Considering Water Use Efficiency for the Environmental Sector

Prepared for

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Executive Summary

The goal of this report is to provide a starting point from which the water planning community can move toward improving the allocation of water within the environmental sector. To facilitate that process, this report presents:

1. A discussion that highlights the water community's points of agreement on the concept of analyzing the application of water to the environment
2. A term, Managed Environmental Water Use Efficiency (MEWUE), to reflect that concept, and a definition of that term
3. A survey of existing methods that could be used to develop MEWUE
4. Suggestions about how to proceed with implementing MEWUE

Based on our analysis, we found that there was genuine interest in understanding and improving how water is allocated to the environment. The idea of maximizing environmental benefits for a given amount of allocated water is a unifying thread among stakeholder interests. We focus on this idea throughout the report as the central concept that MEWUE is intended to achieve.

We propose a new term to reflect the stated concerns of stakeholders that other terms, Environmental Water Use Efficiency and Ecosystem Restoration Water Use Efficiency, did not fully address. We propose *Managed* to indicate that MEWUE does not evaluate the environment's use of water per se but rather the effectiveness of water in controlled systems. We propose *Environmental* to reflect the range of "uses" of water in the ecosystem, including ecosystem maintenance, restoration, and water quality. Lastly, we support the use of the word *Efficiency* because efficiency communicates the intent of maximizing benefit for a given amount of water, providing a basis for comparison of the benefits obtainable from different uses of that water.

MEWUE: a mechanism to analyze alternative uses of managed environmental water to determine which allocation of a given amount of water will maximize environmental benefits, and a means to improve decision-making over time.

We address the issue of why having an explicit decision-making mechanism is essential. It is hard to allay the fears that some have of incorrectly measuring environmental benefits. However, it is even more difficult to claim that decisions based on implicit measures and beliefs are better for the environment than those based on some imperfect but explicit consideration of environmental benefits.

The new term, MEWUE, and its definition can place stakeholders on the same page. There will be less confusion about what WUE for the environment means and is intended to accomplish. This common ground will allow the investigation of methods to implement MEWUE to move forward.

In addition to outlining a concept, this report explores existing approaches that could play a part in implementing MEWUE. The methods researched fall under two major categories: metrics of ecosystem quality and institutional improvements. Each technique described includes a case study to highlight its implementation and applicability to MEWUE. The metric techniques discussed are:

- Ecological Indicators
- Instream Flow Requirements
- Economic Valuation

The institutional techniques discussed are:

- Benchmarking and Best Management Practices
- Improved Water Management and Collaboration

The two broad categories of methods will probably work best in combination with each other. The technical approaches offer a method for calculating changes to the environment, while the institutional methods are necessary to operationalize the technical methods.

This report suggests further investigation of MEWUE. Our analysis finds that there is enough common ground among stakeholders to warrant further development of MEWUE. Furthermore, there are techniques already in practice that promote the goal of MEWUE and that can potentially serve as methods for successful MEWUE implementation. We hope that this report provides sufficient direction to begin an on-going collaborative process of defining and implementing MEWUE that continually improves the allocation of water within the environmental sector.

Main Conclusions

Maximizing the environmental benefits for a given amount of water is a valuable concept for the California water planning community to pursue. MEWUE is a feasible way to implement this concept. Various techniques applicable to assessing and improving MEWUE are in place or are being developed and could feasibly be adapted for use in a specific MEWUE program.
This report is the first step in a process. We hope it can serve to start a collaborative discussion among stakeholders on how to best implement MEWUE.

1.0 Introduction

Background

Water planning in California has historically been a technically and politically complex process, with many diverse stakeholders vying for access to a limited resource. In the past, the water planning process focused on the agricultural and urban water use sectors. Water scarcity affected these sectors as California grew, which prompted development of efficiency measures to address the problem.

Some believe that it is now time to evaluate whether the environmental sector can and should use its water resources more efficiently. Some stakeholders in California water management believe that since understanding of ecosystem health is improving, opportunities are emerging to enable maximizing overall environmental benefits from any given amount of expenditures – whether in monetary or water terms. Since resources for environmental uses are becoming scarcer as compared to the recent past, policymakers increasingly face the need for a method of evaluating the relative environmental benefits of alternative uses of these resources.

Certain water interests believe that water used for environmental purposes should be held to an efficiency standard similar to those in agricultural and urban sectors. However, some members of the water planning community oppose the idea of implementing water use efficiency (WUE) measures for the environmental sector. Reasons for this resistance vary among stakeholders, but we characterize their concerns broadly to include: a fear that implementing such measures will ultimately take water away from environmental uses; reluctance to put a price on something that some believe should not (and cannot) be valuated; and the belief that such measures in the environmental context are inappropriate since some believe the goal of water use efficiency should be to keep as much water in the environment as possible. To date, there is no consensus about whether water use in the environmental sector can or should follow the same path that the urban and agricultural sectors did, or about how to define or measure the efficiency of water used for environmental purposes.

In addition to this lack of consensus between groups, problems also arise regarding the technical feasibility of implementing WUE for the environmental sector. A major barrier to the process is the perceived lack of both a comprehensive way to measure the health and/or value of ecosystems and a method of comparing the relative benefits of alternative water uses. Whether expressed as a single value or as an index of several relevant factors, measuring ecosystem health suggests the use of some quantitative metric of ecological integrity. Such a metric may need to incorporate such diverse factors as chemical water quality, biological species populations, and physical channel structure. Implementing efficiency standards would ideally involve a systematic way to compare the relative benefits of alternative water uses based on these measures of ecosystem health. Developing these methods is a daunting task and leads some to reject this approach due to the difficulties involved.

The lack of consensus about whether or not to pursue the development of such an efficiency standard and how to approach its implementation framed the analysis in this report.

Context of Analysis

We performed this analysis at the request of the Statewide Water Planning Branch of the Department of Water Resources (DWR). DWR is required by statute to provide updates to the California Water Plan every five years, and is currently developing the next version of the update. The Update includes descriptions of "statewide water supplies, water uses, and actions that could be taken by water agencies to improve future water supply reliability."[1] There have been requests that the next Update address the concept of efficiency for environmental water use, and DWR perceived the need to obtain an independent analysis of the topic given the state of contention among stakeholders about the concept.

DWR works with a statewide Public Advisory Committee that provides input to the preparation of the Water Plan Update. Advisory Committee membership "is intended to represent a diverse cross-section of water use and water management interests, with broad geographic distribution from throughout California."[2] The state's primary water interests make up the committee – including agricultural interests, state and federal agencies, environmental groups and urban water districts.[3]

Methodology

We began our analysis by developing a standard questionnaire that we used as the basis for interviews with targeted representative stakeholders.[4] Questions focused on the stakeholders' role in state water planning, their current understanding of the concept of WUE as applied to the environment, examples of inefficiency in environmental water use, and suggestions for how to facilitate the improvement of water use efficiency in the environmental sector. From a list of those interested in participating, we interviewed Advisory Committee members that represent the main sectors of water use planning. These interviews provided valuable information and perspectives that we have made use of in this report; however, we have refrained from citing specific conversations or people.[5]

We then conducted a literature review that aimed to investigate measures of efficiency currently used for environmental purposes that may help develop a concept of WUE for the environmental sector in California. This research included ecosystem performance indicators, ecosystem services valuation, urban and agricultural water use efficiency history and measures, legal and regulatory concerns, and other relevant topics.

Next, as subsequent sections of this report describe, we chose a term and developed a definition that address stakeholders' interests and can serve as a starting point from which to further develop a more complex definition of efficiency. We also developed and evaluated alternative approaches to implement this concept. During the course of our analysis we recognized that these alternatives function more effectively as interrelated components of our definition of efficiency than as stand-alone alternatives from which water planners must choose.

[1] *About CALFED.* California Bay Delta Authority. 15 April 2004 <http://calwater.ca.gov/AboutCalfed/adobe_pdf/CALFED_Standard_Presentation_History_and_Context_3-18-04-2.pdf>.
[2] *About CALFED.* California Bay Delta Authority. 15 April 2004 <http://calwater.ca.gov/AboutCalfed/adobe_pdf/CALFED_Standard_Presentation_History_and_Context_3-18-04-2.pdf>.
[3] See Appendix A for a list of the full Advisory Committee.
[4] See Appendix B for the list of interview questions used.
[5] See Bibliography for names of those interviewed.

