the 5.0 mg/L water quality standard—*not only in waters receiving stormwater discharge, but also in a nearby reference stream that does not receive airport stormwater runoff.* Regardless of the observed low DO, the aquatic community was sustained when water was present.

In addition to the common finding of low DO, analysis of the field data demonstrated that habitat limitations were the primary factors restricting the aquatic community. This demonstration was made by using a tool developed by WERF: *Distinguishing the Relative Influence of Habitat and Water Quality on Aquatic Biota* (Project 98-WSM-1, 2001) (also see Section 3). Demonstrating that the existing aquatic community persisted even under low DO conditions and that habitat conditions were the primary factors limiting what was attainable in the aquatic community were the key steps that led to agreement among stakeholders that development of site-specific DO standards was appropriate.

Site-Specific Standards Development

Following a review of other potential approaches, e.g., recalculation procedure based on the most sensitive species, the stakeholder group agreed to develop site-specific criteria based on daytime ambient conditions. This approach was recommended in part because it could be demonstrated that based on the results of the field studies, the existing and attainable aquatic community was protected under ambient conditions.

Third Creek, near DIA

Pursuant to Colorado regulations (CCR 31.7, see attached CD), ambient quality based standards may be established where the natural or irreversible man-induced ambient water quality levels are higher than specific numeric levels contained in the water quality standards, but are determined adequate to protect classified uses. When adopting ambient quality based standards, the chronic standard shall be equal to the 85th percentile of the available representative data, and the acute standard shall be based on table values (established by rule) or site-specific criteria-based standards. An ambient chronic standard may not be more lenient than the acute standard.

Based on these requirements, the 15th percentile of the DO data was calculated using values recorded periodically for each waterbody over a 3-year period (Note: the 15th percentile was used rather than the 85th percentile since the DO standard is based on a minimum rather than a maximum value). The resulting criteria were 3.3, 4.0, and 4.7 mg/L for Second, Third, and Box Elder Creeks, respectively.

Outcome

EPA supports the use of ambient-based standards per Colorado's approach as long as adequate supporting evidence is provided. To aid the use of this approach, EPA Region 8 has provided guidance to the state that describes its expectations for demonstrating that ambient-based water quality standards should be adopted (EPA Letter to Colorado WQCC regarding revisions to the water quality standards in the Arkansas River Basin, see text box and attached CD).

For the DIA receiving waters, a proposal to adopt ambient-based DO criteria was approved by the Colorado WQCC on September 13, 2004. EPA Region 8 subsequently approved the adopted criteria on January 20, 2005 (see EPA approval letter and justification on CD). In their approval letter, EPA identified the following three important factors that formed the basis for their approval of the site-specific criteria:

- Evidence was presented that the statewide table value for DO (5 mg/L) is not attainable in the receiving waters. Data from the analyses demonstrated that the DO value was exceeded due to natural conditions—no flow or ponded water conditions rather than to the presence of ADF.
- Analysis of the biological and physical habitat data indicated that habitat and flow conditions were more limiting to aquatic life than were water quality conditions.
- Demonstration that fugitive releases of deicing chemicals can reasonably be viewed as irreversible at this time. The water pollution controls in place at the airport are exemplary, when compared to other large airports nationally.

Case Study Recommendations

- Demonstrate the need for a site-specific standard before approaching its development.
- Determine what the limiting factors are, especially the role of habitat in establishing what kind of aquatic community is attainable.
- Involve stakeholders early in the process as their input is critical.
- Use the appropriate tools for analysis, but only after agreement is reached among stakeholders on how these tools will be used.

EPA Recommendations to the Colorado WQCC for Demonstrating the Validity of Establishing an Ambient-Based Water Quality Criterion
(EPA Letter to WQCC regarding Revisions to the Water Quality Standards in the Arkansas River Basin)

If the basis is natural sources:

- What is the basis for concluding that there are no non-trivial anthropogenic sources?
- What modeling and/or field studies have been completed to quantify the "natural" water quality level, how were the studies designed, and what were the results and conclusions?

If the basis is irreversible human-induced sources:

- Has an engineering analysis of the best available treatment or control technologies been completed?
- Have all feasible steps to remedy the problem been taken?
- What are the costs of the various control options?
- What are the funding options?
- What economic threshold was applied in concluding that the costs of source control render the source "irreversible"?
- What studies were conducted to derive an appropriate standard, how were the studies designed, and what were the results and conclusions?
- If existing quality is attributable to a combination of natural/irreversible and reversible sources:
  - What is the basis for concluding that temporary modifications are not the appropriate mechanism to promote water quality improvement?
  - How was the natural/irreversible concentration estimated (see questions above) and how was uncertainty addressed in developing the estimate?

For all ambient-based standards:

- What is the attainable or "target" biological community (e.g., to confirm that the designated use is appropriate and to further define the aquatic life protection goal)?
- What methods were utilized in completing the analysis of the available ambient data and for determining acceptable quality and quantity of data?
- Were "clean" techniques used where appropriate in measuring existing concentrations of metals?
- What statistical method was used to characterize water quality levels as a basis for setting a numeric standard (e.g., the 85th percentile, the median, the 15th percentile, etc.)?

Site-Specific DO Water Quality Criteria

Existing Situation

Metro Wastewater Reclamation District (MWRD) has discharged treated effluent to Segment 15 of the South Platte River in Colorado since 1966. Generally located north of the Denver metropolitan area in Adams and Weld Counties, Segment 15 is a 26-mile river reach from the Burlington Ditch headgate to the South Platte River/Big Dry Creek confluence near Fort Lupton. The effluent discharge creates an effluent-dominated waterbody.

Water Quality Standards Driver

To protect aquatic life uses, the state had established a DO water quality standard of 5.0 mg/L for May 1st to July 31st (spawning season) and 4.5 mg/L for the remainder of the year (instantaneous). However, low DO concentrations were occasionally measured in pools in Segment 15 during the late summer and early fall seasons. Concerns regarding the lack of attainment of the DO dissolved standards led to a presumption that the level of wastewater treatment for the discharge that dominated the flow in the reach was insufficient to attain the instream standard.

Approach to Resolve Problem

Studies showed that the river segment supported a diverse and abundant warmwater aquatic community even though the DO standard was not attained. Accordingly, scientific studies were implemented to develop an appropriate site-specific DO standard. The South Platte River studies were conducted in two parts:

- Field studies to evaluate the relationship between fish communities and DO characteristics under field conditions
- Laboratory studies to evaluate the DO requirements of seven resident fish species

South Platte River downstream of Denver, Colorado metropolitan area.

Outcome

The results from the field studies led to the following general findings regarding the relationship between fish species and DO concentrations in Segment 15 (Camp Dresser & McKee Inc. [CDM] et al. 1994a,b,c):

- Although low DO concentrations were measured in pools, more species were consistently collected there than in other habitats. These data are consistent with the hypothesis that there is no relationship between DO levels and fish abundance or species richness in the habitats sampled. There was no evidence that DO levels below the current standard were related to reduced fish abundance or species richness. These data and the analysis suggested, but did not prove, that a lower site-specific DO standard could be set on Segment 15 of the South Platte River without having an adverse effect on fish populations.

- Habitat quality was found to remain low to moderate for all fish species evaluated, suggesting that habitat quality, not DO, was an important driver affecting fish species richness and abundance.

- Laboratory studies evaluated acute and chronic effects to seven fish species. Of all species tested, the least sensitive species to low DO was fathead minnow; the most sensitive species was Johnny darter.

Based on these findings, the laboratory results for Johnny darter were used as the basis for establishing site-specific DO standards. In 1987, the Colorado WQCC adopted the following DO criteria for South Platte River Segment 15 (CCR 38, see attached CD):

Early Life Stage Protection Period (April 1 through July 31)	
1-Day[1,5,6]	3.0 mg/L (acute)
7-Day Average[1,2,4]	5.0 mg/L
Older Life Stage Protection Period (August 1 through March 31)	
1-Day[1,5]	2.0 mg/L (acute)
7-Day Mean of Minimums[1,3]	2.5 mg/L
30-Day Average[1,2]	4.5 mg/L

(See CCR 38 on attached CD for footnotes)

South Platte River downstream of Denver, Colorado metropolitan area.

To support the implementation of the above site-specific standards and ensure that an adequate margin of safety was established, MWRD entered into a Memorandum of Understanding with the WQCD, CDOW, and EPA Region 8 to construct several instream reaeration structures and conduct additional studies to evaluate alternatives for habitat improvements. The findings from these studies have led to the development of recommended habitat improvement alternatives for a reach (Segment 15) of the South Platte River.

Case Study Recommendations

- Evaluate the importance of habitat as a limiting factor for aquatic community expectations.

- It may be necessary to generate resident species data to support site-specific standard development; however, given the substantial cost associated with these studies, it is critical to work closely with the regulatory agencies early in the process before expending resources.

Establishment of a Variance

Existing Situation

A textile facility in rural Georgia was discharging to a waterbody with both ephemeral and intermittent reaches. The 7Q10 of the receiving water was zero; consequently, no dilution was available and the permit required that all effluent limits be met at the "end-of-pipe." While this example is from a facility located in the eastern United States, the problem with no dilution is a common problem in the arid west.

Water Quality Standards Driver

The permit issued to the textile facility to comply with water quality standards required WET chronic toxicity testing. The facility experienced frequent failures of the chronic WET tests. Evaluation of the data showed that elevated salinity was the cause of the failures.

Approach to Resolve Water Quality Concern

Extensive engineering analysis identified several alternatives to restore compliance: (1) build a pipeline to move the outfall to a location with greater dilution in the receiving water; (2) desalinate the effluent with reverse osmosis; and (3) shift certain operations to other manufacturing facilities.

All of these options were extraordinarily costly and, in the end, would result in no discharge to the receiving water, effectively drying up the stream that the effluent limitations were designed to protect. Given this outcome, developing site-specific water quality standards for the effluent-dependent stream was suggested as a fourth alternative. That approach required the facility to perform a UAA to demonstrate protection of designated uses.

