Managed Environmental Water Use Efficiency

Evidence in Practice

Prepared for the
State of California
Department of Water Resources
Statewide Planning Branch

Prepared by Loida Begley, Karin Edwards,
Sarah Heard and Lisa Walling
University of California – Berkeley
Goldman School of Public Policy

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Executive Summary

The California Water Plan Update 2005 first introduced the term Managed Environmental Water Use Efficiency (MEWUE). Specifically, it defines MEWUE as 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 as a means to improve decision-making over time."[1] While MEWUE is a new term, we found several instances where managers maximized environmental benefit from a given amount of water in current practice. This paper demonstrates and analyzes current applications of MEWUE. It then provides the Department of Water Resources with the following recommendations to advance the concept and formally incorporate it into environmental water management:

- ✓ **Formalize a MEWUE Policy** to clearly state that the goal of MEWUE is a management strategy to maximize environmental benefit and not a water conservation policy.
- ✓ **Develop Best Management Practices** to increase understanding, provide guidance, and encourage use of MEWUE.
- ✓ **Operate a MEWUE Pilot** to learn more about the way MEWUE works, understand its strengths, and improve on its weaknesses.
- ✓ **Facilitate an Environmental Water Market** by applying experience and infrastructure to provide solutions for projects that require more water.

[1] State of California. Department of Water Resources. Deason, Jeff, et al. Considering Water Use Efficiency for the Environmental Sector. *California Water Plan Update 2005*: Volume 4 – Reference Guide. May 14, 2004.

List of Abbreviations

AF – Acre-feet
BMP - Best Management Practice
CVP - Central Valley Project
DFG – California Department of Fish and Game
DOI – Department of the Interior
DWR - Department of Water Resources
EPA - United States Environmental Protection Agency
ESA - Environmental Species Act
EWA - Environmental Water Account
KW - Kilowatt
M – Million
MAF – Million Acre-feet
MOU - Memorandum of Understanding
NMFS – National Marine Fisheries Service
PG&E – Pacific Gas and Electric
SWP - State Water Project
TNC - The Nature Conservancy
USBR - United States Bureau of Reclamation
USFWS – United States Fish and Wildlife Service
WUE - Water Use Efficiency

1.0 Introduction

The California Department of Water Resources (DWR) is responsible for planning for future statewide water needs.[2] The DWR has expressed interest in the idea of efficient water use within the environmental sector. The *California Water Plan Update 2005* first introduced the term Managed Environmental Water Use Efficiency (MEWUE). Specifically, it defines MEWUE as "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 as a means to improve decision-making over time."[3] While MEWUE is a new term, it does not represent a wholly novel concept. Environmental managers in California are accustomed to utilizing a limited amount of water in order to achieve desired outcomes. However, the notion of efficiency is one that is not readily accepted within the environmental sector. As a result, MEWUE has experienced resistance from members of the environmental community. This paper outlines current uses of MEWUE to demonstrate that it is a valid concept in practice and suggests ways to formally incorporate it into environmental water management.

1.1 Scope

We conducted this study at the request of the Statewide Water Planning Branch of the DWR. The DWR's Statewide Water Planning Branch is responsible for producing a water plan every five years, detailing future water planning activities throughout California. The DWR is accountable to a Public Advisory Committee, which has a significant role in the formulation of statewide water planning initiatives. The Advisory Committee consists of a diverse representation of water interests across the state. The Advisory Committee contains an Environmental Caucus, which represents the main interests and concerns of the environmental sector with regard to water management and planning.

The agency first commissioned an independent group to conduct a study of the idea in 2004. Their work first introduced the concept of MEWUE in the *California Water Plan Update 2005*. The Environmental Caucus expressed concern regarding the idea, specifically that it would be used to take water away from the environmental sector. DWR continues their interest in exploring MEWUE and sought an independent analysis of the concept's validity. Specifically, they have an interest in examining practical applications of MEWUE to increase understanding of the concept and decrease resistance to it.

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[2] State of California. Department of Water Resources. <www.water.ca.gov>,
[3] State of California. Department of Water Resources. Deason, Jeff, et al. Considering Water Use Efficiency for the Environmental Sector. California Water Plan Update 2005: Volume 4 – Reference Guide. May 14, 2004.

1.2 Methods

We utilized case studies as our method for understanding and demonstrating existing examples of MEWUE in practice. Our selection of case studies spans a broad range of categories, such as type of environmental problem, project size, managing organization and location. Environmental problems included water quality, endangered species, and habitat restoration projects, among others. Project sizes range from small creeks to large water storage and power generating facilities. Managing organizations included state and federal agencies as well as non-profit special interest groups. We focused on cases primarily in California, but we also include examples from other western states, such as Arizona and Oregon. Because MEWUE is case specific, we recognize that our analysis is not exhaustive. We examined a limited number of case studies to illustrate MEWUE by example.

1.3 Definitions

We acknowledge that multiple definitions exist for management, environmental water, and efficiency. In this report, we use our own definitions for these terms below. By explicitly defining the components of the acronym MEWUE, we hope to further clarify the concept to strengthen its acceptance in and application to the environmental sector.

1.3.1 Managed Environmental Water

The concept of MEWUE involves a very specific aspect of environmental water – *managed environmental water*. Therefore, this paper addresses how water is used in environmental restoration and mitigation projects. Our definition of managed environmental water is water that has been dedicated or transferred to a managed environmental use to improve an environmental condition.

1.3.2 Efficiency

Efficiency refers to maximizing environmental outcomes from a given amount of managed environmental water. An efficient outcome depends upon the best available information and resources at a given point in time. As a result, efficiency may be an improvement[4] and not a perfect solution. Efficiency is not about decreasing the quantity of water but rather, about trying to increase environmental benefit. Although the concept of *efficiency* is central to the concept of MEWUE, we use it in conjunction with the idea of *effectiveness*, the ability to achieve an

[4] We draw from the idea of Pareto improvement, a change that makes one party better off without making any other worse off.

environmental benefit. In the next section, we discuss the difficulty in defining an *environmental benefit*.

2.0 Current Trends In Water Usage

Water is a scarce resource in California because of limited supplies and competition among users. A broad distinction of water interests includes three major sectors: agricultural, urban, and environmental.

2.1 Agricultural Water Use

Agriculture is the leading industry in California and uses water to support $31.8 billion in total revenue cash receipts in 2004, with $23.2 billion from non-livestock and poultry agriculture.[5] California agriculture uses approximately 80% of the state's developed water supply.[6] As the industry continues to thrive, water remains a valuable commodity to California's agricultural producers.

2.2 Urban Water Use

In a state with a population of 37.2 million,[7] urban users demand a substantial quantity of water. The five most populated counties, Los Angeles, Orange, San Diego, San Bernardino, and Riverside account for approximately 55% of the total population and are also the fastest growing.[8] Water for the urban sector sustains domestic, industrial, and commercial uses. The majority of the state's population and industry resides in Southern California and the San Francisco Bay Area, but much of their water comes from the Sierra Nevada and the Colorado River. The Central Valley Project (CVP), operated by the United States Bureau of Reclamation (USBR), and the State Water Project (SWP), operated by the DWR, are the primary developed conveyances that deliver water to urban and agricultural users.

As California's population and industry continue to grow, both the urban and agricultural sectors will continue to demand a significant amount of water in the future.

[5] State of California, Department of Food and Agriculture, California Agricultural Resource Directory, (2004 Crop Year Production Information), 2005.
[6] http://www.owue.water.ca.gov/agdev/index.cfm, accessed 5/9/06.
[7] State of California, Department of Finance, E-1 Population Estimates for Cities, Counties, and the State with Annual Percent Change-January 1, 2005 and 2006, Sacramento, CA, May 2005.
[8] State of California, Department of Finance, E-1 Population Estimates for Cities, Counties, and the State with Annual Percent Change-January 1, 2005 and 2006, Sacramento, CA, May 2005.

2.3 Environmental Water Use

The environment represents a third major "user" of water in California. Environmental water as a general concept includes water used in managed systems as well as water not captured in controlled water systems. While debate surrounds the quantity of water the environmental sector actually uses, in this paper, we refer specifically to the environmental sector as that which uses water in a management context, i.e., through restoration and mitigation projects. Certain legislation and regulations procure water for the environment, such as an 800,000 acre-foot (AF) allocation from the Central Valley Project. Additionally, case law requires set allocations of water for various environmental projects and sites.

3.0 Management of Environmental Water in California

Several federal, state and local agencies, as well as private organizations, play various roles in environmental water management. These agencies and organizations differ in their missions and often have competing interests. Regulation is the primary driver behind decisions involving applications of managed environmental water. For example, agencies can require instream minimum flows to help meet dwindling fish goals. However, since regulation usually focuses on very specific environmental goals, such as species counts or water quality standards, one regulation may not address various environmental needs simultaneously. Environmental water management may include a number of approaches, such as command-and-control, adaptive management, collaborative partnerships, as well as innovative approaches undertaken by special interest groups.

The environmental sector differs from the urban and agricultural sectors in a number of ways. Environmental benefits or outcomes are not usually linked to profit, whereas in the agricultural and urban sectors, it is common to assign a monetary value to water. The environmental sector involves natural systems, which cannot necessarily concretely measure their water use and resulting benefits. Additionally, a degree of uncertainty surrounds the underlying science and outcomes regarding ecosystems. Because of this, it is not always appropriate to compare the way that the environmental sector manages its water with water management in the urban and agricultural sectors.

4.0 Challenges

Because MEWUE is a new term and is not formally recognized, it faces several barriers to advancement. The following is a brief overview of the key challenges facing MEWUE's advancement.

4.1 WUE Precedent

It cannot be emphasized enough that MEWUE is a management strategy to increase the environmental benefit for a given amount of water and *not* a water conservation policy. We do not attempt to compare MEWUE with WUE practices in other sectors; we only suggest that there is room for the environmental sector to improve their management practices. The existence of a similar-sounding term in the urban and agricultural sectors may hinder the acceptance of MEWUE if it is incorrectly perceived to be a water conservation policy.