Scope

Our analysis focused on two main issues: *whether* and *how* to assess the relative efficiency of water use for environmental purposes in California. Interviews with stakeholders and an evaluation of current water allocation practices led us to respond affirmatively to the first issue, and to further pursue the second. Therefore, this report develops the concept of WUE within the environmental sector, and introduces a term that all stakeholders can agree on to describe that concept. We also investigate potential implementation strategies for improving efficiency, as defined in this report. We aim to provide a starting point from which progress can be made on this issue, as well as provide suggestions on how to proceed.

Our analysis is directed strictly towards the environmental sector, and the goal of maximizing environmental benefits from a given amount of water dedicated to that sector. We do not address WUE in the agricultural or urban sectors, and our results are not intended to draw a comparison to those sectors. While we recognize that some stakeholders desire such inter-sector comparisons, environmental benefits are not sufficiently quantifiable (as discussed above) to allow these direct comparisons.

2.0 The Rationale for MEWUE

While WUE is being applied in urban and agricultural contexts, some stakeholders feel it is not a useful term or concept for environmental applications. In this section we forecast and assess the merits of the likely outcomes if the water planning community chooses to disregard this concept and continue current planning practices. In so doing, we briefly describe current decision-making practices for allocating water to the environment. We demonstrate why, in our view, current practice in the environmental sector highlights the need for a more explicit consideration of WUE and in fact is already moving in this direction in an ad hoc fashion.

We then present a term to address the concept of WUE with respect to the environment. We explain how this concept can benefit the environment and promote wise water use planning.

2.1 Present Trends in Management of Environmental Water

Description of Current Practice

Most current environmental water planning decisions are driven by regulatory compliance, not directly by efficiency or environmental benefits. An example of this phenomenon is the effort to meet the Delta salinity requirement in 2003, discussed as a case study below. In general, environmental regulation has provided and continues to provide valuable mechanisms for environmental improvement. However, many regulations themselves are created in response to a crisis and thus are tailored to that specific issue. This leads at times to an inappropriate focus on specific species or components of environmental quality. For example, state and federal endangered species legislation has been an effective mechanism for procuring water for the environment. This legislation motivates action on behalf of the listed species, which may or may not effectively address the needs of ecosystems as a whole.

Given a system of regulation and decision-making that is in large part reactive to crisis, science is often not as critical a component of environmental water use decisions as some desire. Policymakers are rarely in a position to make a considered evaluation of the tradeoffs involved with using water for alternative environmental applications. There is no office or organization serving as a clearinghouse for making comparative judgments of the benefits derived from various projects.

Many stakeholders stress the importance of adaptive management. Adaptive management is, generally, a practice of "learning by doing," or of evaluating the performance of past successes and failures and applying the insights gained to future projects. While some organizations are practicing adaptive management, this approach is not being fully implemented on many projects. CALFED[6] has recently issued an evaluation of its Ecosystem Restoration Program (ERP) that specifically lists improving the process of "learning by doing" as one of its key recommendations.[7] No specific mechanism exists to mandate or encourage adaptive management across organizations. We discuss adaptive management further in this report, particularly in section 3.2.1.

Accountability for the satisfactory environmental performance of projects is currently established through policymakers' scrutiny of dollars and quantities of water spent. Some stakeholders feel that this mechanism is an appropriately rigorous screen. Others feel that this level of accountability is insufficient and weaker than that established by WUE standards in the urban and agricultural sectors.

Many organizations involved with environmental water planning or ecosystem restoration in California are pursuing innovative, evaluative methods. For example, the Bay Institute has developed a Scorecard that grades the ecological condition of San Francisco Bay using eight different science-based indicators.[8] The Nature Conservancy has developed Conservation by Design, a framework for selecting conservation goals and measuring the success of its efforts.[9] We discuss additional examples as case studies in later sections of this report. Other organizations are recognizing a need for a more systematic approach to assessing the success of their efforts. CALFED's recent evaluation of its ERP calls for greater efforts to evaluate the performance of projects.[10]

Case Study 1

<u>The X2 Salinity Standard and the Strand of the 2003 Salmon Hatch</u>

The Bay-Delta Accord (1994) and the resulting Water Quality Control Plan (1995) established the X2 standard to control the penetration of salt water into the Delta estuary. X2 sets a minimum distance, in kilometers, from the opening of the Golden Gate to the point at which the salinity of the Delta is two parts per thousand.[11,12] In order to maintain X2 at various seasonal values, water planners must manage

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[6] CALFED is a consortium of 24 state and federal agencies whose mission is "to develop and implement a long-term comprehensive plan that will restore ecological health and improve water management for beneficial uses of the Bay-Delta System." *About CALFED*. California Bay Delta Authority. 15 April 2004 <http://calwater.ca.gov/AboutCalfed/adobe_pdf/CALFED_Standard_Presentation_History_and_Context_3-18-04-2.pdf>.

[7] *Ecosystem Restoration Program Project Evaluation Phase 2 Report.* CALFED Bay-Delta Program. 15 April 2004. <http://calwater.ca.gov/Programs/EcosystemRestoration/ERPProjects_Phase2/Phase2_Report.pdf>.

[8] The eight indicators track the Bay's environment (habitat, freshwater inflow, water quality), its fish and wildlife (food web, shellfish, fish), management of its resources (stewardship), and its direct value to users (fishable/drinkable/swimmable). For more information about Scorecard, see *Ecological Scorecard - San Francisco Bay Index 2003*. The Bay Institute. 7 April 2004 <http://www.bay.org/Scorecard/Scorecard_report.pdf>. For more information on indicators generally, see Section 3.1.1.

[9] The four steps in the Conservation by Design cycle are setting priorities, developing strategies, taking action, and measuring success. For more information, see *How We Work.* The Nature Conservancy. 7 April 2004. <http://nature.org/aboutus/howwework/about/>.

[10] *Ecosystem Restoration Program Project Evaluation Phase 2 Report.* CALFED Bay-Delta Program. 15 April 2004 <http://calwater.ca.gov/Programs/EcosystemRestoration/ERPProjects_Phase2/Phase2_Report.pdf>.

[11] *Case Studies, Part E: San Francisco Bay/Delta Estuary. Chapter E1: Background.* 15 April 2004 <http://www.epa.gov/waterscience/316b/casestudy/che1.pdf

freshwater diversions upstream of the Delta to ensure that sufficient fresh water is available to flush the Delta. These seasonal distances are set to ensure the survival of several aquatic species, notably the delta smelt and longfin smelt.[12]

In 2003, unusually light winter precipitation created low flow conditions into the Delta. In response, the Bureau of Reclamation released 300,000 acre-feet of water from Folsom Dam on the American River in order to maintain X2 compliance. The high flow conditions on the American persisted for a few days until the extra releases were shut off. During the high-flow period, salmonids laid eggs high on the banks of the river. The subsequent flow reduction stranded these eggs on the riverbank.

These events destroyed much of the 2003 salmon spawn. Moreover, the early release from Folsom Dam meant that this water was not available later in the season, when it would otherwise have been released. These releases, in normal years, provide sufficient water to downstream users to allow the curtailment of pumping from the Delta while young salmonids are passing through on their way to the ocean. Due to the early Folsom Dam release, 300,000 fewer acre-feet of water were available in 2003 to supplant curtailed pumping, so the pumps were run more frequently during the salmonid migration. This further diminished the salmon population. The benefit gained by this series of events was maintaining the X2 standard and averting damage to the smelt and other Delta species.

Several stakeholders we spoke with saw this series of events as an example of inefficient use of environmental water. They felt that the harm caused by the strand of the salmon hatch and the loss of export curtailments outweighed the benefit to the Delta ecosystem gained by meeting the X2 requirement. They argue that there must have been a way to reallocate the available water to produce greater net environmental benefit. However, stakeholders did not agree on the source or explanation of this inefficiency, or on the characteristics of a superior solution. Some felt that the problem was the specific, inflexible standards set by the X2 regulation, and argued that the regulation itself led directly to inefficiency. The solution, in their minds, was to increase regulatory flexibility by allowing selective noncompliance with X2 when compliance would produce undesirable results such as these. Others viewed the situation as a product of bad management decisions, rather than inflexible regulation. They argue that a large short-term release from Folsom Dam was not the only or the best way to ensure compliance with X2, which is an important component of the health of the Delta. In their view, other management options may have existed[13] that would have maintained X2 compliance while avoiding a significant impact on the salmonid population.

This case study illustrates a number of salient features of the current process of environmental water use decision-making. A short-term crisis and a regulation were central drivers of water allocation. The decision-making process did not directly involve scientific or economic analysis of the tradeoffs between different potential actions or the environmental benefits that would accrue in different scenarios. Agencies made an isolated decision based on a single criterion instead of addressing holistic ecosystem needs. The existing systems of management, according to some, were not sufficient to handle the issue optimally.