Outcome

The UAA demonstrated that:

- There was no acute toxicity caused by the effluent; only chronic toxicity (e.g., growth or reproduction effects) was evident. The chronic toxicity effects were entirely attributable to ionic interference caused by elevated salinity levels in the effluent. Other pollutants (e.g., trace metals, organics, chlorine, and ammonia) were neither causing nor contributing to the chronic toxicity observed in the effluent.
- The manufacturing facility was already operating a state-of-the-art WWTP. The production processes were reengineered to minimize the use of chemicals that might increase effluent salinity, but no additional improvements in influent quality were likely without severely compromising product quality and market competitiveness. These conclusions were confirmed in a site visit by EPA's engineering staff who submitted a written report affirming the use of "best available technology (BAT)."
- There was no cost-effective treatment strategy available to desalinate the effluent to non-toxic levels for discharge to a stream with zero dilution. Distillation or reverse osmosis would be required, but no environmentally-acceptable means existed to dispose of the brine. Zero discharge was the only alternative that would assure full compliance; however, no zero discharge disposal options (e.g., evaporation, ground injection, etc.) were available. In addition,
  - The only way to eliminate all discharges would be to cease manufacturing operations entirely. Ceasing operations would cause "widespread and substantial adverse social and economic impact in the region" because the manufacturing plant was, by far, the largest single employer in the small, rural community.

- The receiving stream was an effluent-dependent waterbody. Eliminating the discharge would eliminate at least 2 miles of aquatic habitat. Thus, zero discharge would do more environmental harm to eliminate the pollution than to leave it in place. In addition, biological evidence showed that better water quality was unlikely to produce any significant increase in the richness and/or abundance of aquatic organisms due to natural habitat limitations below the discharge point. Whatever existing uses occurred in the receiving water arose as a direct result of the effluent discharge. Therefore, it was concluded that existing ambient quality protects existing uses.

Rather than adopting a site-specific water quality standard, the original goal of the UAA study, the State of Georgia, and EPA Region 4 relied on results from the UAA to approve a temporary variance, which exempted the discharge from compliance with the narrative toxicity standards (which provided the basis for the WET testing) for a period of 3 years. The basis for the variance was consistent with the requirement that the cause of non-attainment was related to at least one of the six UAA factors defined at 40 CFR 131.10(g). The discharger is still required to apply BAT in order to ensure that water quality does not become worse.

By definition, such variances are intended to be temporary. Therefore, the discharger is required to make continuous progress toward eventual compliance with the applicable water quality standards. To accomplish this, the plant operator must continuously evaluate new and existing technologies in search of a more cost-effective treatment solution. State and federal regulators must also review and reauthorize the variance every 3 years during the normal triennial review process.

Case Study Recommendations

- Variances are criteria-specific and site-specific; accordingly, adoption of a variance can provide an alternative to downgrading or removing a use, either of which may impact a number of critteria and a more extensive reach of the waterbody
- Consider the use of a variance to provide time to conduct the necessary studies to resolve regulatory questions

Use of a Water Effect Ratio to Support NPDES Permit Effluent Limits

Existing Situation

The federal California Toxics Rule was promulgated by EPA on May 18, 2000 to fill a gap in California water quality standards that was created in 1994 when a state court overturned the state's water quality control plans that contained water quality criteria for priority toxic pollutants. The final rule included the following provision (see CD for California Toxics Rule):

"In accordance with the WER guidance [*Interim Guidance on the Determination and Use of the Water-Effect Ratios for Metals* (EPA 823-B–94–001)] and where application of the WER is deemed appropriate, EPA strongly encourages the application of the WER on a watershed or water body basis as part of a water quality criteria in California as opposed to the application on a discharger-by-discharger basis through individual NPDES permits. This approach is technically sound and an efficient use of resources. However, discharger specific WERs for individual NPDES permit limits are possible and potentially efficient where the NPDES discharger is the only point source discharger to a specific water body.

"The rule requires a default WER value of 1.0, which will be assumed if no site-specific WER is determined. To use a WER other than the default of 1.0, the rule requires that the WER must be determined as set forth in EPA's WER guidance or by another scientifically defensible method that has been adopted by the state as part of its water quality standards program and approved by EPA."

Water Quality Standards Driver

The federal regulation allowed the use of a WER in the permit process. However, the State Implementation Plan (SIP), which guides water quality standards implementation in California, stated that regardless of allowances contained in the federal rule, if a WER was used as part of the basis for establishing a permit effluent limitation, the state still had to do a Basin Plan amendment to use the WER. In effect, the state was treating the use of a WER in the same manner as it would treat the establishment of a site-specific criterion. Because Basin Plan amendments were time and resource intensive and required a significant public process, WERs are not commonly used in California—even if their use was scientifically defensible.

Approach to Resolve Problem

To address this disconnect between the federal regulation and state requirements, the SWRCB initiated revisions to the SIP that included the option to issue an NPDES permit with an effluent limitation based on a WER without requiring a Basin Plan amendment.

Outcome

Revisions to the SIP were finalized on February 24, 2005. The approved revisions allow WERs to be established in individual NPDES permits, rather than in the Basin Plan Amendment process as previously required. WERs shall be established in accordance with EPA guidance—*Interim Guidance on Determination and Use of Water Effect Ratios for Metals* (EPA 1994b) or *Streamlined Water-Effect Ratio Procedure for Discharges of Copper* (EPA 2001).

Case Study Recommendations

♦ If your state does not allow a WER to be adopted under the NPDES permit development process, then work with your state regulatory agency to update its regulations

Suspension of Recreational Uses during High Flow Events

Existing Situation

Southern California's dry climate and concentrated wet season naturally results in intense runoff conditions during storm events. Streams experience dramatic increases in flows during and immediately following significant rain events. In order to address these conditions, engineered urban flood control channels are designed to reduce flooding by conveying stormwater runoff to the ocean or other discharge location as efficiently as possible. Natural runoff conditions coupled with the characteristics of engineered channels result in unsafe flow velocities and volumes for recreating.

Los Angeles and Ventura counties addressed these dangerous flow conditions by preventing public access to the channels. Los Angeles County locks the access gate channels on days when rainfall exceeds ½-inch and keeps the gates locked for 24 hours following the event. Ventura County keeps access gates permanently locked.

Water Quality Standards Driver

All waters under the jurisdiction of the CWA are presumed to be suitable for swimming and accordingly must have appropriate uses and criteria adopted to protect this activity. Where swimming is not an attainable use, a UAA is required to demonstrate this finding. The Water Quality Control Plan for the Coastal Watershed of Los Angeles and Ventura Counties (Basin Plan), administered by the Los Angeles RWQCB, addresses this requirement by designating all inland waterbodies, including engineered channels, with an existing, potential, or intermittent Water Contact Recreation (REC-1) use. In 2001, the RWQCB adopted revised bacteria water quality criteria applicable to waters designated with a REC-1 use.

During its review of RWQCB's revised bacteria criteria, California's SWRCB directed RWQCB to review its REC-1 beneficial use designations as they currently applied in freshwaters during wet weather runoff events, specifically those freshwaters to which public entry is prohibited for health and safety reasons through no trespassing postings and fencing (Note: Such waters are engineered channels).

Vertical-walled, concrete-lined reach of the Arroyo Seco in Los Angeles area during dry weather (left) and wet weather (right) (Photographs: Kathleen Bullard).

Approach to Resolve Problem

EPA's *Draft Implementation Guidance for Ambient Water Quality Criteria for Bacteria* (2002) stated it was appropriate to establish "exceptions for high-flow events" based on a flow statistic or number of exceedances allowed. To apply such an exception to a waterbody required a UAA.

> *Engineered Channels* – for inland waters defined as "flowing surface water bodies with a box, V-shaped, or trapezoidal configuration that have been lined on the sides and/or bottom with concrete" (Los Angeles Regional Water Quality Control Board).
>
> *REC-1 Water Contact Recreation* – Uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible (Basin Plan).

The RWQCB conducted such a UAA to review the use designations in engineered flood control channels during storm events. The results indicated that "swiftwater" conditions following a significant precipitation event are unsafe for REC-1 use activity and consequently, recreational uses are not attainable during and immediately following significant storm events. Important factors leading to this finding included (1) public entry is prohibited for health and safety reasons through no trespassing postings and fencing, and (2) the inherent danger of recreating in these channels during stormwater runoff events is widely recognized.

The UAA recommended that the high-flow suspension apply to selected engineered channels on days with rainfall greater than or equal to ½-inch and the 24 hours following the end of the ½-inch or greater rain event, as measured at the nearest local rain gauge, using local Doppler radar, or using widely accepted rainfall estimation methods.

Outcome

In 2003, an amendment to the Basin Plan was proposed to temporarily suspend the REC-1 use and incidental contact (regulated under the REC-2 use) in specific engineered channels that are considered unsafe in high-flow conditions (see CD for Basin Plan amendment and high flow suspension criteria). The proposed amendment was approved by the RWQCB, SWRCB, and, following review by the State Office of Administrative Law, submitted to EPA for review.

In its August 12, 2004 approval letter, EPA concluded that the "categorical suspension of recreational use(s) during and immediately following defined storm events for inland, flowing engineered channels where access is restricted or prohibited is a practical approach and does not reduce public health protection in these channels since the recreational use(s) do not exist under the proposed conditions for the suspension" (see CD for EPA Approval Letter).

Case Study Recommendations

- When working with recreational uses, clearly distinguish what constitutes the existing use.
- Focus the UAA on the appropriate measure of use attainment, e.g., the physical attributes of the channel.
- Establish specific conditions to which the suspension applies so that it is clear when and where the suspension applies.
- Suspending a use is a viable alternative to removing a use.