4.2 Measuring Environmental Benefit

Challenges to quantifying environmental benefits and successful outcomes represent one of the most controversial topics in the conservation world today. As such, this makes measuring environmental efficiency challenging. In the environmental sector, measuring benefit depends upon the definition of the benefit itself and the standard applied to evaluate benefits achieved. In the agricultural sector, benefit gained from a given amount of water is measured by the additional unit of crop produced. And similarly, in the urban sector, benefit can be measured by each additional person served by a given amount of water. Unfortunately, measuring benefit for the environment is hard to quantify and cannot be easily reduced to a simple input/output ratio. The underlying scientific uncertainties inherent in ecosystems further complicate the measurement of environmental benefits. Furthermore, defining an environmental benefit is inherently case-specific, and it depends on the nature of the involved organization. We speak to these issues more comprehensively in **Appendix B**.

4.3 Universal Application

Because achieving efficiency and effectiveness of water use in the environmental sector is case-specific, often the solution to one problem will not be applicable to another. As a result, a universal, one-size-fits all MEWUE policy is not likely to be appropriate or effective. If the DWR does move forward with a policy to maximize environmental benefits from a given amount of environmental water, the case-specific nature of environmental projects serves as a challenge to the development of MEWUE.

5.0 Case Studies

We examined seven case studies in the environmental sector for evidence of management approaches that sought to maximize the environmental benefits from a given quantity of water. With this as our operating definition of MEWUE, we subsequently analyzed these cases to determine the validity and value of the concept in practice. The main focus of this paper is to provide an analysis of trends across case studies, so we do not provide a detailed account of each of our cases within the body. Rather, we include more comprehensive case summaries in **Appendix A**. To provide context for our analysis, **Table 1** summarizes the characteristics of the case studies, and we provide a brief overview of each case.

5. 1 Case Study Key Outcomes

5.1.1 Cosumnes River[9]

Farmers have historically utilized the Cosumnes River floodplain for agriculture, lining the river with a system of levees for flood control purposes. In the mid 1990s, The Nature Conservancy (TNC) performed an experimental levee breech[10] in an attempt to restore native riparian valley oaks following nearly a decade of failed attempts at planting. After repeated levee breeches, today the area is home to a high degree of biodiversity and provides the added benefits of flood control, water quality, open space and recreation.[11]

More recently, extensive municipal groundwater pumping from growing suburban communities in southern Sacramento County has caused portions of the Cosumnes River to dry up during the summer months, threatening fall-run Chinook salmon. TNC and researchers at the University of California at Davis explored several options before successfully purchasing a water right from a rancher's neighbor. The additional flows "pre-wet" the streambed, allowing the groundwater table to rise so that the river no longer runs dry during the fall run of Chinook salmon.

5.1.2 Cold Creek

Local property owners built the Lake Christopher Dam to create a lakefront subdivision in the 1950s.[12] The City of South Lake Tahoe acquired the land in the early 1980s, and soon thereafter found the dam to be a flood-hazard. The City attempted to improve dam safety without negatively impacting the environment, finally partnering with the California Tahoe Conservancy (CTC) to restore the Cold Creek ecosystem. The CTC restored channel form and removed Lake Christopher Dam. This resulted in improved ecosystem health and water quality.

5.1.3 Glen Canyon Dam

Cold water discharges from the Lake Powell reservoir, upstream of the dam, have adversely affected native warm-water fish habitat. The USBR has conducted an extensive alternatives analysis of mitigation strategies to restore habitat, including both water and non-water uses. The current plan is to install temperature control devices in two of the dam's eight intakes, a strategy that offers the most potential for warming the water to the necessary level while minimizing costs and uncertainty regarding the ecosystem.

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[9] We examined two case studies on Cosumnes River. Table 1 outlines the findings from each case.
[10] The levee breech occurred on the reach of the Cosumnes River owned by The Nature Conservancy and known as the Cosumnes River Preserve.
[11] Cosumnes River Preserve Online. Benefits to Water Supply Reliability, Water Quality, Flood Control, and Recreation. 28 March 2006 < http://www.cosumnes.org/benefits.htm>.
[12] American Rivers. Cold Creek, CA. 15 March 2006 <http://www.americanrivers.org/site/PageServer?pagename=AMR_content_b366>.

Table 1. Case Study Overview

	Cosumnes River Riparian Restoration	Cosumnes River Groundwater Pumping	Cold Creek	Glen Canyon Dam	Environmental Water Account	Oregon Water Trust	Iron Mountain Mine	Battle Creek
Location	Sacramento County, CA	Sacramento County, CA	South Lake Tahoe, CA	Colorado River, AZ	San Francisco Bay/Sacramento-San Joaquin River Delta, CA	Deschutes River Basin, OR	Shasta County, CA	Shasta County, CA
Environmental Goals	Riparian Restoration	Increase Salmon populations	Riparian Restoration; Improve Lake Tahoe Water Quality	Increase warm-water fish populations	Reduce fish killed at Delta pumps	Increase fish populations	Improve water quality, reduce pollution of sediments	Restore endangered fish populations
Size and Type	25 acre Nature Preserve	20 mile River Reach	1/2 - 1 mile Stream Reach	26.2MAF total storage capacity & 1.3M kw Powerplant	Large scale pumping project	Small tributary of Deschutes River	4,400 acre former mining site	48 miles of creek and tributary
Approximate Cost (in 2005 dollars)	Low[13]	Not Available	$1.8M	$80M	$50M/year[14]	$6,000/year	$1M/yeartreatment; $0.7M/year disposal; ($950M[15] settlement)	$75M
Organization	Nature Conservancy	Nature Conservancy	Tahoe Conservancy	USBR	CALFED, USBR, DFG, DWR	Oregon Water Trust	EPA	DOI, USBR, USFWS, NMFS, DFG, PG&E

[13] Initial project incurred very low overhead costs – ongoing management costs unavailable
[14] Disagreement surrounds the actual annual cost of the EWA
[15] Initial settlement in 2000 dollars; conversion to 2005 dollars is $1.06Bs

5.1.4 Environmental Water Account

The Environmental Water Account is a water management mechanism designed by CALFED to protect the Bay-Delta ecosystem, specifically the endangered Delta smelt, from the impact of state and federal water projects. The EWA allows for a decrease in pumping activity in the Delta at crucial times without reducing the allocation of water to the SWP and CVP. There is debate as to whether the EWA has mitigated the effect of pumping on the Delta smelt.

5.1.5 Buck Hollow Creek

Buck Hollow Creek, a tributary of the Deschutes River that provides critical summer steelhead habitat, has historically been over-appropriated for agricultural use. The Oregon Water Trust (OWT) began leasing water from a local farmer in 1994 and continues to pay him 76 tons of hay each year since.[16] The instream water leasing allows passage to and from the Deschutes River that would otherwise be impossible for steelhead in the dry summer months. Both parties would like to secure a permanent transfer of the water rights, but have not been given authority to do so.[17]

5.1.6 Iron Mountain Mine

Iron Mountain Mine, abandoned in the early 1960s, continues to discharge high quantities of sulfuric acid and metals into neighboring creeks and rivers. The high levels of pollution threaten the health of the ecosystem, particularly salmon species in the Sacramento River. Managers previously increased water flow to dilute pollution in the receiving water bodies. When the EPA took over the project, it conducted an alternatives analysis and decided to treat the pollution by building a treatment plant instead. This resulted in pollution reduction and water quality improvements.

5.1.7 Battle Creek

Battle Creek is a tributary to the Sacramento River and provides unique habitat for several endangered and threatened species of salmon and steelhead. A hydroelectric project, consisting of eight power-generation dams, has been located on Battle Creek since the early 1900s. This restoration project will remove five of the eight power-generation dams, add fish screens and fish ladders, and employ adaptive management to increase populations of endangered and threatened salmon and steelhead.

6.0 Analysis

In each case study we examined, environmental managers considered methods other than using more water to maximize environmental benefit. In this sense, these cases provide examples of MEWUE in current and recent practice, although the concept is not formally recognized. In this

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[16] OWT website: http://www.owt.org/about.html
[17] Schonek, Kim. Phone Interview. OWT, 17 April 2006.

section we analyze how managers sought to maximize the environmental benefit from a given amount of water. This analysis provides evidence that MEWUE is a valid concept.

Because each ecosystem is unique, decision-makers in each of our cases faced different costs, environmental goals, political feasibility, and management strategies. Despite the case-specific nature of environmental restoration and mitigation, we observed trends throughout our case studies regarding the MEWUE methods used. The MEWUE methods we observed fall into one of three categories: technology MEWUE, management MEWUE, or market-based MEWUE. These three MEWUE categories are not exhaustive or mutually exclusive; they can work independently or overlap.

6.1 Technological MEWUE

Technological MEWUE is a way to increase environmental benefit through physical changes to the environment itself. We observed several examples where a simple or complex change improved the environmental benefit without increasing the amount of water. An example of a simple technological change might be to shade a stream corridor in order to reduce water temperature and improve fish habitat. By contrast, a complex technological change would involve installing a temperature control device to alter the water temperature. Managers at Glen Canyon Dam plan to utilize a temperature control device (TCD) to increase water temperature rather than decrease reservoir levels. This is an example of technological MEWUE, because a TCD does not alter the water quantity in order to achieve environmental benefit.

We observed a number of examples where technology was implemented to improve the environmental benefit without altering the amount of water. **Table 2** provides a summary of these findings; however, the environmental benefits we name are not a complete list. In the next section we discuss the potential for technological MEWUE to overlap with management and market-based MEWUE in order to increase environmental benefits.

Table 2. Summary of Evidence of Technological MEWUE in Case Studies

Case Study	Technology	Environmental Benefit
Cosumnes River	Levee Breech	Riparian Restoration Fish Habitat
Cold Creek	Dam Removal Channel Alteration	Riparian Restoration Water Quality
Glen Canyon Dam	Temperature Control Device	Fish Habitat
Iron Mountain Mine	Pollution Treatment Plant	Water Quality Fish Habitat
Battle Creek	Dam Removal Fish Screens & Ladders	Fish Passage

6.2 Management MEWUE

Management MEWUE contains several components that can increase environmental benefit without altering water quantity. Three specific management MEWUE trends we observed in our case studies include evaluating alternatives that do not use more water, maintaining a long-term commitment to management, and a adopting a flexible approach to management in order to increase environmental benefit. Management MEWUE offers possibilities to pursue alternatives that do not use more water. Management MEWUE also includes more macro-level management strategies, such as a long term commitment and flexible approach, that may be unrelated to water quantity but may in fact increase environmental benefit.