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[12] *San Francisco Bay Freshwater Inflow Index: Indicator Analysis and Evaluation.* The Bay Institute. 15 April 2004 <Thttp://www.bay.org/Scorecard/Freshwater_Inflow.pdf>.

[13] For example, managers could have released water more slowly from Folsom Dam, or released water from other dams as well.

Discussion of Projected Outcomes if Current Trends Continue

Absent the introduction of a water use efficiency approach, we can expect the scene going forward to look much like what we have described above. Some stakeholders would be pleased with this outcome, and see no need for a new paradigm. Others would be disappointed, particularly those desiring greater accountability for the benefits achieved by dedicating water to the environment and those who wish for a better way to understand benefits of water use in the environmental sector. Water managers will continue to make decisions principally on the basis of issues other than direct maximization of environmental benefits, as discussed above. While some organizations are employing some form of adaptive management, there is no cross-organizational mechanism to ensure such practices.

It would be erroneous and dismissive to suggest that current ecosystem restoration practice is static and does not provide the potential for environmental water use to become more efficient. Indeed, many organizations are moving towards innovative processes that hold plenty of promise in further integrating science, adaptive management, and ecosystem performance indicators. Again, CALFED's ERP project evaluation is a good example, and specifically recommends increased use of these practices. So, even without formally implementing a WUE approach, we would expect progress towards efficient water use. Many stakeholders see these practices as distinct from an efficiency concept. However, we see these ideas as potential methods to implement WUE, as we will later discuss. The fact that different organizations are recommending similar measures for improving water use suggests a setting ripe for systemic improvement. Section 3 of this report discusses these methods and ideas for how they can be pursued more comprehensively.

2.2 The MEWUE Concept and Terminology

Agreement on a Central Concept

Though common perception is that there is much disagreement about WUE for the environment, all of the stakeholders that we interviewed for this project agree that water planning should try to *maximize the environmental benefits obtainable from a given amount of water that is dedicated to the environment*. This concept, in our opinion, is the foundation for defining WUE for the environmental sector. The obvious challenge is how to go about measuring or evaluating these benefits. We will discuss some potential methods to measure benefits in section 3 of this report, and we will make some recommendations about how to proceed. The method of evaluating benefits will be critical to some stakeholders' ultimate acceptance of the approach. However, providing consensus on a central concept and engendering acceptance of the need for WUE in the environment will set the basis for a more responsive discussion about how to measure benefits. Therefore, we first seek to attach a term to this concept that best captures what it is trying to accomplish. We propose Managed Environmental Water Use Efficiency (MEWUE).

MEWUE: a mechanism to analyze alternative uses of managed environmental water to determine which allocation of a given amount of water will maximize environmental benefits, and a means to improve decision-making over time.

Discussion of MEWUE as the Chosen Term

The initial term proposed by those considering this concept was Environmental WUE. Subsequently, others proposed Ecosystem Restoration WUE as a potentially superior term. In addition, some suggested *effectiveness* in place of *efficiency*. Different parties we spoke with had concerns with each of these terms. We considered the relative merits of alternative terms and found that MEWUE works the best to capture the ideas on which stakeholders agreed.

The benefit of using the term Environmental WUE is that it is a comprehensive descriptor and clearly represents the third major sector of water use. However, this term can be interpreted to mean that the goal of implementing WUE is to evaluate the returns on the environment's use of water in its natural state. The true goal of WUE with regard to the environment, as expressed by stakeholders and the Department of Water Resources (DWR), is to evaluate the returns on water specifically devoted to the environment by *humans*.

Ecosystem Restoration WUE successfully narrows the issue to how humans use water for ecosystem restoration. However, this term may be overly specific and would leave out activities our concept is intended to encompass, such as ecosystem maintenance. Furthermore, some feel the term implies that there is a goal to restore ecosystems to a pre-existing and unspecified state, and are uncomfortable with this connotation.

We propose the term "Managed Environmental WUE" as a way to resolve the concerns described above. The term "Managed" excludes the possibility of evaluating the returns of water in its natural state, clarifying that only waters subject to human management are being considered. Including "Environmental" rather than "Ecosystem Restoration" allows a broader application of the term to include other activities as well as restoration.

Another issue that arose from our discussions with stakeholders on terminology and from materials written by stakeholders was whether the measurement, the "E" in WUE, should be *effectiveness* or *efficiency*. As commonly used, *effectiveness* refers to the amount of benefit obtained from water. *Efficiency* is the benefit, or *effectiveness*, per some unit of water.

The word *effectiveness* implies improvement. In other words, an action was effective if it made a change for the better. Therefore, Water Use Effectiveness would seem to measure whether a specific application of water is able to bring about ecosystem improvement. This word does not necessitate a measurement of the amount of water used. Because *effectiveness* does not require a measurement of the water used to obtain a benefit, it does not allow water planners to readily evaluate which application of water would be most beneficial given a specific amount of water. While *effectiveness* is preferred by some for its lack of parallelism to other sectors, not having a basis for comparison of competing uses (amount of water) weakens its use within the environmental sector as well.

The term *efficiency* has a more direct parallel with urban and agricultural WUE, which for some is positive, while for others is not. Some feel that *efficiency* implies a more rigorous measure that would allow for water in the environment to be evaluated in a similar manner as water in other sectors. Others are concerned that an efficiency measure requires a simplicity of analysis that is impossible or scientifically unsupportable, and might focus on micro-level indicators that do not accurately capture the complexities of ecosystem performance.

The issue of comparison is highly important to improving the way environmental water is used. If there were an infinite amount of water, there would be no need to compare the benefits of providing water among different uses. Unfortunately, as our readers are well aware, there will always be competing needs for water in California, both between sectors and within each sector. Given a limited amount of water, it is important to figure out which uses will provide the *greatest* environmental benefit. Without an effective measure of how much benefit is gained under each option *for that amount of water*, resources could be misallocated.

There may be times when an additional amount of water will greatly improve the ecosystem in one region, but only mildly improve another. It is even possible that too much water in a specific region could cause harm to that area and should be reallocated to an area in need. For this, understanding incremental improvements based on amounts of water will be necessary.

Therefore, we recommend that MEWUE be a measure of efficiency, not effectiveness. *Efficiency* includes a basis for comparison within environmental uses, which better describes the necessary concept. The definition of *efficiency* we are offering does not imply anything specific about how to measure benefits, nor does it suggest that they will be easily quantifiable. It does not necessarily suggest the existence of a single linear, numerical metric. Using the word *efficiency* is necessary to capture the idea that we want to evaluate benefits per unit of input, rather than simply the total benefit of a project independent of inputs.

The Case for Applying the MEWUE Concept

Many people are uncomfortable with the idea of having to measure environmental benefits, feeling that these benefits are inherently unquantifiable, or are so difficult to quantify that the exercise is best not pursued. It is obviously a difficult task to try to create a comprehensive calculation of the benefits the environment gains from water use. However, planners find themselves making these measurements implicitly all the time. Given competing water needs, there is no way to avoid them. Any time a decision is made to allocate water to one environmental project above another, the decision-maker is making a judgment that the first project creates greater benefit. Right now, those considerations can include political ease of decision, existing legal restrictions, and an understanding of ecosystem needs. MEWUE would be used to improve the information available for the decisions that are already being made. MEWUE would not create a new set of questions; rather, it would inform those questions that are already being asked.

It is hard to allay the fears that some have of incorrectly measuring environmental benefits. However, it is even more difficult to claim that decisions made based on implicit measures and beliefs are better for the environment than those made with broad involvement and based on some imperfect but explicit consideration of environmental benefits.

In addition, without a way to evaluate efficiency, it is difficult for water planners to learn from mistakes. It is necessary to implement a type of measure or process that would allow for a more systematic review of what types of water allocation are most beneficial for the environment. Even if the measure is imperfect, which any measure would certainly be, an effective process of implementing it will enable assessment of and improvement on its flaws. While the water planning community should take all possible steps to develop a correct and comprehensive measure, even an imperfect measure will provide a starting point for improving environmental water use. Without a measure, correct or incorrect decisions can be made, but little evaluation can follow.

The complex nature of the environment requires a comprehensive system to improve the efficiency of how water should be allocated to it. Multiple measurements will likely be necessary to understand environmental efficiency, and these measurements will likely require continual updating and revision. This should not be disheartening. Just as the Department of Water Resources dedicates an Office to understanding and improving urban and agricultural WUE, MEWUE will necessitate ongoing effort. We discuss the potential dimensions of this effort in Section 3.