Refinement of Recreational Uses

Existing Situation

All waters under the jurisdiction of the CWA are presumed to be suitable for swimming and accordingly must have appropriate uses and criteria adopted to protect this activity. The Water Quality Control Plan for the Coastal Watershed of Los Angeles and Ventura Counties (Basin Plan), administered by the Los Angeles RWQCB, addresses this requirement by designating all inland waterbodies with an existing, potential, or intermittent Water Contact Recreation (REC-1) use and Non-Contact Water Recreation use (REC-2).

Ballona Creek, which drains to Santa Monica Bay in the Los Angeles area, has a highly urbanized watershed with only 17 percent open space; mostly in the uppermost part of the watershed. Because of the high population density in the area, the Ballona Creek Channel has been highly modified into an engineered concrete lined channel. The Basin Plan designated portions of the channel with potential REC-1 and REC-2 beneficial uses. The attainability of the REC-1 use designation was questioned.

Reach 1 of Ballona Creek from Hauser Avenue Overpass, south of Venice Boulevard.

Water Quality Standards Driver

Ballona Creek is divided into three reaches in the Basin Plan (see table below). Bacteria levels often exceeded the established REC-1 criteria, and the waterbody was considered impaired for pathogens. In 2006, a bacteria TMDL for Ballona Creek was adapted by the RWQCB and approved by the SWRCB.

The primary water quality standards driver were concerns regarding the applicability of pathogen criteria (bacteria) to protect swimming in a waterbody where it was believed that such REC-1 activity was not attainable.

Recreational Uses Designated for Ballona Creek Prior to UAA

Reach	Description	REC-1	REC-2
Reach 1 – "Ballona Creek"	2-mile upstream reach (Cochran Ave. to National Blvd.); concrete box channel with 20-foot high vertical walls; public access restricted by fencing and locked gates.	Potential	Existing
Reach 2 – "Ballona Creek to Estuary"	4-mile reach (National Blvd. to Centinela Ave.); public access generally restricted by fencing, but two points exist where direct access to the waterbody is possible; bike path, which is separated from the channel by a fence, parallels Ballona Creek.	Potential	Existing
Ballona Creek Estuary	3.5-mile reach (Centinela Ave. to the ocean); public access not restricted; bike path parallels the reach; estuary is used for kayaking and rowing.	Existing	Existing

Approach to Resolve Problem

The recreational use designations for Ballona Creek were evaluated through the development of a UAA (see CD for draft UAA). Data were collected to evaluate existing REC-1 activity and the hydrology and water quality of the waterbody. Gathered data included:

Reach 2 of Ballona Creek south of Duquesne Avenue.

- Water level and flow data.
- Water quality data.
- Recreational use surveys distributed to bike path users.
- E-mail surveys of Ballona Creek Watershed Task Force participants.
- Records and photos gathered during seven site visits.
- UCLA Marine Aquatic Center (near Ballona Creek) staff interviews.

Results of the UAA indicated that:

- All reaches meet the REC-2 designation.
- REC-1 is applicable to the Ballona Creek Estuary, given the lack of a restrictive fence and kayaking and rowing activities.
- Incompatible water levels and restrictive fencing preclude support of a REC-1 designation for Reach 2; instead, it was recommended that this reach be protected for Limited REC-1.
- Very limited access to Reach 1 precludes contact recreation. Accordingly, it was recommended that the REC-1 use be removed from this reach.

Outcome

The recommendations contained in the Ballona Creek UAA were submitted to the RWQCB for approval. On June 15, 2003, the RWQCB rejected the findings of the UAA and a proposed amendment to the Basin Plan. Los Angeles County and the Los Angeles County Flood Control District later petitioned the SWRCB (the state agency that has oversight over the RWQCB) to review the decision. The SWRCB voted on January 20, 2005 to reverse the RWQCB's Ballona Creek decision, concluding that the recommendations contained within the UAA are consistent with federal water quality standards regulations and should be adopted by the RWQCB (see CD for SWRCB Resolution). In 2006, the EPA approved the revised use designations for Ballona Creek (see CD for EPA approval letter).

Ballona Creek near Ballona Creek Estuary.

REC-1 Water Contact Recreation – Uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible (Basin Plan).

REC-2 Non-Contact Water Recreation – Uses of water for recreational activities involving proximity to water, but not normally involving body contact with water, where ingestion of water is reasonably possible (Basin Plan).

LREC-1 – "Uses of water for recreational activities involving body contact with water where full REC-1 use is limited by physical conditions such as very shallow water depth and restricted access; as a result, ingestion of water is incidental and infrequent."

Case Study Recommendations

- When working with recreational uses, separating existing from potential uses is an important step.
- Focus the UAA on the appropriate measure of use attainment, e.g., the physical attributes of the channel.
- Ensure that a sufficient amount of data is provided to justify the change; recognize that the data needs will vary from one UAA to another.

Subcategorization of Aquatic Life Uses

Existing Situation

Prior to 1987, Arizona had established two subcategories of aquatic life uses: coldwater fishery and warmwater fishery. Arizona initiated a routine triennial review of water quality standards in 1987. The timing of this triennial review coincided with significant changes in the water quality standards program at the federal level, specifically the expectation that states adopt criteria for priority pollutants.

Water Quality Standards Driver

The 1987 amendments to the CWA required states to adopt water quality criteria for 126 priority pollutants based on federal guidance. The implications of this amendment on aquatic life criteria became apparent during the ongoing Arizona triennial review when EPA began preparing its National Toxics Rule (final rule - 57 Federal Register 60848, December 22, 1992), and notified Arizona that it would be subject to the regulations unless Arizona completed its development of water quality criteria prior to the 1992 publication date for the regulation. With the National Toxics Rule serving as the primary driver, stakeholders worked closely with the state and EPA to not only establish appropriate aquatic life subcategories, but also use-specific water quality criteria.

Channel carrying treated effluent from City of Phoenix 91st Avenue WWTF to Salt River.

Approach to Resolve Problem

The process to subcategorize aquatic life uses and develop use-specific criteria began in 1989 or 1990 and was not completed until 1992. This effort required close coordination among stakeholders, ADEQ, and EPA. Early in the process there was agreement that four subcategories were needed: retention of the two existing subcategories, coldwater and warmwater, and addition of two new subcategories—effluent-dominated, which are designated by rule and ephemeral, which were defined as waters that have a channel that is at all times above the water table, that flows only in direct response to precipitation, and that does not support a self-sustaining fish population.

> *Aquatic and wildlife (cold water fishery)* – Waters used by animals, plants, or other organisms, including salmonids, for habitation, growth, or propagation.
>
> *Aquatic and wildlife (warm water fishery)* – Waters used by animals, plants, or other organisms, excluding salmonids, for habitation, growth, or propagation.
>
> *Aquatic and wildlife (effluent dominated water)* – Use of an effluent dominated water by animals, plants, or other organisms for habitation, growth, or propagation.
>
> *Aquatic and wildlife (ephemeral)* – Use of an effluent dominated water by animals, plants, or other organisms for habitation, growth, or propagation.

With agreement reached on subcategories and definitions, the next key step was the establishment of applicable water quality criteria. Following is a brief summary of how these criteria were generally developed for the 1992-adopted water quality standards (Note: these are general summaries; there were a few notable differences for specific pollutants, e.g., chlorine and selenium; however, the differences typically resulted in the establishment of criteria more stringent than EPA's national recommendations):

- Coldwater—the state used EPA's nationally recommended criteria with no modification.

- Warmwater—the state modified the aquatic species list used for each federally-recommended criterion by removing coldwater fish, primarily trout and salmon. The criteria were then recalculated using EPA guidelines (Stephan et. al 1985).

- Effluent-Dominated—the state conducted biological surveys of effluent-dominated waters and established a statewide aquatic species list for these waters. The federally-recommended criteria were recalculated using this revised aquatic species list. No attempt was made to prepare site-specific criteria for each effluent-dominated water even though significant differences existed among these waters in their resident aquatic communities. For example, most effluent-dominated waters had (and still have) no fish species. However, rather than calculate criteria for each waterbody separately, the statewide list, which included a number of fish species, was used.

- Ephemeral—the state prepared a species list for ephemeral waters based on best professional judgment and public/scientific review. This list was used to recalculate the federally-recommended criteria. Because the number of species was limited, the recalculation was based on the single most sensitive species—a methodology allowed by EPA's Recalculation Procedure guidelines (EPA 1994b).

Effluent-dependent Santa Cruz River downstream of Rio Rico, Arizona.

Obtaining approval of the aquatic life subcategories and their associated recalculated criteria required close cooperation with EPA. Of particular interest was whether or not UAAs were required to establish the aquatic life subcategories. The written record shows that no formal UAAs were prepared, even though Arizona was establishing uses with less stringent criteria [40 CFR 131.10(j)(2)]. On the other hand, EPA did consult with the state and federal wildlife agencies (Arizona Department of Game and Fish and USFWS). Both of these agencies indicated to EPA that the modified species lists used for the effluent-dominated and ephemeral waters were adequate to demonstrate protection of these types of waterbodies.

Outcome

As noted above, Arizona formally established its four aquatic life subcategories in 1992. Since then, several modifications have occurred (see CD for Arizona Water Quality Standards regulations):

- The aquatic life subcategory "effluent-dominated" has been renamed "effluent-dependent" and the definition has been modified to clarify that this subcategory is only applicable to surface waters that would be ephemeral without the discharge of effluent.

- Definitions for the cold and warmwater subcategories have been refined to establish a relationship between temperature and elevation.

- Definition for ephemeral has been refined to remove the biological reference to a "self-sustaining fish population." The definition is now solely hydrology-based.

- The ephemeral criteria were modified in 2003 to remove the chronic criteria [see Case Study in this section].

Case Study Recommendations

- Stakeholder support is critical to creating subcategories of designated uses that affect the entire state.
- Having the right data in the form of appropriate species lists was critical for making blanket designations for waterbody classes, e.g., effluent-dependent or ephemeral.
- Consideration of exposure factors was important to developing criteria for ephemeral streams, where water was only present for brief periods of time.