6.2.1 Evaluating Alternatives

Evaluating alternatives provides an example of MEWUE at the individual project level. Restructuring project administration, refocusing project goals, or implementing different technology, as mentioned previously, can lead to improved environmental outcomes. For example, restructuring project administration may include undertaking collaborative efforts with other organizations that have related expertise or resources. In the Cold Creek case, the City of South Lake Tahoe partnered with the California Tahoe Conservancy after failing to restore the riparian habitat themselves. The CTC provided funding and leadership, in order to remove an unnecessary dam and restore the channel form. This resulted in a healthy meadow and improved water quality without using additional water.

Cold Creek provides an example of the overlap between both Management and Technological MEWUE. Management MEWUE occurred through the City’s partnership with an organization that had resources and expertise to produce the desired environmental benefit. This, in turn, facilitated Technological MEWUE, evidenced by the dam removal, which produced the environmental benefit of ecosystem restoration.

6.2.2 Committing to the Long-Term

A long-term commitment to managing restoration projects was a characteristic trend of projects that were able to maintain environmental benefits. This provides another example of Management MEWUE because continued management yields a greater benefit than a one-time or short-term action. In the case of Battle Creek, cooperating agencies have committed to pursue restoration through signing an MOU. Long-term commitment is also an example of MEWUE because it is more efficient to sustain a project that generates an environmental benefit than start a new project where outcomes are unknown.

6.2.3 Adopting a Flexible Approach

Adopting a flexible approach to management also provides opportunities for MEWUE. Adaptive management uses learning-by-doing as a mechanism to improve decision-making and increase environmental benefits over time. The adaptive management approach led to a key finding in the

Cosumnes River (riparian restoration) case: levee breeches could provide benefits not only to riparian vegetation but also to overall ecosystem health. Managers incorporated feedback about the presence of fish in floodwaters and capitalized on an opportunity to attain additional environmental benefits. What began as a project specifically aimed at restoring riparian valley oak has achieved much greater benefits such as biodiversity, flood control and recreation. Flexible management approaches that responded to positive outcomes have maximized the benefits from a given amount of water, a clear example of MEWUE.

Management has been the unifying concept behind effective MEWUE practices in our case studies. Good management is an iterative process that includes planning, assessment, and long-term commitment. Regardless of the nature of a particular project's water use, it is MEWUE's management aspect that serves as the concept's underlying strength.

6.3 Market-Based MEWUE

Market-based MEWUE provides a mechanism to increase environmental benefit when more water is the best solution. In the agricultural and urban sectors, where water markets are well established, they have provided the most efficient way to obtain water. Water transfers allow for more control to move water when and to where it is needed, for example from agricultural to urban users. As a result, less water is wasted and both buyers and sellers benefit from the transaction. This fits with our definition of efficiency, which revolves not around reducing the amount of water, but rather, finding the best possible solution to problems involving managed environmental water.

We have observed multiple examples in which environmental water managers have succeeded in acquiring water efficiently. All of these cases have involved water managers participating in some form of a water market. Due to complexity of California water law and the history of water rights, and in part because of high transaction costs, the environmental sector has had limited access to these markets. As a result, we have based our analysis on practices in other western states that have successfully established environmental water markets. Specifically, the Oregon Water Trust[18] (OWT) acquires water through leases, purchases and donations from landowners to increase instream flows to benefit fish populations. In 2006, OWT had eighty-seven projects, evidence that water markets can work in the environmental sector. Water markets are an example of MEWUE, as allowing water to be transferred from lower-valued to higher-valued uses can improve environmental benefits.

The OWT is unique to Oregon, focusing specifically on small stream restoration projects. High transaction costs are a barrier to similar activity in California, but we observed evidence of market-based activity to increase flows in the Cosumnes River. Having exhausted attempts to alleviate large groundwater overdrafts, TNC purchased a water right from a rancher's neighbor not using his right to 5,000 acre feet on the Upper Sacramento River. This provides evidence of MEWUE because it was the most feasible and least costly alternative to increasing salmon runs; it improved environmental benefit without harming any other sector. While this is a unique

[18] Appendix A includes a case study of the Oregon Water Trust.

scenario in California, it demonstrates a willingness to pay for water to achieve environmental benefit. Water markets may provide for positive environmental outcomes, but they cannot stand alone; they require sound management methods to be effective.

7.0 Conclusion

Through our case studies, we have observed a variety of efforts to maximize the environmental benefit from a given amount of water. In many cases, exploring alternative approaches to adding more water led to solutions that were both more effective at improving environmental outcomes and more efficient at attaining these outcomes from a fixed resource. This behavior embodies the definition of MEWUE, and it provides evidence that the concept can and does work in practice. While one may question the need to alter the current state, the success of MEWUE-like practices provides an opportunity to capitalize on a valuable strategy in order to improve environmental water management throughout California. As the agency responsible for statewide water planning, we therefore recommend that the DWR build upon these successes and act to further develop MEWUE in order to incorporate it into the future of environmental water management in California.

8.0 Recommendations

We offer a number of recommendations that may serve as next steps to begin to incorporate MEWUE into the mainstream of environmental water planning and management. We would, however, like to emphasize that the focus of this study has been to evaluate *if* a concept such as MEWUE is valid and feasible, and not *how* to go about implementing it. We offer our ideas as part of the larger recommendation that the DWR pursue a thorough evaluation of potential implementation strategies for further developing MEWUE. In the meantime, we have drawn from our analysis to outline a number of possible opportunities for incorporating MEWUE into current programs and activities while seeking to alleviate MEWUE's current challenges. Far from exhaustive, and certainly not mutually exclusive, we hope these recommendations will serve as a menu of options for the DWR to continue to explore ways to integrate MEWUE into California's statewide water planning initiatives.

Table 3 provides a breakdown of our recommendations, in which we seek to address the various challenges facing MEWUE. We offer ideas for incorporating each recommendation into DWR's current activities with the aim of producing outcomes that improve recognition, acceptance and use of MEWUE.

8.1 Formalize a MEWUE Policy

A recurring theme in our research has been that MEWUE exists in practice, but not as a recognized term or concept. Evidence of MEWUE is not part of a larger framework, a clear barrier to the concept's advancement. To further this goal, the DWR should formally commit to a MEWUE policy, in order to promote an effective practice and encourage its use. The DWR should feel comfortable advancing the behavior already occurring "in the field," and a formal policy will support valuable management approaches currently occurring and unite them under a single, universal concept. It will also serve as overarching guidance for both the DWR and other agencies and organizations to follow sound management strategies when faced with problems involving environmental water management.

Adopting a formal MEWUE policy will allow the DWR to further explain the concept to water managers and stakeholders. It provides an opportunity to clearly state MEWUE’s goals and emphasize that it is not a water conservation initiative. Explicitly stating the difference between MEWUE and urban and agricultural water use efficiency (WUE) will hopefully clarify the DWR’s intentions and increase its credibility within the environmental sector.

Table 3. Recommendations

Problem	Action	Intervention	Outcome
MEWUE is not a recognized concept	Adopt formal policy supporting MEWUE	Use as overarching guidance for programs & projects	Support valuable approaches & unite them under one concept
	Develop MEWUE Best Management Practices (BMPs)	Incorporate into municipal technical assistance & grants	Increase & incentivize MEWUE at local level
		Incorporate into Watershed Management	Build support for MEWUE via collaboration w/ other agencies
MEWUE currently occurs in DWR & environmental sector	Operate a MEWUE pilot project	Apply MEWUE to design habitat & urban restoration projects, fishery studies and fish passage improvements	Increase efficiency & effectiveness w/in DWR; Increase leadership & credibility by demonstrating valid concept; Encourage greater use of MEWUE
Environmental interest groups fear MEWUE will deprive then of water	Adopt formal policy supporting MEWUE	Explicitly state difference b/w urban & agricultural conservation	Increase DWR’s credibility w/in environmental sector
	Develop MEWUE Best Management Practices (BMPs)	Lead by example	Increase understanding of MEWUE; Decrease resistance to MEWUE
Sometimes more water is the only answer	Include the environmental sector in water markets	Facilitate transactions for water for environmental projects	Provide solution for projects requiring more water; Provide incentive for exploring MEWUE alternatives

8.2 Develop Best Management Practices

As a complement to formalizing a MEWUE policy, we recommend that the DWR develop a set of Best Management Practices (BMPs) to serve as guidelines for projects involving environmental water. BMPs can help the DWR to explain the benefits of MEWUE in order to increase understanding of the concept and encourage its use. The DWR has an opportunity to assume a leadership role and increase its credibility by demonstrating a commitment to a valuable approach to water management in the environmental sector. Furthermore, BMPs provide another opportunity to decrease resistance to MEWUE by emphasizing that it is not a water conservation policy but rather, a management strategy to increase environmental benefits.

For this very reason, we specifically recommend that the DWR *not* incorporate MEWUE into the programs of the Office of Water Use Efficiency, whose focus thus far has been specifically to encourage water conservation in the urban and agricultural sectors. Rather, we see opportunitiesfor the DWR to include MEWUE BMPs among its programs in other branches. For example, the Division of Planning and Local Assistance works "collaboratively with locally led stewardship efforts through financial assistance, education and information to support watershed management throughout the state".[19] All of these activities offer opportunities to advise local water managers of MEWUE BMPs that may help to improve environmental outcomes involving water. Additionally, the DWR's collaboration with other agencies through its Watershed Management initiative[20] provides another opportunity to utilize MEWUE BMPs and gain support for the concept as a sound approach to environmental water management.

8.3 Operate a MEWUE Pilot

While our case studies have provided evidence of a number of management approaches similar to MEWUE, none has represented a concerted effort to implement the specific concept of MEWUE. We therefore recommend that DWR engage in the operation of a pilot project to more closely examine MEWUE from start to finish. A pilot would allow the DWR to learn more about how MEWUE actually works, to understand its strengths and improve upon its weaknesses. A number of opportunities exist for the DWR to apply MEWUE to its own restoration activities, for example, in its feasibility studies of fish passage improvement alternatives or its preparation of riparian habitat restoration plans.[21] However, it may be advantageous to partner with outside organizations as a means to involve stakeholders in the process and increase support for MEWUE, while enriching the knowledge base of approaches to environmental water management.