Summary

MEWUE is a term intended to address the concerns of all parties discussing water use efficiency with respect to the environment. It is intended to be a starting point from which people can begin to assess the various ways to measure environmental benefits.

In this section, we have discussed the consensus concept MEWUE is designed to address (maximizing the benefit of given amounts of water dedicated to the environment by human decisions) and why it is important to consider that concept. We have not yet addressed the thorny question of how to implement a measure of the environmental benefits MEWUE would seek to maximize. Some potential approaches will be outlined in the remainder of this report. However, an understanding of how to improve efficiency will take time to evolve. Therefore, we feel that explaining the term and agreeing on its basic meaning are essential to maintaining the motivation to support the idea of improving MEWUE.

3.0 Potential Methods for Implementing MEWUE

3.1 Technical Methods

3.1.1 Ecological Indicators

Description

An ecological indicator is a “measurable feature or features that provides managerially and scientifically useful evidence of environmental and ecosystem quality or reliable evidence of trends in quality."[14] Ecological indicators, as used in this report, refer to both biological indicators of water quality (bioassessment) and physical indicators of habitat suitability. There are variants of both assessment systems in use today in the United States and throughout the world. The most widespread use of biological indicators is in water quality monitoring. Currently, all 50 states, several tribes and territories, and several other countries have some level of bioassessment procedures in place for monitoring water quality, as well as investigating specific impairment or pollution events. Habitat quality assessment is also in wide use, although these protocols are less well-developed and standardized, probably due to the existence of fewer regulatory drivers.

The theory of bioassessment is based on the close relationship between the abundance and diversity of species (primarily benthic macroinvertebrates, algae, and fish) with known water quality tolerances and the quality of that water. Bioassessments are potentially very sensitive to a variety of aspects of water and habitat quality. Additional habitat quality indicators include assessments of channel dimensions, channel gradient, channel substrate size and type, habitat complexity and cover, riparian vegetation cover

[14] *Water Quality Indicators.* State Water Resources Control Board. 12 April 2004 <http://www.swrcb.ca.gov/swamp/wqindicators.html>.

and structure, anthropogenic alterations, and channel-riparian interaction.[15] These indicators may be used to assess the habitat suitability for species of concern, as well as overall ecological health.

Case Study 2

Florida Uses Bioassessment to Target and Evaluate Restoration and Mitigation Projects[16]

The Florida State Department of Environmental Protection (DEP) uses bioassessment in monitoring of specific water bodies of concern, and has also used bioassessment in several cases to measure the effectiveness of specific management actions. For example, the DEP measured the conditions on Canoe Creek in northern Escambia County, before and after paving the upstream clay-bed Bratt Road. The 1997 assessment reported low ecological indicator index scores. The hypothesized cause of these low scores was sediment impacts from the unpaved road, which prompted mitigation measures. The 2002 assessment, after the road was paved, found an increase of 76%, 83%, and 59% in the three indices used, to between 160% and 210% of "threshold significance" levels.

Using ecological indicators allows DEP to target resources to greatest need, evaluate success of projects, and learn from experience.

Case Study 3

Clean Water Act Water Quality Monitoring Increasingly Utilizing Ecological Indicators

Water Quality Standards (WQS) under the Clean Water Act (CWA) consist of three elements: designated use, narrative and numeric criteria adopted to protect the use, and policies to prevent degradation. Ecological indicators are increasingly being used in monitoring to assess whether a waterbody meets its WQS, in reporting this status and in implementing mitigation and restoration measures.

Some states, such as Oregon, Ohio, Florida, Maryland, Kentucky, and Maine, have already constructed biological assessment and standards programs for streams and small rivers, and are managing their CWA programs at least partially through numeric or narrative ecological indicators. Most other states are developing programs and are at various levels of implementation.[17] The U.S. Environmental Protection Agency (EPA) has recently instituted the Consolidated Assessment and Listing Methodology (CALM) to track, publicize, and facilitate states' CWA bioassessment programs, a function exemplary of the benchmarking described in section 3.2.1.[18]

The development of protocols and regulatory structure for the use of ecological indicators across the country provides multiple models and guides for their use in MEWUE assessment, both from a technical and a bureaucratic viewpoint. Adapting the model, not to mention the protocols and the data, of CWA bioassessment could yield significant cost efficiencies in ecological indicator development.

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[15] Barbour, Michael, Jeroen Gerritsen, Blaine D. Snyder and James B. Stribling. "Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition." *EPA 841-B-99-002*. United States Environmental Protection Agency; Office of Water; Washington, D.C. (1999)

[16] *Bioassessment Ecosummaries of All Districts*. Florida Department of Environmental Protection. 15 April 2004 <http://tlhdwf2.dep.state.fl.us/eswizard/eco_results.asp>.

[17] *Summary of Biological Assessment Programs and Biocriteria Development for States, Tribes, Territories, and Interstate Commissions: Streams and Wadeable Rivers*. EPA-822-R-02-048. United States Environmental Protection Agency. (2002)

[18] *Consolidated Assessment and Listing Methodology – Toward a Compendium of Best Practices*. United States Environmental Protection Agency. 12 April 2004 <http://www.epa.gov/owow/monitoring/calm.html>.

California Has Several Ecological Indicators Currently in Use

In California, ecological indicators of several different types are already used by DWR, the Department of Fish and Game, the State Water Resources Control Board, the Regional Water Quality Control Boards, the Department of Parks and Recreation, several municipalities including San Jose and San Diego, and several Native American tribes. Universities (UC Davis, Berkeley, and Los Angeles) and watershed citizen groups have also developed or used ecological indicator assessment. Two of the most developed methods are described in the following table.

Table 1

Indicator	Description and Current Use	Potential Applicability to MEWUE
California Stream Bioassessment Procedure (CSBP):[19]	The CSBP is a regional adaptation of the national Rapid Bioassessment Protocols outlined by EPA. The CSBP has been further refined by the Department of Fish and Game's Aquatic Bioassessment Laboratory to be relevant to California's ecoregions.	CSBP may be applicable in monitoring watershed health, assessing the efficacy and efficiency of specific restoration projects, or in targeting proposed projects.
California Monitoring and Assessment Protocol (CMAP):[20]	CMAP is the California-specific evolution of EPA's Environmental Monitoring and Assessment Protocol[21] which assesses water quality. CMAP uses random, statistical selection of samples from a selection of reference and impacted sites to create a cost-effective monitoring system of trends.	CMAP may be applicable in monitoring the efficiency of water management alternatives across regions and over time.

Applicability to MEWUE

The use of indicators to measure the ecological benefits of managed environmental water use is feasible and appropriate. Myriad methods of ecological assessment that show significant scientific reliability have been and continue to be developed, including several in California. Indicators could be used to monitor ecological quality, to aid in deciding between projects, and to assess the effectiveness of completed projects and programs.

Selection of sufficient and appropriate indicators for assessing MEWUE is critical. A multimetric approach that captures the range of values for which it is important to manage is preferable to a simple measure such as single species populations. Ecological indicator selection should be accessible to broad stakeholder involvement, and not restricted to scientists and agency personnel.

Because bioassessments must be calibrated to reference "unimpaired" conditions, they are necessarily region-specific. The applicable scale of individual indices may range from the watershed to the

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[19] *California Stream Bioassessment Procedure Protocol Brief*. Aquatic Bioassessment Laboratory, California Department of Fish and Game. 26 March 2004 <http://www.dfg.ca.gov/cabw/csbp_2003.pdf>.

[20] *California Monitoring and Assessment Program*. Aquatic Bioassessment Laboratory, California Department of Fish and Game. 30 March 2004 <http://www.dfg.ca.gov/cabw/Field/cmap.html>.

[21] *Environmental Monitoring and Assessment Program*. United States Environmental Protection Agency. 30 March 2004 <http://www.epa.gov/emap/index.html>.

ecoregion.[22] Additional factors relevant to the selection of appropriate indicator protocols for MEWUE include the cost of collecting and analyzing samples and the level of precision desired by decision makers.