Aquatic Life Use Attainability under Low-Flow Conditions

Existing Situation

Wyoming Class 4 waters are those waters where it has been determined that aquatic life uses are not attainable. Three Class 4 subcategories have been established based on different types of waterbodies (see attached CD for Wyoming Water Quality Standards regulations):

- ♦ Class 4A applies to artificial canals and ditches
- ♦ Class 4B applies to intermittent and ephemeral stream channels
- ♦ Class 4C currently applies to effluent-dominated streams, but is under revision so that it will only apply to isolated waters, particularly off-channel effluent-dependent ponds (see attached CD for proposed revision)

Water Quality Standards Driver

Prior to the June 2001 revisions to Wyoming's water quality standards, Coal Draw was designated as a Class 4 water. The 2001 revisions included a stipulation that all existing Class 4 waters would be reclassified as Class 3 waters unless a UAA was approved that contained defensible reasons for not protecting aquatic life uses. As a result of this action, Wyoming DEQ was required to develop UAAs to justify the classification of any waterbody as a Class 4 water.

Approach to Resolve Problem

The Wyoming DEQ submitted a UAA to EPA proposing to reclassify the North Fork of Coal Draw and unnamed tributaries upstream of the Gebo Oil Field discharge from Class 3B to Class 4B. This change would effectively remove the application of aquatic life criteria. The basis for the UAA was the following UAA factor:

> Natural, ephemeral, intermittent, or low-flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for by the discharge of sufficient volume of effluent discharges without violating state water conservation requirements to enable uses to be met (WY Sect 33(b)(ii) – equivalent to 40 CFR 131.10(g)(2)).

Ephemeral channels in Wyoming.

Outcome

Based on the UAA, EPA supported the revised classification. This approval was based on the following key points (EPA Letter to Wyoming DEQ, March 5, 2005; see attached CD):

- Waterbodies are ephemeral with little or no wetland development along their entire channel length, indicating that surface water is present for only brief periods during the growing season.
- There are no existing, regulated discharges to the waterbodies.
- The UAA demonstrates that there is no existing occurrence of an aquatic life use consistent with Section 4(c)(ii) of Wyoming's water quality standards and that the natural, ephemeral flow conditions, unaltered by regulated discharges, prevent attainment of the aquatic life use.
- The UAA satisfies the requirements of EPA's water quality standards regulations.

In the EPA's approval letter, a detailed explanation is provided regarding the basis for the EPA's decision to uphold the findings of the UAA and support removal of the aquatic life use (EPA Letter to Wyoming DEQ, March 5, 2003, see attached CD):

> "Low flow, intermittent and ephemeral waters all sustain some level of aquatic life. And, within the range of low flow habitat types, aquatic communities form a continuum, making it difficult, in the biological sense, to identify the threshold where an aquatic life use begins. Nevertheless, the federal regulation contemplates that there are situations where low flow conditions prevent the attainment of an aquatic life use and that the existence of certain low flow conditions may be an acceptable basis for removing or not designating an aquatic life use…Because aquatic communities under various low flow conditions form a continuum, using biological information alone, to resolve the "threshold" question is difficult. Historically, therefore, the Region has addressed this issue by apply a hydrologic threshold rather than a biological one…Until there is more complete guidance [reference to questions contained in July 7, 1998 Advanced Notice of Proposed Rulemaking] on this topic [circumstances under which a UAA may be used to justify a non-aquatic life use], the Region will continue to use the hydrologic "ephemeral waters" threshold, with a provision for protection of ecological important ephemeral waters, as the flow condition that is judged to be sufficiently limiting to prevent attainment of an aquatic life use."

This last statement, "provision for protection of ecological important ephemeral waters," is significant. Wyoming has established sufficient subcategorization of its waters that waters with potentially important wetlands habitat, that would otherwise be considered ephemeral, are protected by a separate aquatic life use category (Class 3B). Waters in Class 3B have criteria protective of aquatic life applied to them.

Case Study Recommendations

- Establishment of sufficient levels of subcategorization is a critical success factor—it helps EPA clearly understand where uses and criteria should and should not be applied.

Temporary Modification of a Water Quality Standard

Existing Situation

Throughout the arid west, legacy mining is a common cause of impairment in surface waters. The surface waters receiving discharge from these mining areas, e.g., from mine adits, often have metals criteria exceeded. As a result, one or more water quality criteria cannot be complied with, often for a lengthy period of time.

Water Quality Standards Driver

Where a pollutant source, e.g., legacy mining, impacts a surface water, the designated use is often correct. However, certain water quality standards are not being achieved either because pollutant sources have yet to be mitigated, site-specific criteria are warranted, or a combination of both (e.g., for some of these waters, development of a site-specific WER may address the exceedance). In many states, when this situation occurs the waterbody is simply placed on the impaired waters or 303(d) list. However, it can be argued that when the cause of impairment is known, but the impairment cannot be addressed because of the extent of the problem, unknown responsible parties, and/or lack of resources, placing the waterbody on an impaired waters list for TMDL development does not facilitate achieving compliance.

Approach to Resolve Problem

A temporary modification of a water quality standard can be a useful mechanism for addressing the types of water quality concerns described above. Per Colorado's water quality regulations CCR 31.7(3), a temporary modification of a water quality standard may be established under certain conditions (see attached CD for full text of the regulation). A temporary modification may be granted to an entire waterbody or any portion of the waterbody. Temporary modifications are adopted by rule, require a full public hearing process, and are subject to EPA approval. Approved temporary modifications are reviewed at least once every 3 years and may not be established for longer than a 20-year period. Acceptable conditions for granting a temporary modification include:

- Human-induced conditions deemed correctable within a 20-year period, such as:
  - Nonpoint source pollution that cannot be currently controlled using BMPs or point source pollution that cannot be controlled using techniques required by the state and federal acts but where adequate strategies may become feasible.
  - Existing dams or other hydrological modifications that may be removed or operated in such a manner as to satisfy the standards.
  - Deposition of instream toxicants due to past human point or nonpoint source activities that could be removed by natural processes or by human efforts.
  - Other conditions that are correctable but for which time will be required to implement measures to achieve compliance with the standard.
- Where the standards cannot be met because the current imposition of the necessary controls or corrective measures would result in a substantial and widespread economic and social impact. The application of this condition requires a judgment by Colorado's WQCC of what constitutes a substantial and widespread impact warranting modification.
- Where there is significant uncertainty regarding the appropriate long-term underlying standard. Adoption of a temporary modification recognizes the current conditions while providing an opportunity to remove the uncertainty regarding the appropriate water quality standard.

The duration of a temporary modification is established on a case-by-case basis, based upon how soon attainment of the applicable standard is believed feasible. Moreover, when deciding whether to remove or extend the applicability of a temporary modification, the state considers whether the parties benefiting from a temporary modification have agreed to an implementation plan for eliminating the need for the modification, whether due diligence in trying to implement such a plan has been demonstrated, and other relevant factors.

Outcome

Temporary modifications are typically approved by EPA; however, it is important to recognize that EPA has often expressed concerns regarding the use of temporary modifications. These concerns include (see EPA Letter to the Colorado WQCC regarding revisions to the water quality standards in the Arkansas River Basin, 2002, on attached CD):

- If the temporary modification is adopted because of an "underlying uncertainty" in the applicable water quality criterion, what are the state's plans for conducting studies to evaluate this uncertainty?
- Although a temporary modification may be justifiable, EPA prefers that the state still place waters with a temporary modification on the state 303(d) list, primarily because it provides an incentive for completing the site-specific studies necessary to resolve the uncertainty regarding the underlying numeric standard.
- The ability of the state to "implement effective water quality-based protection programs while temporary modifications are in effect."

Case Study Recommendations

- Temporary modifications are a viable method for addressing water quality standards compliance if done in a planned manner.
- Acceptance of the use of temporary modifications requires a demonstration of due diligence on the state's part to resolve water quality criteria issues in a timely manner.

Applicability of Chronic Water Quality Criteria to Ephemeral Waters

Existing Situation

In 1992, ADEQ adopted an aquatic life subcategory for ephemeral waters, waters that have a channel that is at all times above the water table, and that flows only in direct response to precipitation. The water quality criteria established to protect aquatic life in these waters were based on the EPA recalculation procedure that relies on the use of the single most sensitive species to calculate the acute criterion when insufficient numbers of families are resident to allow use of the standard statistical-based "eight-family" approach (EPA 1994b; Stephan et. al 1985). While the acute criteria were calculated using the most sensitive resident species, the chronic criterion was calculated by using the same acute to chronic ratio used for other subcategories, e.g., cold or warmwater, regardless of the resident species.

Water Quality Standards Driver

During a subsequent triennial review of water quality standards, state staff identified the disconnect between the basis for chronic aquatic life water quality criteria (typically 28-day toxicity tests, e.g., see EPA 1991) and the limited time of exposure that would naturally occur in ephemeral waters. Accordingly, it was determined that a chronic exposure scenario does not exist or is very unlikely in ephemeral waters.

Approach to Resolve Problem

The state prepared a proposal to remove the existing chronic aquatic life criteria applicable to ephemeral waters. With stakeholder support, the state proposed rule revisions were successfully promulgated. The state's position was as follows (pg. 1335, Arizona Administrative Register, March 29, 2002):

Cañada del Oro near Tucson, Arizona.