8.4 Facilitate an Environmental Water Market

Water markets are already a well-established practice for the urban and agriculture sectors in California. In addition, other western states[22] with water scarcity issues have successfully included the environmental sector in water markets. We recommend that the DWR explore the possibility of an environmental water market. DWR has the experience[23] and infrastructure to

[19] http://www.water.ca.gov/nav.cfm?topic=Environment&subtopic=Ecosystem/Watershed_Restoration
[20] *California Department of Water Resources Online.* <http://www.dpla2.water.ca.gov/dplanav.cfm?nav=Technical_Assistance,Environment>
[21] http://www.dpla2.water.ca.gov/dplanav.cfm?nav=Technical_Assistance,Environment
[22] Oregon and Colorado are two states that have successful environmental water markets
[23] The DWR organized the California Drought Water Bank Program in the mid-1990s. For the first time, DWR purchased water supply options from willing sellers as insurance against possible water-short years.

store and transfer water, which may lower transaction costs for small-scale transfers for environmental projects. Additionally, we recommend that the DWR act as a water market clearinghouse to improve information sharing among potential buyers and sellers. The DWR should develop materials to educate and provide guidance to interested parties regarding transactions and California water laws.

NEXT STEPS

In addition to the recommendations provided, we suggest that the DWR also consider the following in order to further develop MEWUE:

- Partnering with other agencies and organizations involved with environmental water planning and management to develop the concept.
- Closely evaluating different implementation strategies for MEWUE – in both DWR and other state agencies.
- Taking stock of DWR's own restoration and mitigation activities to identify cases that demonstrate both evidence of MEWUE and opportunities for improvement
- Exploring the creation of a water trust to purchase water for small environmental restoration projects by enlisting the help of outside organizations and drawing from current land and water trusts.

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Michael C. Healey, Paul L. Angermeier, et al. "Conceptual Models and Adaptive Management in Ecological Restoration: The CALFED Bay-Delta Environmental Restoration Program." 12 May 2006. <http://calwater.ca.gov/Programs/ EcosystemRestoration/ERP_Science_Board/Big_Model_Paper_5-3-04.pdf>

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APPENDIX A: CASE STUDIES

Case Study 1: Cosumnes River (Riparian Restoration)

Background

The Cosumnes River in Sacramento County is the only undammed river to flow from the Sierra Nevada mountain range, due to its low elevation and relatively small drainage basin.[24] Its floodplain historically utilized for agriculture, farmers lined the river with a system of levees for flood control purposes. In the mid 1980s the Nature Conservancy (TNC) began the Cosumnes River Preserve with the purchase of land adjacent to the river, as part of their project to preserve and restore native valley riparian oak. After a decade of little success from sowing acorns, in the mid 1990s, TNC discovered an unusual 25 acre plot of land lush with cottonwood and willow trees. Discussions with the landowner revealed a levee break ten years prior had deposited flood sediment on the bank, which he had allowed to remain undisturbed. Termed the "accidental forest," this ten-year-old stand of trees revealed an undergrowth of young valley oaks, leading TNC to conclude that valley oak forests are successionary.[25]

TNC hypothesized flooding to be part of natural river processes, providing for healthy riparian vegetation, and then designed an experiment to test it.[26] In 1993, TNC dug a 50-foot channel in one levee, allowing the river to connect with its floodplain in the winter months, not far from the accidental forest[27]. This first test flood aimed at increasing the *native* riparian vegetation, but researchers at the University of California at Davis observed the first experimental floodwaters to be full of Sacramento splittail and Chinook salmon, both threatened/candidate species[28] [29] [30]. Currently, the Preserve is home to over fifty-four verified species and an additional twenty-eight species assumed to be present[31] a testament of the ecosystem's health. Since the 1990s, the role of the floodplain has become understood as vital to ecosystem health. TNC continues to pursue floodplain connectivity projects, and DWR funds research in this area[32] [33].

Evidence of MEWUE

What began as purely a riparian vegetation restoration project on the Cosumnes River succeeded in achieving the much greater environmental benefit of ecosystem health. The levee breeches have also produced the additional environmental benefits of flood control, water quality, open

[24] Whitener, Keith. Phone Interview. 30 March 2006.
[25] Whitener, Keith.
[26] Whitener, Keith.
[27] Faden, Mike. "Dance of the Cranes: Winter Revels Along the Cosumnes." Bay Nature January-March 2006. 1 April 2006 <http://www.baynature.com/2006janmarch/cosumnes.html>.
[28] Faden, Mike.
[29] Whitener, Keith.
[30] United States. National Marine Fisheries Service. Southwest Regional Office. Fact Sheet: West Coast Chinook Salmon. September 1999. 9 May 2006 <http://swr.nmfs.noaa.gov/psd/99chinfs.htm>.
[31] "Species List." Cosumnes River Preserve. 28 March 2006 <http://www.cosumnes.org/specieslist.htm>.
[32] Whitener, Keith.
[33] Sommers, Ted, Personal Interview, 25 April 2006.

space and recreation.[34] TNC's initial use of the water to restore valley oak demonstrates a MEWUE application, in that it required no additional water; it merely altered the manner of flow through one reach of the river. The organization has capitalized upon the successful outcome of the first levee breech, pursuing similar projects that aim to maximize the environmental benefit from a fixed amount of water, evidence that MEWUE is alive in practice and not merely a coincidental occurrence. The levee breech on the Cosumnes River Preserve began as an experiment, following an adaptive management approach of monitoring and learning-by-doing. While not formally a MEWUE approach, the project demonstrates an efficiency improvement by increasing outcomes for the environment without decreasing them for other users. In fact, reconnecting the Cosumnes River with its floodplain has increased the benefits beyond the environmental sector by providing multiple uses of educational and recreational opportunities for other water users at the Preserve. This management approach to expanding environmental outcomes offers valuable evidence of efforts to maximize environmental benefits from a given amount of water, a clear example of MEWUE in practice.

Case Study 2: Cosumnes River (Groundwater Pumping)

Background

The Cosumnes River in Sacramento County is home to a fall Chinook salmon run, which has ranged from 0 to 5,000 over the past 40 years.[35] More recently, however, salmon runs in the Cosumnes River have declined to below 600 fish.[36] In the mid 1990s this prompted The Nature Conservancy (TNC) and researches at the University of California at Davis to investigate the causes. The Cosumnes River experiences intermittent dry periods due to its low elevation and drainage area; however, increased ground water pumping to support suburban growth in southern Sacramento County has lowered the groundwater table up to seventy-five feet in some areas. In its original state, the water table lies just beneath the surface of the Cosumnes River, but the large groundwater overdrafts have led to a complete, year-round disconnect between the river and its aquifer. As a result, it typically requires three or four big rains for the river to support instream flows, a series of events that usually occurs late in the fall season and later than the start of the Chinook salmon run, thereby limiting its size.[37] UC Davis researchers determined that to reconnect the river to its aquifer would require a 50% decrease in groundwater pumping.[38] This reduction in pumping would limit water supplies available to southern Sacramento County urban and agricultural users by 36%, an alternative deemed unfeasible given the urban sector's demand for water.[39]

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[34] "Benefits to Water Supply Reliability, Water Quality, Flood Control, and Recreation." Cosumnes River Preserve. 28 March 2006 < http://www.cosumnes.org/benefits.htm>.
[35] Fleckenstein, Jan, et al. "Managing Surface Water-Groundwater to Restore Fall Flows in the Cosumnes River." Journal of Water Resources Planning and Management. (July/August 2004): 301. Cosumnes Research Group. UC Davis. 9 May 2006. < http://baydelta.ucdavis.edu/reports/QWR00301.pdf>.
[36] Whitener, Keith. Phone Interview. 30 March, 2006.
[37] Whitener, Keith.
[38] Fleckenstein, Jan, Suzuki, Eriko, and Fogg, Graham. "Options for Conjunctive Water Management to Restore Fall Flows in the Cosumnes River Basin, California." Cosumnes Research Group. UC Davis. <http://baydelta.ucdavis.edu/reports/IAHS-fin.pdf>.
[39] "Options for Conjunctive Water Management to Restore Fall Flows in the Cosumnes River Basin, California."

TNC failed to persuade Sacramento County to decrease their reliance upon groundwater pumping for municipal supplies and so turned to other avenues. In the southern part of the county, jet fuel-contaminated groundwater from the AreoJet plant further exacerbated the water shortage. AeroJet's mitigation activities required that they clean the contaminated water, which the company then discharged into the American River. Sacramento County won the right to this cleaned water, arguing that discharging it into the American River was a waste of the county's water supplies.[40] TNC previously sought to purchase water for the Cosumnes River but failed due to an inability to identify a willing seller of the scarce resource. In 2005, TNC successfully purchased its first water right for 5,000 acre-feet of water on the Upper Sacramento River from the neighbor of a rancher not using the right. TNC plans to use or bank the water and now has a long-term contract with Sacramento County and the United States Bureau of Restoration to maintain the water right.[41]

TNC intended to discharge the 5,000 acre-feet of water from the Folsom South Canal, a plan which the USFWS blocked because the water was not native to the Cosumnes River. As a result, TNC designed a plan to use its water right to "pre-wet" the Cosumnes, with the idea that the first rainstorm would reestablish connectivity between the river and its aquifer. In the fall of 2005, TNC performed a partial test-release, and with the first rainstorm on November 1, the Cosumnes River supported flows through previously dry zones. Within the first few hours, observers counted 500 salmon running through the channel, evidence that the plan had achieved the intended outcome.[42]

Evidence of MEWUE

In one vein, this case might provide evidence of MEWUE's failure in that it was not possible to achieve the desired environmental benefit without increasing the quantity of water applied. While this outcome appears to directly conflict with the idea of MEWUE, which aims to maximize the environmental benefit from a fixed amount of water, this case does not wholly derail the concept. The aim was to improve the fall Chinook salmon run, an outcome that had previously failed as a result of dry zones in the migratory region. In this case, the only solution was to increase the quantity of water in the Cosumnes River. Although TNC and UC Davis researchers explored several alternatives to bring about this outcome, such as decreased groundwater pumping and artificial recharge, ultimately the most feasible plan was one that discharged more water directly into the channel.