3.1.2 Instream Flow Requirements

Description

The term "instream flow requirements" refers to the quantity and schedule of water required to protect the structure and function of aquatic ecosystems at some specified level of ecological health. While methods for directly measuring ecological health are still evolving, there are currently several techniques available that can provide such measurements in comparison to a reference condition, such as natural flow. One such technique is the Instream Flow Incremental Methodology (IFIM),[23] a tool used nationwide that is accepted by most resource managers as the best available method for determining the relationship between flows and aquatic habitats.[24] This methodology aims to assess the ecological effect of incremental changes in stream flow through the following five steps:[25]

- Problem Identification – Conduct physical analysis to define the affected physical location, and the aquatic resources of most concern. Perform legal-institutional analysis to identify interested parties and their objectives, and provide a better understanding of the impacts of the proposed project.
- Study Planning – Outline necessary data collection and require that all interested parties agree to a baseline hydrologic time series that will act as the reference condition.
- Study Implementation – Select sampling locations and collect data outlined in the Study Planning step, and use the results and predictive model (e.g. PHABSIM – physical habitat simulation) to estimate the relation between flow and total habitat.
- Alternatives Analysis – Compare alternative water uses against these instream flow requirements to determine the potential impacts of a proposed water project, and identify the habitat costs and benefits of the project.
- Problem Resolution – Reconvene interested parties to make a decision based on the results.

Collaboration among stakeholders is an important component of this process, as varying interests should agree on ecological health goals. Once instream flow requirements are set, environmental water allocation decisions can be guided by the relative ecological health improvements that result from application of a given amount of water. For example, if several areas are competing for water, planners could look at how well current allocations are meeting instream flow requirements in those areas. They could then make a decision based on which area(s) would achieve the greatest benefit relative to their targeted ecological health goals, thereby increasing the efficiency of managed environmental water.

[22] An ecoregion is an area of the country with similar geography, climate, and biology. There are considered to be 13 "Level III" ecoregions in California, according to EPA.

[23] "Instream Flow Incremental Methodology (IFIM)." Fort Collins Science Center. 10 April 2004 <http://www.fort.usgs.gov/products/software/ifim/ifim.asp>.

[24] "Instream Flows in Washington State of Washington: Past, Present and Future." Washington Department of Ecology. 10 April 2004 <http://www.olympus.net/community/dungenesswc/InstreamFlowversion12.PDF>.

[25] "Instream Flows in Washington State of Washington: Past, Present and Future." Washington Department of Ecology. 10 April 2004 <http://www.olympus.net/community/dungenesswc/InstreamFlowversion12.PDF>.

While uncertainty is present in this process, it can be reduced through careful study design, full inclusion of multiple viewpoints, and selection of an appropriate scale. Also, the accuracy of water project decisions can be evaluated and revised through post-project monitoring and analysis. In this way, adaptive management can reduce uncertainty and improve assessment and management of future projects.

Case Study 4

Washington State's Use of Instream Flows[26]

Washington State first introduced a systematic approach to instream flow protection in 1967. The legislation was updated with the Water Resources Act of 1971, which states the goals of water allocation in Washington as follows: "Allocation of water among potential uses and users shall be based generally on the securing of the maximum net benefits for the people of the state. Maximum net benefits shall constitute total benefits less costs including opportunities lost." As stated in section 2.2 of this report, this concept of maximizing net benefits is consistent with views expressed by stakeholders in California.

The process for setting flows in Washington is a collaborative effort led by the Department of Ecology, the state's principal environmental management agency. The department has authority to set flows only after going through public processes to ensure that issues are identified and considered. This gives local citizens, local government, state agencies, and tribes an avenue for involvement in establishing or amending instream flows. Flow recommendations must have unanimous support of all government members and tribes and a majority of non-government members. The technical process of setting flows utilizes IFIM and PHABSIM and takes multiple factors into account when setting flows, including fish, water quality, climate, dams, cultural values, and recreation, among other things. Using this information, the tools predict how the quantity of available fish habitat changes in response to incremental changes in flow.

The use of instream flow requirements in Washington has been influential in establishing management goals and maintaining sufficient levels of aquatic health. While controversy surrounded the initial setting of flows, the more collaborative approach that is now in place has acted to increase stakeholder satisfaction with the process. If California decided to pursue this approach, the state could benefit from Washington's experiences, particularly regarding the collaborative process and the scientific techniques employed.

Applicability to MEWUE

This method provides an eco-centric approach to managed environmental water use efficiency. It attempts to determine the water needs of an ecosystem to protect fish and other environmental values, and to make management decisions based on this science. If implemented, a collaborative process[27] like the one employed in Washington State allows stakeholders to provide input in setting or amending instream flow requirements and can thus increase stakeholder satisfaction. In addition, the process is quite amenable to adaptive management, as post-project assessment allows for a substantive evaluation of the accuracy of predicted instream flow requirements, which can subsequently be updated. This approach can also reduce uncertainty, as future modeling can be revised based on these post-project analyses. Technical feasibility is another strength of this technique, as widely accepted technology (IFIM) is

[26] "Instream Flows in Washington State of Washington: Past, Present and Future." Washington Department of Ecology. 10 April 2004 <http://www.olympus.net/community/dungenesswc/InstreamFlowversion12.PDF>.

[27] We discuss the importance of collaboration in more detail in Section 3.2.2.

available to develop instream flow requirements based on a baseline hydrologic time series. The technical viability of this method is also supported by successful implementations in other countries (such as South Africa)[28] and states, including Washington.

This technique improves efficiency of environmental water use by ensuring that management decisions are made in the context of approaching an accepted “goal” condition. The extent to which managed flows achieve this goal is a measure, albeit rough and unquantified, of benefits. Stakeholders interested in achieving a single metric of efficiency may not be satisfied. Furthermore, several factors prohibit this method from guaranteeing a single, best solution. Ecological complexity makes it impossible to fully assess and model the health of a given ecosystem, which leads to imperfection and uncertainty in the data and models. In addition, rational people may disagree, even on a science-based process, and so the collaborative process is not guaranteed to produce consensus. Still, the process would strengthen the scientific basis for environmental water allocation decisions.

3.1.3 Economic Valuation

Description

Economic valuation of ecological services and environmental quality is a rapidly developing field and is increasingly being used in natural resource management. Theoretically, accurate economic valuation of the benefits of alternative environmental water uses could be used to calculate the relative efficiency of these actions.

The purpose of any economic valuation is to estimate the value that consumers place on goods and services. When those goods and services are traded in a well-functioning market, their value can be assumed to equal their price. When, like environmental values, these goods and services are not traded in a market, their value must be deduced through “non-market valuation” techniques. There are a variety of such techniques that have been developed to estimate the public’s value for environmental goods and services.[29] Because of the large number of people affected, the sum of the value citizens place on environmental amenities can be quite large.

Economic valuation is already used to some extent by government agencies in cost-benefit analysis of water management alternatives, including water storage development, conservation measures, and specific restoration projects. It is also used in environmental damage assessment. Most non-market economic valuation is being conducted in the academic context.

[28] “Environmental Flow Assessments for Rivers: Manual for the Building Block Methodology.” 7 April 2004 <http://www.fwr.org/wrcsa/tt13100.htm>.
[29] See Appendix C for more details.

Case Study 5
South Platte River Conservation and Restoration Valuation Study[30]

Loomis et al. studied local residents' value for restoring certain ecosystem services along a 45-mile stretch of the ecologically important yet highly impacted South Platte River in Northern Colorado. One hundred residents participated in an in-depth valuation survey that elicited yes-or-no reactions to randomly-generated "proposed" water fees, which were analyzed to arrive at respondents' average "willingness to pay" regarding purchasing increased ecosystem services.

The study involved extensive respondent education in current resources and land use, proposed restoration and mitigation activities, and expected environmental benefits. These benefits would be achieved through specific management actions including purchasing a ten-mile-wide conservation easement along 45 miles of the river, creating buffer strips where cropland and cattle grazing would be eliminated and native vegetation would be planted, and buying water rights to increase stream flows by 50% to 70%. The ecosystem services residents were asked to value included dilution of wastewater, natural purification of water, erosion control, habitat for fish and wildlife, and recreation.

A mean annual household willingness to pay of $252 was estimated for the increase in ecosystem services on the 45-mile stretch of the river. This value, summed across the area's population, establishes an estimated value to the public of performing the actions of at least $19 million, compared to an estimated cost of the proposed actions of $13.5 million. Although no tax or charge resulted from the study, this estimated value has supported the conservation work of the Fish and Wildlife Service and Centennial Land Trust.[31]

Applicability to MEWUE

Economic valuation may be useful *as a component* in estimation and quantification of environmental benefits to aid in MEWUE assessment. A study such as the South Platte study could be conducted before a project or management decision to gauge the public's value of the environmental benefits, or after a change to determine the value achieved. With additional development, such a study could be used to inform decision-making on proposed projects, to assess relative efficiency of alternative programs or projects, and to evaluate success of existing programs.