> "Water quality criteria to protect aquatic life contain two expressions of allowable magnitude. Acute criteria are established to protect against short-term effects and chronic criteria are established to protect against long-term effects of pollutants. In general, EPA derives chronic criteria from longer term toxicity tests (often greater than 28 days) that measure survival, growth, and reproduction of test organisms. The term of these toxicity tests is often greater than the length of time that ephemeral waters typically flow in Arizona.
>
> "ADEQ has determined that chronic A&We [aquatic life and wildlife use applicable to ephemeral waters] criteria are unnecessary to protect the designated use. ADEQ defines an ephemeral water as a surface water that flows only in direct response to precipitation and that is at all times above the water table. Surface waters that flow continuously for 30 days or more are considered to be intermittent waters that are protected by A&Wc [aquatic and wildlife coldwater] or A&Ww [aquatic life and wildlife warmwater] designated uses. The A&Wc and A&Ww designated uses have both acute and chronic criteria. ADEQ has determined that chronic criteria are unnecessary for ephemeral waters because they flow for less than 30 days at a time and the duration of exposure of organisms to pollutants is short-term."

Outcome

EPA Region 9 approved the removal of chronic criteria from waters classified as ephemeral. However, in the original proposal submitted to EPA, the ADEQ also established an "intermittent water" definition that placed a 30-day black and white line between waters classified as ephemeral and waters classified as intermittent (this approach is consistent with the quote provided above):

> "Intermittent surface water" means a surface water that flows continuously for 30 days or more at times of the year, when the surface water receives water from a spring or from another source, such as melting snow.

This proposal raised concern with EPA because if ephemeral waters had no applicable chronic criteria, then by specifying a minimum number of days for a waterbody to be considered intermittent, then any waterbody that flowed less than 30 days would have no applicable chronic criteria. To resolve the EPA's concern, the state revised its "intermittent" definition to provide flexibility in the interpretation of whether a waterbody was ephemeral or intermittent:

> "Intermittent surface water" means a stream or reach of a stream that flows continuously only at certain times of the year, as when it receives water from a spring or from another surface source, such as melting snow.

Case Study Recommendations

- ♦ Clearly define waterbody types. Using hydrologic definitions supported the Arizona rationale for removing chronic criteria.
- ♦ ADEQ used a sound scientific basis for removing chronic criteria that was based on EPA guidance. This helped support EPA's approval of the adopted rule.
- ♦ The demarcation between an ephemeral and intermittent water can be difficult to determine. Leaving flexibility in the definitions makes it easier to obtain approval.

Reliance on Tributary Rules to Establish Use Designations

Existing Situation

The City of Vacaville, located halfway between San Francisco and Sacramento, discharges more than 8 mgd of treated municipal effluent to Old Alamo Creek. The receiving water is a dry wash with little or no natural background flow except when it rains. Old Alamo Creek flows into New Alamo Creek, which flows into Ulatis Creek, which flows into the Sacramento River, which flows into San Francisco Bay at Cache Slough approximately 30 miles downstream from Vacaville.

Water Quality Standards Issue

In California, water quality standards (uses and criteria) are identified in regional water quality control plans called Basin Plans. The relevant Basin Plan (Central Valley) designated beneficial uses for nearly 100 surface waterbodies. It also stated that: "streams not listed have the same beneficial uses as the streams, lakes, or reservoirs to which they are tributary." This has since come to be called the "Tributary Rule." In 1995, the Central Valley Regional Water Quality Control Board ("Central Valley RWQCB") sought to delete the original text of the Tributary Rule and replace it with the following:

> "The beneficial uses of any specifically identified water body generally apply to its tributary streams. In some cases a beneficial use may not be applicable to the entire body of water. In these cases, the Regional Water Board's judgment will be applied. It should be noted that it is impractical to list every surface water body in the Region. For unidentified water bodies, the beneficial uses will be evaluated on a case-by-case basis."

Until recently, state permitting authorities relied on the revised Tributary Rule to develop appropriate NPDES limits. Because there were no water supply intakes located within 20 miles downstream of Vacaville's point-of-discharge, the permit simply required the city to meet traditional technology-based standards for secondary treatment. However, in 2000, EPA disapproved the revised Tributary Rule stating that it was tantamount to eliminating designated uses without having performed a formal UAA or complied with other public process requirements. Thus, the original Tributary Rule was back in full force and effect.

Outcome of Action

There are no water intakes located on Old Alamo Creek, New Alamo Creek, or Ulatis Creek. And, none of these stream segments is designated for municipal water supply (MUN). Nevertheless, all are assumed to support such a use because they are tributary to the Sacramento River and Bay Delta, which are designated MUN. Consequently, Vacaville's new NPDES permit contained much stricter effluent limitations for several organic chemicals as required by EPA's California Toxics Rule.

No allowance was made for the distance between Vacaville's outfall and the remote water intakes. Nor was any dilution credit authorized. Downstream water quality standards were applied to all of the upstream tributaries just as though the same beneficial uses were occurring immediately adjacent to the point-of-discharge.

Ironically, the Central Valley RWQCB acknowledged that the MUN designation was likely inappropriate for Old Alamo Creek. On appeal, the SWRCB upheld the more restrictive effluent limits but also agreed that the stream designations were misclassified (see attached CD for SWRCB decision). The SWRCB ordered the Central Valley RWQCB to "promptly initiate amendments to consider dedesignating the MUN use for Old Alamo Creek." Unfortunately, in the 5 years since, there have been no further revisions to the Basin Plan and Vacaville must continue investing many tens of millions of dollars in unnecessary treatment plant upgrades.

Need for a Solution

Vacaville's plight is not unique. In the late 70s, it was common for states to apply beneficial uses in blanket fashion. Indeed, most municipalities strongly encouraged such action because completing the formal stream classification process was perquisite to establishing statewide eligibility for federal construction grants. State and local authorities acted expediently and assumed that corrections could be made on a case-by-case basis if the need arose at some later date.

The combination of blanket use designations and widespread use of the Tributary Rule has led to more stringent effluent limits throughout the arid west, not just in California. In some cases, such constraints may be appropriate. In others, the more restrictive requirements are merely an accident of law.

Public works departments and flood control agencies now find themselves afflicted by misapplications of the Tributary Rule just as Vacaville was. Stormwater channels, covered culverts, and even street gutters have all been identified as "waters of the U.S." And, by virtue of the Tributary Rule, each has come to carry the same designated use classification as distant natural waterbodies far downstream. But, because these upstream locations lack any natural background flow for dilution, the applied effluent limits are frequently more restrictive than places where the relevant use is actually occurring.

The solution is relatively straightforward: reliance on the tributary rule must be reduced. This can only be accomplished by designating the specific beneficial uses for each individual waterbody. However, such a solution is likely to be complex, controversial, and costly because it will likely require a UAA in order to gain necessary regulatory approvals.

Case Study Recommendations

- Review the state regulations and identify the use designations that are being applied to the waterbody to which your facility discharges.
- If the state is applying use designations from a downstream waterbody that are inappropriate, then petition state regulators to consider the adoption of more appropriate uses.

Use Designation and Ambient-Based Criteria Procedures for Effluent-Dependent Waters

Existing Situation

The Wyoming water quality standards contain numerous subcategories to recognize different types of attainable aquatic life uses [see attached CD for Wyoming Water Quality Standards]:

- Class 2 waters (three subcategories) are known to support fish.
- Class 3 waters (three subcategories) are generally those waters "that are intermittent, ephemeral, or isolated waters and because of natural habitat conditions, do not support nor have the potential to support fish populations or spawning, or certain perennial waters which lack the natural water quality to support fish (e.g., geothermal areas)."
- Class 4 waters (three subcategories) are generally those waters, "where it has been determined that aquatic life uses are not attainable," and no aquatic life water quality criteria are applicable.

Discharge from oil production facility creates effluent-dependent water.

Water Quality Standards Driver

Oil and gas production makes up a significant part of the Wyoming economy. Most of the oil fields operating in the state have been discharging produced groundwater to naturally ephemeral channels in arid areas of the state for many years. This produced water is viewed as a valuable resource and is often the only water available for livestock, wildlife, and irrigation. In addition, it creates wetlands and aquatic habitat that would not naturally exist. In many cases, the quality of the produced water does not meet aquatic life criteria for various constituents, most commonly chloride and hydrogen sulfide and in some cases selenium or iron. Imposing a requirement to meet all of the federally-recommended aquatic life criteria would result in the removal of these surface discharges and a loss of the beneficial uses that are dependent upon a reliable supply of surface water. In addition to historic oil production, the state is currently experiencing a boom in coal bed methane development, which also involves the discharge of produced groundwater to naturally ephemeral drainages and may create similar circumstances as have been occurring as a result of oil and gas production. As a result of these energy producing activities, Wyoming has numerous naturally ephemeral waters that now have continuous flow in portions because of the discharge of produced water. Numerous aquatic life subcategories already existed in the Wyoming water quality standards, but

Effluent-dependent reach created by discharge from oil and gas facility.

none of the subcategories specifically addressed these created effluent-dependent waters. Although the perennial aquatic habitat is created by the discharge, per the existing Wyoming water quality standards, all of the aquatic life criteria would apply. Implementation of these criteria would result in the application of potentially non-attainable effluent limitations for certain constituents.

In 2003, the Wyoming DEQ completed UAAs on Whitetail Creek (a naturally ephemeral tributary to the Little Powder River) and an unnamed naturally ephemeral tributary to Whitetail Creek for the purpose of reclassifying both surface waters. Both the tributary and mainstem Whitetail Creek are hydrologically influenced by the discharge of produced water from adjacent oil and gas production. The completed UAAs proposed the following:

Reservoir created by discharge to ephemeral tributary from upstream oil and gas facility.

- Reclassify Whitetail Creek from Class 3B to Class 4B (Class 4B applies to waters that are intermittent or ephemeral and that lack the hydrologic potential to normally support and sustain aquatic life)
- Reclassify the unnamed tributary from Class 3B to Class 4C (Class 4C includes, but is not limited, to "effluent-dominated streams where it has been determined…that removing a source of pollution to achieve full attainment of aquatic life uses would cause more environmental damage than leaving the source in place")

If successful, the UAAs would have resulted in the removal of currently applicable aquatic life criteria. However, following review of the UAAs, EPA Region 8 issued a disapproval, arguing that the recommended reclassification removed the aquatic life use protection for these waters, an act that was not approvable under the CWA:

> "Where an ephemeral waterbody receives a discharge of sufficient volume to alter the natural, ephemeral character of the waterbody, establishing or sustaining an aquatic life use, that existing use is to be designated in the water quality standards and protected…[T]he regulated discharges to these segments alter the natural ephemeral character in, at a minimum, portions of these waterbodies, creating aquatic habitat." (EPA Letter to Wyoming DEQ, February 24, 2005; see attached CD).