Demand for diverting more water into the Cosumnes River occurred only after a thorough analysis of other possible alternatives. In this case, applying more surface water was more efficient than decreasing groundwater pumping, which would have overburdened the urban sector to the point of being unfeasible. Ultimately, there was no way around the fact that to improve the fall Chinook salmon run in the Cosumnes required water in areas that had been allowed to remain dry. However, stakeholders adopted an analytical approach similar to that utilized in cases where MEWUE has succeeded, and they settled on the alternative that increased environmental benefit without causing harm to others with interests in the water. This case offers

[40] Whitener, Keith.
[41] Whitener, Keith.
[42] Whitener, Keith.

support for MEWUE as a management tool even in situations that require more water, and no doubt there are others for which increasing instream flows is the only solution.

Furthermore, TNC's purchase of a water right provides evidence of the market as the most efficient solution in some cases. This case study reveals a willingness to pay for water used to achieve environmental outcomes, which gave rise to an environmental water market. While not necessarily appropriate in every case, allowing a market for environmental water may produce efficient and effective outcomes not possible via other management avenues. While different from other MEWUE approaches that revolve around a fixed amount of water, if water markets can achieve the best possible outcome, then they, too, should be considered examples of MEWUE.

Case Study 3: Cold Creek Restoration Project

Background

Cold Creek is a tributary to Trout Creek, which feeds into Lake Tahoe. Since the 1940s, the Cold Creek ecosystem has been disrupted by human influences. In the 1940s, a farmer dammed Cold Creek to create an agricultural water supply for his land. In the 1950s, the landowners created a lakefront subdivision bordering Cold Creek and built up the previous dam to form Lake Christopher.[43] Additionally, they created a diversion channel for Cold Creek around Lake Christopher. In the early 1980s, the City of South Lake Tahoe acquired Lake Christopher, and surrounding land. Soon thereafter, the California Division of the Safety of Dams found Christopher Dam to be a flood-hazard.[44] This finding led the City of South Lake Tahoe to lower the water level in Lake Christopher to reduce flood-hazard. As a result, the lake became stagnant and eutrophic. In 1989, a City of South Lake Tahoe restoration project diverted the channel and breached the dam. However, the project was unable to restore the meadow and channel to a sustainable ecosystem. Erosion still carried too much sediment to Lake Tahoe, and the meadows were not being replenished with water because the channel shape was unnatural.[45]

In the early 1990s, the City of South Lake Tahoe partnered with The California Tahoe Conservancy (CTC) to reattempt ecosystem restoration on Cold Creek. A $1.4 million restoration project, led by CTC, restored a functional, riparian ecosystem by altering channel shape, and removing Christopher Dam.[46] This project also involved several educational meetings for the public and other stakeholders to learn about the restoration process. In addition to restoring the meadow and stream ecosystems, the project improved water quality in Lake Tahoe by reducing sediment outflow from Cold Creek.

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[43] American Rivers. Cold Creek, CA. 15 March 2006 <http://www.americanrivers.org/site/PageServer?pagename=AMR_content_b366>.
[44] Goldman, Steven. Phone interview. 29 Mar. 2006.
[45] Goldman, Steven.
[46] "California Tahoe Conservancy: Cold Creek Restoration Project" Progress Report. July 1997. 4 Apr. 2006. <http://www.tahoecons.ca.gov/library/progrep/ coldcreek.html>.

Evidence of MEWUE

The Cold Creek restoration methods are an example of MEWUE because they increased environmental benefit but did not increase the amount of water flowing through Cold Creek. The Cold Creek restoration project shows that the same amount of water can produce an unhealthy ecosystem if non-water factors are not considered.

Cold Creek is located in the Sierra Nevada, and is fed directly with snowmelt. So, it was possible to restore Cold Creek to its natural state because no water is diverted from the creek before it gets to the Cold Creek restoration area. In contrast, the other restoration projects in this paper are located further downstream and it is likely more difficult to restore these areas to a natural state because of human influences, and diversions.

Case Study 4: Glen Canyon Dam

Managers at the Glen Canyon Dam on the Colorado River face the challenge of mitigating the effects of dam operations, specifically cold water discharges, on native and endangered warm-water fish. The U.S. Bureau of Reclamation (USBR), the dam's managing agency, has conducted a thorough cost-benefit analysis of a number of alternatives that seek to increase the temperature of water downstream of the dam. The agency ultimately found that altering the quantity of water proved to be both less effective and less efficient at providing the desired environmental outcome than other alternatives. This case study provides valuable evidence of MEWUE in practice on a large-scale mitigation project.

Background

In 1963, the USBR erected the Glen Canyon Dam (GCD) on the Colorado River in Arizona to supply water and power to the Southwestern United States.[47] With the creation of Lake Powell, the dam ensures compliance with the Colorado River Compact of 1922, which entitles Colorado, Utah, New Mexico and Wyoming to 7.5 million acre feet (MAF) of Colorado River water annually.[48] GCD further meets the statutory mandate of water delivery to downstream users in Arizona, California and Nevada, which must total 75 MAF over any ten-year period.[49] The Glen Canyon Powerplant at the dam has a generating capacity of 1.312 million kilowatts of hydroelectric power from eight penstocks.[50]

The dam regulates the river's flow by drastically decreasing the volume of water allowed in the channel. This, in turn, has altered the hydrology, channel morphology, habitat and ecosystem of the river below the dam. Following nearly twenty years of dam operations, visible changes to the river and its environs stimulated the managing agencies to develop a strategic management plan for GCD. The USBR conducted an Environmental Impact Study, which generated broad stakeholder input and resulted in the prescription of an adaptive management approach[51] to

[47] "Drought Conditions in the West." Upper Colorado Region: Managing Water in the West. United States Bureau of Reclamation. 9 April 2006 < http://www.usbr.gov/uc/feature/drought.html>.
[48] "Drought Conditions in the West"
[49] "Drought Conditions in the West"
[50] "Glen Canyon Powerplant." Upper Colorado Region: Managing Water in the West. United States Bureau of Reclamation, 10 April 2006 < http://www.usbr.gov/power/data/sites/glencany/glencany.html>.
[51] Formally known as the Glen Canyon Dam Adaptive Management Program (GCDAMP).

"provide an organization and process for cooperative integration of dam operations, downstream resource protection and management, and monitoring and research information, as well as to improve the values for which the Glen Canyon National Recreation Area and Grand Canyon National Park were established".[52] As a result, strategies for addressing a number of complicated and controversial issues surrounding the GCD have sprung from an approach that emphasizes information gathering and collaboration among stakeholders.

Water Temperature

Prior to the construction of the GCD, late summer flows in the Upper Colorado River warmed naturally to nearly 85 degrees, a condition which provided suitable habitat for native and endangered warm-water fish such as the humpback chub.[53] The dam's eight power-generating intakes, which discharge cold water drawn from deep within Lake Powell, altered this environment by causing the temperature downstream of the dam to drop to between 45 and 50 degrees year round.[54] Native fish populations decreased, and the U.S. Fish and Wildlife Service (FWS) suggested a need for warmer water downstream of the dam to restore warm-water fish habitat and subsequently increase populations. In 1999, the USBR proposed a plan to install a Temperature Control Device (TCD), enabling the intakes to draw in and discharge warm surface water, thus increasing the overall temperature of instream flows below the dam. With the goal of increasing the welfare of endangered warm-water fish and mitigating any negative environmental consequences, the USBR has proposed a plan that modifies the intakes and monitors results.[55] Due to the uncertainty surrounding the environmental outcomes of a TCD on the Upper Colorado River, USBR has further amended their proposal to modify only two of the eight intakes, for an estimated cost of $80 million.[56]

Evidence of MEWUE

Prior to its TCD proposal, the USBR considered a number of alternatives, including lowering the level of the Lake Powell reservoir; decreasing summer intakes; using waste heat from the nearby Navajo Powerplant; stringing a plastic curtain a quarter of a mile across Lake Powell; installing surface water pumps; reservoir destratification and, funding endangered fish hatcheries or other recovery efforts.[57, 58] For each of the alternatives, the USBR weighed the costs and benefits to endangered fish and other species, as well as the monetary costs and feasibility of implementation. The agency found significant shortcomings for all of the alternatives except the selective withdrawal approach utilizing the TCD.[59]

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[52] "Glen Canyon Dam Adaptive Management Program." Upper Colorado Region: Managing Water in the West, United States Bureau of Reclamation. 10 March 2006 <http://www.usbr.gov/uc/rm/amp/background.html>.
[53] "Glen Canyon Dam Temperature Control Modifications." Upper Colorado Region: Managing Water in the West. United States Bureau of Reclamation. 10 March 2006 < http://www.usbr.gov/uc/rm/amp/tcd/index.html>.
[54] "Glen Canyon Dam Temperature Control Modifications."
[55] United States. Department of the Interior. Bureau of Reclamation. Upper Colorado Region. Glen Canyon Dam Modifications to Control Downstream Temperatures: Plan and Draft Environmental Assessment. January 1999: ii. 10 March 2006 <http://www.usbr.gov/uc/rm/amp/tcd/pdfs/ea_draft.pdf>.
[56] Ryan, Tom, Personal Interview, 22 March 2006.
[57] Glen Canyon Dam Modifications to Control Downstream Temperatures: Plan and Draft Environmental Assessment 15-16.
[58] Kubly, Dennis, Phone Interview, 28 March 2006.
[59] Kubly, Dennis

Two approaches – lowering Lake Powell and minimizing summer releases – would alter the water quantity by decreasing the discharge levels of the dam's intakes, thus lowering water levels below the dam. However, both of these alternatives were found to have prohibitively large drawbacks. Lowering Lake Powell would decrease its storage capacity, and without any other storage options, this option would directly violate GCD's statutory purpose of supplying water to urban users.[60] Analyses revealed that lowering intakes to reduce flow beneath the dam would not warm the water enough for the fish[61] -- in other words, altering the quantity of environmental water would not produce the desired environmental benefit, and would therefore be considered ineffective. Furthermore, maintaining a constant low flow would cause large spikes in demand for power to go unmet, as the fluctuation in supply would result in a variation in discharge and flow. The resulting loss of hydroelectric power would exceed $100 million annually[62] and be far greater than the cost of other alternatives considered, rendering the use of less water inefficient.