Economic valuation would probably be most useful as a measurement of long-term, regional-scale, aggregate benefits of environmental water allocations. For instance, an economic valuation of CALFED ecosystem restoration activities is a feasible use of this technique. Economic valuation may also be most useful as a component of ex ante assessment of restoration alternatives. Depending on the quality and comprehensiveness of the analysis, comparative valuation of ecosystem benefits between projects may be an important contribution to decision making.

However, economic valuation cannot stand as a sole quantitative assessment of environmental benefits. Valuation techniques still only measure a portion of value that may be attributed to environmental

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[30] Loomis, John, Paula Kent, Liz Strange, Kurt Fausch and Alan Covich. "Measuring the Total Economic Value of Restoring Ecosystem Services In an Impaired River Basin: Results From a Contingent Valuation Survey." *Ecological Economics* 33 (2000): 103–117.
[31] *Partners for Fish and Wildlife Program, South Platte River Focus Area*. US Fish and Wildlife Service. 30 April 2004 <http://coloradopartners.fws.gov/co31.htm>.

resources.[32] To the extent that important environmental values are missing, economic valuation may not be an appropriate tool for seeking to maximize environmental benefit.

Given the range of services to be valued and the immaturity of the methods, economic valuation continues to be highly controversial. It is often questioned by those that find the methods and values unreliable and by those that feel it is immoral or impossible to value the natural world. For these reasons, economic valuation continues to have limited support in some sectors, including public opinion.

3.2 Institutional Methods

3.2.1 Benchmarking and Best Management Practices

Description - Benchmarking

Benchmarking is the process of monitoring the performance of management practices and restoration projects and identifying the most efficient among them for possible adaptation and implementation elsewhere. Benchmarking establishes performance standards that other managers or projects seek to emulate. The process of benchmarking moves an industry overall toward greater efficiency over time.

Benchmarking has two parts: the harvesting of benchmarks from existing projects and the application of these standards to future projects. In the harvesting step, assessing the success of projects and identifying best practices requires some process of systematic assessment and some measure of success. Benchmarks may be tolerant of some uncertainty in the measurement of benefits and could be implemented with relatively loose quantitative or even qualitative measures. Benchmarks might be based on ecological indicators, or on more subjective criteria, such as the success of projects in meeting pre-project objectives.

With a centralized agency monitoring the success of projects or programs across agencies and districts, benchmarks can be identified and publicized, allowing future projects or management decisions to adapt and apply successful models. Benchmarking is also accomplished by project sponsors being responsible for post-project auditing of water management regimes and restoration projects and publicizing exceptional results. This serves the dual purpose of harvesting benchmarks of success and providing some degree of accountability for success.

An ongoing benchmarking process would institutionalize adaptive planning. Projects would be explicitly studied for successful and unsuccessful components, which would then be incorporated or avoided, respectively, in future projects. Benchmarking can be conducted on a comprehensive basis across programs, as an added audit requirement on individual projects, or both. A benchmark program may be implemented by individual managers, or it may be undertaken by a centralized agency.

Benchmarking the efforts of California's water managers to measure and improve MEWUE would increase the rate of diffusion, adoption, and innovation of successful practices and over time increase efficiency. Benchmarking may also lead to the identification of Best Management Practices.

[32] For instance, valuation techniques will only capture anthropogenic value. That is, they do not express any intrinsic value of nature, but rather reflect the values humans ascribe to nature.

Description - Best Management Practices (BMPs)

Best Management Practices are practices or policies that have consistently provided examples of successful performance and have been demonstrated to be cost-effective when implemented on a wide basis. BMPs reduce information costs to individual water managers and are by design robust in the face of uncertainty. BMPs represent "no regrets" actions, actions that have a high likelihood of being successful, regardless of uncertainties as to the magnitude of the effect. BMPs provide off-the-shelf solutions to improving efficiency, and so reduce information costs to individual water managers.

BMPs are well established in the agricultural and urban sectors. Effective Water Management Practices (EWMPs) in the agricultural sector have helped drive significant gains in efficiencies in this sector. Similarly, urban water suppliers have adopted BMPs requiring the implementation of 14 specific management programs or practices, as discussed in the case study below.

Case Study 6

California Urban Water Conservation Council Best Management Practices[33]

In 1991, more than 100 urban water suppliers committed to implementing long-term conservation measures called Best Management Practices, or BMPs, by signing the Memorandum of Understanding Regarding Urban Water Conservation (MOU). Today, more than 310 urban water suppliers, public advocacy organizations, and other interested parties have signed the MOU, forming a coalition known as the California Urban Water Conservation Council (CUWCC). These signatories have voluntarily committed to implementing 14 BMPs, including surveys of users' baseline consumption and practices, audits of waste and leaks, implementation of specific conservation technologies, and conservation pricing.

The development of urban WUE BMPs allows water managers some certainty in the cost-effectiveness and benefits of proposed actions. Furthermore, the CUWCC process demonstrates a process for developing statewide, stakeholder-based agreement on BMPs.

Applicability to MEWUE

The evaluation of managed environmental water use efficiency is of little value without a process for deriving lessons from the process to be applied to future projects and management regimes. BMPs in a MEWUE context would be restoration projects, technologies, or management programs that have proven to be cost-effective in increasing efficiency of managed environmental water use. Examples of possible MEWUE BMPs include fish screens on water supply intake facilities and restoration techniques developed for the California Salmonid Stream Habitat Restoration Manual.[34]

BMPs have potential to be successful in cost-effectively increasing WUE for managed environmental water, just as they have done for agricultural or urban WUE. MEWUE BMPs must be carefully developed to ensure effectiveness and must be adaptable over time.

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[33] *California Urban Water Conservation Council About Us*. California Urban Water Conservation Council. 30 April 2004 <http://www.cuwcc.org/aboutus.html>.

[34] Flosi, Gary, Scott Downie, James Hopelain, Michael Bird, Robert Coey, and Barry Collins. *California Department of Fish and Game*, California Salmonid Stream Habitat Restoration Manual. 1998. 3rd edition. <http://www.dfg.ca.gov/nafwb/manual.html>.

3.2.2 Improved Water Management and Collaboration

Description

Several stakeholders mentioned that a lack of effective communication mechanisms and regulatory inflexibility often stand in the way of effective decision-making. Many argue that this lack of communication has led to inefficiencies in water management. For example, several stakeholders suggest that this lack of communication led to the inefficient use of water in the 2003 Folsom Dam release that we reference as a case study in Section 2.1. As we mentioned, that process did not involve a discussion of the tradeoffs between different potential actions. Making this decision within a framework of collaborative decision-making may have helped mitigate the negative results.

This section suggests the need for a new or enhanced mechanism for communication and decision-making that more effectively addresses ecosystem needs. The goal would be to create a collaborative process that would allow for a more flexible response to situations like the Folsom Dam release. Such an approach requires a commitment to understanding the interrelation of various goals within water planning.

Incorporating this approach would involve choosing from a range of options – from increased reliance on existing collaborative communication structures to replication of those systems that work well in some areas into other water planning situations. One possible outcome could take the form of a more formal communications structure, such as the case study discussed below. Another option might incorporate collaboration into decision-making processes that currently occur at various water planning levels (districts, etc.). The actual form that collaboration would take will vary across settings and requires an evaluation of current planning processes to determine where gaps in communication exist. The most important aspect of this approach is establishing a framework within which multiple stakeholders with diverse interests can identify areas of conflict and commonality.

Case Study 7

CALFED Operations Group (CALFED Ops)

The agreement to establish CALFED in 1994 "ended decades of infighting and regulatory uncertainty."[35] Multiple agencies with a stake in Bay-Delta water planning created CALFED to address a lack of agency communication and deadlocked interests. CALFED, a collaborative resource program, was created with the mission to "develop and implement a long-term comprehensive plan that will restore ecological health and improve water management for beneficial uses of the Bay-Delta."[36] CALFED makes real-time management decisions through an interagency group known as CALFED Ops. The fundamental notion of CALFED Ops is that agencies can best meet their individual responsibilities by sharing information.