The disapproval of these UAAs was followed shortly by a disapproval of a similar UAA for the mainstem of Coal Draw below the Gebo Oil Field Discharge. As in Whitetail Creek, the discharge of produced water from nearby oil field production activities created an existing aquatic life use that may not be removed. In this case, EPA noted that as a result of the discharge, the waterbody supports a:

> "narrow wetland fringe along much of its length and approximately six acres of emergent wetlands in low lying areas in and along the channel…creates habitat and forage for a variety of aquatic…species, and…This flow helps sustain a 20 acre wetland at the confluence of Coal Draw and the Bighorn River." (EPA Letter to Wyoming DEQ, March 5, 2003; see attached CD).

Approach to Resolve Conflict

In 2004, DEQ implemented its water quality standards triennial review. Included in this review are proposed revisions to address the basis for EPA's disapproval of the above-mentioned UAAs and lay the foundation to address related issues in other effluent-dependent waters. The basis for the proposed revisions was the result of close collaboration between the Wyoming DEQ and the EPA Region 8:

> "…EPA and DEQ have been in discussion on the general matter of available options for addressing and resolving the effluent-dependent waters issue…EPA has reached agreement with DEQ on an approach that will resolve the Whitetail Creek and Coal Draw disapprovals and will similarly settle the effluent-dependent waters issue throughout the State. The proposed resolution includes two elements: 1) two new use classifications, and 2) a new provision for criteria derivation" (EPA Letter to Wyoming DEQ, February 24, 2005 regarding Whitetail UAA; note: even though EPA letter to Wyoming DEQ is dated 2005, the state agency was already aware of the pending disapproval and began developing a solution in 2004).

The DEQ has developed a UAA Implementation Policy that clearly identifies how uses and criteria are developed for effluent-dependent waters. The DEQ's approach includes the following key elements (see attached CD for proposed approach):

- ♦ The proposal establishes two new aquatic life classifications, Classes 2D and 3D, which would be specifically applicable to effluent-dependent waters. Class 2D applies to waters where fish are present; Class 3D applies to waters where no fish are present. These classifications only require protection and maintenance of the existing aquatic community, i.e., the aquatic community established and supported as a result of the discharge.
- ♦ Waters may be categorized as effluent-dependent, i.e., Class 2D or 3D, only if four key findings are demonstrated (see text box) through the development of a UAA.
- ♦ Categorical or site-specific criteria may be established in Class 2D or 3D waters to reflect ambient conditions.
- ♦ Effluent-dependent criteria may be set equal to the background concentration plus a margin of error for each parameter where the highest background concentration exceeds the statewide numeric criteria. The background concentration shall be the highest concentration recorded over the course of a 1-year period where samples have been taken at least once in each month. The margin of error shall be one standard deviation calculated from the same data set used to establish background. The DEQ procedures specify where water quality samples should be collected.
- ♦ In addition to the water quality criteria, aquatic life tissue criteria will be established for any parameter known to be bioaccumulating and recommended criteria are available.

> **Class 2D & 3D use designations require that the following findings be made:**
>
> - ♦ Demonstration that 100 percent of the flow or standing water is attributable to permitted effluent discharges except for occasional snow melt and storm events
> - ♦ There is a Net Environmental Benefit associated with the created waterbody
> - ♦ The quality of the water does not pose a hazard to humans, wildlife, or livestock that may be exposed to it
> - ♦ There is a credible threat to remove the discharge

Outcome

This Case Study is still developing. Currently, the proposal is undergoing public review in Wyoming. EPA has indicated its support of the use classifications, use attainability methodology, and use of the net environmental benefit concept to establish an effluent-dependent use. They also support the methodology for establishing ambient-based water quality criteria for effluent-dependent waters.

Case Study Recommendations

- ♦ Close coordination with EPA has been key to progress in the Wyoming case study.
- ♦ Net environmental benefit is an acceptable approach for establishing alternative uses and criteria—as long as it is carefully linked to UAA provisions.
- ♦ Refining the designated use by defining subcategories should, to the extent practical, be accompanied by criteria or a process for developing criteria.
- ♦ Establishing net environmental benefit concept is an important step in conserving water resources established in effluent-dependent ecosystems.

Section 7
Finding the Best Regulatory Solution

7.1 Introduction

Finding a regulatory solution to a water quality standards compliance issue can use up an inordinate amount of time and energy for all parties concerned. However, even with potential resource constraints, many examples exist of regulators working in partnership with the regulated community to find *the* regulatory solution that works best for all involved. Sometimes the solution is elegant and breaks new ground, but more often the solution is found by simply putting to use the many tools already available.

Working in partnership with regulators is an important key to success in finding a regulatory solution. The primary reason that this partnership is so important is that it allows stakeholders an opportunity to better understand the compliance issue, ask the critical questions, evaluate data needs, and develop an approach to address those data needs.

As Figure 7-1 illustrates, rarely are the necessary data available to completely resolve the compliance issue. Thus, research is typically necessary. However, as this figure also shows, this research should only be done if decisionmaking criteria have been developed to establish what decisions will be made based on the research findings. Also, it must be recognized that more than one iteration of the process illustrated in Figure 7-1 may be warranted. That is, research findings may result in the identification of new questions that must be answered before a proposed regulatory solution may be implemented. A key to avoiding a process with apparently never-ending iterations is to have established clear decisionmaking criteria before implementing each iteration.

With "finding the best regulatory solution" as the theme, this section will explore further several important considerations when addressing water quality non-compliance.

7.2 Addressing Water Quality Non-Compliance

Although the shortest distance between two points is a straight line, when addressing a water quality standards compliance issue, the path to the solution often is not straight. In fact the path can be somewhat circuitous and even contain reversals, where the path takes you back to where you started from.

Figure 7-1
Finding the best regulatory solution involves a number of critical steps.

The path to finding a solution to a water quality standards compliance issue can be somewhat shortened and straightened by taking the time up front to evaluate different options for resolving the problem and then selecting the option that is the most practicable. To facilitate this approach, decisionmaking criteria are critical (see Section 5). By having these criteria stated at the beginning, then the outcome of research conducted to resolve the issue already is somewhat pre-decided. For example, if the research shows "A," then the regulatory decision is "B." Or, if the research shows "B," the regulatory decision will be something else; and so on.

When implementing the regulatory process a number of considerations come into play when attempting to find the best regulatory solution. The following sections discuss briefly three key considerations.

7.2.1 Role of Waterbody Type

Available regulatory solutions can be dependent on the type of waterbody. In fact, solutions that may be difficult to develop and implement in a natural cold water or warm water designated waterbody may be more applicable or relevant to other types of waters, e.g., ephemeral and effluent-dependent waters or even concrete-lined flood control channels. This difference in potential outcome reflects the recognition of the important differences that may exist between natural and created waters due to differences in hydrology and degrees of urban impact.

Often states place waterbodies with widely varying physical characteristics in the same aquatic life and recreational use categories even though the physical characteristics of specific waterbodies may prevent attainment of the use. This approach is not wrong, but it can lead to the application of water quality standards that may not be attainable.

Understanding the nature and potential of a waterbody type for supporting uses provides the foundation for establishing appropriate water quality standards and making decisions regarding regulatory options when a water quality standard non-compliance issue is being addressed. Accordingly, it is critical to have agreement among stakeholders regarding the definitions used to describe waterbodies.

A major step forward to create a common understanding and basis for describing arid west waters, the EDDW Drafting Group, comprised of staff-level members from EPA and state agencies, recently developed a list of waterbody definitions that is especially applicable to the arid west (see text box).

Recommended Definitions for Arid West Waters (EDDW 2006)

- **Naturally Ephemeral Stream** – A stream channel that carries flow only during, and for a short duration as the result of, precipitation events, and that has a channel bottom that is always above the groundwater table under normal hydrologic conditions. Example: a dry wash that only flows with water after a storm or for a limited time following snow melt.
- **Anthropogenically (Human Caused) Ephemeral Stream** – Any stream that, due to hydrologic modifications, dams, or other diversions, has been dewatered and carries flow only during, and for a short duration as the result of, precipitation events. Example: a perennial or intermittent stream that is dewatered due to hydrologic modifications, including surface water and/or groundwater withdrawals.
- **Effluent-Dependent Water** – A stream that would be a naturally or an anthropogenically ephemeral stream without the presence of wastewater effluent, but which has continuous or periodic flows for all or a portion of its reach as the result of the permitted discharge of wastewater. Example: a continuous stream flow in an otherwise ephemeral stream created and maintained by the discharge of water from an oil and gas operation.
- **Effluent-Dominated Water** – A stream that would be either intermittent or perennial without the presence of wastewater effluent, but whose flow for the majority of the year is primarily composed of the discharge of treated wastewater. Example: an otherwise intermittent stream that flows year-round after the discharge of treated wastewater from a municipal wastewater treatment plant.
- **Perennial Stream** – A stream that typically carries flow year-round and whose channel bottom remains below the groundwater table during normal hydrologic conditions. Example: a continuously flowing river.
- **Intermittent Stream** – A stream whose channel bottom is alternately above and below the groundwater table for different portions of the year. An intermittent stream does not maintain a perennial surface flow, although permanent pools of standing water may be present at points along the stream. Example: a stream that generally carries flow for the spring and summer months, but is mostly dry during portions of the fall and winter.

Significant in these definitions is the distinction between effluent-dependent and effluent-dominated waters. In Section 2 of this document, we presented a conceptual model for effluent-based ecosystems. This model can be used to help visualize how the distinction between dependence and dominance can influence expectations for what uses are attainable downstream of an effluent discharge. This model can also be used as the basis for asking research questions, especially in conjunction with a process to find a regulatory solution to a water quality standards non-compliance.