For each of the proposed non-water uses, the USBR found considerable deficiencies in the areas of environmental benefit, cost-effectiveness and feasibility. The powerplant waste heat involved high costs over long distances. The plastic curtain posed the risk of entrainment and the potential for high costs due to repair and lost power generation. Surface pumps were found to be ineffective in warming the water because the Lake Powell reservoir is so deep and cold. The USBR considered their involvement in fish hatchery and recovery efforts to beyond the scope of their organization.[63]

While not formally known as MEWUE, the USBR evaluated both the efficiency and effectiveness of its alternatives in achieving a specific environmental benefit. The agency considered altering the quantity of water used but instead identified an approach that would provide both a greater environmental benefit and a lower cost than reducing flow levels. The USBR explored using less environmental water to no avail, and ultimately it created a plan to maximize the environmental outcome from the current amount of water. The TCD approach requires no change in water quantity, merely a reallocation of the resource. It succeeds in increasing the welfare of the environmental sector without decreasing that of the urban sector, reflecting an efficiency improvement and an example of how MEWUE can be integrated into sound water management practices.

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[60] Kubly, Dennis.
[61] Ryan, Tom.
[62] Glen Canyon Dam Modifications to Control Downstream Temperatures: Plan and Draft Environmental Assessment.
[63] Glen Canyon Dam Modifications to Control Downstream Temperatures: Plan and Draft Environmental Assessment 16.

Case Study 5: The Environmental Water Account

Background

The Environmental Water Account (EWA) is a water management mechanism designed by CALFED to protect the Bay-Delta ecosystem, specifically endangered fish species, from the impact of state and federal water projects. The EWA allows for a decrease in pumping activity in the Delta at crucial times without reducing the existing water allocation to the California Water Project and the Central Valley Project.

The EWA Operating Principles Agreement (2000) states:

> *"The EWA is a cooperative management program whose purpose is to provide protection to the fish of the Bay-Delta Estuary through environmentally beneficial changes in the operations of the State Water Project and the federal Central Valley Project, at no uncompensated water cost to the projects water users."*[64]

One of the many controversial issues in the Bay-Delta associated with the growing competition between human demands and declining fisheries were the rules governing export pumping. State and federal wildlife agencies along with environmentalists insisted that pumping was killing a significant number of fish in the Delta. This environmental consequence of pumping is called "fish-take."[65] They asserted that there should be rules that allowed pumping to stop when a large number of a specified endangered species was in the vicinity. Because it is not always possible to know in advance when a decrease in pumping might be necessary, it was agreed that the most efficient way to simultaneously address environmental protection and urban and agricultural water demands was to find a mechanism that could work in real-time. CALFED was looking for a solution that would allow for flexibility without disrupting deliveries to the Projects.

After months of negotiations and running simulations, stakeholders delivered a plan for the EWA in 2000. The U.S. Fish and Wildlife Service, the National Marine Fisheries Service, and the California Department of Fish and Game (DFG) were designated as the management agencies of the EWA. They act as a regulatory body and are responsible for deciding when and how to change pumping. These decisions are based on scientific data and monitoring. The U.S. Bureau of Reclamation and the California Department of Water Resources (DWR) oversee the operation as well as the actual implementation of the EWA.

When "fish-takes" are approaching limits set by the EWA regulatory agencies, a EWA panel can ask for pumps to be shut down. For example, DFG biologists monitoring the salmon populations on the Sacramento River could advise the DWR to decrease pumping for a designated amount of time, allowing migrating fish to swim safely through. The Water Projects are then reimbursed for the loss of water associated with the periods of decreased pumping.

[64] Hymanson, Zach et al. 2003. "Comprehensive Evaluation of the EWA: Evaluation Framework, Potential Criteria, and Evaluation Steps." Testimony Presented to the EWA Technical Review Panel. (October 16, 2003) 12 May 2006 <science.calwater.ca.gov/pdf/ewa/oct16/Hymanson.pdf>.
[65] Number of fish deaths associated with pumping

CALFED agencies use EWA water to annually acquire, bank, and transfer approximately 380,000 acre-feet of water.[66] The EWA acquires water or right to water.

Acquiring Water
EWA water is acquired either through purchases or operations. Each year, half of the water assets in the account are purchased from willing sellers, both above and below the Delta. The other half of the water, called operational assets, comes from water project pumping. The EWA borrows this water from the CVP and the SWP. Another way the EWA acquires operational assets is by relaxing regulatory requirements when such actions pose no threat to fish. For example, in wet years, the EWA is allowed to limit the amount of water leaving the Delta and any excess water is then credited to the account. In addition, anytime the projects experience excess pumping capacity, the water is stored for the EWA.

Banking Water
The EWA can store water in project reservoirs.

Transferring Water
The EWA stores and purchases most of its water north of the Delta because it is much cheaper. This creates a side benefit because by transferring water from north to south it must pass through the Delta, when water can be used for environmental purposes, such as habitat restoration. However, because water north of the Delta is less expensive than water south of the Delta, a larger amount is required for exchange.[67]

Evidence of MEWUE
When proposed and developed, the EWA represented an innovative approach to solve a seemingly simple problem. However, the complexity of measurement and interpretation of results have impeded the achievement of its initial goals. The EWA has seen limited success because scientists have limited understanding of the hydrologic and biological dynamics of the Delta, and therefore have a difficult time making the right decisions – despite their best efforts. In addition, the EWA has also been under funded from the start and has not been provided all the tools that it was designed to use. These conditions have limited the ability for EWA to be successful.[68]

[66] This was the amount allocated to them in the 2000 CALFED Plan. They have yet to receive this amount (insert graph). The EWA and the CVPIA have been underendowed by an average of 436,000 acre-feet per year.
[67] Winternitz, Leo, and White, James. *Implementing the CALFED Bay-Delta Program's Environmental Water Account – California* (2001)
[68] Yolles, Peter. Personal Interview. 5 April 2006.

Case Study 6: Oregon Water Trust

Oregon

Despite Oregon's reputation as a perpetually rainy place,[69] the Eastern part of Oregon is considerably dry and receives relatively low amounts of precipitation. And, like most other Western states, Oregon faces an over-appropriation problem. Approximately 80% of Oregon's water is used by the agriculture sector. Historically in Oregon, ranchers and farmers have left too little water in the rivers. Low instream flows have been identified by the NMFS as a reason why most fish are on Oregon's endangered or threatened species list.[70]

In the late 1980s, the Oregon legislature passed a law called the Instream Water Rights Act. The landmark law made it possible for the first time for water rights to remain "instream"; in other words, letting water remain in a creek or river was now a beneficial use and would not put landowners at risk of losing their water rights. It also authorizes the purchase or lease of water rights by private groups. The right is similar to an "instream flow right", but is called a "flow enhancement water right".[71] All water right transfers must be approved by the Oregon Water Resources Department.[72]

The Oregon Water Trust

Founded in 1993, the Oregon Water Trust (OWT) was the first private, non-profit organization to participate in water markets. Its mission is to acquire water rights for environmental benefits, specifically for instream flow restoration. By acquiring water through leases, purchases, and donations from landowners, the OWT is able to increase instream flows to aid fish populations.[73] Although the purpose of the OWT is narrow – it specializes in water right acquisition for the environment – it represents a variety of different interest including conservation, fishing, farming, and ranching.[74] The focus of the OWT is to improve stream flow and not to eliminate agriculture or other water uses.

The nonprofit OWT gets most of its funding from individual and corporate donations as well as government and foundation grants. Last year, the firm had operating revenue of more than $500,000.[75] To encourage participation of willing landowners, the OWT provides incentive-based programs. Incentives provide compensation to the landowner for the lost production that would have achieved by the use of the water. The OWT sets it own standards for evaluating the ecological benefits of the project and do not seek to eliminate all irrigation and include landowners not interested in transferring all water rights.

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[69] "About Us: Why We Need a Water Trust" Oregon Water Trust. 1 May 2006. <http://www.owt.org/about.html>.
[70] Paulus, Fritz. "Allocating Water for a Sustainable Future." Oregon Water Trust. (21 June 2004). May 12, 2006 <http://www.ucowr.siu.edu/proceedings/2004%20Proceedings/2004%20UCOWR%20Conference%20Proceedings/Wednesday/PM%20Technical%20Sessions/Session%2026/Paulus.pdf>.
[71] Landry, Clay. "Saving our Streams through Water Markets." PERC (1998), May 12, 2006 <http://www.perc.org/pdf/sos.pdf>.
[72] Schonek, Kim. Phone Interview. 17 Apr. 2006
[73] "About Us: Why We Need a Water Trust"
[74] Schonek, Kim.
[75] "About Us: Why We Need a Water Trust"

In addition, due to the complexity of the water rights system, other environmental groups and watershed councils often work through the OWT to purchase water rights to attain their restoration goals.[76] In 2006, the OWT was involved in 87 projects.

The OWT is specifically interested in acquiring water for small to medium sized tributaries that support significant fisheries.[77] Two of these "priority basins"[78] are the Deschutes River in Central Oregon and the Columbia River Basin in Northern Oregon.

Deschutes River: Buck Hollow Creek

Buck Hollow Creek, a tributary of the Deschutes River, was the location of the OWT's first paid instream lease. Buck Hollow Creek provides critical summer steelhead habitat and has historically been over-appropriated for agricultural use. The instream water leasing has allowed passage to and from the Deschutes River that would otherwise be impossible for the steelheads in the dry summer months.

In a partnership that continues today, the OWT began leasing water from a local rancher in 1994.[79] In return for 76 tons of hay worth approximately $6000, the rancher transfers his rights to instream water to the OWT.[80] Both parties would like to secure a permanent transfer of the water rights, but have not been given authority to do so.[81]

Columbia River Basin: 15-Mile Creek

Another water rights transfer the OWT actively participates in involves 15-Mile Creek, a small stream that feeds into the Columbia River. It houses important spawning and rearing habitat for steelhead. Unfortunately, water diverted from the creek for agricultural use has caused summer-time stream flows to be low, endangering the steelhead habitat.