CALFED Ops functions as a resource for all agencies involved in water planning in the Bay-Delta.[37] The idea behind the Ops group was that "information on fisheries, and water quality and flows, could be evaluated quickly using the distributed intelligence of the diverse agency and stakeholder members."[38]

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[35] *About CALFED.* California Bay Delta Authority. 15 April 2004 <http://calwater.ca.gov/AboutCalfed/adobe_pdf/CALFED_Standard_Presentation_History_and_Context_3-18-04-2.pdf>.
[36] *About CALFED.* California Bay Delta Authority. 15 April 2004 <http://calwater.ca.gov/AboutCalfed/adobe_pdf/CALFED_Standard_Presentation_History_and_Context_3-18-04-2.pdf>.
[37] Participating agencies include DWR, Bureau of Reclamation, NMFS, USF&WS, EPA, DF&G and SWRCB.
[38] Connick, S. and Judith Innes. *Outcome of Collaborative Water Policy Making: Applying Complexity Thinking to Evaluation.* University of California at Berkeley, Institute of Urban & Regional Development. 16 April 2004 <http://www-iurd.ced.berkeley.edu/pub/WP-2001-08.PDF>.

CALFED Ops works to identify the interrelation of the goals of its subcommittee members[39] to detect potential conflicts and identify actions that will promote the goals of multiple subcommittees.[40] This process helps project planners determine the potential impacts of the activities they are pursuing, and CALFED Ops creates the communication and coordination mechanism within which consensus-based decisions can be made. CALFED Ops holds monthly meetings to make decisions and discuss potential changes and strategies. Decisions can involve changes in export rates, barrier operations, and reservoir releases. Ops group deliberations are conducted in consultation with water user, environmental, and fishery representatives.

On a host of outcomes by which to evaluate collaborative decision making, CALFED Ops scores highly. These measures include increased social and political capital, agreed-on information and shared understanding, end to stalemate, high quality agreements, innovation, and institutions and practices that involve flexibility.[41] For example, the Ops group played a critical role in November and December of 1999, when “dry conditions, in combination with record high tides and the onset of a salmon out-migration produced a very complex and difficult water management situation.”[42] CALFED Ops work groups held almost daily consultations during the five weeks these conditions prevailed, and “decision making was quick and effective, occurred at the lowest levels possible and the process provided a much more nuanced response than a single bureaucratic agency could provide.”[43]

What stands out about how decisions were made in November and December of 1999 is that “unlike the way decisions were made prior to CALFED, the regulatory agencies were all involved in the decision-making, along with the resource managers and stakeholders.”[44] “A particularly extraordinary aspect of this innovation [CALFED Ops] was that stakeholders representing typically opposing viewpoints were able to come to agreement.”[45] In this case, resource managers faced different regulatory requirements that conflicted with each other. In the end, despite the fact that not all stakeholders were pleased with all outcomes, they all believed in the process of reaching decisions together.

Applicability to MEWUE

This approach to MEWUE would aim to improve communication by introducing a collaborative decision-making approach that explicitly aims to reduce conflicts and to support multiple goals of water planning interests. Water planners are likely to improve the efficiency of environmental water use within an improved decision-making structure. Currently, conflicts between various regulatory requirements and lack of a comprehensive water management structure for day-to-day communication and management may create inefficiency in the application of environmental water. Once a collaborative process is underway, it could potentially serve as a way to identify regulations that perhaps need changing or system-wide review among federal, state, and local water managers.

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[39] Subcommittees include: Delta Levee habitat, drinking water, ecosystem restoration, environmental justice, water use efficiency, watershed, water supply and working landscapes.
[40] *Interrelation of CALFED Subcommittee Goals from the Ecosystem Restoration Subcommittee Perspective*. California Bay Delta Authority. 15 April 2004 <http://calwater.ca.gov/BDPAC/Subcommittees/EcosystemRestoration/ERP_Interrelation_Matrix_10-20-03.pdf>.
[41] Connick & Innes (2001)
[42] Connick & Innes (2001)
[43] Connick & Innes (2001)
[44] Connick & Innes (2001)
[45] Connick & Innes (2001)

This approach does not establish a mechanism with which to measure these improvements. Still, guidelines do exist for developing performance measurements using criteria such as an increase in high quality agreements, an end to stalemate, etc.[46]

If instituted in a more formal manner, this method may take some time to yield results. The development of CALFED was a multi-year effort that required commitment from many stakeholders to work through the process. However, given that there is an existing framework from which to model future communication structures, it is possible that planners would see preliminary results reasonably quickly.

Implementing this method could involve some technical or legal difficulties to the extent that it suggests the need for changes in institutional structure or behavior or changes in regulation. However, the main thrust of this suggested approach is increasing communication and developing consensus-based decisions around current regulatory requirements, which in and of itself is not likely to involve technical or legal difficulty. Should future legislative action be determined necessary, a framework will exist within which to advocate for proposed legal changes. This method does not directly encourage adaptive management, but enhanced communication could potentially create a more flexible, adaptive decision-making context.

4.0 Conclusions and Recommendations

Coming To Terms with MEWUE

The scarcity of water in California necessitates the efficient use of any given quantity. Despite perceived disagreement about WUE for the environment, there is consensus among the stakeholders with whom we spoke that environmental water management should strive to achieve the greatest amount of benefit possible from the water made available. This key concept can provide the foundation for developing and implementing MEWUE.

Terminology being as important as it is, a large part of our task has been to develop a term to accurately describe what the concept encompasses and what it doesn’t. We propose the term Managed Environmental Water Use Efficiency – MEWUE – to satisfy these concerns. We intend MEWUE to address the objections stakeholders voiced with other suggested terms, and to define our scope of inquiry as uses of water dedicated to the environment through human management.

Appropriately implemented, MEWUE would be a systematic method of measuring and improving the benefits of specific environmental water uses. It would also allow evaluation of the relative efficiency of one use of managed environmental water over another. MEWUE would replace implicit assumptions about the efficiency of managed environmental water with explicit assessment. MEWUE can also provide a mechanism for improving management over time and increasing accountability for environmental water use decisions.

Many tools that could be used to measure or improve MEWUE are currently in place or are being developed. The condition of California’s aquatic environments (including water quality, habitat suitability, etc.) is monitored under a variety of programs and with various techniques. Also, individual restoration projects or ecological flow regimes are often evaluated for effectiveness in meeting some set

[46] Connick & Innes (2001)

of goals. Successful management practices and standard restoration techniques are identified and publicized. Regulatory changes and interagency management and communication initiatives are occasionally initiated. To a large extent, then, the recommendation of this report is to recognize and embrace these components as ingredients in a system to evaluate and maximize the efficiency of water management for environmental benefits, under the common rubric of MEWUE.

A Comprehensive and Collaborative Approach to Defining and Implementing MEWUE

The identification of the environmental benefits that are gained per unit of water is a difficult and controversial task, given the complexity of any ecological system. Precisely quantifying these benefits is beyond the reach of current science and economics. In the absence of a single measure, whatever method is used to determine these benefits should be as comprehensive as possible to accommodate the range of values associated with healthy ecosystems. Single species metrics will generally not be sufficient. However, a modification of the variety of ecological assessment techniques and metrics presently available could be constructed to act as a standardized measure of ecological benefits, at least within ecoregions.

Potential Approaches to Implementing MEWUE

- Employ quantitative ecological monitoring and evaluation programs to create baseline data, monitor trends and aggregate performance, and perform targeted efficiency assessment of individual projects.
- Perform instream flow requirements analysis to establish habitat goals for California's aquatic habitats.
- Further develop the role of non-market economic valuation in cost-benefit analysis of alternative projects and management regimes.
- Establish a benchmarking process for environmental water management.
- Create a process for establishing Best Management Practices for environmental water uses.
- Create an interagency collaborative working group for environmental water management decision-making, program and regulatory harmonization, and coordination of research.

Furthermore, there are ongoing efforts to improve environmental water use and ecosystem restoration projects, but they have not been recognized as measures that increase the efficiency of managed environmental water uses. We recommend populating MEWUE with a variety of efficiency-promoting practices. These practices include instream flow assessments, project auditing, benchmarking, and best management practices.

Given the variety of viable approaches and the diversity of stakeholder perspectives, we recommend an ongoing collaborative process (similar to those conducted by CALFED) to define and implement MEWUE. We view such an approach as important in ensuring a comprehensive and mutually acceptable approach to solving the difficult benefits evaluation issue. A collaborative approach would also facilitate improvements in interagency communication and decision-making structures.

We do not provide in this report a single answer or approach for defining and implementing MEWUE. Rather, we have demonstrated the importance of the concept and introduced the idea that many practices championed by various stakeholders can play a part in MEWUE. We hope that this report provides a term and concept around which a collaborative discussion can be structured about how best to implement this concept.