Establishing the appropriate waterbody type has important implications for not only the development of water quality standards but their implementation. Having a conceptual implementation framework can be especially helpful for evaluating the implications of establishing a particular subcategory structure. With a framework to critique, all stakeholders will have a point of reference from which to evaluate potential regulatory solutions. An example of such a conceptual framework, based on how a discharging facility impacts the waterbody type, was developed by the AWWQRP Regulatory Working Group (Tables 7-1 and 7-2).

The columns in Table 7-1 identify three natural waterbody types. The rows in Table 7-2 describe the existing natural condition; the created condition after the facility is operational, and considerations regarding minimum criteria requirements that could be applied to the waterbody.

The example framework indicates that for a perennial waterbody, the "traditional" approach to implementing water quality programs applies, e.g., development of effluent limitations taking into account receiving water flow and quality (see EPA 1991). In contrast, for an ephemeral waterbody, after the facility is operational the ephemeral waterbody will become effluent-dependent.

Table 7-1 Conceptual Framework for Developing and Implementing a Water Quality Standards Program Taking into Account Waterbody Type

	Waterbody Type		
	Ephemeral	Intermittent	Perennial
Existing Condition	♦ Hydrology ♦ Groundwater ♦ Geomorphology ♦ Terrestrial/Riparian Community	♦ Hydrology ♦ Groundwater ♦ Geomorphology ♦ Aquatic Community ♦ Terrestrial/Riparian Community	♦ Hydrology ♦ Groundwater ♦ Geomorphology ♦ Aquatic Community ♦ Terrestrial/Riparian Community
Created Condition	♦ Effluent-Dependent ♦ Terrestrial/Riparian Community ♦ Limited Aquatic Community	♦ Effluent-Dominated ♦ Terrestrial/Riparian Community ♦ Alternative or Limited Aquatic Community (see Table 7-2)	Remains Perennial
Minimum Criteria	♦ No persistent bioaccumulative toxics ♦ Limited water quality criteria ♦ Minimum treatment requirements ♦ Pretreatment	Hybrid Approach (see Table 7-2) ←→	Traditional approach to implementation of water quality programs

Intermittent waters receiving a discharge may become classified as effluent-dominated. In many ways this waterbody type can be the most difficult to work with when attempting to find a regulatory solution to non-compliance. This difficulty occurs because the created condition depends greatly on the degree of intermittency under existing or natural conditions. Table 7-2 expands on the range of outcomes possible for intermittent waters. The extent of the range depends on factors such as the ratio of effluent and ambient water and degree of urbanization impacts that limit what can be attained in the waterbody (e.g., channel attributes).

Tables 7-1 and 7-2 are provided only as concepts. However, when working with stakeholders to find a regulatory solution, developing such a framework can be very helpful for talking through options, framing research questions, establishing decisionmaking criteria, and developing a research plan.

7.2.2 Role of Science

The AWWQRP was established to generate scientific information to address questions regarding water quality standards development and implementation in the arid west. Section 3 summarized the findings from AWWQRP projects. However, a review of the study reports will show that as each project progressed, the number of new scientific questions generated grew substantially. This is a common and appropriate outcome of any research endeavor—light is shone on the question, but at the end of the day more questions arise.

If a research project ends up generating more questions than what was answered, does this mean that the research findings from that project cannot be used? Of course, the answer to this question is no. Rarely does any study answer all questions in such a definitive manner that all parties agree wholeheartedly on how to apply the findings. However, it is important to have sufficient scientific data to increase the confidence (or reduce the uncertainty) associated with making a regulatory decision.

In the regulatory arena, scientific data are only part of the equation for finding a regulatory solution. Other considerations, such as public policy, economics, and risk-based factors, come into play when deciding what regulatory solutions are acceptable.

Table 7-2 Additional Considerations for a Conceptual Framework when Working with Effluent Discharge to Intermittent Waters

	Waterbody Type		
	Ephemeral	Intermittent	Perennial
Existing Condition		♦ Hydrology ♦ Groundwater ♦ Geomorphology ♦ Aquatic Community ♦ Terrestrial/Riparian Community	
Created Condition		♦ Impacts of effluent on groundwater, geomorphology, aquatic biota, and terrestrial/riparian community will vary as a result of a variety of factors, including: – Increasing ratio of effluent to ambient water – Seasonal flow variability of both effluent and ambient water – Degree of channel modification (e.g., urban vs. non-urban environments) – Degree of flow modification (e.g., dams and diversions)	
Minimum Criteria		♦ Approach is a hybrid between ephemeral and perennial waters ♦ Outcome is dependent on the relative proportions of effluent and ambient water ♦ Impacts from urbanization may be an important factor in establishing what is attainable under the created condition	

By way of illustrating the concept of acceptability, one can consider the terms "practical," and "practicable." In the regulatory arena, these terms are most often read or heard in the context of the stormwater permit program. For example, the regulations at 40 CFR 122.26 state that stormwater programs should focus on reducing pollutants in stormwater discharges "to the maximum extent practicable." The use of the term "practicable" rather than "practical" is significant. Technically, many stormwater controls may be "practical," that is, from a purely engineering standpoint they are technically doable. However, they are often not "practicable," because of other limitations, e.g., costs or land availability, which limit the space available for locating engineered water quality control facilities.

Finding a regulatory solution to water quality standards non-compliance that is acceptable to all interested parties often reaches a point of separating what is "practical" from what is "practicable." We can keep studying a problem to answer technical questions but at some point the incremental benefit of the information gained from each additional study begins to decline. Additional study is practical, but not practicable. That is, at some point a decision must be made.

From a scientific standpoint, this conflict can best be resolved by having data from areas that provide multiple lines of evidence. For example, questions regarding appropriate water quality criteria for aquatic life can best be resolved if data are available not only from toxicity studies, but bioassessments and possibly sediment and tissue studies.

Having scientific data from multiple lines of evidence to assist with regulatory decisionmaking ultimately can lead to a risk-based type decision. Such a decision often becomes necessary simply because one can rarely devise the perfect study that definitively answers all the pertinent questions.

With the limitations of scientific research understood, it should also be clear why establishing decisionmaking criteria prior to implementing research studies is so important to addressing a non-compliance issue. When the study results are reported, they may be checked against the decision criteria. For example, for metals non-compliance it may be agreed up front that three lines of evidence will be studied: toxicity tests, bioassessment, and water effect ratio. The decision criteria could state that as long as at least two of the lines of evidence are definitive in their results, then a particular decision may be made. Or, all three lines of evidence must support the decision, but the water effect ratio must be at least five to provide a sufficient margin of safety.

7.2.3 Role of the Regulator

When resolving a water quality standards non-compliance issue one should first understand what options are available for resolving the issue. The presumption that a UAA or site-specific criterion is the answer to the problem may be incorrect. To fully understand the available options, a discussion with key regulators is necessary.

For example, there have been UAAs and site-specific criteria studies implemented that have cost hundreds of thousands of dollars or more that resulted in no regulatory decision being made. These costs are most often borne by the regulated community, and from their perspective the cost produced little to no benefit. What went wrong in these situations? There may be many perceived answers to this question, but the reality is most of the disapproved or undecided proposals can be traced back to one key underlying problem—lack of coordination or communication with key decisionmakers, e.g., the state agency tasked with regulating water quality, the EPA, and state or federal wildlife agencies. Working closely with the decision-makers early in the regulatory process will increase the likelihood of success, often because the decisionmakers can provide guidance on the best options or tools available or acceptable to resolve the issue.

It is important to recognize that the process of developing a regulatory solution to a water quality standards non-compliance issue can involve legal, political, institutional, as well as technical constraints. For example, there may be limitations to what can be accomplished in the regulatory arena because of legal issues such as a TMDL consent decree that may include a compliance schedule. In this situation, insufficient time may exist to do the recommended up front water quality standards analysis (e.g., see NRC 2001).

In other instances, what may appear to be a technically justifiable approach may find little institutional or political support. For example, one may be able to demonstrate that the criteria applicable to a blue-ribbon coldwater fishery artificially created by a dam release are inappropriate given what is naturally attainable in the waterbody. However, any attempt to establish standards to reflect the natural condition would likely be unacceptable to the key stakeholders—the general public who use the waterbody for recreation, and fish and wildlife agencies vested with the maintenance of the fishery.

In other instances, it may be scientifically defensible to modify water quality criteria, which would result in less stringent permit limits on a wastewater effluent discharge. However, the merits of the technical arguments are overshadowed by antidegradation or antibacksliding regulations. In these cases a technological solution may be more appropriate.

When developing an approach to resolving a non-compliance issue, the key is to select the right tools. Moreover, before even making a decision regarding the best approach to address the issue, it is critical to ask a number of questions (see text box). Section 4 provides a summary of some of the key tools available for resolving water quality concerns.

Ultimately, the key to selecting the right tool(s) is to work closely with your regulator to identify the regulatory options and the stakeholders that must be involved in the process. It is important to remember that implementing changes to water quality standards is more than a technical exercise. Successful regulatory processes also include planning and public involvement elements. Figure 7-2 depicts these three elements with the technical, planning, and public involvements representing 50 percent, 25 percent, and 25 percent of the total effort, respectively.