The OWT is currently engaged in 20 separate water rights leases from seven landowners — including the City of Dufur.[82] Prior to participating in the environmental water market facilitated by the OWT, all seven landowners felt they were wasting water.[83] This behavior is not an isolated incident.

Due in part to OWT's water rights leasing program, which works in conjunction with restoration efforts by the Oregon Department of Fish and Wildlife including installing removable dams and fish ladders, the steelhead population on Fifteen Mile Creek has significantly improved.

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[76] "Allocating Water for a Sustainable Future."
[77] "Allocating Water for a Sustainable Future."
[78] "Allocating Water for a Sustainable Future."
[79] "About Us: Why We Need a Water Trust"
[80] Schiller, Erin. "The Oregon Water Trust." Issue Analysis. 1 (November 1998). May 12, 2006 <http://www.cei.org/utils/printer.cfm?AID=1354>.
[81] Schonek, Kim.
[82] Schonek, Kim
[83] Schonek, Kim.

Evidence of MEWUE

The OWT believes that their work is part of a growing national trend that uses the market to further environmental goals. They believe that rather than encouraging greater regulation increase environmental benefit, working directly with landowners to find a cooperative solution that benefits all is a more efficient approach.

Even though the actual amount of water purchased by the OWT for Buck Hollow Creek and 15-Mile Creek is relatively small, it has been able to maintain water movement through pools and has kept the creeks connected from their mouths to the headwaters.[84] Still, it is important to keep in mind that water rights leasing programs are only one part of a bigger picture, but it is a good option to have when increasing flows is necessary to maintain a healthy ecosystem.

Case Study 7: Iron Mountain Mine

Summary

The contaminated acid discharged from Iron Mountain Mine (IMM) poses little threat to the surrounding human communities. The City of Redding's drinking water treatment plant treats the discharge once diluted.[85] However, the pollution source poses a serious threat to local fish species, especially those in the nearby Sacramento River. While previous solutions were water intensive, this approach was not sustainable or acceptable given growing water demands. Ultimately, litigation determined that financial responsibility for improving the site belonged to those responsible for IMM mining. The EPA led the project to adopt less-water dependent solutions, and adopted a technologically dependent approach to mitigate the discharges.

Background

IMM is located approximately 8.7 miles northwest of the City of Redding. IMM was once the tenth largest copper producer in the world. Currently, the site releases approximately one-fourth of the nation's total pollution discharge of copper and zinc to surface waters from industrial and municipal sources[86]. The source of pollution from IMM is acid mine drainage (AMD). AMD for this site contains sulfuric acid which forms from the exposure of pyrite to moisture and oxygen, and heavy metals contained in the acid. AMD contaminates the receiving water bodies below[87]. These water bodies include the Slickrock Creek, Spring Creek, and Spring Creek Reservoir, and the AMD poses risks to the Keswick Reservoir and the Sacramento River, which contains Chinook salmon, steelhead, and resident trout[88]. High concentrations of metals in the water stream directly impact the young fish population (fry) by binding to gill surfaces[89]. Site studies showed that upstream tributaries supported healthy ecosystems while areas downstream of the discharges were absent of aquatic organisms.

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[84] Schonek, Kim.
[85] United States. Environmental Protection Agency. Iron Mountain Mine – Success Through Planning, Partnerships, and Perseverance. Washington D.C. 2006.
[86] Iron Mountain Mine – Success Through Planning, Partnerships, and Perseverance.
[87] Iron Mountain Mine – Success Through Planning, Partnerships, and Perseverance.
[88] United States. Environmental Protection Agency. Record of Decision, Iron Mountain Mine, Shasta, California, 1997.
[89] Iron Mountain Mine – Success Through Planning, Partnerships, and Perseverance.

IMM has affected its surrounding environment for the last 100 years. On many occasions state and federal agencies took action to address issues generated by the mine, including[90]:

- 1899-1900 - The California Fish Commission investigates periodic fish kills
- 1902 - U.S. Forest reserve sues for vegetation damage
- 1928 - California Fish and Game Commission files a complaint regarding dam tailings
- 1964 - Spring Creek Debris Dam Constructed[91]
- 1976-1982- State of California fines owners for unacceptable releases of metals
- 1983 - IMM is listed on the National Priorities List (NPL) for EPA Superfund

- 1983 - IMM is listed on the National Priorities List (NPL) for EPA Superfund
- 1988 Emergency treatment plant reduces discharges by treating the most concentrated contaminant streams
- 1986-1997 EPA requires several remedial activities
- 2002 EPA implements additional remediation activities bringing load reduction of copper and zinc to 95%
- 2007 Dredging of contaminated sediments to occur in the Spring Arm Creek of Keswick Reservoir

Before the EPA's current remediation approach, site managers used dilution of contaminants in downstream waters to improve water quality. Specifically, the United States Bureau of Reclamation (USBR) constructed the Spring Creek dam as a mitigation measure for the AMD discharges.[92] AMD retention behind Spring Creek Debris Dam limited the migration of sediments downstream. In addition, it controlled releases to coincide with large releases from the Shasta Lake to meet interim water quality criteria in the Sacramento River.[93] However, there are two main reasons why the Spring Creek Debris Dam could not meet water quality goals: (1) the storm inflows to the SCR are highly contaminated from IMM, and (2) storms that cause these contaminated waters to fill the reservoir within just a few days will likely occur every 5 to 10 years.[94]

This water-dependent alternative also carried substantial costs. In March 1992, during a drought period, the Bureau of Reclamation was required to release 77,000 acre-feet of water from Shasta Lake to mitigate a spill from IMM. This water was valued at $18 M and would have otherwise been delivered to Central Valley farmers[95].

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[90] Iron Mountain Mine – Success Through Planning, Partnerships, and Perseverance.
[91] Stene, Eric. "Dams Projects & Powerplants: Central Valley Project Trinity River Division." United States. Department of the Interior. Bureau of Reclamation. 10 May 2006 <http://www.usbr.gov/dataweb/html/trinity.html>.
[92] Record of Decision, Iron Mountain Mine, Shasta, California.
[93] Record of Decision, Iron Mountain Mine, Shasta, California.
[94] Record of Decision, Iron Mountain Mine, Shasta, California.
[95] Iron Mountain Mine – Success Through Planning, Partnerships, and Perseverance.

Solutions and Alternatives

The EPA established primary goals for the IMM Superfund remedial action and used these goals to evaluate alternatives. These goals included:

1. Comply with the water quality criteria established under the Clean Water Act.
2. Reduce the mass discharge of toxic heavy metals through application of appropriate control technologies.
3. Minimize the need to rely on special releases of California's valuable water resources to ensure compliance with water quality standards in the Sacramento River through special releases of waters to dilute toxic spills of IMM contaminants.[96]

Through extensive environmental review and comparison, the EPA selected the lime stabilization treatment alternative (creating high density sludge, HDS) from the acid effluent from the mine. Because the discharge point is known, direct treatment of the discharge was feasible and provided a reliable treatment effectiveness of 95%[97]. The EPA currently consolidates lime-stabilization plant discharges into a high-density sludge and disposed of in a nearby upland disposal site. Current costs of running the lime-stabilization plant are approximately $1 M/ year and disposal is approximately $0.7 M/year[98].

The EPA considered other less expensive treatment methods, such as purging the mountain with fresh water, but rejected because of the uncertainty of the treatment outcome[99]. Figure 2 shows some of these considered alternatives.

Alternatives		Present Worth Basis		
		Capital Costs ($)	Operating Costs ($)	Total Costs ($)
P0	No-Action		462,000	462,000
P1-A	Treat Portal Flows Simple Mix	13,178,000	21,214,000	34,392,000
P1-B	Treat Portal Flows HDS	16,344,000	27,394,000	43,738,000
P2	Plug Mine Internal Pool Treatment Treat Residual Flows	20,878,000	19,226,000	40,104,000
P5	Plug Mine External/Internal Pool Treatment Treat Residual Flows	32,598,000	22,255,000	54,853,000
P6-A	Cap and Treat Portal Flows Simple Mix	27,411,000	18,140,000	45,551,000
P6-B	Cap and Treat Portal Flows HDS	29,829,000	23,443,000	53,272,000

Figure 2: Alternatives created for the 1992, Feasibility Study (with costs)[100]

96 Record of Decision, Iron Mountain Mine, Shasta, California.
97 Sugarek, Richard. Phone Interview. 9 March 2006.
98 Sugarek, Richard.
99 Sugarek, Richard.
100 United States. Environmental Protection Agency. Public Comment, Feasibility Study, Boulder Creek Operable Unit, Iron Mountain Mine, Redding California, Volume I—Text, EPA WA NO. 31-01-9N17, May 1992, RDD69017.FS.RI, Redding, CA, 1992.

Evidence of MEWUE

Because the EPA set as one of their project goals to reduce the amount of water needed to mitigate the problems presented by IMM, the final selected alternative demonstrates a water-minimizing solution. Another project goal, and the measurable environmental benefit, includes compliance with the Clean Water Act. The lime stabilization process entails capturing the contamination, which is in liquid form, drying it through the lime process, and disposing it in an on-site landfill.

This project demonstrates that establishing project goals, evaluating alternatives, and implementing the best option functioned through a centralized and focused management and decision-making team. In contrast, from 1899 to 1988, no significant discharge mitigation occurred. It was only after 1988 when the EPA provided funding and leadership, when site improvements occur. Involvement of the EPA and legal action were key components to the successful remediation of the site, and finally resulted in a settlement agreement exceeding $950M to fund on-going remediation activities.[101]

[101] Iron Mountain Mine – Success Through Planning, Partnerships, and Perseverance.

Case Study 8: Battle Creek

Background

The Battle Creek Salmon and Steelhead Restoration Project (BCSSRP) aims to restore 42 miles of salmon and steelhead habitat on Battle Creek, and 6 miles of habitat on its tributaries while maintaining renewable energy production from the "Battle Creek Hydroelectric Project."[102] Battle Creek is a desirable restoration area because it is one of the last tributaries to the Sacramento River that contains threatened or endangered fish. These fish include Central Valley spring-run Chinook salmon, Sacramento River winter-run Chinook salmon, and Central Valley steelhead.[103] Battle Creek conditions simulate upper Sacramento River conditions, now blocked to salmon and steelhead because of Shasta Dam.[104] Battle Creek is well-shaded, making the water cold. In addition, Battle Creek's rugged geology and adjacent private land-ownership make the creek difficult to access, which reduces human impacts.