Summary of Key Points

- This report provides a term and concept around which a collaborative process can be structured.
- Despite perceived disagreement about WUE for the environment, there is consensus that environmental water management should strive to achieve the greatest amount of benefit possible from the water made available.
- MEWUE – Managed Environmental Water Use Efficiency – is a suitable term to express this goal.
- Multiple current efforts and practices are related to MEWUE, and potentially can be incorporated into its implementation.
- Although precise quantification of environmental benefits is exceedingly complex, ecological indicators can provide useful measurements of ecosystem health and instream flow requirements can provide management goals. Benchmarking and Best Management Practices are techniques that could operationalize MEWUE.
- Given the variety of viable approaches and the diversity of stakeholders, an ongoing collaborative process (similar to those conducted by CALFED) can help define and implement MEWUE.

APPENDIX A: State Water Plan Update 2003 Public Advisory Committee Members

Margit Aramburu	Delta Protection Commission
Mary Bannister	Pajaro Valley Water Management Agency
Kirk Brewer	California Water Association
Merita Callaway	California State Association of Counties
Scott Cantrell	California Department of Fish and Game, Sacramento
Grace Chan	Metropolitan Water District of Southern California, Los Angeles
Jim Chatigny	Mountain Counties Water Resources Association
Marci Coglianese	League of California Cities, Rio Vista
Bill Cunningham	U.S. Natural Resources Conservation Service, Davis
Grant Davis	Bay Institute of San Francisco, San Rafael
Martha Davis	Inland Empire Utilities Agency, Rancho Cucamonga
Mary Ann Dickinson	California Urban Water Conservation Council, Sacramento
Nick Di Croce	California Trout, Solvang
Anisa Divine	Imperial Irrigation District
William DuBois	California Farm Bureau Federation, Sacramento
Howard Franklin	Monterey County Water Resources Agency
Lloyd Fryer	Kern County Water Agency, Bakersfield
Bill Gaines	California Waterfowl Association, Sacramento
Fran Garland	ACWA, Contra Costa Water District, Concord
Peter Gleick	Pacific Institute for Studies in Development, Environment, and Security, Oakland
Zeke Grader	Pacific Coast Federation of Fishermen's Associations, San Francisco
Brent Graham	Tulare Lake Basin WSD, Corcoran
David Guy	Northern California Water Association
Martha Guzman	California Rural Legal Assistance Foundation
Alex Hildebrand	South Delta Water Agency, Manteca
Mike Hoover	U.S. Fish and Wildlife Service
Bill Jacoby	WateReuse Association, San Diego
Craig Jones	State Water Contractors, Inc., Sacramento
Rachel Joseph	Lone Pine Paiute-Shoshone Tribe
Kevin Kauffman	Stockton East Water District, Stockton
Joseph Lima	ACWA, Modesto Irrigation District, Modesto
Jay Lund	University of California, Davis
Steve Macaulay	California Urban Water Agencies, Sacramento
Jennifer Martin	The Nature Conservancy, San Francisco
Benjamin Magante, Sr.	San Luis Rey Indian Water Authority
William Miller	Consulting Engineer, Berkeley
John Mills	Regional Council of Rural Counties
Clifford Moriyama	California Business Properties Association, Sacramento
Valerie Nera	California Chamber of Commerce, Sacramento
James Noyes	Southern California Water Committee, Inc., Ontario
Enid Perez	Del Rey Community Services District, Del Rey

Lloyd Peterson	U.S. Bureau of Reclamation, Sacramento
Cathleen Pieroni	City of San Diego Water Department
Nancy Pitigliano	Tulare County Farm Bureau, Tipton
Robert Quitiquit	Robinson Rancheria, Nice
Betsy Reifsnider	Friends of the River, Sacramento
Terry Roberts	Governor's Office of Planning and Research
Larry Rohlfes	California Landscape Contractors Association, Sacramento
Spreck Rosekrans	Environmental Defense
Jennifer Ruffolo	California Research Bureau
Steve Shaffer	California Department of Food and Agriculture, Sacramento
Polly Osborne Smith	League of Women Voters of California, Tiburon
Jim Snow	Westlands Water District, Fresno
Frances Spivy-Weber	Mono Lake Committee, Redondo Beach
John D. Sullivan	League of Women Voters, Claremont
Walter Swain	U.S. Geological Survey, Sacramento
Greg Thomas	Natural Heritage Institute, Berkeley
Michael Wade	California Farm Water Coalition, Sacramento
Michael Warburton	The Ecology Center, Berkeley
Tom Ward	California Department of Parks & Recreation
Brian White	California Building Industry Association
Arnold Whitridge	Trinity County
Robert Wilkinson	University of California Santa Barbara
Kourt Williams	Executive Partnership for Environmental Resources Training, Inc.
Carolyn Yale	U.S. Environmental Protection Agency, San Francisco
Gary Yamamoto	California Department of Health Services, Sacramento
Tom Zuckerman	Central Delta Water Agency

APPENDIX B: Interview Questions[47]

Background

What do you work on? How is this concept relevant to your interests and those of your organization?

The WUE concept

When you hear the term "water use efficiency," what is your reaction? What do you understand the term to mean generally?

To you, what should Ecosystem Restoration Water Use Efficiency mean?[48] What is the concept fundamentally about? What should it measure (regardless of whether it can or not)?

What, specifically, are you most interested in changing through this concept? If this concept will not change whatever you feel is the critical issue, what would?

If conducted correctly, what good will come out of the process of defining and implementing this concept?

What, if anything, concerns you about the process of defining and implementing WUE? Are there critical interests that you fear may be compromised by this endeavor? What, specifically, are they?

Existing Reference Points

Do you have examples of water use for ecosystem restoration that is inefficient or could be more efficient?

Do you see any significant regulatory barriers to WUE? What, specifically, are they? Are there new regulatory approaches that could facilitate the concept?

How do you feel that your concept of ecosystem restoration efficiency might be measured? Are you aware of any existing literature that you find particularly applicable/compelling? What ecological indicator methods are you aware of that might be specifically relevant to this project?

How do you currently measure/assess the merit of restoration projects at this time (assuming you think about such things)?

Are you aware of approaches to this problem that you consider best management practices?

Have you done work on this concept before? Are you aware of others who have, or others we should talk to for whatever reason? Who? How about the parallel concept for other uses (agricultural/urban water use)?

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[47] These questions served as the basis for our conversations with stakeholders and often we did not ask them verbatim. Rather, the questions served to guide these interviews and ensured that major points would be addressed during the course of our conversations.

[48] At the time we prepared this questionnaire, Ecosystem Restoration WUE was the term in use.

Current Project

What do you feel would be the most potentially beneficial outcomes of the GSPP team's work on this issue? What specific outputs would you find valuable? How can we be helpful to you and to the problem?

How do you feel about the interaction of different actors and stakeholders who participate in the water planning process? How do you feel this process could be improved?

APPENDIX C: Economic Valuation Methods[49]

Market Price Method

Estimates economic values for ecosystem products or services that are bought and sold in commercial markets.

Productivity Method

Estimates economic values for ecosystem products or services that contribute to the production of commercially marketed goods.

Hedonic Pricing Method

Estimates economic values for ecosystem or environmental services that directly affect market prices of some other good. Most commonly applied to variations in housing prices that reflect the value of local environmental attributes.

Travel Cost Method

Estimates economic values associated with ecosystems or sites that are used for recreation. Assumes that the value of a site is reflected in how much people are willing to pay to travel to visit the site.

Damage Cost Avoided, Replacement Cost, and Substitute Cost Methods

Estimates economic values based on costs of avoided damages resulting from lost ecosystem services, costs of replacing ecosystem services, or costs of providing substitute services. Most famous example is New York City's estimation of the value of watershed protection and enhancement, based on avoided costs of drinking water treatment.

Contingent Valuation Method

Estimates economic values for virtually any ecosystem or environmental service. The most widely used method for estimating non-use, or "passive use" values. Asks people to directly state their willingness to pay for specific environmental services, based on a hypothetical scenario.

Contingent Choice Method

Estimates economic values for virtually any ecosystem or environmental service, based on asking people to make tradeoffs among sets of ecosystem or environmental services or characteristics. Does not directly ask for willingness to pay—this is inferred from tradeoffs that include cost as an attribute.

Benefit Transfer Method

Estimates economic values by transferring existing benefit estimates from studies already completed for another location or issue.

[49] *Ecosystem Valuation.* U.S. Department of Agriculture Natural Resources Conservation Service and National Oceanographic and Atmospheric Administration. 1 March 2004 <http://www.ecosystemvaluation.org/>.

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