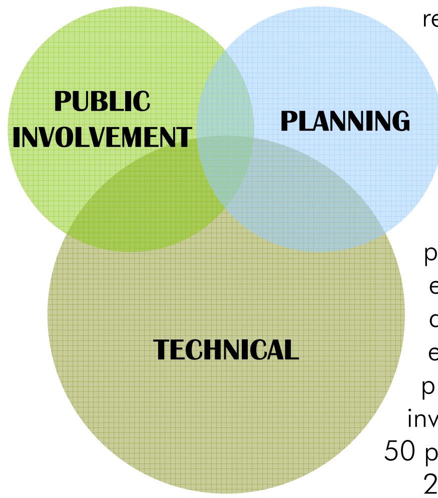


Figure 7-2
Successful Regulatory Processes

Important Questions to Consider before Implementing a Regulatory Process

- How is existing use defined and how is it being applied? Do existing uses vary by season (particularly applicable to recreational uses)?
- Are the uses for the waterbody too broadly defined to describe the actual potential of the waterbody?
- Are there any downstream uses that must be protected that could affect implementation of a regulatory solution?
- How will decisions be made regarding what is attainable? What are the key attainment factors for recreational or aquatic life uses?
- Is the designated use the concern, or are the water quality criteria the concern (often simpler to modify a criterion than to change a use)?
- What is the simplest path to address the concern – from simplest to most complex, address the concern through the permit, develop a site-specific criterion, refine the designated use or remove the use?
- Which is the best regulatory approach? Use removal or use refinement?
- Are any special studies needed or can available literature and/or field data provide sufficient support to address the regulatory concern?
- What evidence is needed to demonstrate that a use or criteria change is justified?
- What regulatory outcomes are associated with each specific data type or analysis associated with the concern?
- Are there any threatened or endangered species associated with the waterbody?
- What is the cost of compliance v. the cost of a regulatory process (especially when the outcome of the regulatory process has a high degree of uncertainty)?

The relative importance of each will depend on the action being sought. In addition, significant interaction occurs among the three elements. For example, seeking an alternative approach for establishing effluent limits in an NPDES permit may ultimately be 80 percent technical and only 10 percent for each of the other elements. This difference reflects the fact that the methods and processes associated with NPDES permitting are generally accepted.

At the opposite extreme is the situation where a discharger, or even the state itself, desires to remove an aquatic life use from a waterbody. Not only is this difficult to do legally, except in very specific situations (for example, see Section 6 Wyoming Case Study), the public perception of this action can be very negative. In this instance, the technical demonstration may require much less than 50 percent of the resources, and instead, much of the resource effort is in planning and public involvement.

7.3 Paradigm Shift

It has long been understood that states had the authority to adopt water quality standards that were either more or less restrictive than those recommended by EPA. However, doing so would require substantial documentation to support the site-specific adjustments when those changes resulted in less restrictive standards. Historically, the cost and complexity of developing the necessary scientific evidence has discouraged any stakeholder (both regulators and the regulated community) from undertaking such efforts. However, that situation is changing rapidly, especially in the arid west. Several factors are contributing to the "paradigm shift."

First, the stigma once associated with re-evaluating designated uses has nearly vanished. In the past, any suggestion that a waterbody be designated something other than "fishable/ swimmable" was difficult to consider. Today, most regulators understand that the majority of stream classifications were initially adopted in blanket fashion without much site-specific data. This was done early in the water quality standards program to facilitate eligibility and access to federal construction grants for wastewater treatment plants. And, it was done with the clear understanding that any adjustments needed to account for local conditions could be implemented on a case-by-case basis at some later date. Consequently, review and revision of water quality standards is increasingly seen as a normal and expected activity—especially in light of the need to develop and implement TMDLs.

Second, early attempts to modify water quality standards tended to focus on deleting designated uses. However, state authorities were reluctant to approve alternatives that appeared to "write-off" a waterbody regardless of how limited the habitat conditions might be. Today, the emphasis has shifted to subcategorizing classifications so as to protect the existing uses without making over-optimistic assumptions about what the attainable use might be. This approach promotes adoption of site-specific water quality criteria that may be less stringent than EPA's default recommendation but are, nevertheless, adequate to protect the actual aquatic life and recreational uses.

Effluent-dominated Crow Creek, near Cheyenne, Wyoming.

Third, the level of wastewater treatment in many arid states is now very high. It is not unusual for wastewater facilities to go well beyond the primary and secondary treatment. Nitrification, denitrification, filtration, disinfection, and dechlorination are now relatively common throughout the arid west. And, the trend toward applying such advanced processes is accelerating. However, all of the easy fixes have already been done. If even better effluent quality is desired (as, for example, would be necessary to reduce the concentration of complex organics such as pesticides or pharmaceuticals) then more exotic treatment strategies (such as reverse osmosis or carbon filtration) would probably be required. The cost of such facilities can be staggering and, sometimes, beyond a community's ability to pay. This, in turn, increases the willingness of stakeholders to look more closely at the true need for higher water quality and to seek out appropriate regulatory alternatives.

Finally, municipal effluent is increasingly viewed as a resource to be preserved rather than a waste to be disposed. Extraordinary population growth, competition for finite water supplies, and drought have converged to change the perceived value and utility of "wastewater." Many cities are opting to recover the resource and recharge it to groundwater for future use. Doing so helps recapture some of the investment they made in advanced waste treatment facilities while helping to stabilize long-term water supplies. State authorities have come to understand that stricter permit limits may, indeed, produce cleaner effluent but that it may then be too good to discharge.

Nowhere is the competition for scarce water resources more fierce than in the arid west. And, nowhere are effluent limits likely to be more stringent. Wastewater facilities must routinely meet discharge limits at the end-of-pipe owing to an absence of dilution in the receiving waters.

Ephemeral wash near Tucson, Arizona.

Where the discharge is to an ephemeral stream, aquatic ecosystems often arise as a direct result of the perennial flow provided by wastewater discharges. However, such effluent-dependent habitats may be lost if more stringent permit limits result in a superior quality effluent that is too valuable to throw away. Consequently, where there are multiple competing demands for the same resource, supporting all of the uses simultaneously often requires some consideration and compromise.

State and federal regulatory authorities have developed many tools for resolving apparent water quality standards conflicts, and new tools are even now emerging.

7.4 Conclusion

It has been said that typically the establishment of a regulation will easily address about 80 percent of the problem that the regulation was designed to address. However, the remaining 20 percent of the problem is not so easily resolved. Put into water quality standards terms, the blanket establishment of a water quality standard for the protection of aquatic life will be appropriate for the majority of waters to which it is applied. Invariably, however, some waters will by nature be "different" and require a different standard.

When the "different" situation occurs and non-compliance exists, a regulatory solution is needed, and research may be necessary to generate the data needed to identify that solution. However, research cannot take place in a vacuum. A consistent theme that should be apparent after reading this document is that the key factor associated with the achievement of a successful resolution to a regulatory non-compliance issue is stakeholder collaboration. How much collaboration takes place and which stakeholders are among the collaborators will vary depending on the complexity of the issue, but it is a given that collaboration must take place. This collaboration is necessary simply because the questions that need to be addressed, the study plan that needs to be developed, and how the generated research data will be applied to the regulatory issue all require consensus before any research is implemented.

Given the paradigm shift that was described above, it is expected that the need for research to address the "20 percent" of the regulatory issues, i.e., the most difficult issues, will continue to grow. The simple fixes have been done, and now it is time to focus on the more complex issues. This document has pointed to a variety of existing and emerging tools that allow stakeholders to make use of the inherent flexibility already built into the CWA. To increase the likelihood that research can be used successfully as a tool to make use of this flexibility, collaboration among stakeholders must continue.

Effluent-dependent Santa Fe River, near Santa Fe, New Mexico.

Section 8
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Acronyms

ACERP	Arizona Comparative Environmental Risk Project
ADEQ	Arizona Department of Environmental Quality
ADF	aircraft deicing fluid
AWQC	Ambient Water Quality Criteria
AWWQRP	Arid West Water Quality Research Project
BAT	best available technology
BLM	Biotic Ligand Model
BMP	best management practices
BOD	biochemical oxygen demand
BOR	U.S. Bureau of Reclamation
Ca	Calcium
CCC	Criterion Continuous Concentration
CCR	Colorado Code of Regulations
CDM	Camp Dresser & McKee Inc.
CDOW	Colorado Division of Wildlife
CEC	Chadwick Ecological Consultants
cfs	cubic feet per second
CHAID	Chi-Square Automatic Interaction Detection
CMC	Criterion Maximum Concentration
CWA	Clean Water Act
CWCB	Colorado Water Conservation Board
DIA	Denver International Airport
DO	dissolved oxygen
ECE	Extant Criteria Evaluation
EDDW	Effluent-Dependent/Dominated Waters
EPA	U.S. Environmental Protection Agency
EPG	Environmental Planning Group
EPT	Ephemeroptera, Plecoptera, Trichoptera
ESA	Endangered Species Act
FAV	Final Acute Value
FWPCA	Federal Water Pollution Control Act

GMAVs	Genus Mean Acute Values
LRW	Limited Resource Water
M&I	municipal and industrial
Mg	magnesium
mgd	million gallons per day
mg/L	milligrams per liter
MWH	Modified Warmwater Habitat
MWRD	Metro Wastewater Reclamation District
NACWA	National Association of Clean Water Agencies
NMWQCC	New Mexico Water Quality Control Commission
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRC	National Research Council
ONRWs	Outstanding National Resource Waters
PCWMD	Pima County Wastewater Management Department
QA/QC	quality assurance/quality control
REC-1	Water Contact Recreation
REC-2	Non-Contact Water Recreation
RWG	Regulatory Working Group
RWQCB	Regional Water Quality Control Board
SAG	Scientific Advisory Group
SAWPA	Santa Ana Watershed Project Authority
SETAC	Society of Environmental Toxicology and Chemistry
SIP	State Implementation Plan
SMAVs	Species Mean Acute Values
SWRCB	State Water Resources Control Board
TMDL	Total Maximum Daily Load
UAA	Use Attainability Analysis
USACE	U.S. Army Corps of Engineers
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WDEQ	Wyoming Department of Environmental Quality
WDOE	Washington's Department of Ecology

WER	Water Effect Ratio
WERF	Water Environment Research Foundation
WET	Whole Effluent Toxicity
WSWC	Western States Water Council
WQCD	Water Quality Control Division
WWTPs	wastewater treatment plants