The primary mechanism of restoration in the Battle Creek Restoration Plan is to alter operations and facilities of the Hydroelectric Project (a Federal Energy Regulatory Commission (FERC) Project). Battle Creek has been diverted for hydroelectric power generation since the early 1900s. Between 1901 and 1911, Keswick Electric Power Company built the Volta, South, Inskip and Coleman Powerhouses.[105] PG&E constructed a fifth powerhouse in 1980, called Volta II. PG&E has owned and operated the Battle Creek Hydroelectric Project since 1919.[106] The original pool and weir fish ladders were replaced in the 1980s with Alaska Steeppass ladders.

In 1999, U.S. Department of Interior, Bureau of Reclamation, U.S. Fish and Wildlife Service, National Marine Fisheries Service, California Department of Fish and Game, and the Pacific Gas and Electric Company reached an agreement (memorandum of understanding (MOU)) to restore the Battle Creek for Salmon and Steelhead. The resulting restoration project for Battle Creek must comply with the National Environmental Policy Act, and the California Environmental Quality Act.[107] In order to comply, cooperating agencies have completed a series of

[102] United States. Department of the Interior. Bureau of Reclamation. Draft Battle Creek Salmon and Steelhead Restoration Project Adaptive Management Plan. Prepared by Terraqua, Inc. Wauconda, Washington. April 2004. 22 April 2006 <www.usbr.gov/mp/battlecreek/pdf/docs/adapt/AMP_April_2004.pdf>.

[103] Draft Battle Creek Salmon and Steelhead Restoration Project Adaptive Management Plan.

[104] "Battle Creek Salmon and Steelhead Restoration Plan. Prepared for the Battle Creek Working Group by Keir Associates." (January 1999) Klamath Resource Information System. 22 April 2006. <http://krisweb.com/biblio/battle_xxxx_wardetal_1999_restplan.pdf>.

[105] "Battle Creek Salmon and Steelhead Restoration Plan. Prepared for the Battle Creek Working Group by Keir Associates."

[106] "Battle Creek Salmon and Steelhead Restoration Plan. Prepared for the Battle Creek Working Group by Keir Associates."

[107] United States. Department of the Interior, Bureau of Reclamation. Battle Creek Salmon and Steelhead Restoration Project Final Environmental Impact Statement/Environmental Impact Report Volume I: Report. (July 2005) 22 April 2006. <http://www.usbr.gov/mp/mp150/envdocs/title-toc-es-ch-1_3.pdf>.

administrative actions since 1999.[108] As a result, a "Record of Decision" is pending, and after seven years of planning and development, restoration should begin soon pending funding from CALFED.

In addition to the MOU signatories, the Greater Battle Creek Watershed Working Group (GBCWWG) actively participates in collaborative Battle Creek Restoration efforts. The GBCWWG is a group of local stakeholders partnered with state and federal agencies, and non-profit organizations.[109] GBCWWG's strives to restore salmon and steelhead in the Battle Creek watershed.

Environmental evaluations for Battle Creek restoration analyzed several alternative restoration plans in terms of fish passage, owner liability, operation and maintenance, water rights, stream characteristics, stream hydrology and biological criteria.[110] In 1999, as a result of the MOU, CALFED funded $28 million toward the preferred alternative restoration project. The preferred alternative was to remove five of the eight dams, install fish ladders and fish screens at three diversion dams, and increase instream flow releases from all remaining diversion dams. This plan incorporates adaptive management to evaluate and update restoration efforts, and establishes the Water Acquisition Fund to purchase environmental flows when necessary.[111] Additional funding came from the Packard Foundation ($3 million for the Adaptive Management Fund) and from PG&E, who contributed $20.55 million for the cost of fish monitoring and the cost of foregone power during construction.

Since 1999, cost-estimates of the BCSSRP have increased from $28 million to $75 million,[112] and are currently being renegotiated.[113] While PG&E, the Bureau of Reclamation and the Nature Conservancy agree on the five-dam removal plan, some environmentalists think the plan is inadequate, and that we should remove all eight dams.[114] However, changing the current plan and starting the EIS/EIR process anew would delay restoration. As construction delays increase, chances of fish extinctions increase and the cost of restoration increases.[115]

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[108] filed a notice of intent (1/12/00), conducted a scoping meeting (1/31/00), filed a draft joint Environmental Impact Statement/Environmental Impact Report (7/18/03), held public hearing (8/27/03) resulting in an updated EIS/EIR (3/1/05) and a final EIS/EIR (7/29/05), Record of Decision (ROD) currently pending

[109] Greater Battle Creek Watershed Working Group. Brochure. 12 May 2006. <http://www.battle-creek.net/docs/gbcwwg/gbcwwg_brochure_03_13_06.pdf>.

[110] State of California. The Resources Agency. Department of Water Resources. Division of Planning and Local Assistance. 2000. Dossey, Kevin, Kennedy, Scot , and McLaughlin, Bill. Battle Creek Salmon And Steelhead Restoration Project Fish Ladder And Fish Screen Features: Inskip Diversion, North Battle Creek Feeder Diversion, Eagle Canyon Diversion, Preliminary Engineering Concepts Technical Report.

[111] Battle Creek Salmon and Steelhead Restoration Project Final Environmental Impact Statement/Environmental Impact Report Volume I: Report

[112] Martin, Glen. "Battle of Battle Creek: Which Way to Save Salmon?" San Francisco Chronicle 15 March 2004. 10 April 2006 <http://sfgate.com/cgi-bin/article.cgi?f=/c/a/2004/03/15/MNG5T5KMGE1.DTL>.

[113] "Ecosystem Restoration Program Battle Creek" California Bay-Delta Authority. 12 May 2006. <http://calwater.ca.gov/Programs/EcosystemRestoration/Ecosystem_BattleCreek.asp>.

[114] "Battle of Battle Creek: Which Way to Save Salmon?"

[115] Battle Creek Watershed Conservancy. Greater Battle Creek Watershed Working Group Issue Tracking (January 10, 2006) 12 May 2006. <http://www.battle-creek.net/issue_tracking_1_10_06.html#cost>.

Increased funding from CALFED is likely to be secured once outstanding environmental paperwork, and local property-owner issues are resolved.[116] Also, the process is tied together politically by the 1999 MOU, which provides some security that the restoration project will proceed, even if there are further delays.

Evidence of MEWUE

The BCSSRP shows evidence of MEWUE because fish ladders, fish screens, and ozone treatment at the CNFH all increase environmental benefit without using more water. The BCSSRP will implement MEWUE mechanisms concurrently with increased instream flows. Flows will increase because five hydroelectric power diversion dams will be removed and instream flow minimum requirements will increase. This is a complex restoration project with legal constraints including CEQA, ESA, and NEPA, political constraints from the large number of collaborating organizations, and an array of funding sources. The complexity of this case illustrates some of the ways MEWUE can improve environmental benefit, but shows some of the problems and constraints to implementing MEWUE.

[116] Fris, Rebecca. Phone Interview. 8 May 2006.

APPENDIX B: MEASURING ENVIRONMENTAL BENEFIT

Defining Environmental Benefit

Case Specific

Defining an environmental benefit is inherently case-specific, as it depends upon the following:

- Problem definition and scope
- Project goal and the extent or quantity of the outcome sought, for example targeted species vs. ecosystem health
- Available inputs (temperature, channel form, vegetation, water quantity, etc.)
- Site constraints

Organizational

Defining environmental benefits also depends on the nature of the involved organization as a public agency responsible for regulatory compliance may have different goals than a non-profit seeking to further a more narrowly-defined mission. Organizations have different values, and different angles may include

- Targeted species improvement
- Ecosystem health/biodiversity
- Mitigation/remediation
- Reactive vs. proactive approach

Standards of Measurement

Absolute

An absolute measurement of an environmental outcome is arguably difficult, as quantitative measures of benefits do not always exist. For example, it may be difficult to determine whether the presence of six hundred fish in a stream represents a successful environmental outcome. However, several examples offer support for quantifying environmental benefits. The Endangered Species Act listing and de-listing process utilizes an index of species population counts juxtaposed against environmental factors to assess a species' health and likelihood of survival.[117] Water quality standards set threshold levels of pollutants d as measures of environmental health and safety.

Relative

Several of our case studies revealed positive environmental outcomes that were determined on the basis of comparison to some other outcome. Benchmarking involves a measure of improvement that compares the present outcome to a previous one. One example is to compare this year's fish runs to those in the past, with an increase in population considered an environmental benefit. Another example is to evaluate the presence of a desired element that might otherwise be absent, for example, water year-round in a river that had previously run dry

[117] Whitener, Keith. Personal Interview. March 2006.

in the summer represents an improved outcome. Mitigation, or remediation, offers another example of an environmental benefit that is comparative in nature, by emphasizing doing less harm rather than seeking to produce a specific positive outcome.

Indicators
Ecosystem health, or biodiversity, takes stock of the number and sensitivity of species present. and assigns a high environmental value to sites that house sensitive species. Again, this is a relative measure of environmental outcomes, the guiding principle being the more and the more sensitive species present, the better. Indicators may be used on the micro-level, for example, macroinvertebrates offer a method for measuring water quality. Species as indicators may also be used on a larger scale, in the case of birds, which can signify overall ecosystem health[118].

Uses
The number and type of environmental benefits that a site provides can serve as a measure of environmental outcomes.. One example would be expanding a riparian vegetation restoration project to meet the needs of native fish populations.

Multiple uses, where environmental benefits spill over to different sectors, also offers a measure of outcomes. For example, habitat restoration, recreation and flood control may overlap at a single site to increase the overall benefits across sectors.

[118] Elliott, Gregg, et al. Developing and Implementing an Adaptive Conservation Strategy. Point Reyes Bird Observatory. 20 March 2006 <http://www.prbo.org/cms/docs/consplans/ACP_intro.pdf>.